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Correlation Studies for Yield and Yield Attributes in Field Pea (*Pisum sativum* L.)

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Abstract

The present investigation was carried out at Research Farm, ICAR Research Complex for NEH Region Tripura centre Lembucherra Agartala (Tripura). The experiment comprising F_1 , F_2 , Bc_1P_1 (B_1) and Bc_1P_2 (B_2), (B_2) Populations of two crosses viz., IM 9214-10 x Rachna (C-1) and IM 9214-10 x Ambika (C-2) was conducted in randomized block design with three replications. The populations were employed in the detection and estimation of genetic parameters for days to first flowering, plant height, number of clusters per plant, seed setting percent, pods per cluster, number of pods per plant, pod length, hundred seed weight and seed yield per plant utilizing the models suggested by Mather (1949) and Hayman (1958). Analysis of variance revealed that sufficient genetic variation has been created for seed yield and its attributes for taking different biometrical analyses. Correlation studies show positive relationship of seed yield with all the attributing traits except pod length and hundred seed weight, where it was inconsistent in both the crosses. Days to flowering, plant height, clusters per plant, seed setting per cent and pods per cluster had significant positive association with seed yield, indicating that major emphasis should be given on these component characters for improving seed yield in the populations of pea, under improvement

Introduction

Field pea or dry pea (*Pisum sativum* L.) belongs to family leguminosae and sub family Papilionaceae is considered to be the native of Ethiopia, the Mediterranean and Central Asia. It is a nutritious and protein rich (19.6%) crop, mostly used for green and dry seeds. Hence, pea is categorized as vegetable type and field pea. The area of field pea in India is about 0.76 million hectares with annual production of 0.84 million tones and productivity of 1100 kg ha⁻¹ (Anonymous, 2013 a). Its area, production and productivity in the state of Tripura are 1028 hectare 897 mt tonnes and 873 kg/ ha respectively, (Anonymous, 2013 b).

To meet out challenging demand of pulses it has become necessary to boost up their production in the country. Field pea has high production potential of more than 2.0 tons per ha under better agronomic management (Anonymous, 2013c). Field pea, very much response to low soil pH and one/two irrigations hence, there is plenty of scope for its horizontal and vertical expansion in rice based cropping system of Tripura. Relatively this crop dose not has much problem of pest and diseases except powdery mildew, to which genetic resistance is available.

Selection for yield and quality traits can be better achieved if the information with respect to correlation between such traits is also available with a better understanding of the association between the relevant characters with yield (Kumar et al., 2015). The present study therefore, was taken up to estimate character

association in pea so that the desired targets are achieved.

Materials and Methods

The experiment comprising F_1 , F_2 , Bc_1P_1 (B_1) and Bc_1P_2 (B_2), (B_2) Populations of two crosses viz., IM 9214-10 x Rachna (C-1) and IM 9214-10 x Ambika (C-2) was conducted in randomized block design with three replications. The populations were employed in the detection and estimation of genetic parameters for days to first flowering, number of branches per plant, days to maturity, plant height, number of clusters per plant, pod bearing length, seed setting percent, pods per cluster, number of pods per plant, pod length, hundred seed weight and seed yield per plant utilizing the models suggested by Mather (1949) and Hayman (1958). In each replication, each genotype was sown in a plot size 2.0 x 0.90 m² consisting of three row. The row to row and plant to plant distance was 30 cm and 10 cm, respectively. Five competitive plants were selected at random in P_1 , P_2 , F_1 , BC_1 and BC_1 while 20 plants in F_2 for recording the observations on number of branches per plant, plant height, number of clusters per plant, pod bearing length, seed setting percent, pods per cluster, number of pods per plant, pod length, hundred seed weight and seed yield per plant. Data on days to 50% flowering and Days to maturity was however recorded on whole plot basis. The crop was raised as per the recommended package of practices.

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1985). Genotypic and phenotypic correlation coefficients of variability were estimated according to the Burton and Devane (1953) by using the following formulae:

$$PCV = \frac{\sqrt{{}^2p}}{\bar{x}} \quad GCV = \frac{\sqrt{{}^2g}}{\bar{x}} \quad 100$$

Where,

PCV = Phenotypic Correlation Coefficient, GCV = Genotypic Correlation Coefficient

${}^2g$ = Genotypic variance = (Mean sum of squares due to genotypes – Error mean sum of squares) ÷ Replications

${}^2p$ = Phenotypic variance = ${}^2g + {}^2e$

${}^2e$ = Environmental variance = (Error mean sum of squares) ÷ Replications

$\bar{x}$ = General mean

PCV and GCV were classified as suggested by Sivasubramanian and Menon (1973).

Less than 10%	=	Low
10-20%	=	Moderate
More than 20 %	=	High

Results and Discussion

Analysis of variance was carried out separately for cross and characters (Table-1). The mean sum of squares due to treatments (different generations) were highly significant for all the characters except number of branches per plant and hundred seed weight in cross-1, and pod length and pods per cluster in cross-2. The mean performance of six generations for each of the twelve characters is given in table 2. F_1 means as compare to their parental values varied in magnitude from cross to cross and character to character. Similarly, F_2 means also deviated from F_1 means. In general, backcrosses gave superior performance as compare to their parents for seed yield and other important attributes related to seed yield.

Correlation coefficient analysis is a statistical measurement which is used to find out the degree and direction of relationship between two or more variables. Correlation coefficients were worked out at phenotypic level for twelve characters using F_2 data from cross — 1 and 2. The correlation coefficients (r) obtained from this investigation are presented in Table-2. Seed yield per plant had significant positive correlation with days to first flowering, plant height, clusters per plant, seed setting

percent and pods per

Cluster in both the crosses, branches per plant, pod bearing length and pods per plant

in cross-1 and days to maturity, pod length and hundred seed weight in cross-2. However, pod length and hundred seed weight exhibited negative association in cross-1.

Days to first flowering : Days to first flowering had significant negative correlation with number of clusters per plant, seed setting percent and pods per cluster in both the crosses. It had positive association with days to maturity in both the crosses; pod length and hundred seed weight in cross-1 and plant height and pod bearing length in cross-2. It exhibited negative but non significant association with plant height and pod bearing length in cross-1.

Plant height : Significant positive association of plant height was observed with number of clusters per plant, pod bearing length, pods per cluster, number of pods per plant and pod length, in both the crosses, whereas it showed positive association with seed setting percent and hundred seed weight only in cross-1.

Clusters per plant : Significant and positive association of this character was observed with pod bearing length, seed setting per cent, pods per cluster and number of pods per plant in cross-1, while, it had significant negative association with pod length and hundred seed weight in cross-1 and with seed setting percent in cross-2.

Seed setting per cent : It showed significant and positive association with seed yield and pods per cluster in both the crosses and with number of pods per plant in cross-1 and with hundred seed weight in cross-2. It was negatively associated with hundred seed weight in cross-1 and with number of pods per plant in cross-2 respectively.

Pod per cluster : It showed significant and positive correlation with number of pods per plant and seed yield per plant in both the crosses, but negatively associated with hundred seed weight onus in cross-2.

Pods per plant : Pods per plant had significant positive correlation with seed yield in cross-1 while, it had significant negative correlation with hundred seed weight in both the crosses.

Pod length : Pod length exhibited significant positive correlation with hundred seed weight in both the crosses and with seed yield per plant in cross-2. While, it had negative correlation with seed yield in cross-1.

Table-1 : Analysis of variance for yield and its attributes in field pea.

Source of variation	df	First flower (days)	No of branches Plant ⁻¹	Maturity (days)	Plant height (cm)	No of clusters plant ⁻¹	Pod bearing length (cm)	Seed setting (%)	Pods cluster ⁻¹	Number of pods plant ⁻¹	Pod length (cm)	100 seed weight (g)	Seed yield plant ⁻¹ (g)
C-1 : IM 9214-10 × Rachna													
Replication	2	0.0273	0.1088	0.4375	2.5430	0.4066	0.1486	0.8710	0.0016	0.6571	0.0720	0.1203	0.1668
Treatment	5	2.756**	0.1622	3.7875*	1015.973**	7.2306**	68.227**	22.9135**	0.0386*	65.40**	0.1418*	2.792	18.865**
Error	10	0.2664	0.0755	0.2375	0.5054	0.0733	0.2715	1.0065	0.0103	0.0745	0.0405	0.1571	0.1526
C-2 : IM 9214-10 × Ambika													
Replication	2	0.6914	0.2338	0.8906	0.1015	0.06222	0.2271	0.0039	0.0072	0.2772	0.0816	0.4257	0.1433
Treatment t	5	2.7679**	0.3498*	5.3416**	1424.687**	7.2818**	42.7472**	21.1802**	0.0222	26.9245**	0.0936	2.1602**	9.604**
Error	10	0.4011	0.1025	0.8666	0.8250	0.05356	0.7952	1.9200	0.0125	0.9372	0.0869	0.1424	0.1173

*, **Significant at 5 and 1 percent level of significance.

Table-2 : Correlation coefficients among yield and its attributes in F2 population in two crosses of field pea in field pea (*Pisum sativum* L.)

Characters	Cross	No of branches Plant ⁻¹	Maturity (days)	Plant height (cm)	No of clusters plant ⁻¹	Pod bearing length (cm)	Seed setting (%)	Pods cluster ⁻¹	Number of pods plant ⁻¹	Pod length (cm)	100 seed weight (g)	Seed yield plant ⁻¹ (g)
First flower (days)	C ₁	-0.387**	0.285**	-0.096	-0.213**	-0.090	-0.408**	-0.202**	-0.317**	0.236**	0.497**	0.366**
	C ₂	0.150	0.382**	-0.398**	-0.396**	-0.197**	-0.490**	-0.197	0.087	-0.264**	-0.598**	0.646**
No of branches plant ⁻¹	C ₁		-0.423**	-0.371**	0.279**	-0.421**	-0.049	-0.181*	0.206**	-0.401**	-0.685**	0.355**
	C ₂		0.47**	0.090	-0.138	-0.025	0.171	0.239**	0.149	0.457**	0.277**	0.072
Maturity (days)	C ₁			0.656**	0.061	0.721**	0.508**	0.401**	0.205**	0.615**	0.263**	0.046
	C ₂			0.585**	-0.044	0.710	0.203**	0.211**	0.369**	0.338**	-0.129	0.271**
Plant height (cm)	C ₁				0.376**	0.953**	0.482**	0.752**	0.248**	0.331**	0.298**	0.471**
	C ₂				0.575**	0.837**	0.026	0.438**	0.662**	0.393**	-0.098	0.520**
Clusters plant ⁻¹	C ₁					0.444**	0.723**	0.543**	0.847**	-0.210**	-0.552**	0.908**
	C ₂					0.082	-0.196**	0.035	0.129	0.047	0.122	0.590**
Pod bearing length (cm)	C ₁						0.586**	0.750**	0.438**	0.428**	0.159	0.441**
	C ₂						0.008	0.522**	0.703**	0.277**	-0.312**	0.168
Seed setting (%)	C ₁							0.504**	0.701**	0.131	-0.334**	0.665**
	C ₂							0.411**	-0.221**	0.104	0.704**	0.572**
Pods cluster ⁻¹	C ₁								0.436**	0.165	-0.055	0.509**
	C ₂								0.464**	-0.030	0.208**	0.432**
Number of pods plant ⁻¹	C ₁									-0.055	-0.716**	0.665**
	C ₂									0.013	-0.310**	0.053
Pod length (cm)	C ₁										0.392**	-0.313**
	C ₂										0.228**	0.342**
100 seed weight (g)	C ₁											-0.462**
	C ₂											0.668**

*, ** Significant at 5 and 1 percent level of significance C₁= Cross-1 (IM 9214-10 × Rachna), C₂ = Cross-2 (IM 9214-10 × Ambika)

Hundred seed weight : It had significant and positive association with seed yield per plant in cross-2 but negative association in cross-1.

A sound genetic information has been an indispensable prelude for modifying the vast array of gene frequencies to enable genetic enrichment in a genotype. The presence of genetic variability is essential and pre-requisite for an effective improvement in a crop species. Besides, genetic variability, heritability which measures the relationship between phenotypic and genotypic appearance is another important consideration for the success of a breeding programme. It is obvious that the selection is usually based on phenotypic observations and the success would naturally depend upon the relationship between phenotype and the genotype. The knowledge of association between yield and yield components are useful in determining suitable selection scheme for maximum genetic gain. This information can also be used for locating the most important yield components.

Yield is a complex character and resultant of interactions from many components. A plant breeder is therefore, always interested in finding out components which are closely associated with yield. Further, inter-relationship among the characters could be of great significance to the breeder to exert selection pressure most profitably in order to make rapid yield gains. A knowledge of correlation between the components and yield may also be valuable for the breeder as an indication about the components on which selection pressure could most profitably be exercised in order to obtain an increase in yielding ability (Grafius, 1964). The inter-relationships among the components often serve to compound such relationships with yield and techniques such as path analysis (Wright, 1921), have been developed which can unentangle their complex relations.

Correlations indicate linkages of characters. Study of character correlations, therefore, becomes useful in any crop improvement programme. Such studies have been done both at fixed population level i.e. parental genotypes; and segregating population level i.e.; F_2 and later generations later ones are more useful and relevant since selection is generally practiced in the F_2 or later generations.

In the present study study associations were determined at the F_2 population level in the two crosses among twelve important growth and yield

components. Correlation coefficient were inconsistent in different genetic back grounds.

Positive association of seed yield per plant with days to first flowering, plant height, clusters per plant, seed setting percent and pods per cluster in both the crosses; number of branches per plant and number of pods per plant in cross-1 and days to maturity, pod length and hundred seed weight in cross-2 as recorded in this study are in agreement with the results of Pratap *et al.* (1995) and Sharma and Bala (1997) for days to first flowering, plant height, pod length and seed yield.

Days to first flowering had significant positive correlation with days to maturity, pod length and hundred seed weight, are in agreement with results of Nandpuri and Kumar (1973) and Vaishnav (2000) for days to maturity and hundred seed weight.

On the other hand days to first flowering had significant and negative association with plant height, clusters per plant, pod bearing length, seed setting percent, pods per cluster and pods per plant. Similar results have also been reported by Kashyap (1979) and Narsinghani *et al.* (1978) for clusters per plant.

Number of branches per plant did not show the uniform relationship with other characters. It had negative association with days to maturity, plant height, pod bearing length, pods per clusters, pod length, hundred seed weight in cross-1, while it had positive association with days to maturity, pods per cluster, pod length and hundred seed weight in cross-2. None had reported such type of relationship.

Maturity had significant positive correlations with plant height, seed setting percent, pod bearing length, pods per cluster, number of pods per plant and pod length in both the crosses; hundred seed weight only in cross-1. Similarly Joshi *et al.* (1992) and Vaishnav (2000) also reported positive association of days to maturity, branches per plant, seed setting percent and pods per cluster.

Significant positive association of plant height was observed with number of clusters per plant, pod bearing length, pods per cluster, number of pods per plant and pod length in both the crosses; seed setting percent and hundred seed weight in cross-1 as also recorded by Chaudhary and Singh (1971), Pratap *et al.* (1995), Sharma and Bala (1997) and Vaishnav and Pandey (2001). On the contrary, Ranalli *et al.* (1981) reported negative association of plant height with pods per plant.

Significant and positive association of clusters per plant was observed with pod bearing length, seed setting per cent, pods per cluster and number of pods per plant in cross-I, while it was negative with pod length and hundred seed weight; and negative with seed setting percent in cross — 2. The results clearly indicate that any increase in number of clusters per plant there may be corresponding increase in pod bearing length, pods per cluster and number of pods per plant but there could be decrease in pod and seed size. Similar results were also obtained by Makasheva and Varlkhov (1995) and Vaishnav (2000) for clusters per plant with pod bearing length, pods per plant and hundred seed weight.

Pod bearing length had positive significant association with pods per cluster, number of pods per plant and pod length in both the crosses; seeds setting in cross-1; and negative with hundred seed weight in cross-2. This reveals that with increase in pod bearing length there may be increase in pods per cluster, pods per plant and pod length and ultimately seed yield.

Correlations of number of seeds per cluster and pods per plant with seed yield and between themselves were positive indicating that for improving seed yield in dry pea, the number of pods per plant must be increased. Vaishnav (2000) had also reported positive associations of these traits with yield in field pea. In accordance to this Kumar *et al.* (1965), Malik and Haffeez (1973), Nandpuri and Kumar (1973), Narsinghani *et al.* (1978), Kashhyap (1979), Yadava (1989), Joshi *et al.* (1992) Pratap *et al.* (1995), Sharma and Bala (1997), Makasheva *et al.* (1998), Singh and Joshi (1978), Gupta *et al.* (1998), Vikas and Singh (1999) and Mahanta *et al.* (2001).

Seed setting percent showed positive relationship with pods per cluster in both the crosses but sowed inconsistency with pods per plant and hundred weight.

Seed index exhibited positive association with pod length but had negative association with pods per plant, indicating that higher number of pods may affect the seed development in field pea. Hence, emphasis on higher number of pods with longer pod size should be given while exercising selection for desirable genotype. Vaishnav (2000) had also reported positive correlation between pod length and seed size in pea but no relation between pod number and seed size.

Results of association studies clearly gave an indication that correlations among the component

characters were somewhat inconsistent depending upon the genetic background of the population under study. However, relationships of the component characters with seed yield in general, were consistent and positive, indicating that for yield improvement in pea, plant breeders should pay attention on these attributes while exercising the selection in segregating population.

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Variability, Heritability and Genetic Advance in Field Pea (*Pisum sativum* L.)

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Abstract

The present investigation was carried out at Research Farm, ICAR Research Complex for NEH Region Tripura centre Lembucherra Agartala (Tripura) during rabi 2012-13. The experiment comprising F_1 , F_2 , Bc_1P_1 (B_1) and Bc_1P_2 (B_2), (B_2) Populations of two crosses viz., IM 9214-10 x Rachna (C-1) and IM 9214-10 x Ambika (C-2) was conducted in randomized block design with three replications. The populations were employed in the detection and estimation of genetic parameters for days to first flowering, number of branches per plant, days to maturity, plant height, number of clusters per plant, pod bearing length, seed setting percent, pods per cluster, number of pods per plant, pod length, hundred seed weight and seed yield per plant utilizing the models suggested by Mather (1949) and Hayman (1958). Analysis of variance revealed that sufficient genetic variation has been created for seed yield and its attributes for taking different biometrical analyses. Relative magnitude of phenotypic coefficients of variation was higher than genotypic coefficients of variation for all the characters under study indicating environmental influence on the traits.

Key word : Fieldpea, GCV, PCV, heritability and genetic advance.

Introduction

Proteins are the essential ingredients of our food and are considered to be building block of our body. The deficiency of protein particularly in growing children and nursing mothers causes "Protein caloric malnutrition" IPCMI. Proteins constitute about 20 percent of our body weight and are derived from the dietary foods (Swaminathan, 1990).

Pulses are considered to be the cheapest and economic source of protein. However, the availability of pulses had declined from 64 g to less than 37 g as against the recommendation of 80 g per capita per day. It is estimated that the Indian population will touch nearly 1350 million by 2020 A.D. and country would then need a minimum of 30.0 million tones of pulses, as against today's pulses production of 28.17 million tones (Anonymous, 2013). Among the major pulse crops grown in India, field pea or dry pea (*Pisum sativum* L.) belongs to family leguminosae and sub family Papilionaceae is considered to be the native of Ethiopia, the Mediterranean and Central Asia. It is a nutritious and protein rich (19.6%) crop, mostly used for green and dry seeds. Hence, pea is categorized as vegetable type and field pea. The area of field pea in India is about 0.76 million hectares with annual production of 0.84 million tones and productivity of 1100 kg ha⁻¹ (Anonymous, 2013 a).

Its area, production and productivity in the state of Tripura are 1028 hectare 897 mt tonnes and 873 kg/ ha respectively, (Anonymous, 2013 b).

To meet out challenging demand of pulses it has become necessary to boost up their production in the country. Field pea has high production potential of more than 2.0 tons per ha under better agronomic management (Anonymous, 2013c). Field pea, very much response to low soil pH and one/two irrigations hence, there is plenty of scope for its horizontal and vertical expansion in rice based cropping system of Tripura. Relatively this crop dose not has much problem of pest and diseases except powdery mildew, to which genetic resistance is available.

The farmers of the state are small and marginal hence, there is urgent need to give them varieties which yield better even under average agronomic management. Dwarf types have greater potential under one or two irrigations. Hence, there is need to combine together desirable gene(s) from tall and dwarf types for evolving high yielding, disease resistant and widely adopted varieties for the state of Tripura. To attain the goal, the information on genetic architecture of yield and its attributing traits is essentially needed. Hence, the present study has been undertaken to generate basic information in relation to genetic improvement in seed yield. Estimates of parameters of variability importantly, heritability and genetic gain are reliable indicators for improvement of characters in a particular genetic material through selection. Since, the selection for highly heritable characters is more effective, therefore, heritability along with other parameters can be used in predicting the gain for a given selection intensity and expected genetic gain

further gives the idea of the extent of improvement in a character through simple selection.

Materials and Methods

The present investigation was carried out at Research Farm, ICAR Reesearch Complex for NEH Region Tripura centre Lembucherra Agartala (Tripura) during rabi 2012-13. The experiment comprising F_1 , F_2 , Bc_1P_1 (B_1) and Bc_1P_2 (B_2), (B_2) Populations of two crosses viz., IM 9214-10 x Rachna (C-1) and IM 9214-10 x Ambika (C-2) was conducted in randomized block design with three replications. The populations were employed in the detection and estimation of genetic parameters for days to first flowering, number of branches per plant, days to maturity, plant height, number of clusters per plant, pod bearing length, seed setting percent, pods per cluster, number of pods per plant, pod length, hundred seed weight and seed yield per plant utilizing the models suggested by Mather (1949) and Hayman (1958). In each replication, each genotype was sown in a plot size 2.0 x 0.90 m² consisting of three row. The row to row and plant to plant distance was 30 cm and 10 cm, respectively. Five competitive plants were selected at random in P_1 , P_2 , F_1 , BC_1 and BC_1 while 20 plants in F_2 for recording the observations on number of branches per plant, plant height, number of clusters per plant, pod bearing length, seed setting percent, pods per cluster, number of pods per plant, pod length, hundred seed weight and seed yield per plant. Data on days to 50% flowering and Days to maturity was however recorded on whole plot basis. The crop was raised as per the recommended package of practices. Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1985). Genotypic and phenotypic correlation coefficients of variability were estimated according to the Burton and Devane (1953) by using the following formulae.

$$PCV = \frac{\sqrt{{}^2p}}{\bar{x}} \quad GCV = \frac{\sqrt{{}^2g}}{\bar{x}} \quad 100$$

Where,

PCV = Phenotypic Correlation Coefficient, GCV = Genotypic Correlation Coefficient

${}^2g$ = Genotypic variance = (Mean sum of squares due to genotypes – Error mean sum of squares) ÷ Replications

${}^2p$ = Phenotypic variance = ${}^2g + {}^2e$

${}^2e$ = Environmental variance = (Error mean sum of squares) ÷ Replications

$\bar{x}$ = General mean

PCV and GCV were classified as suggested by Sivasubramanian and Menon (1973).

Table-1 : Analysis of variance for yield and its attributes in field pea.

Source of variation	df	First flower (days)	No of branches Plant ⁻¹	Maturity (days)	Plant height (cm)	No of clusters plant ⁻¹	Pod bearing length (cm)	Seed setting (%)	Pods cluster ⁻¹	Number of pods plant ⁻¹	Pod length (cm)	100 seed weight (g)	Seed yield plant ⁻¹ (g)
C-1 : IM 9214-10 x Rachna													
Replication	2	0.0273	0.1088	0.4375	2.5430	0.4066	0.1486	0.8710	0.0016	0.6571	0.0720	0.1203	0.1668
Treatment	5	2.756**	0.1622	3.7875*	1015.973**	7.2306**	68.227**	22.9135**	0.0386*	65.40**	0.1418*	2.792	18.865**
Error	10	0.2664	0.0755	0.2375	0.5054	0.0733	0.2715	1.0065	0.0103	0.0745	0.0405	0.1571	0.1526
C-2 : IM 9214-10 x Ambika													
Replication	2	0.6914	0.2338	0.8906	0.1015	0.06222	0.2271	0.0039	0.0072	0.2772	0.0816	0.4257	0.1433
Treatment	5	2.7679**	0.3498*	5.3416**	1424.687**	7.2818**	42.7472**	21.1802**	0.0222	26.9245**	0.0936	2.1602**	9.604**
Error	10	0.4011	0.1025	0.8666	0.8250	0.05356	0.7952	1.9200	0.0125	0.9372	0.0869	0.1424	0.1173

*, **Significant at 5 and 1 percent level of significance.

Table-2 : Estimation of heritability and genetic advance in two crosses of field pea (*Pisum sativum* L.).

	Cross-1		Cross-2	
	h^2 (ns)	GA %	h^2 (ns)	GA %
First flower (days)	75.70	3.73	66.30	3.40
No of branches plant ⁻¹	52.64	5.36	36.50	2.60
Maturity (days)	83.30	1.66	63.30	1.62
Plant height (cm)	99.90	54.20	98.80	64.05
Clusters plant ⁻¹	97.00	51.30	97.80	53.10
Pod bearing length (cm)	98.80	57.95	94.60	51.54
Seed setting (%)	87.90	7.25	77.00	6.40
Pods cluster ⁻¹	47.80	10.00	20.40	3.65
Number of pods plant ⁻¹	99.70	78.86	90.00	48.80
Pod length (cm)	45.40	5.65	10.66	0.20
100 seed weight (g)	84.80	9.30	82.50	7.40
Seed yield plants (g)	97.60	69.20	96.40	46.40

Table-3 : Cross wise mean performance of different generations for yield and attributes in field pea.

	First flower (days)	No of branches Plant ⁻¹	Maturity (days)	Plant height (cm)	Clusters plant ⁻¹	Pod bearing length (cm)	Seed setting (%)	Pods cluster ⁻¹	Number of pods plant ⁻¹	Pod length (cm)	100 seed weight (g)	Seed yield plant ⁻¹ (g)
C-1 : IM 9214-10 × Rachna												
P ₁	43.73	3.67	121.80	60.00	4.67	7.33	68.67	1.20	8.00	4.33	18.73	5.17
P ₂	42.20	3.27	125.20	76.00	4.80	18.07	72.97	1.40	9.93	4.73	19.43	5.90
F ₁	42.40	3.67	123.53	79.67	8.80	19.33	75.33	1.53	19.03	4.33	17.70	12.07
F ₁	44.00	3.23	124.33	63.44	6.73	17.80	73.77	1.37	17.00	4.83	18.65	6.47
BC ₁	44.30	3.20	123.87	79.60	6.27	17.87	77.67	1.40	8.47	4.67	20.40	8.07
BC ₂	44.33	3.13	123.80	85.07	5.33	20.53	69.33	1.47	10.60	4.73	19.85	6.33
C-2 : IM 9214-10 × Ambika												
P ₁	45.43	3.47	120.87	63.20	4.60	8.00	69.00	1.23	8.60	4.40	20.03	5.62
P ₂	45.13	3.67	124.20	88.67	4.47	19.53	69.67	1.43	16.33	4.70	19.28	6.40
F ₁	43.27	3.27	123.47	96.20	8.30	15.33	69.83	1.37	12.83	4.67	20.20	9.53
F ₁	43.47	3.13	124.60	65.33	4.13	15.83	72.17	1.33	9.37	4.50	19.81	6.70
BC ₁	43.80	3.53	124.03	64.17	4.50	14.00	72.33	1.43	13.70	4.43	20.73	8.30
BC ₂	43.33	3.70	123.33	71.47	5.17	13.73	76.17	1.47	9.93	4.80	21.73	10.00

Less than 10% = Low

10-20% = Moderate

More than 20 % = High

Results and Discussion

Analysis of variance was carried out separately for cross and characters (Table-1). The mean sum of squares due to treatments (different generations) were highly significant for all the characters except number of branches per plant and hundred seed weight in cross-1, and pod length and pods per cluster in cross-2. The mean performance of six generations for each of the twelve characters is given in table 2. F₁ means as compare to their parental values varied in magnitude from cross to cross and character to character. Similarly, F₂ means also deviated from F₁ means. In general, backcrosses gave

superior performance as compare to their parents for seed yield and other important attributes related to seed yield.

Heritability in narrow sense and genetic advance over mean estimated as percentage of mean for all the characters and cross wise (Table-2).

Cross-1 : Nine characters viz., days to flowering (75.70%), days to maturity (83.30%), plant height (99.90%), pod bearing length (98.80%), number of clusters per plant (97.00%), seed setting percent (87.90%), number of pods per plant (99.70%), hundred seed weight (84.80%) and seed yield per plant (97.60%) expressed high heritability, while number of branches per plant (52.64%), pods per cluster (47.80%) and pod length (45.40%) expressed moderate heritability under study.

Genetic advance as percentage of mean was found to be

Table-4 : Genetic parameters of variability for yield and its components in field pea.

Parameters Characters	Range		Mean	Coefficient of Variation	
	Minimum	Maximum		Genotypic	Phenotypic
First flower (days)	43.33	46.80	44.70	02.97	05.96
No of branches plant ⁻¹	02.33	03.55	03.10	01.05	17.35
Maturity (days)	122.00	125.00	123.80	00.30	00.91
Plant height (cm)	41.86	78.67	65.50	14.27	20.57
Clusters plant ⁻¹	04.60	05.33	04.90	00.61	17.88
Pod bearing length (cm)	07.73	22.33	16.60	14.53	25.53
Seed setting (%)	68.00	76.66	72.00	00.39	04.80
Pods cluster ⁻¹	01.20	01.60	01.40	04.11	08.38
Number of pods plant ⁻¹	08.00	14.70	11.10	00.29	37.84
Pod length (cm)	04.30	04.90	04.60	02.88	05.78
100 seed weight (g)	17.40	22.06	19.80	04.96	06.02
Seed yield plant ⁻¹ (g)	04.50	09.33	06.80	08.60	21.31

the highest for number of pods per plant (78.86%), followed by seed yield per plant (69.20%), pod bearing length (57.95%), plant height (54.20%), number of clusters per plant (51.30%). It was low for pods per cluster (10.00%), hundred seed weight (9.30%), seed setting percent (7.25%), pod length (5.65%), number of branches per plant (5.36%), days to first flowering (3.74%) and days to maturity (1.66%).

Cross-2 : Nine characters viz., days to flowering (66.30%), days to maturity (63.30%), plant height (98.8).%, pod bearing length (94.60%), number of clusters per plant (97.80%), seed setting percent (77.00%), number of pods per plant (90.00%), hundred seed weight (82.50%) and seed yield per plant (96.40%) expressed high heritability. However, number of branches per plant (36.50%), pods per cluster (20.40%) and pod length (10.66%) showed moderate to low heritability.

Genetics advance as percentage of mean was found to be the highest for plant height (64.05%) followed by number of clusters per plant (53.10%), pod bearing length (51.54%), number of pods per plant (48.80%), seed yield per plant (46.40%), while it was moderate to low for hundred seed weight (7.40%), seed setting percent (6.40%), pods per cluster (3.65%), days to first flowering (3.40%), number of branches per plant (2.60%), days to maturity (1.62%) and pod length. (0.20%).

A sound genetic information has been an indispensable prelude for modifying the vast array of gene frequencies to enable genetic enrichment in a genotype. The presence of genetic variability is essential and pre-requisite for an effective improvement in a crop

species. Besides, genetic variability, heritability which measures the relationship between phenotypic and genotypic appearance is another important consideration for the success of a breeding programme. It is obvious that the selection is usually based on phenotypic observations and the success would naturally depend upon the relationship between phenotype and the genotype. The estimates of heritability are also useful in prediction of genetic improvement following selection and deciding suitable breeding procedures for the improvement of a crop plant. The knowledge of association between yield and yield components are useful in determining suitable selection scheme for maximum genetic gain. This information can also be used for locating the most important yield components.

The present investigation was under taken to ascertain the basic information regarding the genetic variability, heritability and inter-relationship at phenotypic levels for grain yield and its components in field pea.

Three parents used in the present investigation differing in origin showed sufficient variability for the characters under study. The treatments consisting six generations showed significant differences for all the traits in both the crosses except for number of branches per plant, hundred seed weight in cross-1, pods per cluster and length in cross-2. Thus it is evident from data that adequate variability was generated for carrying out the various analyses as well as fulfilling the long term objectives of selecting desirable genotypes, possessing high yield.

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Shatavari Root Powder (*Asparagus racemosus* Willd.) as herbal Nutritional supplement for Japanese Quail

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Abstract

The present study was done to study the average body weight gain and increase in feed conversion efficiency in broiler chicks administered with different level of *Asparagus racemosus* Willd. root powder mixed in their feed. A 150-day old quail chicks were randomly distributed in 5 treatments 30 chicks in each treatment with 3 replicate having 10 chicks in each and reared on standard managemental conditions. The root powder of Shatavari was added over the basal ration at 1.0% level (Ts1), 1.5% (Ts2), 2.0% level (Ts3), 2.5% level (Ts4), whereas the Ts0 was the control group. A maize, soybean and rice bran-based quail starter diet having all the nutrients in the required quantity was prepared. Each of such diets was offered as mash *ad libitum* to Japanese quails chicks for a period of 49 days (up to 7th week of age). After the trial, marked ($P < 0.05$) overall improvements were evidenced in the form of increase in average body weight gain and feed conversion efficiency of the birds.

Key words : weight gain, conversion efficiency, japanese quail, shatavari.

Introduction

An immuno-modulator is a substance that stimulates or suppresses the components of the immune system including both innate and adaptive immune responses (Agarwal and Singh, 1999). The modulation of the immune system by various medicinal plant products has become a subject for scientific investigations currently worldwide. One such plant, *Asparagus racemosus*, commonly called 'Shatavari' possesses anti-diarrhoeal, anti-ulcerative, anti-spasmodic, aphrodisiac, galactagogue and other properties and has therefore gained its importance in Ayurveda, Siddha and Unani systems of medicine (Nadkarni, 1954). It has also been examined for its immunomodulatory properties. Presently, poultry farming has gained immense importance in the socio-economic scenario in the Indian livestock sector. For enhanced productivity of eggs and meat, it is needed for cheaper feed supplements to improve the overall weight gain of the birds and their feed conversion efficiency within a short period of time. So, nowadays research is being carried out by scientists regarding different herbal preparations. These also possess adequate immune-modulatory effects which augment the resistance of the birds against various infectious diseases. The present study has been carried out with the objective of an increase in total body weight gain and feed conversion ratio after the supplementation of *A. racemosus* root powder mixed with their feed mash in different levels.

Materials and Methods

One fifty-day-old quail chick was procured from the

hatchery and maintained under standard hygienic conditions of feeding and housing at poultry farm, Department of Animal Production, Rajasthan College of Agriculture, Udaipur. The chicks were divided into five groups with three replicate and reared from day old to seven week age. They were provided with ration as chick starter (0–3 weeks) and grower (3–7 weeks). *A. racemosus* root powder was brought from local market and administered in different levels in the diet. The root powder of Shatavari was added in ration at 1.0% level (Ts1), 1.5% (Ts2), 2.0% level (Ts3), 2.5% level (Ts4), whereas the Ts0 was the control group. The live body weight of chicks was measured at weekly intervals on 1st, 7th, 14th, 21st, 28th, 35th, 42nd and 49th days of the experiment. The feed efficiency was calculated in terms of feed conversion efficiency (ratio). Feed conversion efficiency was measured at weekly intervals on the basis of total feed intake and total gain in body weight. The feed conversion efficiency was interpreted as given below :

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{Feed consumed (g)}}{\text{Body weight gain (g)}}$$

Statistical analyses for different parameters were done as per the method described by Snedecor and Cochran (1994). Data were tested for statistical significance using Duncan multiple range test (DMRT) (Duncan, 1955).

Results and Discussion

Average means of body weight gain on supplementation of *Asparagus racemosus* and control diet are presented in Table 1 respectively. At zero to third week age, the mean values of body weight gain in Ts0, Ts1, Ts2, Ts3 and Ts4

Table-1 : Average body weight gain (gm) of quail chicks on inclusion of *Asparagus racemosus*, (Mean±SE).

Body weight gain	Ts0 (Control)	Ts1 (1.0% SRP)	Ts2 (1.5% SRP)	Ts3 (2.0% SRP)	Ts4 (2.5% SRP)	Overall mean	SEM	CD 5%
Zero to three weeks (g)	78.76 ^d ±0.51	83.41 ^c ±0.65	88.07 ^{ac} ±0.64	91.94 ^a ±0.66	90.40 ^{ab} ±1.85	86.52 ^c ±0.86	0.99	3.13*
Three to six weeks (g)	74.43 ^d ±3.01	76.34 ^d ±1.42	83.59 ^c ±0.47	90.88 ^b ±1.34	94.89 ^a ±2.05	84.03 ^c ±1.66	1.86	5.87*
Four to seven week (g)	44.24 ^d ±0.91	48.86 ^c ±1.24	54.89 ^b ±1.30	60.81 ^a ±2.11	59.84 ^a ±2.00	53.73 ^b ±1.5	1.58	4.99*
Zero to six weeks (g)	153.19 ^d ±2.52	159.75 ^c ±1.26	171.66 ^b ±0.34	182.82 ^a ±0.81	185.28 ^a ±1.12	170.54 ^b ±1.21	1.41	4.45*
Zero to seven weeks (g)	162.64 ^d ±0.84	172.22 ⁼ ±1.76	185.81 ^b ±0.84	197.23 ^a ±1.60	197.74 ^a ±0.66	183.28 ^b ±1.05	1.22	3.86*

Values bearing different superscripts in a row differed significantly, Values bearing the same superscript in the column did not differ significantly, NS: Nonsignificant, *P<0.05

Table-2 : The feed conversion ratio of Japanese quails on the inclusion of *Asparagus racemosus*, (Mean±SE).

Feed Conversion Ratio	Ts0 (Control)	Ts1 (1.0% SRP)	Ts2 (1.5% SRP)	Ts3(2.0% SRP)	Ts4 (2.5% SRP)	SEM	CD 5%
Zero to three week (g)	1.22 ^a ±0.02	1.08 ^b ±0.02	1.01 ^c ±0.03	0.92 ^d ±0.03	0.95 ^d ±0.00	0.02	0.07*
Three to six week (g)	2.89 ^a ±0.12	2.64 ^b ±0.08	2.39 ^c ±0.07	2.05 ^d ±0.08	1.92 ^d ±0.06	0.08	0.27*
Four to seven week (g)	6.69 ^a ±0.15	5.57 ^b ±0.13	4.88 ^c ±0.19	4.03 ^d ±0.10	4.14 ^d ±0.16	0.15	0.46*
Zero to six week (g)	2.03 ^a ±0.05	1.83 ^b ±0.03	1.68 ^c ±0.05	1.48 ^d ±0.02	1.44 ^d ±0.02	0.04	0.12*
Zero to seven week (g) (overall)	2.41 ^a ±0.03	2.11 ^b ±0.02	1.92 ^c ±0.05	1.67 ^d ±0.01	1.68 ^d ±0.02	0.03	0.09*

Values bearing different superscripts in a row differed significantly, Values bearing the same superscript in the column did not differ significantly, NS: Nonsignificant, *P<0.05

groups were 78.76±0.51, 83.41±0.65, 88.07±0.64, 91.94±0.66 and 90.40±1.85 g, at three to six week age 74.43±3.01, 76.34±1.42, 83.59±0.47, 90.88±1.34 and 94.89±2.05, at four to seven week age 44.24±0.91, 48.86±1.24, 54.89±1.30 and 60.81±2.11, at zero to six week age 153.19±2.52, 159.75±1.26, 171.66±0.34, 182.82±0.81 and 185.28±1.12 and at zero to seven week age 162.64±0.84, 172.22±1.76, 185.81±0.84, 197.23±1.60 and 197.74±0.66g respectively with the overall means 86.52 ±0.86, 84.03 ±1.66, 53.73 ±1.5, 170.54 ±1.21 and 183.28 ±1.05 g in the different week of age. The maximum value was observed in group Ts3 diet containing 2.0% SRP and minimum in Ts0 (control) group during zero to three week age of chicks, which differed significantly among different treatments of Satavari and untreated group. At three to six weeks the maximum value was observed in group Ts4 and minimum in the Ts0 group, respectively. Similarly higher values were observed in Ts3 and Ts4 group than control and other treated group and differ significant among the group, but Ts3 and Ts4 non significant to each

other. These results are higher than reported by Jothie, (2014) on feeding of shatavari root extract to Japanese quail in different levels i.e. 0, 0.5, 1.0 and 1.5 per cent in Japanese quails and observed body weight 203.47, 211.89, 210.52 and 207.17 g, respectively. Rao *et al.* (2020) found that the feeding of Ashwagandha extracts supplemented diet to *L. vannamei* led to significantly ($p<0.05$) increased growth rate (weight gain and SGR) compared to control. FCR and PER were significantly ($p<0.05$) better than control in all the treatments receiving diet supplemented with Ashwagandha extract. Mossa *et al.* (2019) also observed the effect of adding different levels of dietary Marjoram (*Origanum vulgare*) and (*Rosmarinus officinalis*) on some productive of Japanese quail in the study (450) chick and concluded that ($p = 0.05$) increase in the final body weight and cumulative weight gained. Similarly, Singh and Jaswal (2018) reported the total cumulative weight gain (g) of experimental birds supplemented with SRP was significantly ($P<0.05$) higher as compared to the control group. A weight gain (g/bird) was found to be considerably ($P<0.05$) higher in the 1.5%

SRP supplemented group (T3) as compared to the control. The results also accordance with Kant *et al.* (2015) and Joshi *et al.* (2015), Kale *et al.* (2016) those were reported significantly increase overall body weights, weekly gain in body weight of broilers compared to the control group when supplements the different level of herbs in the diet.

The average feed conversion ratio of Japanese quails chicks during different weeks of age on the inclusion of *Asparagus racemosus* were presented in Table-2. The maximum FCR values observed in Ts3 and Ts4 treated group which was not significant to each other but differed significantly from other treated and control groups. The maximum FCR observed between zero to three weeks age and lowest FCR values reported between four to seven week ages of chicks which were significantly ($P<0.05$) different among control and different Shatavari treated groups. These results were accordance with Rasouli *et al.* (2020) found that the weight gain, feed intake of chicks were significantly ($P=0.05$) lower with inclusion of 100 ppm *salvia officinalis* extract in the basal diet than the control group for the whole of experiment period (1–42 days) compared with the higher level (200, 300 and 400 ppm) from sage and control group. Mane *et al.* (2012) observed the feed intake was significantly higher in T1 (control) than T2 (Ashwagandha @ 5kg/ton), T3 (shatavari @10kg/ton) and T4 (ashwagandha and shatavari @ 10kg/ton) group. The group supplemented with shatavari @ 10kg/ton had more net profit than T1, T2 and T4 groups. Similarly, Bhardwaj, (2009) and Bhardwaj and Gangwar (2011) reported that cumulative feed intake (g/b) for 8- 23 weeks feeding period was significantly ($P<0.05$) higher in control and lower in the entire Ashwagandha treated groups; FCR (feed intake/egg mass) and net FCR were significantly ($P<0.05$) poorer in T group than other supplemented group but, Shisodiya *et al.* (2008) reported no significant difference in feed intake between treatment groups of broilers fed *Withania somnifera* root powder as an herbal feed supplement. Our findings were also accordance with Yadav *et al.* (2018) who observed the feed conversion ratio was comparatively higher in the Shatavari root meal supplemented groups than the control group throughout the experiment.

Conclusions

The present study showed that herbal preparations of *A. racemosus* root powder can be beneficially used as an effective feed supplement in Japanese quail for its encouraging results in relation to total body weight gain and feed conversion efficiency. The SRP 2.0 to 2.5% level supplemented in the diet of Japanese quail chicks were

beneficial for growth and Bodyweight gain and had no adverse effect on chicks during the experimental period.

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Recommended Suitable Management Practices to Sheep Farmers in Tonk District of Rajasthan

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Abstract

The study was conducted in Tonk district of Rajasthan. It comprised of 8 tehsils, out of which one tehsil was selected randomly. The selected tehsil was Malpura. Further, four villages selected tehsil was identified from each village 20 respondents were selected randomly. Thus, the entire sample consisted 80 respondents from selected four villages in one tehsil of the district. However, the study also revealed that majority (88.75 %) of the farmers had sound knowledge about the signs of heat in sheep whereas very few 11.25 %) were not aware of them. These findings revealed the association shepherds had with their flocks and the traditional knowledge they possessed. It was observed that the breeding seasons of sheep were during June to August and January to March. The study clearly showed that 'within flock' selection of both rams and ewes though in an unscientific way, was prevalent among the farmers. It was felt that imparting knowledge to the farmers regarding the importance of selection and changing the rams will help in obtaining better breeding efficiency and genetic improvement in the flock.

Key words : Sheep, management practices, revealed, knowledge.

Introduction

Livestock is one of the fastest growing agricultural sub sectors in developing countries and indispensable to the economic, nutritional, and social well-being of the farmers. Livestock and poultry are important contributors to the national economy. Livestock generated output worth of Rs. 5, 91, 691 crores, which comprised 4.11 per cent of the GDP and 25.6 per cent of the agricultural GDP (DAHDF, 2016-17). Animal husbandry is an integral part of Indian agriculture providing livelihood support to more than two third of the rural population. Animal husbandry along with agriculture has not only contributed to the food basket but also by maintaining ecological balance. Agriculture and livestock are inter-dependent in our economy and livestock has been recognized as an important approach for sustained livelihood. Livestock contributes manure and draught power to agriculture while crop residues form the major source of feed to the livestock and this system of interdependence has sustained for centuries. Livestock are important sources of income and employment in rural sector. They help to meet the equity objective in rural development through their contribution to the cash income of small and marginal farmers and landless laborers. Animal husbandry has been an inseparable part of human civilization and culture from the very ancient period. It is also emphasized in Vedas and Puranas that possessing livestock is a symbol of prosperity, which not only enhance income at higher level but also diversify the risk in farming and stabilizes the income of the farmers, thereby increasing the standard of

living of rural masses. There are various types of services of animals such as to provide nutrient-rich food products, draught power, dung as organic manure and domestic fuel, hides and skin, and are a regular source of cash income for rural household in India. At farm level, cash can be generated regularly from direct sale of milk, eggs, meat, manure, The role of small stock can hardly be regulated as small stocks like sheep and goats are more likely to be owned by the poor since they cost less, are more convenient size for home consumption or sale during time of distress and reproduce & grow faster. They are natural capital, which can be easily reproduced to act as a living bank with offspring as interest, and an insurance against income shocks of crop failure and natural calamities.

Animal products play a pivotal role in the human nutrition and food security. Though the consumption of animal products is criticized on the ground that the animals being poor converters of plant protein to animal protein, yet their consumption is desired to produce balanced diet at national level and animals play a complimentary role in crop production for achieving nutrition and food security. Livestock products not only represent a source of high quality food, but equally important they are as main source of income for many small farmers in developing countries for purchasing food as well as agricultural inputs.

Sheep is a warm blooded animal and sheep have a unique quality among the domestic animals and are adaptable to a wide range of environmental conditions.



Fig. : Study area Tonk district.

Wool is a very valuable product, since it is relatively non-perishable, capable of being stored and transported to markets. Sheep meat is the most palatable and rich in nutrient than any other meat. It is rich in proteins (26-28 per cent), calories, minerals (phosphorous and iron) and vital vitamins (B1, B2, B12 and Niacin). Sheep dung is an important source of plant nutrients such as Nitrogen (0.6 per cent), Phosphorous (0.5 per cent) and Potash (0.65 per cent). An Australian farmer says “take care of the sheep and the sheep will take care of you”.

Research Methodology

The study was conducted in Tonk district of Rajasthan. Which was selected randomly? Tonk district comprises of 7 tehsils, out of one tehsil “Malpura” was selected from the district because sheep farming is major source of income in Malpura tehsil. Further, five villages selected from tehsil were identified. From each village 20 respondents were selected randomly. Thus, the entire sample consists of 80 respondents from selected four villages in Malpura tehsils of the district. A list of Sheep owners of selected villages was prepared with the help of village Sarpanch and Patwari with the criteria to select from all strata, was divided in three categories according to Flock size viz. small, medium, large.

For the study about breeding and feeding management practices followed by sheep farmers, a face-to-face interview method by using an interview schedule was prepared with the help of Department of Animal Husbandry and Dairying, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) and Rajasthan Cooperative Dairy

Federation, District Animals Husbandry Department and experts on the subject. The data was collected through personal interview technique from each selected respondent.

Frequency : Distribution the total numbers of respondents in the survey.

Percentage : Simple comparisons were made on the basis of percentage.

Chi Square (χ^2) : Chi square analysis was done to study independence of attributes as per Snedecor and Cochran (1967).

Results and Discussion

Recommended suitable management practices to sheep farmers in Tonk district of Rajasthan.

Area :

Colostrum feeding :

Colostrum is the first milk secreted after parturition.

It contains large amount of gamma globulins which are anti-bodies produced by the ewe against antigens encounter during her life including those against many disease producing organisms.

Colostrum is highly fortified source of nutrient having 7 times the protein and twice the total solids of normal milk, thus it gives an early boost in portion and solid intake.

It contain higher amount of minerals and vitamin A which are essential to combat disease. Ingestion of these through colostrum substantially increases the lamb's survivability.

Colostrum gives a laxative effect which is helpful in expulsion of muconium (first faeces).

It will be highly useful to feed colostrum in the first 15-30 minutes followed by a second dose in approximately 10-12 hours.

First ½ hour to 12 hours of life, lamb should be given with colostrum of its 5-8% of body weight. Then 2nd and 3rd day, it should be of 10% of its body weight.

Ear tagging :

It is the most popular method of identification of farm animals.

It facilitates easy supervision, management and accurate record maintenance. It requires tagging forceps and tags

The numbers in the tags should be contrast and clear style based on the skin colour of the animal.

Location of tag in the ear for tagging should be half the way between base and tip of the ear.

The ear tag is applied in the ear by puncturing the ear with the applicator.

Castration :

To render the animal docile, to control indiscriminate breeding and to prevent certain genital diseases castration is performed. It is also performed to induce faster gain in body weight and to improve the quality of meat.

Castration also results in lean and slender neck which facilitates the correct fitness of yoke especially in work sheep. It is performed in young animals within 2-3 months through surgical method and elastrator method. In adult animals within one year of age, castration performed through closed method using Burdizzo castrators.

The Burdizzo castrator crushes the spermatocord and thus stopping the blood to the testes and results in atrophy of the testes and stoppage of spermatozoa production.

Castration should be performed during cold season and strictly avoid rainy season for fear of fly problems.

Castrated animals should be rested for few days in clean and comfortable pens.

Burdizzo castrator method is safe, quick and less chance of getting infection.

Elastrator rings are very painful to the animal and so it is not usually recommended.

Disinfection :

Disinfection means destruction of pathogenic

microorganisms from a place so that the place becomes free from infection.

Disinfection can be brought about with the help of physical, chemical and gaseous agents.

Chemical disinfectants are very widely used in veterinary practice, as their aqueous solutions are easy to prepare.

Chemical disinfectants are cheap and have a broad spectrum of activity.

Chemical disinfectants are good disinfectant neither stains nor damages materials and are free of undesirable odors.

Boric acid (4-6%), Sodium hydroxide (1, 2 and 5%) and Calcium hydroxide (lime water, slaked lime) are commonly available for disinfection of animal houses.

Formaldehyde (5-10%) can be used for washing floor of animal houses.

Glutaraldehyde 2% aqueous solution is useful for sterilization of instruments.

Quaternary ammonium compounds; cetavlon; savlon are detergents and soaps, are used mainly for washing. They remove grease, dirt and other organic matter.

Bleaching powder (calcium hypochlorite), Copper sulfate (5mg/lit) and Potassium permanganate (1-2mg/lit) are commonly used disinfectants. Calcium oxide is used in the burial pits to dispose the carcass and for land application.

Calcium hydroxide (slaked) mixed with 5% phenol is commonly used in white washing of the walls of farm houses as disinfectant.

1 kg of bleaching powder (chlorinated lime) can be used with 25 liters of water makes a very good deodorant.

Phenol (0.5 to 5%) and Sodium carbonate (2.5-4%) can be used for farm buildings.

Quarantine :

Quarantine is the process of segregating apparently healthy animals (especially animal being introduced into a flock or into the country for the first time) which have been exposed to the risk of infection.

Quarantine period depends on the incubation period of diseases.

In practice, a minimum period of 30 to 40 days has been generally accepted as the reasonable period; but in case of diseases like rabies this period is up to 6 months. Normally newly purchased animals and animals returned from show should be kept in the quarantine shed.

The shed should be constructed at the entrance of the farm.

They should be dipped or sprayed on the 25th / 26th day to remove the ectoparasites.

Isolation of sick animals

Isolation is the process of segregation of affected and in contact animals from the apparently healthy ones, in the event of outbreak of a contagious disease.

Such segregated animals should preferably be housed in a separate isolation shed situated far away from the normal animal house.

If a separate shed is not available the animals for isolation should be tied at one end of the shed as far away from the apparently healthy stock as possible.

Attendants and equipment for sick animals should be ideally separate.

If due to practical reasons this is not possible the sick animals should be attended only after the healthy stock.

The equipment should be thoroughly disinfected after use in the isolation group.

Insuring the animals

It provides protection mechanism to the farmers and sheep rearers against any eventual loss of their animals due to death and to attaining qualitative improvement of livestock and their products. Farmers (small/ large/ marginal) and sheep rearers having the cross breed and high yielding sheep and goat are the eligible beneficiaries.

Covered risks are death of sheep due to accident inclusive of flood, cyclone, famine or any other fortuitous circumstances, diseases, surgical operations, riot, strike, terrorism and earthquake. Animals can be insured for maximum (100%) of their current market value. The General Insurance Corporation of India (GIC), New India Insurance and Oriental insurance are the major insurance companies providing cattle, buffalo, goat, & sheep insurance. For insuring animals, the farmers and animal owners first have to contact their nearest government veterinary doctors / qualified veterinary practitioners / Animal Husbandry department.

Disposal of carcass

The primary purpose of safe disposal of carcass is to ensure the check and spread of disease either to other susceptible animals or humans. Carcasses of animals may be disposed of by sending them to knackeries or by burial or burning.

The carcass must be buried in its skin, be covered

with a sufficient quantity of quicklime or other disinfectants.

The dead animals should be arranged upon its back with feet upwards. The skin is slashed inside the pit all cases except in the case of anthrax. Burning of carcass can be done by surface burning and flame gun methods.

Record maintenance

Record keeping is an essential practice in animal husbandry. It needs daily, regular recording the details in the farm office by manager or farmer. Each animal in the flock is identified with respect to their production performance by using available records. With the help of records close management and appropriate feeding levels can be provided on the basis of production level. It also facilitates increased efficiency of culling and selection which in turn will increase the profit rate. Relative influence of feeding, management and breeding can be assessed on production performance. Livestock marketing can be promoted on the basis of performance records. Comparison of flock performance between and within breeds is possible. Superior stock can be identified for extensive use in breeding programmes. flock and breed registration programmes can be implemented more effectively.

Registers to be maintained in a dairy farm

Daily stock register
Birth/lambing register
lamb / young stock register
Adult stock register
Breeding register / AI register
Weighment / growth register
Milk yield and distribution register
Sales / disposal register
Fodder / feed stock register
Receipt / Income register
flock health register
Mortality / Morbidity register

Conclusions

Animal products play a pivotal role in the human nutrition and food security. Though the consumption of animal products is criticized on the ground that the animals being poor converters of plant protein to animal protein, yet their consumption is desired to produce balanced diet at national level and animals play a complimentary role in crop production for achieving nutrition and food security. Goat management practices are suitable uses in Tonk

district farmers near suggestion under station CSWRI Malpura Tonk scientist.

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Effect of Toxic Metabolites Produced by *Alternaria cyamopsidis* on *Cyamopsis tetragonoloba* (Linn.) Taub. Germination and Vigour

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Abstract

Alternaria cyamopsidis pathogen of guar causing blight is responsible for the production of toxin *in vitro* and *in vivo* too, therefore, characteristic symptoms are developed on the host by the toxins. Culture filtrate (crude toxin) was partially purified using ammonium sulphate precipitation method, which was further separated through Sephadex G-75 column and eluted with acetate buffer (0.05 M, pH 5.5) which resulted in different 20 fractions of toxins. Out of these fractions, fraction nos. 9 and 13 were found to be highly toxic. Out of ten moderately/resistant varieties of guar tested against toxin, it was observed that resistant variety (RGC-1000) expressed least symptoms whereas, maximum symptoms, were observed in highly susceptible variety (Pusa Nav Bahar). There was adverse effect of toxin on the germination percentage, fresh and dry weight of seedlings as well as epicotyl and hypocotyle. Hence screening of varieties can easily be done by toxin inoculation. The per cent inhibition in germination ranged between 34.7-63.4, minimum being in RGC-1000, RGC-1002 and RGC-1003 while maximum was in case of Pusa Nav Bahar (PNB). The maximum per cent reduction of fresh as well as dry weight of seedlings of variety PNB, followed by Ud. local which were highly susceptible to pathogen as well as toxin. Minimum per cent reduction in fresh and dry weight of seedling was found in variety RGC-1000 which was reported to be resistant to the pathogen. The minimum differences were in length of both epicotyl as well as hypocotyl between treated and control in resistant germplasm (RGC-1000). The differences in length of epicotyl and hypocotyl, however, were more in susceptible (HG-7 and CAZG-69) and maximum in highly susceptible variety (PNB and Ud. local).

Key words : Clusterbean, *alternaria*, blight, toxin, toxin bioassay.

Introduction

Guar or Clusterbean [*Cyamopsis tetragonoloba* (Linn.) Taub.] is an important leguminous crop and is being grown for vegetable, fodder, gum and green manure. Guar is known as various names in India such as Gorani (Sanskrit), Guar ki Fali, Gower (Hindi), Bavachi, Guwar, Gavari (Marathi), Gover (Gujarati), Guara, Guwar (Panjabi), Kothaverai (Malyalam). This vernacular name suggests its wide uses (Menon, 1973). Clusterbean is an excellent soil building crop with respect to available nitrogen. India accounted approximately 80% of the world trade of guar gum and guar seed was among the top three traded agricultural commodity on Indian market and Rajasthan is leading producer with about 75% of total production of India. It provides nutritional concentrate, fodder for cattle and add to the fertility of soil by fixing considerable amount of atmospheric nitrogen.

The crop suffers from number of phytopathogenic fungal and other diseases which are responsible for its poor quality and low yield resulting in severe economic losses to the country as it is an important cash crop with a great potential for foreign exchange (Chand and Gandhi, 1978). The major diseases causing low planting value of crop include fungal, bacterial and viral diseases. Few

names are cited so as to highlight the problem. The important fungal diseases are *Alternaria* blight and leaf spot (*Alternaria cucumerina* var. *cyamopsidis*, *A. tenuis*, *A. tenuissima*) causes major losses to yield of cluster bean crop (Shivanna and Shetty, 1991 a & b). *Alternaria* blight of guar disease alone has been reported to be responsible for reduction in yield by 55.76-58.70 per cent under artificial epiphytotic conditions (Gupta, 1994). The disease appears year after year in mild to severe form, since the pathogen is seed borne in nature (Sowell, 1965). *Alternaria* blight is a major disease in North India. In early stages of infection, the water soaked spots appear on leaf blade which later turn greyish to dark brown with concentric zonation, demarcated with light brown lines inside the spot on the under surface. The lesions are light to greyish brown. In severe infection several spots coalesce together involving a major portion of the leaf blade. In such cases, the leaflet becomes chlorotic and usually drops off. If the plants are infected in the early stages of the growth then there may not be any flowering and pod formation. The maximum severity of the blight takes place between bloom and pod setting. Higher yield losses (43-78 %) were recorded when leaves were infected at seedling stage than at old stage (Sharma, 1983). Toxins are of the weapons produced by

the pathogens which may or may not be necessarily toxic to plants. Many plant pathogens have been reported to produce toxic metabolites which may be host-specific or non-host-specific. Parasite diseases commonly arise as a result of an interchange of metabolites between a parasite and an invaded host. The weapons used by parasites to attack their host differ widely in chemical structure and correspondingly in the type of response that they elicit from a host. Many plant pathogens have been reported to produce toxic metabolites which may be host-specific or non host-specific.

Many of the fungi are known to produce toxic metabolites and in several cases these fungi also adversely affect on seed germination and seedling growth, possibly due to production of toxic metabolites. Presumably, factor of cell wall degrading enzymes might be got linked with the toxin factor of polysaccharides as reported by Cronshaw and Peg (1976) in toxin of *Verticillium albo-atrum* of tomato. Toxic metabolites produced from the culture filtrate of *Alternaria cyamopsidis* which effect adversely on the seed germination as well as growth of hypocotyls and epicotyls of cluster been. The toxicity of toxic metabolites increase as its purification done at molecular level.

Materials and Methods

Extraction of toxin(s) : For the extraction of toxin, 25 ml of Richard's medium (pH 6.5) was poured in 100 ml Erlenmeyer conical flasks which were then sterilized in autoclave at 1.045 kg/cm² for 20 minutes. These sterilized flasks were inoculated with 4 mm diameter fungal bits of 7-day-old culture of *A. cyamopsidis*, grown on PDA. The inoculated flasks were incubated in a BOD incubator at 25±1 C for 15 days. The culture filtrate was obtained by filtration through Whatman No.42 filter paper and used for bioassay, by using detached plant twigs.

Purification of Toxin(s) : The culture filtrate which was obtained from 15-day-old culture of *A. cyamopsidis* was centrifuged at 600 rpm for 20 min. The clear supernatant solution was collected in clean sterilized conical flask and pellet sedimented at the bottom of the centrifuge tube was discarded. The clear supernatant solution served as a sample of crude toxin preparation produced by *A. cyamopsidis* *in vitro*. The crude toxins were partially purified using ammonium sulphate fractionation and then gel filtration using Sephadex G-75 column.

To purify toxin(s), crude toxin was precipitate by 70% ammonium sulphate. Ammonium sulphate was dissolved in to the crude toxin with constant stirring to get 25% saturation. The mixture was kept at 4 C for 24 hrs resulting in an extremely heavy precipitate. The precipitate was centrifuged at 3000 rpm for 20 min and supernatants were discarded and dried at 30 C. The whitish grey powder

obtained, was dissolved in 10 ml of double distilled water and dialyzed in dialyzing tubes which were bathed in double distilled water in a beaker at 4 C in refrigerator by changing double distilled water after every 6 hrs for 24 hrs. The dialyzed samples then purified by employing gel filtration using Sephadex G-75 column under standard conditions. The bioassay was done by detached guar plant twigs, dipped in solution and control was kept as double distilled water instead of toxic metabolites (the method stated by Gouret *al.*, 1992).

Fraction Collection : The gel filtration of toxin was carried out using Sephadex-G-75 column. The column (40x2 cm) was prepared, washed and eluted with acetate buffer (0.05 M, pH 5.5). One ml partially purified toxin which was obtained from ammonium sulphate fractionation, was then applied on the top of the column and the acetate buffer flow maintained with constant head and the effluent was collected in pre-marked test tubes in twenty fractions of 10 ml each. Toxin activity was detected by using the detached leaf twig bioassay. Effectiveness of each step in the purification procedure was tested to induced symptoms in guar leaves of variety Pusa Nav Bahar in detached leaf twig bioassay.

Bioassay test : The toxicity of toxins in usually determined by its bioassay to study the manifestation of disease symptoms by partially purified toxin in laboratory conditions and plants grown in pots. The fresh twigs having 3-4 leaves of 30 days old plant were gently excised and brought in laboratory. The cut end of these twigs of equal size were immersed in test tubes containing 10 ml partially purified toxin solutions. Proper control was maintained in uninoculated sterilized culture media. The experiment was run in four replications. The leaves were observed for symptoms after 24 hrs of treatment.

Symptoms Rating Scale :

For chlorosis :

- 0 = No chlorosis
- 1 = Slight chlorosis occurs and covers 1 per cent or less leaf area.
- 2 = Slight chlorosis with slight vein clearing
- 3 = Chlorosis increase and primary lesions are forming
- 4 = Light brown patches are formed
- 5 = Chlorosis increase and covers more than 50 percent leaf area.

For wilting :

- 0 = No wilting
- 1 = Slight wilting occurs

2 = Wilting increase but leaves contained some water

3 = Leaves has curled by wilting

4 = Leaves dried and complete curled

5 = Complete leaves dried and die by wilting

Effect of toxin(s) on different line/varieties :

Resistant/moderately resistant nine lines/ varieties sent by All India Coordinated Research Project on Arid Legumes, Department of Plant Breeding and Genetics, A.R.S. Durgapura, Jaipur (Raj.) were tested against isolated partially purified toxin of the pathogen of guar blight (*A. cyamopsidis*). The fresh twigs from each variety/line of 30-day-old plants having 3-4 leaves were immersed in test tubes containing toxin solution. Twigs dipped in distilled water were kept as control for every variety. Observations of leaves for symptoms were taken 72 hrs after toxin treatment. Each treatment was replicated four times and experiment was repeated.

Effect of toxin(s) on germination percentage and seedling vigour :

To find out the effect on seed germination of the different germplasm of guar, 100 surface sterilized seed were soaked in partially purified toxin for 12 hrs separately. The soaked seeds were placed on top of 3 blotters moistened with the same filtrate fixed in the bottom of a Petridish. Ten seeds were accommodated in one Petri dish. Seeds soaked in sterilize distilled water served as control. The Petridishes were incubated at 25 ± 1 C for 7 days and observations on seed germination were recorded. The experiment was repeated and each treatment was replicated four times. The observations also recorded for fresh as well as dry weight of each treatment and length of epicotyl as well as hypocotyl of each treatment.

Results and Discussion

Production of toxin(s)

Isolation and Purification : Twenty partially purified fractions of 10 ml were collected in pre-marked test tubes in which detached guar leaf twigs were immersed and symptoms for toxicity for each fraction were recorded after 24 hrs. The data in Table-1 clearly indicate that fraction No. 9 and 13 were highly toxic as observed after 24 hrs. Where chlorosis and wilting in dipped leaf twigs increased and covered about 50 per cent of leaf area, ultimately completely wilted. Moderate toxicity was also observed in fraction no. 8. Least toxin activity was noted in fraction No. 4, 5, 6, 7, 10, 11, 12 and 14. Remaining fractions did not show any toxicity.

Toxin Bioassay : Different methods for bioassay of toxin(s) in terms of symptoms expressed were examined to find out most suitable method for toxin assessment quickly. Bioassay of partially purified toxin(s) was carried out both under laboratory and pot house conditions. Fraction 9 and

Table-1 : Production of symptoms by fractions of partially purified toxin(s) of *A. cyamopsidis* using ammonium sulphate in sephadex G-75 fractionation.

Fraction No.	Symptoms expressed by toxin(s) (24 hrs after treatment)*	
	Chlorosis	Wilting
1.	0.00	0.00
2.	0.00	0.00
3.	0.00	0.00
4.	0.50	1.00
5.	0.50	1.00
6.	0.75	1.50
7.	1.00	2.00
8.	1.25	3.00
9.	2.75	5.00
10.	1.25	2.00
11.	1.00	1.50
12.	1.00	1.50
13.	2.25	4.50
14.	0.50	1.00
15.	0.50	1.00
16.	0.00	1.00
17.	0.00	0.00
18.	0.00	0.00
19.	0.00	0.00
20.	0.00	0.00

* Average rating of four replications.

13 were used throughout the experimentation as these indicated maximum toxicity out of all the 20 fractions collected. A suitable control with sterile distilled water was run for comparison. The experiments were replicated four times. Observations were made after 24 hrs of treatment.

Effect of toxin(s) on different germplasm/line of guar :

Nine varieties/line resistant or moderately resistant sent by All India Coordinated Research Project on Arid Legumes, Department of Plant Breeding and Genetics, ARS, Durgapura, Jaipur (Raj.) and along with a susceptible one local variety of Udaipur were tested against the partially purified toxin(s) of pathogen. The detached plant twigs of the plants belonging to different germplasm of guar were dipped in partially purified toxin and resulting symptoms like chlorosis and wilting were recorded.

Out of 9 varieties/germplasm RGC-1000 was found resistant to toxin of *A. cyamopsidis* as there was minimum chlorosis (0.75) as compared to 3.0 in other varieties (Table 13). Similarly, it showed less wilting (1.75). Other varieties/lines showed chlorosis between 2-3 as well as wilting 3-5. Hence it can be concluded from the experimentation that RGC-1000 can effectively withstand the toxin of the pathogen as well as detached leaf technique

Table-2 : Reaction of different guar cultivars against toxin(s) of *A. cyamopsidis*.

S. No.	Germplasm / lines	Disease reaction	Symptoms expressed by toxin* (24 hrs after treatment)			
			Chlorosis		Wilting	
			Treated	Control	Treated	Control
1.	RGC-1000	R	0.75	0.00	1.75	0.00
2.	RGC-1002	MR	1.50	0.00	2.75	0.00
3.	RGC-1003	MS	1.50	0.00	3.00	0.00
4.	RGC-1005	MS	2.00	0.00	3.00	0.00
5.	RGC-1011	MS	2.00	0.00	3.25	0.00
6.	RGC-1013	MS	1.75	0.00	3.25	0.00
7.	HG-7	S	2.25	0.00	3.50	0.00
8.	CAZG-69	S	2.25	0.00	3.50	0.00
9.	PNB	HS	3.00	0.00	5.00	0.00
10.	Ud. Local	HS	2.75	0.00	4.50	0.00

* Average rating of four replications (0-5)

R = Resistant, MR = Moderately resistant, MS = Moderately susceptible, S = Susceptible, HS = Highly susceptible, PNB = Pusa Nav Bahar, Ud. Local = Udaipur Local

Table-3 : Effect of toxin(s) of *A. cyamopsidis* on germination percentage of guar germplasm/lines.

S. No.	Germplasm / lines	Disease reaction	Germination percentage* (7 day after treatment)		Percent inhibition of germination over control
			Treated	Control	
1.	RGC-1000	R	53.5	83.2	35.7
2.	RGC-1002	MR	55.2	84.6	34.7
3.	RGC-1003	MS	52.5	82.2	36.1
4.	RGC-1005	MS	46.0	80.0	42.5
5.	RGC-1011	MS	45.4	76.6	40.0
6.	RGC-1013	MS	50.6	78.2	35.2
7.	HG-7	S	44.3	81.6	45.7
8.	CAZG-69	S	44.0	79.2	44.4
9.	PNB	HS	32.7	89.6	63.4
10.	Ud. Local	HS	35.5	86.5	58.9

* Average of four replications

evaluation method for different varieties/lines using toxin of pathogen can be used for screening. Present findings are in agreement with these of obtained by Sherkar *et.al.*(2015) that inhibition of germinability of sorghum seeds treating with toxin isolated from *Fusarium* sp. causing grain mold of sorghum. Ozcelik and Ozcelik (1996) reported that germination and hypocotyl growth of seedling of wheat is suppressed by culture filtrates obtained by *Alternaria alternata* and *A. solani*. Moreover, it is clear from these experimentation that effect of pathogen toxins can be evaluated on resistant/or susceptible leaves under lab condition to set precise lines or cultivar for further breeding programme.

Effect of Toxin on Germination as well as Fresh and Dry Weight of Seedlings : The toxin of pathogen reduced the germination of the different germplasm/lines which were

reported to be either resistant or moderately resistant. The per cent inhibition in germination ranged between 34.7-63.4, minimum being in RGC-1000, RGC-1002 and RGC-1003 while maximum was in case of Pusa Nav Bahar (PNB) (Table 3). Similarly, toxins of *Alternaria helianthi* inciting blight in sunflower inhibited the germination of seed (Patole *et. al.*, 2017)

To find out the effect of toxin on fresh and dry weight of 7-day-old toxin treated seedlings, it was found that maximum per cent reduction of fresh as well as dry weight of seedlings of variety PNB, followed by Ud. local which were highly susceptible to pathogen as well as toxin (Table 4). Minimum per cent reductions in fresh and dry weight of seedling were found in variety RGC-1000 which was reported to be resistant to the pathogen.

Table-4 : Effect of toxin(s) of *A. cyamopsidis* on fresh and dry weight of seedlings of guar varieties (7 day of treatment).

S. No.	Germplasm / lines	Disease reaction	Average fresh wt./seedling (mg)			Average dry wt./seedling (mg)		
			Treated	Control	Reduction in weight (%)	Treated	Control	Reduction in weight (%)
1.	RGC-1000	R	492.0	524.0	6.1	65.2	75.0	13.0
2.	RGC-1002	MR	438.3	512.0	14.3	58.0	74.9	22.5
3.	RGC-1003	MS	468.0	545.6	14.2	62.0	79.2	21.1
4.	RGC-1005	MS	472.0	554.0	14.8	61.2	78.3	21.8
5.	RGC-1011	MS	450.9	519.0	13.1	54.4	74.4	26.8
6.	RGC-1013	MS	418.2	497.0	15.8	65.6	82.0	19.9
7.	HG-7	S	398.0	505.0	21.1	51.0	78.0	34.6
8.	CAZG-69	S	390.0	508.1	23.2	46.0	68.4	32.7
9.	PNB	HS	402.2	572.2	29.7	53.2	88.7	40.0
10.	Ud. Local	HS	409.4	564.3	27.4	57.5	91.6	37.2

* Average of four replications

Table-5 : Effect of toxin(s) of *A. cyamopsidis* on length of epicotyl and hypocotyl of seedlings of guar varieties (7 day of treatment).

S. No.	Germplasm/ Lines	Disease reaction	Average length of epicotyl/seedling (cm)			Average length of hypocotyl/seedling (cm)		
			Treated	Control	Reduction in length (%)	Treated	Control	Reduction in length (%)
1.	RGC-1000	R	3.2	3.7	13.8	3.4	3.8	10.8
2.	RGC-1002	MR	3.1	4.2	26.7	3.8	4.5	16.1
3.	RGC-1003	MS	3.9	4.7	17.2	4.0	4.6	14.1
4.	RGC-1005	MS	3.6	4.5	18.6	3.9	4.7	17.6
5.	RGC-1011	MS	3.7	5.2	23.8	4.0	5.4	25.2
6.	RGC-1013	MS	3.4	4.5	23.1	3.7	4.9	24.4
7.	HG-7	S	3.2	5.4	39.9	3.7	5.7	34.3
8.	CAZG-69	S	3.1	4.9	37.1	3.5	5.2	32.5
9.	PNB	HS	2.8	5.9	52.2	3.0	5.7	43.9
10.	Ud. Local	HS	2.7	4.7	41.4	2.9	4.9	40.9

* Average of four replications

Effect of Toxin on Length of Epicotyl and Hypocotyl of Seedling :

The data presented in Table-5 reveals that effect of toxin treatment on the length of epicotyl and hypocotyl of seedlings. It can be gleaned that the minimum differences were in length of both epicotyl as well as hypocotyl between treated and control in resistant germplasm (RGC-1000). The differences in length of epicotyl and hypocotyl, however, were more in susceptible (HG-7 and CAZG-69) and maximum in highly susceptible variety (PNB and Ud. local). Present findings are in agreement with these of obtained by Ozcelik and Ozcelik (1996) that germination and hypocotyl growth of seedling of wheat is suppressed by culture filtrates obtained by *Alternaria alternata* and *A. solani* and Patole et. al.(2017) also supported that toxins of *Alternaria helianthi* inciting blight in sunflower suppress the root and shoot length the seedlings. Evaluation of resistant or susceptible

varieties can be done under laboratory conditions, thought application of pathogen toxin on leaves.

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Yield Economics of Strawberry (*Fragaria × ananassa* Duch.) cv. Winter Dawn in Part of Southern Rajasthan

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Abstract

An experiment was carried out during October, 2020 to March, 2021 at Horticulture Farm, Rajasthan College of Agriculture, Udaipur, Rajasthan during to work out the most suitable foliar spray of micronutrient (Fe, Zn and B) in different concentration to obtain better growth, yield and quality of strawberry. The experiment was laid out in randomized block design with a total of eleven treatments replicated thrice. Result showed that the treatment combination (S₁₀) comprising RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) were recorded significantly increased in terms of runner per plant (5.87), number of picking (17.07), fruit length (36.03 mm), fruit width (27.17 mm), length diameter ratio (1.24), fresh weight of fruit (12.32 g), fruit per plant (16.20), fruit yield per plant (177.96g). The treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) was also found economically viable resulting in highest gross return of ₹ 7.15 Lakh ha⁻¹, net return ₹ 3.72 Lakh ha⁻¹ as compare to other treatment studied.

Key words : Strawberry, foliar application, growth, yield micro-nutrient like iron, zinc, boron.

Introduction

Strawberry (*Fragaria × ananassa*) is one of the most delicious fruit of the world which attained a prime position in the world fruit market as fresh fruit with in the processing industries. All the cultivated varieties of strawberry are octaploid (2n=8x=56) in nature and belongs to the family Rosaceae. It is short day plant, native from France in 17th century and the two American diploids *Fragaria × chiloensis* and *Fragaria × virginiana* are considered as its progenitors. Strawberry is perennial, stoloniferous herbs which spread via stolons or runners. The strawberry have a type of aggregate fruit botanically. In India, many strawberry cultivars were introduced in early 1960. Primarily strawberry was growing in temperate zone of the country. However, it can also be cultivated under sub-tropical climate, even at higher altitudes of tropical climate. In India its main centers of cultivation are Nainital (district) and Dehradun in Uttarakhand, Mahabaleshwer (Maharashtra), Kashmir Valley, Bangalore and Kalimpong (West Bengal). In recent years, strawberry is being cultivated successfully in plains of Maharashtra around Pune, Nashik and Sangli towns. In Rajasthan strawberry is getting popularity for the cultivation in Jhadol and Mavali (Udaipur), Nimbaheda (Chittorgarh), Mandalgarh (Bhilwara) and Jhalawar. The strawberry plants are strongly affected by the environmental factors like temperature, photoperiod and light intensity. It requires optimum day temperature of 22°C to 25°C and night temperature of 7°C to 13°C.

Photoperiod has a marked effect on strawberry vegetative growth, plant morphology and yield. Stolon formation, petiole length, leaf area and yield increases with the increase in photoperiod. It is a short day plant which requires exposure to about 10 days of less than 8 hours sunshine for initiation of flowering. In cold climate the soil is covered with mulch in winter to protect the root from chilling injury. The mulch keep the fruits free from soil, reduces decay of fruits, conserves the soil moisture, lowers soil temperature in hot weather, protects flower from frost in mild climates and protect plants from freezing injury in cold climates. Several kinds of mulches are used but the commonest one is straw mulch. The name strawberry has been derived from this fact. Black alkathene mulch (40 micron) is also used to cover the soil it saves irrigation water, prevents the growth of weed and keeps the soil temperature high. Strawberry plant grows best in sandy loam soil but in case of light soil frequent irrigation needed for establishment of runners. The heavier soil with adequate soil moisture is better than lighter soil. Strawberry prefers soil reasonably rich in humus because of 70-90 % of its roots were found in the top 15 cm soil. It grows well in soil with pH 5.0- 7.5. However the plant thrives best in slightly acidic soil (pH 5.5-6.5). The availability of micronutrient like iron, zinc and boron to the plant at less than pH 6.5. Boron is absorbed in H₃BO₄ form. Next to zinc, boron is widely deficient nutrient. It is a micronutrient mobile in soil and immobile in the plant. Availability of boron in soil is reduced on account

of calcareousness, salinity or sodicity, over liming. Very little is known about mineral of B in soils. Boron plays many important roles in plant metabolism. Zn absorbed by the plant in Zn^{2+} form. Zn is very most important micro-nutrient of global concern, and highly deficient micro-nutrient of equal magnitude on both acid as well as alkaline soils. zinc is an immobile micro-nutrient in the plants. The availability of zinc in soil is adversely affected by soil calcareousness, high phosphorus content, salinity or sodicity, over liming *etc.* Iron absorbed by plant in Fe^{2+} form. It is one of the micronutrients becomes extremely mobile under waterlogged conditions and it is highly immobile in the plant. In acid soils, soluble iron could fix phosphates which are aggravated further by high water table and water logging. Whereas on alkaline calcareous soils, lime induced Fe chlorosis is perhaps the most researched nutritional disorder in citrus. Availability of iron becomes less available in soils having beyond pH 7.8. High available iron could induce manganese-deficiency. Chandrakar *et al.*, 2019 studies on nutritionally, strawberry contains low calorie carbohydrate and a potential source of vitamin-C and fibers. It contains more vitamin-C than oranges. The chemical composition of strawberry is ascorbic acid (64.0 mg), water (91.75 g), protein (0.61 g), fat (0.37 g), carbohydrate (7.02 g), fiber (2.3 g), calcium (14.0 mg), potassium (166 mg/100 g) and vitamin-A (27 IU). Ellagic acid is a naturally occurring plant phenol. It has been found to inhibit the cancer disease and asthma by the regular consumption of the fruit. Currently, the production of strawberry in more than 63 countries, the global production of strawberry in 2012 about 4516810 tons and planted area of 2.41 Mha and the United States ranks first in the list of producing countries with a total of 1.36 MT, more than a quarter of the world production (FAO, 2014).

Materials and Methods

The experiment was conducted from October, 2020 to March, 2021 at Horticulture Farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. This is situated at 24° 34' N latitude and 73° 42' E longitude at an elevation of 582.17 meter above mean sea level. Soil of this region is Sand (32.40%), Silt (28.65%), Clay (38.95%), Bulk density (1.35%), Particle density (2.64%), Porosity (28.21%, Organic carbon (0.68%), Available N kg ha^{-1} (194.8), Available P_2O_5 kg ha^{-1} (17.1) and Available K_2O kg ha^{-1} (255.3). Planting material of the cultivar Winter Dawn (Strawberry) was procured from Kimya Biotech Pvt. Ltd. Kasaba, Pune. The experiment was laid out in randomized block design with 11 treatments viz. S₁ i.e. RDF + Control (Water spray), S₂ i.e. RDF + Borax (0.1%), S₃ i.e. RDF + ZnSO_4 (0.2%), S₄ i.e. RDF + FeSO_4 (0.2%), S₅ i.e. RDF + Borax (0.2%), S₆ i.e.

RDF + ZnSO_4 (0.4%), S₇ i.e. RDF + FeSO_4 (0.4%), S₈ i.e. RDF + Borax (0.1%) + ZnSO_4 (0.2%) + FeSO_4 (0.2%), S₉ i.e. RDF + Borax (0.1%) + ZnSO_4 (0.4%) + FeSO_4 (0.4%), S₁₀ i.e. RDF + Borax (0.2%) + ZnSO_4 (0.2%) + FeSO_4 (0.2%), S₁₁ i.e. RDF + Borax (0.2%) + ZnSO_4 (0.4%) + FeSO_4 (0.4%). Boron application, 1g and 2g of borax were weighed and solutions were made in one litre of distilled water for making 0.1 per cent and 0.2 per cent concentrations, respectively. Iron and zinc solution was prepared from same procedure. After harvesting period that total number of runner were counted, Data were recorded on the basis of average number of days taken from planting date to start flowering after planting, same procedure follow to determined for days to initiation of fruit set, days to first harvest and final harvest, Fruit length and width was determined with digital Vernier Caliper in mm from 20 strawberry fruit from each treatment. The ratio (length: diameter) was also calculated of 20 fruits, After ripening, average fruit weight of fruit was calculated from each tagged plants with the help of electronic balance and the mean five of fruit was express in grams.

Results and Discussion

The data recorded for various parameters are statistically analyzed, their mean value are presented in Table-1 and 2. It is clear that maximum fruit length (36.03 mm) and fruit width (27.17 mm) was noted in treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO_4 (0.2%) + FeSO_4 (0.2%) whereas, S₁ i.e. RDF + Control (Water spray) recorded minimum fruit length (34.07 mm) and fruit width (25.53 mm). it might be due to the effect of zinc, as zinc plays a vital role in the promote of starch formation and other activity involve in the plant is transportation of carbohydrate and another function of zinc in plant is faster loading and mobilization of photo assimilates to the fruits and involvement in cell division, cell expansion, ultimately reflected into more length of the fruits in treated plants. Related results were also obtained by Bakshi *et al.* (2013) and Mehraj *et al.* (2015) in strawberry, Chandrakar *et al.* (2019) in strawberry, Etehadnejad and Aboutalebi (2014), Pawar *et al.* (2019) in mandarin, Tagad *et al.* (2018) in acid lime found that foliar application of zinc increased diameter of fruits. This change might be due to that iron, zinc and boron help in cell division, elongation and growth of meristamatic tissue and also due to enhanced photosynthetes which forced plant to produce higher petiole length. Similar findings were observed by Saadati and Moallemi (2012), Bakshi *et al.* (2013), Gurjar *et al.* (2015), Bhanukar *et al.*, (2021) in sweet orange, Chandrakar *et al.*, (2019) in strawberry, Pawar *et al.* (2019) in mandarin, Tagad *et al.* (2018) in acid lime. The maximum fresh weight of fruit, fruit per plant and fruit yield per plant (12.32 g, 16.20 and 198 g respectively) was

Table-1 : Response of micronutrient on fruit length, fruit width, length: diameter, fresh weight of fruit, number of fruit plant⁻¹, number of picking, runner per plant and fruit yield/plant.

Notations	Treatments	Fruit length (mm)	Fruit width (mm)	Length : Diameter	Fresh weight of fruit (g)	Number of fruit plant ⁻¹	Number of picking	Runner plant ⁻¹	Fruit yield plant ⁻¹ (g)
S ₁	RDF + Control (Water spray)	34.07	25.53	1.15	10.88	14.93	15.07	3.27	162.00
S ₂	RDF + Borax (0.1%)	34.17	26.00	1.16	10.95	15.00	15.33	3.27	164.00
S ₃	RDF + ZnSO ₄ (0.2%)	34.20	26.10	1.18	11.12	15.13	15.53	3.33	168.33
S ₄	RDF + FeSO ₄ (0.2%)	34.50	26.20	1.17	11.26	15.33	15.73	3.47	172.67
S ₅	RDF + Borax (0.2%)	34.83	26.27	1.16	11.39	15.47	15.80	3.40	176.00
S ₆	RDF + ZnSO ₄ (0.4%)	35.13	26.30	1.19	11.56	15.60	15.93	3.33	180.00
S ₇	RDF + FeSO ₄ (0.4%)	35.27	26.40	1.17	11.73	15.60	16.13	3.40	183.33
S ₈	RDF + Borax (0.1%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	35.43	26.50	1.16	11.87	15.67	16.33	3.40	186.00
S ₉	RDF + Borax (0.1%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	35.53	26.67	1.20	12.02	15.80	16.60	3.53	190.00
S ₁₀	RDF + Borax (0.2%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	36.03	27.17	1.24	12.32	16.20	17.07	3.67	198.00
S ₁₁	RDF + Borax (0.2%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	35.87	26.83	1.23	12.20	16.00	16.93	3.60	194.67
	SEm±	0.36	0.34	0.02	0.12	0.26	0.49	0.05	7.82
	CD @5%	1.06	NS	0.06	0.34	0.76	1.44	0.14	23.07

Table-2 : Economics of the treatments.

Treatment	Fruit yield ha ⁻¹ (ton)	Total fruit return ha ⁻¹ (Rs.)	Runner ha ⁻¹	Total runner return (Rs.)	Total cost ha ⁻¹	Gross return ha ⁻¹ (Rs.)	Net return ha ⁻¹ (Rs.)	B: C
S ₁	9.01	540743	181483	108890	342000	649633	307633	0.90
S ₂	9.07	544329	181483	108890	342046	653219	311173	0.91
S ₃	9.16	549505	185187	111112	342189	660617	318428	0.93
S ₄	9.29	557627	192594	115556	342315	673183	330868	0.97
S ₅	9.41	564568	188890	113334	342630	677903	335273	0.98
S ₆	9.44	566428	185187	111112	342255	677540	335285	0.98
S ₇	9.43	565982	188890	113334	342510	679316	336806	0.98
S ₈	9.51	570429	188890	113334	342664	683764	341100	1.00
S ₉	9.64	578659	196298	117779	343235	696437	353202	1.03
S ₁₀	9.89	593216	203705	122223	342759	715439	372680	1.09
S ₁₁	9.74	584110	200002	120001	343329	704111	360782	1.05
SEm	0.19	11697.20	2689.41	1613.65		12514.38	12514.38	0.04
CD 5%	0.57	34303.64	7887.07	4732.24		36700.13	36700.13	0.11
CV	3.59	3.59	2.45	2.45		3.19	6.44	6.43

Selling price of fruit (Rs.) - 60/kg, Selling price of runner (paisa) - 60/runner

recorded under the treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas S₁ i.e. RDF + Control (Water spray) recorded minimum fresh weight of fruit, fruit per plant and fruit yield per plant (10.88 g, 14.93 and 162 g respectively). It might be due to higher number of fruit might be due to the effect of zinc, as zinc plays a vital role in the promote of starch formation and other activity involve in the plant is transportation of carbohydrate and another function of zinc in plant is faster loading and mobilization of photo assimilates to the fruits and involvement in cell division, cell expansion similar findings were also obtained by Tagad *et al.* (2018) in acid lime, Thorat *et al.* (2018) Kazemi (2014), Bakshi *et al.* (2013) and Mehraj *et al.* (2015) in strawberry, Chandrakar *et al.*, (2019) in strawberry, Pawar *et al.* (2019) in mandarin. The reason behind that increase in fresh weight of the fruits might be due to more growth of the fruit by accelerate rate of cell enlargement (increase in cell size) & cell division (increase in number of the cells) and larger intercellular space and another reason for that due to increase the photosynthetic activities & accumulation of more carbohydrate. The increase in number of fruit per plant could be attributed to increased fruit size, diameter and fruit weight. Furthermore, probably there was a larger diversion of photosynthates to sink (Fruit), which was ultimately added to the number of fruits. Related results were also obtained by, Chandrakar *et al.* (2018) in strawberry, Bakshi *et al.* (2013) and Mehraj *et al.* (2015) in strawberry, Tagad *et al.* (2018) in acid lime. This change might be due to Zn is necessary for the production of tryptophan which is the precursor of indole acetic acid synthesis resulting in the growth and development of tissues which leads to vegetative growth of plant. It added cell membrane integrity, stabilizes sulflahydryl groups in membrane proteins involved in ion transport. The increase in vegetative growth has been reported by Ram and Bose (2000) in mandarin, Pawar *et al.* (2019) in mandarin, Haque *et al.* (2000) in mandarin orange, Ahmad *et al.* (2012) in tangerine, Gurjar *et al.* (2015) in kinnow and Choudhary *et al.* (2016) in kinnow mandarin, Chandrakar *et al.*, 2018, in strawberry, Tagad *et al.* (2018) in acid lime. This change might be due to foliar spray of micronutrient mainly boron Fe promotes the formation of florigin (hypothetical hormone) from leaf to the leaf axils thus produces early flowering and fruiting. This findings are close conformity with the findings by the Yadlod and Kadam (2003) in banana and Mehraj *et al.* (2015) in strawberry crop, Similar results about days to fruit setting were also observed by Tagad *et al.* (2018) in acid lime, Ashoori *et al.*, 2013, Chandrakar *et al.*, 2018 in strawberry, Pawar *et al.* (2019) in mandarin.

Conclusions

On the basis of results which were obtained in the present investigation entitled "Response of foliar spray of iron, zinc and boron in strawberry (*Fragaria x ananassa* Duch.) cv. Winter Dawn" It can be concluded that among the various treatment S₁₀ i.e. RDF (100: 80: 80 NPK) + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) was found the superior treatment in number of picking, fruit length, fruit width, length diameter ratio, fresh weight of fruit, fruit per plant and fruit yield per plant.

The treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) was also found economically viable resulting in highest gross return (? 715439 ha⁻¹), net return (? 372680 ha⁻¹) and benefit cost ratio (1.09) than other treatments under the study.

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Sporocarps Production of Pink *Pleurotus* [*Pleurotus djamor* (Rumph. ex. Fr.) Boedijn] Mushroom on Different Agro-Wastes by Low Cost Techniques

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Abstract

All the agro-waste substrates viz., oats straw, wheat straw, paddy straw, apple leaves, chinara leaves and poplar leaves were found suitable for sporocarps production of 'Pink *Pleurotus*'. A minimum time of around 13 day were taken by the paddy straw and wheat straw agro-waste for complete spawn run while maximum time (21.40 days) were taken by the chinara leaves. Minimum time was taken by paddy straw and wheat straw for initiation of sporocarps production while chinara leaves took maximum time for the same. The slow spawn run and sporocarps initiation in chinara leaves may be attributed to its texture and composition. The highest number of sporocarps per flush were recorded in paddy straw (28.19) followed by wheat straw (26.03) whereas among leafy substrates, highest number of sporocarps were recorded in apple (20.73) and poplar leaves (20.32) while chinara leaves recorded lowest number of sporocarps (14.12).

Key words : Agro-waste, *Pleurotus djamor*, sporocarps production.

Introduction

Pleurotus mushrooms also known as oyster or dhingri mushrooms belong to the genus *Pleurotus*. Approximately 70 species of *Pleurotus* have been recorded throughout the world (Won-Sik, 2004) while twenty five species of *Pleurotus* have been reported from India. *P. flabellatus* syn, *P. djamor*, *P. ostreatus*, *P. cornucopia*, *P. sajor-caju*, *P. platypus*, *P. sapidus* and *P. pulmonaria* are under cultivation in India (Jandaik, 1997). *Pleurotus djamor* (Rumph. ex. Fr) Boedijn is a complex specie and is recognised with typically pink coloured fruit bodies. The cultivation practices of almost all the *Pleurotus* species are more or less same (Kumar, 1997). *Pleurotus* spp. are able to derive their nutrition directly by degrading lingo-cellulose present in the substrates like straw, sawdust or wood. It has been successfully cultivated in India and abroad on wide range of plant waste materials containing lignin, cellulose and hemi-cellulose. Researchers world over have used various substrates for spawn production and cultivation of *Pleurotus* mushrooms. The lignocellulosic complex constitutes a major portion of the total carbon fixed by photosynthesis. However, only a small fraction of cellulose, hemicellulose and lignin produced as agricultural by-product is utilized; most of this material is considered waste material. The abundant availability of wastes pose problem of disposal. The cultivation of mushrooms on agricultural and animal wastes is a very old practice in European countries, but in India and other developing countries it is gaining popularity day by day. The cultivation of pink oyster mushroom is less documented therefore, there is a vast

scope of study in respect of its cultivation. Keeping this in mind, present study was under taken to evaluate different locally available agro- wastes for better sporocarps production of this mushroom species.

Materials and Methods

The pure culture of *Pleurotus djamor* (Rumph. ex. Fr.) Boedijn used in present investigation was procured from Directorate of Mushroom Research, Chambaghat, Solan. The culture was maintained and subcultured on potato dextrose agar (PDA) medium.

Spawn strategy : Apparently healthy, unbroken wheat grains were used for 'Master Spawn' preparation and the procedure given by Patil (2012) was followed. Wheat grains were washed 2-3 times with tap water and boiled in plain water for 10-15 minutes till the grains soft. These grains were then dried under shade by spreading them on wire mesh followed by mixing with calcium carbonate and calcium sulphate in 1:4 ratio after cooling of grains. The grain mixture was filled in empty, well cleaned narrow mouthed bottles upto 3/4th of their capacity and plugged with non-absorbent cotton and sterilized in autoclave at 1.05 kg cm⁻² pressure and 121°C temperature for one and half hour. The sterilized bottles were taken out of the autoclave and allowed to cool at room temperature and inoculated with pure culture of 'Pink *Pleurotus*' (*Pleurotus djamor*), procured from DMR, Chambaghat, Solan, under aseptic conditions of 'Laminar Air Flow Cabinet'. The inoculated bottles were kept for incubation in B.O.D incubator at 25±2°C till the colonisation of the grains was complete. The spawn bottles free from any contamination

were used as 'Master culture' for inoculation of different substrate under evaluation.

Substrate preparation : The substrates used for sporocarps production of *Pleurotus Djamor* were Apple leaves (*Malus domestica*), Poplar leaves (*Populus alba*), Chinar leaves (*Platanus orientalis*), Paddy Straw (*Oryza sativa*) and Oats straw (*Avena sativa*). These were compared to wheat straw (*Triticum aestivum*) which had been recommended as the best substrate for mushroom cultivation sungh 1994. The substrates were collected, cleaned, air dried and chopped in-to small pieces of about 1 cm length and filled (500 g) in polypropylene bags (42x30 cm size). These were washed separately in fresh water and then pasteurized in the solution of formaldehyde (500ppm) and Bavistin (75 ppm) for 18 h as recommended by Vijay and Sohi, 1987.

Method of Cultivation : The beds were prepared from pasteurized substrate by layer spawning following the procedure of Bano, 1971. These were incubated in a cultivation room at 22-30°C temperature for spawn run. When the mycelium had completely covered the beds, the polythene covering was taken off and the relative humidity was maintained 85-95 per cent with the help of humidifier.

Data concerning and Biological efficiency : The yield parameters recorded were, time lapsed in spawn running, Sporocarp initiation and number of sporocarps and weight per sporocarps on different agro waste. The biological efficiency of mushroom was worked out as percentage yield of fresh mushrooms in relation to the dry weight of the substrate.

Statistical analysis : Completely randomized design (CRD) was followed for the experiment. All data were statistically analysed. The critical difference (CD) was processed at the five per cent probability level.

Results and Discussion

Mushroom cultivation could be a possible option to alleviate poverty and develop the life style of the vulnerable people (Imtiaj and Rahman, 2008). Oyster mushroom cultivation is gaining popularity due to low cost technology and easy availability of various substrates for its cultivation. In Jammu and Kashmir, prevalence of varied agro-climatic conditions and availability of vast quantities of lignocellulosic raw materials have stimulated the cultivation of *Pleurotus* spp. (Shukla and Biswas, 2000). All the substrates supported the growth of 'Pink *Pleurotus*'. However time required for complete spawn run, sporocarp initiation with different substrates. A minimum time of around 13 day were taken by the paddy straw and wheat straw substrates for complete spawn run while maximum time (21.40 days) were taken by the chinar leaves. Spawn run in oat straw, apple and poplar

Table-1 : Effect of different substrates on spawn run and sporocarp initiation of 'Pink *Pleurotus*' (*P. djamor*).

Substrate	Complete spawn run (days)	Sporocarp initiation
Paddy straw	12.60	14.60
Oats straw	14.20	16.00
Apple leaves	18.10	20.20
Chinar leaves	21.40	25.00
Poplar leaves	18.40	20.40
Wheat straw (check)	13.00	15.00
S.E(d)	0.245	0.243
C.D (p=0.05)	0.485	0.488

Data represents mean of 10 replication



C. Mature Fruit body of Pink *Pleurotus* Mushroom in bags
Fig.-1 : Effect of different agro-waste on different stages A, B and C.

leaves was completed in 14.20, 18.10 and 18.40 days respectively. All the substrates varied in time taken for sporocarp initiation. The time taken for sporocarp initiation ranged from 14.60 to 25.00 days while time taken for first flush ranged from 19.70 to 28.40. Minimum time was taken by paddy straw and wheat straw for initiation of sporocarp production of first flush while chinar leaves took maximum time for the same. Poplar leaves and apple leaves were equally efficient substrates for initiation of sporocarp and took around 20 days. The slow spawn run, sporocarp initiation in chinar leaves may be attributed to its texture and composition. Furthermore, since the mushrooms are saprophytic in nature, the slower rate of decomposition of chinar leaves may be one of the possible reasons responsible for slow growth and frutification of 'Pink *Pleurotus*'. Different workers across the globe have investigated spawn run on various substrates. The results of present investigation are in agreement with the findings of Chauhan *et al.* (2012) who

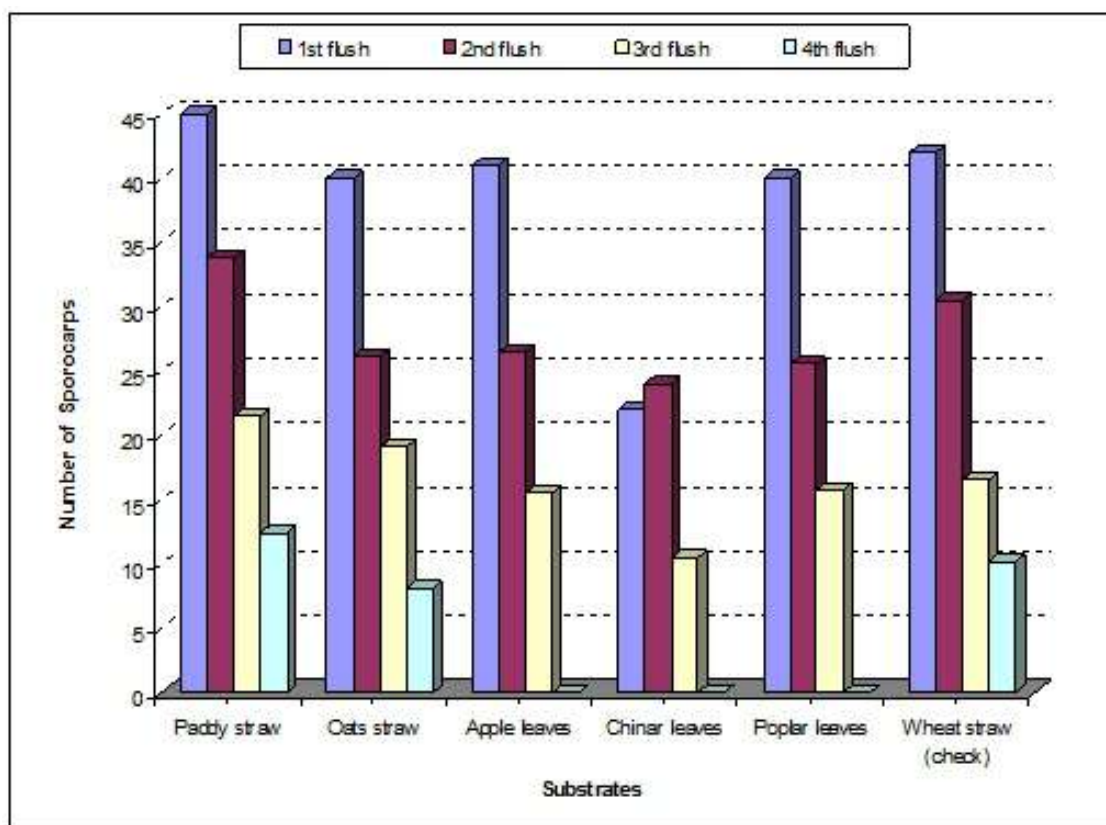


Figure-2 : Effect of different substrates on numbers of sporocarps of 'Pink Pleurotus'.

Table-2 : Effect of different substrates on weight of sporocarps of 'Pink Pleurotus' (*P. djamor*).

Substrate	Average weight of sporocarp (g)				Mean
	1 st flush	2 nd flush	3 rd flush	4 th flush	
Paddy straw	13.49	13.47	13.46	13.45	13.47
Oats straw	11.24	11.23	11.22	11.19	11.22
Apple leaves	11.44	11.41	11.39	-	8.56
Chinar leaves	9.25	9.30	9.10	-	6.91
Poplar leaves	11.19	11.18	11.17	-	8.38
Wheat straw (check)	13.15	13.11	13.10	13.08	13.11
Mean	11.62	11.61	11.57	6.28	
S.E(d)	0.163	0.142	0.106	0.023	
C.D (p=0.05)	0.337	0.294	0.221	0.057	

Data represents mean of 10 replications.

reported that spawn run and pin head formation on wheat straw was completed in 12.75 and 14.25 days, respectively while Sharma (2005) recorded 11.50 and 13.30 days for spawn run and 15.80 and 16.50 days for sporocarps initiation of 'Pink Pleurotus' on paddy straw and wheat straw, respectively. Pala *et al.* (2012) reported that apple leaves and chinar leaves took 25 to 28 days and 30 to 34 days for complete spawn run while Jan-Shaheen (2001) recorded 16 days for complete spawn on oats straw for oyster mushroom. The results of other scientists whose findings are in conformity with present findings are Patra and Pani (1995); Shah *et al.* (2004); Rajak *et al.* (2011) and Sidhant *et al.* (2013).

Number of sporocarps per flush (Fig.-2), higher weight of sporocarps (Table 2) was recorded with straw substrates. The highest number of sporocarps per flush were recorded in paddy straw (28.19) followed by wheat straw (26.03) whereas among leafy substrates, highest number of sporocarps were recorded in apple (20.73) and poplar leaves (20.32) while chinar leaves recorded lowest number of sporocarps (14.12). The number of sporocarps decreased with every flush except in chinar leaves where number of sporocarps in second flush were higher (24.00) than first flush (22.00). The average weight of sporocarps per flush was higher in straw substrates than leafy substrates. Paddy straw produced sporocarp with highest

average weight (13.47g) while lowest average weight of sporocarp (6.91g) was recorded in chinar leaves. The production of oyster mushroom in paddy straw was very high, because the paddy straw contain all the essential micronutrients for the development of mushroom such as minerals, vitamins, amino acids etc., (Govindaraju, 2013).

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Genetic Variability in Lentil (*Lens culinaris* M.) Genotypes for Seed and Seedling Characteristics

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Abstract

In this study, thirty genotypes of lentil (*Lens culinaris* M.) were evaluated in randomized block design with three replications during 2017-18 in laboratory of Department of Plant Breeding and Genetics, SKN college of agriculture, Jobner to determine genetic variability, heritability and genetic advance for seed and seedling characteristics. Observations were recorded on 100 seed weight, seed volume, true density, bulk density, porosity, water absorption capacity, water absorption index germination, seedling length, seedling fresh weight, seedling dry weight and seedling vigour index. The analysis of variance indicated significant difference among genotypes and considerable variability with respect to all the characters except germination percentage. The highest PCV and GCV expressed as percentage was observed for porosity followed by seed volume, seedling length and seedling vigour index, whereas low for bulk density and water absorption index. The estimates of heritability were high for all the characters ranging from 61.39 to 97.37. The estimate of very high heritability with high genetic advance was observed for seed weight, seed volume, water absorption capacity and seedling dry weight whereas high heritability with low genetic advance was recorded for bulk density.

Key words : genetic variability, physical properties, seedling, water absorption, lentil, selection, porosity.

Introduction

Lentil (*Lens culinaris* M.) was one of the earliest cultivated crop in the world with archeological evidence from the early Stone Age. Lentil belongs to family Fabaceae (Leguminosae) and subfamily Papilionaceae. Among the different taxa of wild lentils *L. orientalis* is considered to be the progenitor of the cultivated lentil and is now generally classified as *L. culinaris* subsp. *orientalis*. According to Ladizinsky (1979) lentil has been originated in Southern Turkey. It is cultivated in semi-arid regions of the world particularly in the Indian sub-continent and the dry areas of Middle East (Malik, 2005). Lentil is divided into two sub-species including macrosperma (broad and large seeds with a diameter of 9-6 mm) and microsperma (concave shaped tiny seeds with a diameter of 6-2 mm) (Rathore, 2002). Lentil is known as poor man's meat. Nutritionally lentil seeds are valued for their high protein content (as much as 30%) and good source of vitamins and other important minerals (K, P, Fe, Mg, Zn), low in fat and cholesterol free. Lentils have second highest ratio of protein per calorie of any legume, after soybean. Physical characteristics of seed play an important role in equipment design for plant cultures, storage, harvest, transportation and yield. Therefore it seems to achieve these basic scientific information about these characteristics is necessary. Genetic variability, heritability and genetic advance for different types of physical properties of seeds have been reviewed by other researchers such as Amin *et al.* (2004) and Cetin (2007),

Makkawi *et al.* (2008), Adewale *et al.* 2010, Malik *et al.* (2011), Latha (2014), Altuntas *et al.* (2005) and Hadi *et al.* (2016).

Materials and Methods

In order to investigate the seed and seedling characteristics of lentil genotypes, the experiment was carried out in the Laboratory of Department of Plant Breeding and Genetics, Sri Karan Narendra College of Agriculture, Jobner (SKNAU, Jobner, Rajasthan) during the period from October, 2017 to April, 2018. This work was done in a randomized complete block design with three replications. For this purpose 30 lentil genotype were obtained from AICRP on MULLaRP at Rajasthan Agricultural Research Institute, Durgapura, Jaipur. Seed and seedling characteristics like 100 seed weight, seed volume, true density, bulk density, porosity, water absorption capacity and water absorption index, seedling length, seedling fresh weight, seedling dry weight, and seedling vigour index was measured. Uniformly selected seeds were sterilized with 0.1% mercuric chloride for 1 minute and then washed repeatedly for two to three times under running tap water followed by washing with distilled water.

Seed characteristics : Seed volumes was measured by liquid displacement technique (Shepherd, 1986) ^[20]. For each lentil genotype 100 seeds were weighed and put into a 100 ml measuring cylinder containing 15 ml (initial reading) of water. Seed volume was recorded as (final

reading – initial reading)/100 (Mohsenin, 1986) ^[18] and expressed as (µl/seed). To measure the true density, individual seed weight (g) was divided by its volume which was measured already in cm³ and it was expressed as g/cm³. To determine the bulk density of seed, the mass of seed (g) was divided by volume of container (cm³) by using following formulae suggested by Khattak *et al.*, 2006:

$$\text{Bulk density (g/cm}^3\text{)} = \frac{M}{V}$$

Where, M = Mass of seed (W₂ - W₁) in grams

V = Volume of container in cm³

To calculate the water absorption capacity, 100 seeds from each replication were weighted, soaked in water and was maintained at a temperature of 22° C for 12 hours. The seeds were then removed from water and the excess moisture on the seed surface was removed with filter paper and seeds were weighted. Water absorption capacity in terms of grams per seeds was obtained by dividing the difference between these two values multiplied by 100 (Mohsenin, 1986).

WAC (mg/seed)

$$= \frac{\text{Weight after soaking} - \text{Weight before soaking}}{100}$$

Where, WAC = Water absorption capacity

Water absorption index was obtained by dividing the water absorption capacity of a single seed by its size/weight (Williamsa *et al.*, 1983) ^[23].

The porosity () of bulk seed was computed from the values of true density (ρ_t) and bulk density (ρ_b) using the following formula (Singh and Goswami, 1996) ^[21]:

$$\text{Porosity (\%)} = 1 - \frac{\rho_b}{\rho_t} \times 100$$

Seedling characteristics : Germination paper was used as a matrix for seed germination. Then the germination papers were sterilized at 15 psi and 121°C for 20 in autoclave. A seed was considered to have germinated at the emergence of both radicle and plumule up to 2 mm length (Chartzoulakis and Klapaki, 2000). The number of germinated seeds was recorded 7th day after planting in petridishes and the germination percentage was determined by using the following formula (Aniat *et al.*, 2012) :

Germination Percentage

$$= \frac{\text{Number of seeds germinated}}{\text{Total number of seeds planted}} \times 100$$

The seedling length of germinated seeds was recorded on 11th day of planting in petridishes. Five

seedlings from each petridish were randomly selected from each replication and seedling length was measured by using a measuring scale in centimeter and averaged. The fresh weight of seedling from the five seedlings from each replication was measured in milligram by using a sensitive electronic balance and averaged. After taking fresh weight of seedlings, these were kept in oven at 65°C for 48 hours for drying. After drying, the dried seedlings were weighed using sensitive electronic balance in milligram and average was recorded. The seedling vigour index was determined by multiplying the seedling length with concerned germination percentage by the following formula (Iqbal and Rahmati, 1992) :

$$\text{Seedling Vigour Index (SVI)} = (\text{SL}) (\text{GP})$$

Table-1 : List of genotypes used in the experiment.

S. No.	Genotype	S.No.	Genotype
1.	RLG – 43	16	RLG – 257
2.	RLG – 191	17	RLG – 258
3.	RLG – 223	18	RLG – 234
4.	RLG – 224	19	RLG – 195
5.	DPL – 58	20	RLG – 255
6.	RLG – 147	21	RG – 254
7.	RLG – 48	22	RLG – 5
8.	RLG – f8(3)	23	SAPNA
9.	RLG – 245	24	RLG – 273
10.	RLG – 261	25	RLG – 279
11.	DPL – 62	26	RLG – 270
12.	LG – 262	27	RLG – 283
13.	RLG – 250	28	RLG – 274
14.	RLG – 256	29	RLG – 281
15.	RLG – 266	30	RLG – 276

Results and Discussion

The results showed the maximum and the minimum value of the coefficient of variation was dedicated to seedling vigour index (12.80%) and bulk density (1.15%) respectively. In a study on three lentil genotypes, wide differences were reported for physical properties that the maximum value of the coefficient of variation was dedicated to the 100 seed weight trait with 32.2% (Hadi *et al.*, 2016). In another study, wide differences were reported for physical characteristics such as 100 seed weight, seed volume, water absorption capacity and water absorption capacity among these cultivars (Malik *et al.*, 2011).

Mean squares for different source of variation for different characters are given in table-2. The data were analysed and analysis of variance revealed that there was significant difference among the genotypes for different seed and seedling characteristics viz., 100 seed weight (g), seed volume (µl/seed), true density (g/cm³), bulk density (g/cm³), porosity (%), water absorption capacity

Table-2 : Mean sum of squares for various characters in lentil.

S. No.	Characters	Replications	Genotypes	Error
1.	100 seed weight (g)	0.0161	0.5167**	0.0079
2.	Seed volume (μ /seed)	0.7111	56.2284**	1.2398
3.	True density (g/cm^3)	0.0017	0.0276**	0.0025
4.	Bulk density (g/cm^3)	0.0003	0.0013**	0.0001
5.	Porosity (%)	0.7498	92.1571**	8.0808
6.	Water absorption capacity (mg/seed)	0.1597	42.1086**	0.5531
7.	Water absorption index	0.0016	0.0041**	0.0008
8.	Germination (%)	9.3817	17.8612**	17.0461
9.	Seedling length (cm)	3.3105	6.5993**	1.1439
10.	Seedling fresh weight (mg)	35789.6413	127058.6508**	29945.7383
11.	Seedling dry weight (mg)	84.0884	3640.0117**	32.5013
12.	Seedling vigour index	29145.0226	62066.7193**	12794.0533

* and ** represent significant at 5% and 1% level of significance, respectively.

Table-3 : The general mean, range, GCV, PCV, Hbs, GA etc for different characters.

Parameters	Mean	SE	Min.	Max.	² g	² p	GCV	PCV	h ² (%)	GA (%)
100 seed weight (g)	3.12	0.05	2.19	3.68	0.17	0.18	13.20	13.51	95.55	26.59
Seed volume (μ /seed)	26.98	0.64	19.00	35.00	18.33	19.57	15.87	16.40	93.66	31.64
True density (g/cm_3)	1.16	0.03	0.98	1.36	0.01	0.01	7.85	8.95	77.01	14.20
Bulk density (g/cm_3)	0.78	0.01	0.75	0.82	0.00	0.00	2.52	2.94	73.65	4.46
Porosity (%)	32.34	1.64	21.78	43.75	28.03	36.11	16.37	18.58	77.62	29.71
Water absorption capacity (mg/seed)	29.28	0.43	19.00	34.22	13.85	14.40	12.71	12.96	96.16	25.67
Water absorption index	0.94	0.02	0.86	1.02	0.00	0.00	3.56	4.63	59.09	5.63
Germination (%)	97.70	2.38	91.11	100.00	0.27	17.32	0.53	4.26	1.57	0.14
Seedling length (cm)	9.05	0.62	6.50	12.55	1.82	2.96	14.91	19.03	61.39	24.06
Seedling fresh weight (mg)	1455.03	99.91	1163.53	2040.93	32370.97	62316.71	12.37	17.16	51.95	18.36
Seedling dry weight (mg)	261.16	3.29	170.33	325.47	1202.50	1235.00	13.28	13.46	97.37	26.99
Seedling vigour index	883.68	65.30	636.08	1196.50	16424.22	29218.28	14.50	19.34	56.21	22.40

(mg/seed), water absorption index, seedling length (cm), seedling fresh weight (mg), seedling dry weight (mg) and seedling vigour index except germination per cent. The results were in partial confirmation with the results of Tizazu and Emire (2010), Latha (2014), Kumar *et al.* (2014), Mekonnen *et al.* (2014), Khan *et al.* (2015) and Hadi *et al.* (2016).

The mean performance, range, genotypic variation, phenotypic variation, genotypic coefficient of variation, phenotypic coefficient of variation, heritability in broad sense and genetic advance are presented in the table-2. Wide range of differences for GCV was observed which varied from 16.37% (porosity) to 2.52% (bulk density), whereas PCV ranged from 19.34% (seedling vigour index) to 2.94% (bulk density). The GCV and PCV were moderate in 100 seed weight, water absorption capacity, seedling fresh weight and seedling dry weight. The lower magnitude of GCV and PCV were found for true density, bulk density and water absorption index. The magnitude of phenotypic coefficient of variation is higher than genotypic coefficient of variation for all the characters in the present study with small difference between these two genetic parameters. These results are in agreement with Makkawi *et al.* (2008), Malik *et al.* (2011), Mekonnen *et al.* (2014) and Hadi *et al.* (2016).

In this study, the estimates of broad sense heritability were high for all the characters ranging from 61.39% (seedling length) to 97.37% (SDW). Seedling fresh weight (51.95%), seedling vigour index (56.21%) and water absorption index (59.09%) showed moderate estimates of heritability. High heritability values for quantitative characters are always preferred by the breeders as characters with high heritability estimates enable them to base their selection on the basis of expression of these characters.

The expected genetic advance expressed as percentage of mean was observed to be higher for seed volume, porosity, seedling dry weight, water absorption capacity, 100 seed weight, seedling length and seedling vigour index ranging from 22.40% to 31.64%, which are in accordance with the earlier reports of Makkawi *et al.* (2008) and Malik *et al.* (2011). Low genetic advance was observed for bulk density (4.46%) and water absorption index (5.63%), whereas moderate genetic advance was observed for true density (14.20%) and seedling fresh weight (18.36%). The present findings are in agreement with earlier reports of Makkawi *et al.* (2008) and Malik *et al.* (2011).

High heritability (broad sense) coupled with high

Table-4 : The overall rank of different genotypes in lentil.

S. No.	Variety	SW	SV	TD	BD	Por	WAC	WAI	Germ	SL	SFW	SDW	SVI	Total	Overall Rank
1.	RLG – 43	29	29	18	7	21	29	24	13	3	13	21	2	209	23
2.	RLG – 191	27	28	4	2	4	25	1	13	15	5	28	16	168	11
3.	RLG – 223	19	11	20	24	17	21	26	1	27	29	13	27	235	29
4.	RLG – 224	15	11	13	13	15	17	21	22	21	20	7	21	196	19
5.	DPL – 58	7	3	27	28	25	13	28	13	9	10	9	9	181	15
6.	RLG – 147	24	20	22	21	22	24	4	13	10	15	26	10	211	27
7.	RLG – 48	3	2	24	1	28	12	30	1	13	2	2	13	131	1
8.	RLG – f8(3)	5	4	25	19	24	6	23	1	20	16	12	17	172	13
9.	RLG – 245	26	21	23	14	26	26	7	22	7	12	18	8	210	26
10.	RLG – 261	22	21	16	5	19	22	9	1	6	6	25	6	158	9
11.	DPL – 62	1	5	19	26	16	3	20	25	2	1	20	3	141	2
12.	LG – 262	30	30	17	3	20	30	29	22	12	28	30	11	262	30
13.	RLG – 250	21	18	11	8	14	20	18	1	4	7	15	4	141	2
14.	RLG – 256	4	9	10	23	7	4	19	1	24	25	10	24	160	10
15.	RLG – 266	20	16	14	18	12	18	13	13	19	24	14	19	200	21
16.	RLG – 257	14	16	7	12	8	14	10	1	18	19	16	15	150	6
17.	RLG – 258	12	11	8	16	5	15	25	30	14	4	6	23	169	12
18.	RLG – 234	9	24	1	20	2	7	14	25	28	30	19	28	207	22
19.	RLG – 195	23	26	3	30	1	23	8	28	11	21	23	12	209	23
20.	RLG – 255	2	7	15	29	10	2	15	13	17	14	5	18	147	5
21.	RG – 254	28	27	26	27	23	28	3	1	8	18	29	7	225	28
22.	RLG – 5	25	24	21	25	18	27	10	1	5	9	27	5	197	20
23.	SAPNA	18	18	5	11	6	19	22	25	1	3	22	1	151	7
24.	RLG – 273	16	14	12	14	13	16	16	1	16	11	11	14	154	8
25.	RLG – 279	11	21	2	5	3	8	12	13	22	8	17	20	142	4
26.	RLG – 270	13	14	6	10	9	11	17	13	30	26	3	30	182	17
27.	RLG – 283	8	1	30	22	30	1	2	1	26	22	4	25	172	13
28.	RLG – 274	10	5	28	3	29	5	6	13	25	23	8	26	181	15
29.	RLG – 281	6	10	9	9	11	10	27	28	29	17	24	29	209	23

genetic advance as percentage of mean was observed for the characters viz., 100 seed weight, seed volume, porosity, water absorption capacity, seedling length and seedling dry weight, which is in agreement with earlier reports of Makkawi *et al.* (2008), Adewale *et al.* (2010) and Malik *et al.* (2011), while true density showed high heritability with moderate genetic advance. The high heritability and low genetic advance was recorded for bulk density. Low heritability and low genetic advance was found for WAI. The rank total of different genotypes also done based on character wise rank which was presented in.

Conclusions

The study concluded, that selection based on high 100 seed weight, seed volume, water absorption capacity, true density, porosity, seedling length, seedling fresh weight, seedling dry weight and seedling vigour index may play an important role in lentil for designing desirable machines and equipments to be used during harvesting, seed processing, storing and transportation of the seed. Based upon the rank analysis the genotypes RLG-48, DPL-62, RLG-250, RLG-279 and RLG-225 were found to be most desirable for breeding purpose in respect to all the characters studied.

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Determine the Varietal Resistance in Indian Bean, *Lablab purpureus* (L.) Sweet against Pod Borer Complex

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Abstract

Field experiment was conducted at Horticulture farm SKN College of agriculture, Jobner, Rajasthan, during *kharif* 2009. Out of 12 varieties/cultivars of Indian bean screened against pod borer complex based on pod damage both number and weight basis. None of them was found completely free from infestation of pest. Based on the statistically categorization, the varieties Ankur Goldy, JDL-79-1 and Pusa Early Profilic were found resistant had pod damage both number and weight basis below 16.29 and 16.21 per cent, respectively. Whereas, cultivars Local-2-1 and Local-2-2 were found highly susceptible had pod damage both number and weight basis above 27.39 and 27.29 per cent, respectively. The remaining varieties/cultivars Swarna Utkrisht, IS-1, IS-2, Local-1-2, Local-1-1, Local-3-2 and Local-3-1 were found moderately susceptible had 16.29 to 27.39 per cent pod damage on number basis and 16.21 to 27.29 per cent pod damage on weight basis.

Key words : Pod borer, number and weight loss, cultivars/varieties, and resistance.

Introduction

The Indian bean, *Lablab purpureus* (L.) Sweet (Family : Fabaceae) originated from India and its wild form are found all over the sub-continent. It is a perennial twining or creeping rainy season herb that is generally cultivated as annual. Indian bean is a fast growing tropical and subtropical pulse-cum-vegetable suitable crop in India (Sprent *et al.* 2010). Considering its potential, the high protein grain Indian bean (Khan *et al.* 2005). It is cultivated for its fresh tender, pods and seeds forms an important source of protein diet of human beings also for fodder. The mature and dark coloured seeds of Indian bean have trypsin inhibitor (Butani and Jotwani, 1984). Insect-pests are one of the major limiting factors for production of Indian bean. The crop is attacked by as many as 55 species of insects and one species of mite. Among them, the pod borers are considered to be the most devastating pests causing pod to the tune of nearly 54 per cent (20 q/ha) (Naik *et al.*, 2009), where as a others were considered as minor pests. important group causing crop loss to the tune of 80 to 100 per cent (Katagihallimath and Siddappaji, 1962). The crop suffers from a variety of insect-pests *Apporasca atkinsoni* (Hewitson) and *Helicoverpa armigera* (Hubner) which reduce yield (up to 70%) and productivity (Brachmapra Kash *et al.* 2004) in field conditions (Rekha & Mallapur 2007). The pod borer complex include avare pod borer, *Adisura atkinsoni* (Moore); gram pod borer, *Helicoverpa armigera* (Hubner); spotted pod borer, *Maruca testulalis* (Geyer); bean pod borer moth / pea pod borer, *Etiella zinckenella*

(Treitschke); soybean pod borer, *Lampiodes boeticus* (L.); and black cowpea seed moth, *Cydia ptychora* Meyrick. These borer causes substantial damage to flowers by webbing and boring into the pods.

Materials and Methods

The experiment was laid out in a simple randomized block design (RBD). Twelve varieties as treatments including local cultivar each replicated four time. The plot size was 1.8 x 1.5 m² with row to row and plant to plant distance of 60 and 30 cm, respectively. The crop was sown on 21th July, 2009. The varieties screened and their source of supply is given below :

Name of varieties / cultivars	Source of supply
Pusa Early Profilic, Swarna Utkrisht, Ankur Goldy, IS-1, IS-2, JDL-79-1	Department of Horticulture, agricultural research Station, Durgapura, Jaipur (Rajasthan)
Local-1-1 (Laxmi seeds), Local-1-2 (Laxmi seeds), Local-2-1 (Ekta seeds), Local-2-2 (Ekta seeds), Local-3-1 (Pooja seeds), Local-3-2 (Pooja seeds)	Local market, Jaipur (Rajasthan)

Observations : To assess the incidence of pod borers, observations on pod borer damage was taken at the time of peakings at weekly intervals on randomly selected five tagged plants and per cent damage was estimated by counting and weighting both damaged and total number of pods. Besides, observations on flowering and pod initiation time were also taken.

Table-1 : varietal resistance of Indian bean varieties/cultivars against pod borer complex in 2009 (number basis).

S. No.	Varieties	Per cent pod infestation* (at weekly picking)														Mean	
		15/09	22/09	29/09	06/10	13/10	20/10	27/10	03/11	10/11	17/11	24/11	01/12	08/12	15/12	22/12	Mean
1.	Pusa Early Proflic	3.33 (10.51)**	5.00 (12.93)	8.19 (16.63)	8.91 (17.37)	11.32 (19.66)	12.56 (20.76)	13.68 (21.70)	13.70 (21.72)	14.53 (22.41)	15.38 (23.09)	14.02 (21.99)	13.69 (21.71)	13.56 (21.61)	0.00 (0.00)	0.00 (0.00)	11.37 (19.71)
2.	Swarna Utkrisht	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	19.18 (25.97)	17.34 (24.61)	16.50 (23.97)	16.12 (23.67)	15.45 (23.15)	14.75 (22.58)	16.56 (24.01)
3.	Ankur Goldy	3.03 (10.02)	4.70 (12.52)	7.98 (16.41)	8.56 (17.01)	11.15 (19.51)	12.31 (20.54)	13.39 (21.46)	13.48 (21.54)	14.35 (22.26)	15.22 (22.96)	13.82 (21.82)	13.43 (21.50)	13.29 (21.38)	0.00 (0.00)	0.00 (0.00)	11.13 (19.49)
4.	IS-1	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	16.81 (24.20)	18.05 (25.14)	19.27 (26.04)	17.46 (24.70)	16.59 (24.03)	16.21 (23.74)	15.58 (23.24)	14.93 (22.73)	16.86 (24.24)
5.	IS-2	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	16.90 (24.26)	18.11 (25.19)	19.34 (26.09)	17.59 (24.79)	16.71 (24.13)	16.37 (23.86)	15.69 (23.33)	15.04 (22.82)	16.96 (24.33)
6.	JDL-79-1	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	13.56 (21.61)	13.61 (21.65)	14.41 (22.31)	15.29 (23.02)	13.91 (21.90)	13.58 (21.62)	13.42 (21.49)	13.24 (21.33)	12.37 (20.59)	13.71 (21.73)
7.	Local-1-1 (Laxmi seeds)	5.74 (13.86)	8.01 (16.44)	11.51 (19.83)	12.90 (21.05)	15.65 (23.30)	17.86 (24.99)	18.96 (25.81)	20.48 (26.91)	21.88 (27.89)	23.48 (28.98)	21.18 (27.40)	19.78 (26.41)	19.20 (25.99)	0.00 (0.00)	0.00 (0.00)	16.66 (24.09)
8.	Local-1-2 (Laxmi seeds)	5.61 (13.70)	7.88 (16.30)	11.39 (19.72)	12.76 (20.93)	15.59 (23.26)	17.79 (24.95)	18.92 (25.78)	20.42 (26.86)	21.84 (27.86)	23.43 (28.95)	21.13 (27.37)	19.83 (26.44)	19.11 (25.92)	0.00 (0.00)	0.00 (0.00)	16.59 (24.04)
9.	Local-2-1 (Ekta seeds)	6.77 (15.08)	9.34 (17.79)	14.55 (22.42)	16.61 (24.05)	18.02 (25.12)	20.51 (26.93)	21.96 (27.94)	23.95 (29.30)	26.14 (30.75)	32.02 (34.46)	25.25 (30.16)	23.73 (29.15)	22.29 (28.17)	0.00 (0.00)	0.00 (0.00)	20.09 (26.63)
10.	Local-2-2 (Ekta seeds)	6.86 (15.18)	9.44 (17.89)	14.65 (22.50)	16.73 (24.13)	18.10 (25.18)	20.57 (26.97)	20.05 (28.01)	24.07 (29.38)	26.32 (30.08)	32.16 (34.55)	25.42 (30.28)	23.89 (29.26)	22.44 (28.27)	0.00 (0.00)	0.00 (0.00)	20.21 (26.71)
11.	Local-3-1 (Puja seeds)	5.88 (14.03)	8.15 (16.59)	12.81 (20.97)	14.51 (22.39)	15.73 (23.37)	17.97 (25.08)	19.15 (25.95)	20.68 (27.05)	22.09 (28.03)	23.69 (29.12)	21.38 (27.54)	20.38 (26.84)	19.38 (26.12)	0.00 (0.00)	0.00 (0.00)	17.06 (24.40)
12.	Local-3-2 (Pua seeds)	5.78 (13.91)	8.07 (16.50)	12.73 (20.90)	14.63 (22.49)	15.68 (23.33)	17.92 (25.04)	19.07 (25.89)	20.57 (26.97)	21.98 (27.96)	23.58 (29.05)	21.27 (27.46)	20.27 (26.76)	19.27 (26.04)	0.00 (0.00)	0.00 (0.00)	16.99 (24.34)
	S.Em.±	0.29	0.35	0.39	0.43	0.45	0.48	0.52	0.73	0.87	0.98	0.89	0.78	0.68	0.51	0.51	
	CD at 5%	0.84	1.00	1.14	1.24	1.30	1.38	1.48	2.10	2.49	2.83	2.55	2.23	1.96	1.46	1.47	

* , Per cent pod infestation of four replications, ** , Figures in parentheses are angular transformed values.

Table-2 : varietal resistance of Indian bean varieties/cultivars against pod borer complex in 2009 (weight basis).

S. No.	Varieties	Per cent pod infestation* (at weekly picking)														Mean	
		15/09	22/09	29/09	06/10	13/10	20/10	27/10	03/11	10/11	17/11	24/11	01/12	08/12	15/12	22/12	Mean
1.	Pusa Early Proflic	3.29 (10.45)**	4.91 (12.80)	8.09 (16.52)	8.81 (17.27)	11.22 (19.57)	12.47 (20.68)	13.58 (21.62)	13.64 (21.67)	14.47 (23.36)	15.32 (23.05)	13.96 (21.94)	13.63 (21.66)	13.50 (21.56)	0.00 (0.00)	0.00 (0.00)	11.30 (19.64)
2.	Swarna Utkrist	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	19.08 (25.90)	17.24 (24.53)	16.40 (23.89)	16.01 (23.58)	15.33 (23.04)	14.61 (22.47)	16.44 (23.92)
3.	Ankur Goldy	2.98 (9.94)	4.65 (12.45)	7.89 (16.31)	8.47 (16.92)	11.05 (19.41)	12.22 (20.46)	13.29 (21.38)	13.39 (21.46)	14.26 (22.19)	15.13 (22.89)	13.73 (21.75)	13.34 (21.42)	13.20 (21.30)	0.00 (0.00)	0.00 (0.00)	11.05 (19.41)
4.	IS-1	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	16.72 (24.13)	17.95 (25.06)	19.17 (25.96)	17.36 (24.62)	16.48 (23.95)	16.10 (23.66)	15.49 (23.17)	14.81 (22.64)	16.76 (24.17)
5.	IS-2	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	16.81 (24.20)	18.05 (25.14)	19.28 (26.04)	17.53 (24.75)	16.65 (24.08)	16.29 (23.80)	15.59 (23.25)	14.91 (22.71)	16.89 (24.27)
6.	JDL-79-1	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	13.47 (21.53)	13.50 (21.56)	14.32 (22.23)	15.19 (22.94)	13.81 (21.81)	13.48 (21.54)	13.32 (21.40)	13.15 (21.26)	12.24 (20.48)	13.61 (21.65)
7.	Local-1-1(Laxmi seeds)	5.64 (13.74)	7.90 (16.33)	11.41 (19.74)	12.80 (20.96)	15.55 (23.22)	17.78 (24.94)	18.86 (25.74)	20.38 (26.84)	21.78 (27.82)	23.38 (28.92)	21.08 (27.33)	19.68 (26.33)	19.10 (25.91)	0.00 (0.00)	0.00 (0.00)	16.56 (24.02)
8.	Local-1-2(Laxmi seeds)	5.50 (13.56)	7.78 (16.20)	11.28 (19.62)	12.67 (20.85)	15.50 (23.18)	17.70 (24.88)	18.82 (25.71)	20.32 (26.97)	21.74 (27.79)	23.33 (28.88)	21.03 (27.29)	19.73 (26.37)	19.01 (25.85)	0.00 (0.00)	0.00 (0.00)	16.49 (23.96)
9.	Local-2-1 (Ekta seeds)	6.67 (14.97)	9.24 (17.70)	14.46 (22.35)	16.52 (23.98)	17.92 (25.04)	20.41 (26.86)	21.86 (27.87)	23.84 (29.23)	26.04 (30.68)	31.91 (34.39)	25.14 (30.09)	23.62 (29.08)	22.18 (28.10)	0.00 (0.00)	0.00 (0.00)	19.58 (26.55)
10.	Local-2-2 (Ekta seeds)	6.76 (15.07)	9.34 (17.79)	14.55 (22.42)	16.63 (24.07)	18.01 (25.11)	20.47 (26.90)	21.96 (27.94)	23.99 (29.33)	26.22 (30.80)	32.07 (34.49)	25.32 (30.21)	23.80 (29.20)	22.35 (28.21)	0.00 (0.00)	0.00 (0.00)	20.11 (26.64)
11.	Local-3-1 (Puja seeds)	5.82 (13.96)	8.09 (16.52)	12.75 (20.92)	14.40 (22.30)	15.64 (23.29)	17.87 (25.01)	19.05 (25.88)	20.60 (26.99)	22.03 (27.99)	23.63 (29.08)	21.32 (27.50)	20.31 (26.79)	19.32 (26.07)	0.00 (0.00)	0.00 (0.00)	16.96 (24.32)
12.	Local-3-2 (Pua seeds)	5.69 (13.80)	7.97 (16.40)	12.63 (20.82)	14.52 (22.40)	15.58 (23.25)	17.83 (24.99)	18.98 (25.83)	20.48 (26.90)	21.88 (27.89)	23.48 (28.98)	21.17 (27.39)	20.18 (26.69)	19.17 (25.96)	0.00 (0.00)	0.00 (0.00)	16.89 (24.26)
	S.Em.±	0.28	0.34	0.38	0.41	0.46	0.48	0.51	0.73	0.86	0.96	0.87	0.76	0.67	0.49	0.46	
	CD at 5%	0.81	0.99	1.08	1.17	1.32	1.38	1.48	2.09	2.49	2.76	2.51	2.20	1.93	1.42	1.38	

* Per cent pod infestation of four replications, ** Figures in parentheses are angular transformed values.

Table-3. Categorization of Indian bean varieties/cultivars against pod borer complex in 2009.

S. No.	Per cent pod damage at peak period		Varieties/cultivars	Category
	Number basis	Weight basis		
1.	Below 16.29 ($< \bar{x} - s$)	16.21	Ankur Goldy, JDL-79-1 and Pusa Early Profilic	Resistant
2.	16.29 to 27.39 ($\bar{x} - s$ to x)	16.21 to 27.29	Swarna Utkrisht, IS-1, IS-2, Local-1-2 (Laxmi seeds), Local-1-1 (Laxmi seeds), Local-3-2 (Puja Seeds) and Local-3-1 (Puja Seeds)	Moderately susceptible
3.	above 27.39 ($> \bar{x} + s$)	27.29	Local-2-1 (Ekta seeds) and Local-2-2 (Ekta seeds),	Highly susceptible

$\bar{x}$ = 21.84 and 21.75

s = 5.55 and 5.54

Where

$\bar{x}$ = mean of peak per cent pod infestation

s = standard deviation

on number basis $\bar{x}$

on weight basis $\bar{x}$

Result and Discussion

In the present investigations 12 varieties/cultivars of Indian bean viz., Pusa Early Prolific, Swarna Utkrisht, Ankur Goldy, IS-1, IS-2, JDL-79-1, Local-1-1, Local-2-2, Local-3-1 and Local-3-2 were screened for their relative resistance against pod borer complex infestation. The results revealed that none of the variety/cultivars of Indian bean were found completely free from the infestation of pod borer complex. The data revealed that significant difference existed among the varieties/cultivars in their resistance/susceptibility. During peak minimum infestation on pod of Indian bean was observed on Ankur Goldy followed by JDL-79-1 and Pusa Early Profilic and maximum was on Local-2-1 followed by Local-2-2. The peak per cent infestation on pod of different varieties/cultivars of Indian bean both number and weight basis were categorized on the basis of formula $x \pm s$. The varieties Ankur Goldy, JDL-79-1 and Pusa Early Profilic were categorized as resistant had below 16.29 and 16.21 per cent infestation on number and weight basis respective, whereas, cultivars Local-2-1 and Local-2-2 were categorized as high susceptible had more than 27.39 and 27.29 per cent infestation on number and weight basis, respectively. The remaining varieties/cultivars viz., Swarna Utkrisht, IS-1, IS-2, Local-1-2, Local-1-1, Local-3-2 and Local-3-1 were categorized as moderately susceptible had 16.29 to 27.39 per cent infestation on number basis and 16.21 to 27.29 per cent infestation on weight basis. These finding showed wide range of diversity among tested varieties/cultivars of Indian bean with respect to pod borer damage. These observations are in conformity with the findings of Chakravarthy and Lingappa (1986), Rashid (1999), Kundari *et al.* (2000), Sultana (2001), Mass *et al.* (2003) and Rudranaiik *et al.* (2009) in field bean. The partially support revealed that the accession, EC-92956 recorded the least pod damage (9.58%) and highest yield of 1.55 kg (Parvathy *et al.* 2011).

Similarly, Shivashankar *et al.* (1989) found cultivar PLS-24 and PLS-16-1 as resistant, PLS-93 on as highly tolerant and M-39579 and IC-661-1 moderately tolerant. However, they observed a high degree of resistance in *L. purpureus* var. *ignosus*. Likewise, Ghuguskar (2001) observed least infestation of pod borer on Kokanbushan followed by AKW-9303, AKW-9304 and AKW-9301. However, AKW-9306, AKW-9611 and AKW-9312 had significantly high infestation which indicate the presence of diversity with respect to reaction pattern against pod borer complex in Indian bean.

Conclusions

Out of 12 varieties/cultivars of Indian bean screened against pod borer complex based on pod damage both number and weight basis. None of them was found completely free from infestation of pest. Based on the statistically categorization, the varieties Ankur Goldy, JDL-79-1 and Pusa Early Profilic were found resistant had pod damage both number and weight basis below 16.29 and 16.21 per cent, respectively. Whereas, cultivars Local-2-1 and Local-2-2 were found highly susceptible had pod damage both number and weight basis above 27.39 and 27.29 per cent, respectively.

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Diversity of Pest Complex and their Associated Natural Enemies in Cabbage

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Abstract

Field experiments were conducted during *Rabi* season of 2012-13 and 2013-14. The study revealed that tobacco caterpillar, *Spodoptera litura* (Fab.), diamond back moth, *Plutella xylostella* (Linn.), cabbage semilooper, *Thysanoplusia orichalcea* (Fab.), flea beetle, *Phyllotreta chotanica* (Duviv) and the aphids, *Lipaphis erysimi* (Kalt.) and *Myzus persicae* (Sulze) were the major pests on cabbage crop; while the major natural enemies recorded were coccinellids, *Coccinella septempunctata* (Fab.), *Cheilomenes sexmaculatus* (Fab.) (Coleoptera: Coccinellidae); common green lacewing, *Chrysoperla* sp. (Neuroptera: Chrysopidae); aphid parasitoid, *Diaeretiella* sp. (Hymenoptera: Braconidae); diamond back moth and tobacco caterpillar on parasitoid of *Cotesia* sp. (Hymenoptera: Braconidae). However, their population were found fluctuate during the crop season. Among the major pests infesting cabbage, as per mean and relative density values for foliage feeding pests the tobacco caterpillar incidence was higher followed by diamond back moth. While, natural enemies the maximum mean and relative density was found for *Coccinella septempunctata* during both the years.

Key words : Diversity, insect pests, natural enemies, cabbage.

Introduction

Cruciferous vegetables have an important place among *rabi* crops grown in India. Cabbage, *Brassica oleracea* var. *capitata* (Linn.), is a popular vegetable that is grown in all the states of India and has appreciable nutritional and economic value. The total area under cabbage cultivation in India is 372.40 million hectares with an annual production of 8534.20 million tonnes, while in Rajasthan the total area and production is 1188 ha and 5690 metric tonnes (NHB, 2013), respectively. Insect pests are a serious menace in the profitable cultivation of cabbage. The important insect pests that infest cabbage crop are the tobacco caterpillar (*Spodoptera litura* Fab.), diamond back moth (*Plutella xylostella* L.), cabbage semilooper (*Trichoplusia ni* Hubner), painted bug (*Bagrada hilaris* Burmeister and *Bagrada cruciferarum* Kirk.), cabbage butterfly (*Pieris brassicae* L.), flea beetle (*Phyllotreta cruciferae* Goeze), aphids (*Lipaphis erysimi* Kalt. and *Brevicoryne brassicae* L.), Cabbage leaf webber (*Crocidolomia bionotalis* Zell) and the mustard saw fly (*Athalia lugens proxima* Klug.) (Choudhari *et al.*, 2001, Rao and Lal, 2005). Therefore, the present study was undertaken in the cabbage growing area to the insect biodiversity associated with this system.

Materials and Methods

The experiment was carried out during *rabi*, 2012-13 and

2013-14 in cabbage variety Golden Acre. The experimental site is situated at Horticulture Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. Weekly meteorological data were obtained from the Meteorology Unit at the Instructional farm of the College. All the normal agronomic practices were followed for raising the crop. The experiment was replicated thrice in a randomized block design. The observation on tobacco caterpillar, *Spodoptera litura* (Fab.), diamond back moth, *Plutella xylostella* (Linn.), cabbage semilooper, *Thysanoplusia orichalcea* (Fab.) and flea beetle, *Phyllotreta chotanica* (Duviv), coccinellids, *Coccinella septempunctata* (Fab.), *Cheilomenes sexmaculatus* (Fab.); common green lacewing, *Chrysoperla* sp., direct visual counting method was used and population was recorded on ten plants selected randomly from each replicate at weekly intervals. The estimation of aphid population was based on the numerical count method as described by Heathcoate (1972). The population was counted only on three leaves. For recording the aphid population marked leaves were grasped at the petiole by thumb and fore finger and twisted until entire underside of the leaves were clearly visible. The aphid population was counted weekly with the help of magnifying lens. To record the larval parasitization of *P. xylostella* and *S. litura* known numbers of larvae were collected from cabbage field at weekly intervals brought to the laboratory and

Table-1 : Diversity of pests faunal complex and natural enemies recorded in cabbage ecosystem during *rabi* 2012-13 and 2013-14.

S. No.	Common name	Scientific name	Order and Family	Period of activity	Crop stage	Mean Density (%)		Relative Density (%)	
						2012-13	2013-14	2012-13	2013-14
(A) Insect-pests									
1.	Tobacco caterpillar	<i>Spodoptera litura</i> (Fab.)	Lepidoptera: Noctuidae	Second week of December to first week of March	Vegetative and head formation	11.33	12.23	29.37	32.50
2.	Dimond back moth	<i>Plutella xylostella</i> (Linn)	Lepidoptera: Plutellidae	Second week of December to first week of March	Vegetative and head formation	11.27	10.33	29.33	27.41
3.	Cabbage semilooper	<i>Thysanopulsia orichalcea</i> (Fab.)	Lepidoptera: Noctuidae	Second week of December to first week of Marc	Vegetative and head formation	8.73	7.77	22.61	20.60
4.	Flea beetle	<i>Phllotreta chotanica</i> (Duviv)	Coleoptera: Chrysomelidae	Second week of December to first week of Marc	Vegetative and head formation	7.23	7.33	18.79	19.45
5.	Aphid	<i>Lipaphis erysimi</i> (Kalt.)	Hemiptera: Aphididae	Mid of December to first week of March	Vegetative and head formation	70.93	69.80	-	-
(B) Natural enemies									
1.	Ladybird beetle	(a) <i>Coccinella septempunctata</i> (Fab.)	Coleoptera: Coccinellidae	Fourth week of December to first week of March	Vegetative and head formation	3.70	4.10	56.06	53.71
		(b) <i>Cheilomenes sexmaculata</i> (Fab.)	Coleoptera: Coccinellidae	First week of January to first week of March	Vegetative and head formation	3.23	3.93	43.94	46.29
2.	Larval parasitoid	<i>Cotesia</i> sp.	Hymenoptera: Braconidae	Fourth week of December to first week of March	Vegetative and head formation	1.27	1.20	-	-
3.	Mummified aphid	<i>Diaeretiella</i> sp.	Hymenoptera: Braconnidae	Second week of January to first week of March	Head formation	24.57	25.97	-	-
4.	Common green lacewing	<i>Chrysoperla</i> sp.	Neuroptera: Chrysopidae	Second week of January to first week of March	Head formation	1.33	1.40	-	-

reared in glass jars (500ml capacity) separately on fresh cabbage leaves. The jars were covered with a muslin cloth secured with rubber bands and placed in the laboratory at ambient conditions of temperature and humidity. The larvae were observed upto the emergence of parasitoids and the numbers of parasitization larvae were counted. The emerged parasitoids from larvae were identified. The seasonal mean population counts of different insect pests and their natural enemies were expressed as mean density and relative density (%) :

Mean density (M.D.)

$$\text{Mean density} = \frac{\sum X_i}{N} \times 100$$

Where,

X_i = Numbers of insects or natural enemies in i th sample

N = Total numbers of plants sampled

Relative density (R.D.)

$$\text{RD (\%)} = \frac{\text{No. of individuals of one species of insect}}{\text{Total no. of individuals of all species}} \times 100$$

Results and Discussion

Pest faunal complex : Cabbage crop during both years of study (2012-13 and 2013-14) was infested by five major insect pests (Table-1) viz., tobacco caterpillar, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae), diamond back moth, *Plutella xylostella* (Linn.) (Lepidoptera: Plutellidae), cabbage semilooper, *Thysanopulsia orichalcea* (Fab.) (Lepidoptera: Noctuidae), flea beetle, *Phyllotreta chotanica* (Duviv) (Coleoptera: Chrysomelidae) and aphid, *Lipaphis erysimi* (Kalt.) (Hemiptera: Aphididae)]. Among the foliage feeding insects, the tobacco caterpillar population had a mean density of 11.33 per cent and relative density value of 29.37 per cent during *rabi* 2012-13 whereas, during *rabi* 2013-14 the tobacco caterpillar population had a mean density of 12.23 per cent and relative density value of 32.50 per cent. The diamond back moth population had a mean density of 11.27 per cent and relative density value of 29.33 per cent, on cabbage during *rabi* 2012-13; whereas, during *rabi* 2013-14, the diamond back moth population had a mean density of 10.33 per cent and

relative density value of 27.41 per cent. The cabbage semilooper population had a mean density of 8.73 per cent and relative density value of 22.61 per cent during *rabi* 2012-13; whereas, during *rabi* 2013-14 the cabbage semilooper population had mean density of 7.77 per cent and relative density value of 20.60 per cent. The flea beetle population had a mean density of 7.23 per cent and relative density value of 18.79 per cent during *rabi* 2012-13; whereas, during *rabi* 2013-14 the flea beetle population had a mean density of 7.33 per cent and relative density value of 19.45 per cent. The aphid population had mean density of 70.93 per cent during *rabi* 2012-13, while 69.80 per cent during *rabi* 2013-14. Among the major pests infesting cabbage, as per relative density values for foliage feeding pests the tobacco caterpillar incidence was higher followed by diamond back moth. The population of tobacco caterpillar were relatively more in 2013-14 than in 2012-13. Critical evaluation of the rise and fall in the population of various pests during the year of study and their relationship with existing weather conditions revealed some interesting points, depicting different trends in population build up and formation of peaks. Abiotic factors played important role in the population buildup of these pests. Earlier, these pests have been recorded as serious pests of cabbage crop in and around Udaipur region (Kushwaha, 1983)

Diversity of natural enemies in cabbage : The major natural enemies (Table-1) recorded were the coccinellids, *Coccinella septempunctata* (Fab.), *Cheilomenes sexmaculatus* (Fab.) (Coleoptera: Coccinellidae); common green lacewing, *Chrysoperla* sp. (Neuroptera: Chrysopidae); aphid parasitoid, *Diaeretiella* sp. (Hymenoptera: Braconidae); diamond back moth and tobacco caterpillar on parasitoid of *Cotesia* sp. (Hymenoptera: Braconidae). *C. septempunctata* had a mean density of 3.70 per cent and relative density value of 56.06 per cent during *rabi* 2012-13; whereas, during *rabi* 2013-14, *C. septempunctata* had a mean density value of 4.10 per cent and relative density value of 53.71. *C. sexmaculata* had a mean density of 3.23 per cent and relative density value of 43.94 per cent during *rabi* 2012-13, whereas, during *rabi* 2013-14, *C. sexmaculata* had a mean density value of 3.93 per cent and relative density value of 46.29 per cent. The mummified aphids had a mean density value of 24.57 per cent during *rabi* 2012-13, and 25.97 per cent during *rabi* 2013-14. The parasitoid *Cotesia* sp. had a mean density value of 1.27

per cent during *rabi* 2012-13, and 1.20 per cent during *rabi* 2013-14. Based on the field collected infested parasitized larvae. The predator, *Chrysoperla* sp. had a mean density value of 1.33 per cent during *rabi* 2012-13, and 1.40 per cent during *rabi* 2013-14. The present findings are in agreement with that of Singh *et al.* (2006), Mandal and Patnaik (2008), Ahuja *et al.* (2012) and Patra *et al.* (2013).

Conclusions

The major pests infesting cabbage, as per mean and relative density values for foliage feeding pests the tobacco caterpillar incidence was higher followed by diamond back moth. While, natural enemies the maximum mean and relative density was found for *Coccinella septempunctata* during both the years.

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Heterosis for Yield and its Attributing Traits in Pumpkin (*Cucurbita moschata* Duch. Ex. Poir.)

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Abstract

Twenty eight hybrids developed by utilizing eight parents in 8 x 8 diallel mating design excluding reciprocals were evaluated in randomized block design with three replications for twelve characters in order to understand the heterosis in pumpkin. Observations were recorded on the traits, viz., number of primary branches per vine, node number at which first female flower appears, days to initiation of first female flower, number of fruits per vine, days to first fruit harvest, fruit weight, fruit size, 100 seed weight, flesh thickness, vine length and fruit yield per vine. Among the 28 hybrids of pumpkin studied, the cross 'Kashi Harit x Punjab Samrat' excelled in yield per vine followed by the cross 'Narendra Upcar x Suvarna'. The selection should be made for improvement of traits like node at which first female flower appears, number of fruits/vine and average fruit weight. While days to initiation of first female flower, days to first fruit harvest, fruit size and fruit yield per vine may be improved through hybridization.

Key words : Diallel, hybrid, reciprocal and heterosis.

Introduction

Pumpkin (*Cucurbita moschata* Duch. Ex. Poir) is the most important seed propagated monoecious climbing vegetable crop that belongs to the family *Cucurbitaceae*, with the chromosome number $2n=40$. In India, pumpkin (*Cucurbita moschata*) is being grown commercially and consumed as culinary vegetable at immature and mature fruit stage. The different parts of the plant have also been used as medicine in the developed world and the leaves are haematinic, analgesic and also used externally for treating burns (ayurvedakalamandiram.com). Traditionally, the pulp is used to relieve intestinal inflammation enteritis, dyspepsia and stomach disorders. Pumpkin seed is an excellent source of protein and also has pharmacological activities such as anti-diabetic (Li *et al.* 2003), antifungal (Wang and Ng 2003), anti bacterial and anti inflammation activities (Fu *et al.* 2006) and antioxidant effects. It provides a valuable source of carotenoids and ascorbic acids that have a major role in nutrition in the form of pro-vitamin A and vitamin C as antioxidants. A wide variation of total carotenoid contents and yield contributing traits in the Indian germplasm of pumpkin has been recorded (Pandey *et al.*, 2002a & 2003), whereas, Murkovic *et al.* 2000 found 0.06 to 7.4 mg β -carotene in Austria pumpkin. Pumpkin as vegetable is becoming important ingredient in daily diet, but relatively little attention has been paid towards development of hybrids/varieties rich in carotenoids with high yielding capacity. Although there are reports of high heterosis to the extent of 181.5 % and 97.52 % for yield and 70% for more number of female flowers, 68.7% for fruit weight and

150% for number of fruits (Mohanty and Mishra; 1999, Pandey *et al.*, 2002b, c). A knowledge of general combining ability (*gca*) and specific combining ability (*sca*) helps to make choice of the parents of hybrid and to know the nature of gene action as a basis of choosing an effective breeding methodology. Being a most common nutritional rich crop scientific attempt is needed for its genetic improvement. The present investigation therefore was undertaken to identify potential parental combinations in order to have superior hybrids.

Materials and Methods

The investigation was conducted at experimental farm of Vegetable Crops, Rajasthan Agricultural Research Institute, Durgapura, Jaipur during 2014-15 with 28 F_1 hybrids and their parents obtained through diallel mating design excluding reciprocals. The resulting hybrids of 28 cross combinations were evaluated in a Randomized Block Design with three replications during Zaid, 2015. The crop was grown on a raised bed of 52 meter length and 1.0 m width and 15 cm height having sandy loam soil. Between the two beds 2.4 meter distance was kept for proper intercultural operations as well as crop management. On each bed drip line was stretched parallel to bed. Two seeds were sown directly on both side of the bed at 2.0 cm depth. Observations were recorded on five competitive plants in each parent and F_1 's from each replication selected as randomly for number of primary branches per vine, node number at which first female flower appears, days to initiation of first female flower, number of fruits per vine, days to first fruit harvest, fruit weight, fruit size, seed cavity size, 100 seed weight,

flesh thickness, vine length and fruit yield per vine .The combining ability variances and their effects were worked out according to Griffing (1956) and heterosis was worked out over better parent.

Results and Discussion

The analysis of variance for yield, yield components and quality traits were presented in Table-1 which revealed the presence of significance differences among the genotypes, parents and crosses for all the fifteen traits viz., days to initiation of first female flower, node number at which first female flower appears, vine length, number of primary branches, number of fruits per plant, days to first fruit harvest, fruit size, average fruit weight, flesh thickness, seed cavity size, 100 seed weight, fruit yield per vine, fruit yield per hectare, total carotenoid content, crude fiber content and two visual characters viz., fruit shape and fruit colour which revealed the presence of variation among the genotypes, parents and crosses .

Hybrid vigour is a direct property of heterozygosity and is due to superior gene content possible in a hybrid contributed by both the parents (Mather, 1995). Heterosis is a genetic phenomenon and conventionally refers to the expression of increased or decreased vigour of hybrids over mid parent (relative heterosis) and better parent (heterobeltiosis) in plant breeding programmes. Heterosis for yield reflects through the heterosis in individual components, a quick and convenient way of combining desirable characters has assumed greater significance in the production of F_1 hybrids in pumpkin. However, the commercial usefulness of hybrid would primarily depend on its performance when compared to the best commercial variety of concerned crop species. Expression of heterosis even to a small magnitude for individual component character is a desirable factor (Hathcock and David, 1973).The possibility of getting much better hybrids was explored to strengthen the heterosis breeding with available combinations of parents. Pumpkin is an important cucurbitaceous vegetable crop that can be well exploited for production of F_1 hybrids in view of the advantages such as uniformity in fruit shape, size, earliness and high yield besides economy in the production of hybrid seed as the fruit contains more seed number per fruit. Heterosis is the superiority of F_1 over the mean of the parents or over the better parent or over the standard check (Hayes et al. 1956). Significant better parent heterosis in desired direction is used for selection of best hybrids. Most of the crosses were proved to be highly positive heterotic for almost all the characters except node number at which first female flower appears, days to initiation of first female flower and days to first fruit harvest. Significantly negative

Table-1 : Analysis of variance for yield and quality components of pumpkin.

Sources	df	Mean sum of square											
		No. of primary branches/vine	Node no. at which 1st female flower appears	Days to initiation of 1st female flower	No. of fruits/ vine	Days to 1st fruit harvest	Fruit weight (kg)	Fruit size (cm ²)	Seed cavity size (cm ²)	100 seed weight (g)	Flesh thickness (cm)	Vine length (m)	Yield/vine (kg)
Replications	2	0.03	0.01	1.73	0.01	2.10	0.01	14.00	0.93	0.10	0.04	0.01	0.07
Genotypes	35	15.86**	300.05**	1606.38**	43.65**	7073.45**	25.69**	131149.23**	8100.46**	80.70	18.28**	43.69**	355.48**
Parents	7	0.03*	2.58**	9.08*	0.01**	25.36**	0.05**	301.49**	80.29*	0.65**	0.11**	0.09**	0.30**
Crosses	27	1.47**	14.74**	145.34**	3.70**	626.43**	1.69**	8958.74**	662.73**	6.96**	1.32**	3.74**	18.51**
P vs cr	1	14.36**	282.73**	1451.97**	39.94**	6421.66**	23.95**	121889.00**	7357.44**	73.09**	16.85**	39.86**	336.66**
Error	70	0.20	4.33	16.20	0.28	43.22	0.16	318.66	126.28	0.97	0.14	0.55	1.74

** Significant at 5 and 1% levels, respectively.

*, ** Significant at 5 and 1% levels, respectively.

Table-2 : Estimates of heterobeltiosis for yield and yield components in pumpkin.

Crosses	Number of primary branches per vine	Node number at which first female flower appears	Days to initiation of first female flower	Number of fruits per vine	Days to first harvest	Average fruit weight (kg)	Fruit size (cm ²)	Seed cavity size (cm ²)	100 seed weight (g)	Flesh thickness (cm)	Vine length (m)	Fruit yield per vine (kg)
P1XP2	-12.50	2.73	1.50	42.02**	2.05	75.54**	43.35	20.16**	-27.51**	11.94	10.03	76.17**
P1XP3	56.67**	-14.27	-13.15**	42.41**	-3.38**	-10.42	14.20**	9.67	-0.15	-11.90	-42.22	-22.76
P1XP4	26.09	-14.72	-11.57	36.48	-10.37**	-13.29*	-8.54	22.83**	-5.71	-12.83**	-5.33	9.64
P1XP5	10.88	-7.38	1.10	70.84**	-4.79	17.87	-34.47**	-11.32	-16.35**	47.80**	52.07**	85.22**
P1XP6	39.81**	-22.04**	3.15	43.94**	-3.64	65.48**	-10.85	29.96**	19.05**	-25.00**	-36.24	68.60**
P1XP7	50.21**	-22.20**	-16.18**	63.81**	-12.79**	-17.64	25.54**	2.41	-10.53**	-3.62	-41.79*	-66.32**
P1XP8	-17.28	-6.93	5.20	11.90	1.09	-13.49**	-10.94	-11.86**	-21.29**	47.80**	-39.05	-35.89
P2XP3	53.33**	4.03	8.52	25.53	-6.79	62.58**	-57.61**	3.45	-11.86**	-32.56*	-40.78**	44.66**
P2XP4	44.44	-10.91	-13.30	66.78**	-8.07**	-20.26*	-4.66	9.19	-14.30**	-23.26	-5.61	-58.81**
P2XP5	10.88	-6.99	6.15	45.89**	6.59	74.41**	75.25**	17.39**	-10.27**	35.35**	-25.03	79.14**
P2XP6	33.33	-22.63**	-13.57**	19.42	-7.34	76.86**	60.94**	6.25	26.28**	8.33	39.70**	65.83**
P2XP7	9.37	4.38	9.24	6.11	1.45	30.32	23.30**	21.94**	-21.03**	6.10	46.27**	44.75**
P2XP8	-19.75	-17.06	9.04	-13.18**	-7.83	-8.93	-21.74**	-1.06*	-9.78	-14.26*	-1.83	-6.51
P3XP4	-24.44	-18.15	-13.69**	32.20	-13.73**	54.19**	-13.15	10.13	16.68**	-0.79	-31.11**	-15.46
P3XP5	47.84**	-20.30	11.11	31.77	0.62	31.10	-8.60	-4.02*	1.40	39.46**	-38.33**	-59.85**
P3XP6	37.78	-27.15**	-18.01**	96.35**	-23.64**	78.14**	62.48**	18.83**	-14.90**	57.46**	51.67**	115.42**
P3XP7	-4.17	-14.62	10.29	-6.38	16.57**	81.32**	38.74*	37.68**	21.08**	-8.14**	44.78**	-44.86**
P3XP8	-28.22	8.12	17.10**	17.02	-7.23	0.53	-25.00**	4.29	18.12**	-13.81	9.44	-11.15
P4XP5	-33.26	-15.23	18.49**	21.43	5.19	-18.79**	14.27	-10.13	-17.42**	-5.08	1.33	76.42**
P4XP6	27.78	-24.62**	15.24**	34.45	-13.11**	65.36**	-22.19**	17.26**	-6.27	11.54	-12.58	78.47**
P4XP7	14.58	11.29*	20.11**	24.43	10.56**	73.76**	25.84**	-19.93**	1.70	-10.73	16.42	62.88**
P4XP8	13.09	-12.69	18.81**	-18.57*	-7.78	-22.59	-8.12	25.11**	-8.96	47.22**	-3.47	36.48
P5XP6	46.30**	-22.81**	-12.40**	46.13**	-11.54**	65.24**	12.66	16.37	18.94**	-7.44*	52.83**	69.10**
P5XP7	51.95**	-22.41**	-4.49	10.23	1.84	-7.20*	29.05**	-4.19*	1.83	-8.47	19.10	-12.40
P5XP8	-34.70	-28.32**	-3.97	78.72*	-21.33**	77.08**	39.76**	6.53	19.45**	50.98**	-41.08	78.93**
P6XP7	42.59**	-23.36**	-11.37**	44.96**	10.40**	53.60**	17.26**	2.67	-13.90**	-26.10**	42.79**	78.58**
P6XP8	-41.67**	-23.14**	-9.20	16.50	-0.05	-23.47*	15.58	-3.97*	-1.77	-29.49**	-15.09*	-56.59**
P7XP8	36.46	-15.14	-3.79	45.50**	12.33**	38.08	-21.12**	12.54	14.85**	-1.24	18.91	77.92**
SE	0.26	1.20	2.32	0.31	3.80	0.23	10.31	6.49	0.57	0.22	0.43	0.67

for both kinds of heterosis for node number at which first female flower appears was observed in the hybrids Narendra Upcar x Suvarna ($P_5 \times P_8$) followed by Punjab Samrat x Pusa Vishwas ($P_6 \times P_7$) and Kashi Harit x Punjab Samrat ($P_3 \times P_6$). Similar results of heterosis for earliness based on node number for first female flower appearance was reported by Kumar and Sirohi (2002) in bottle gourd. Earliness is an important character contributing much towards development of hybrid vegetables of commercial importance (Thakur *et al.*, 1984). Earliness as days to first female flower appearance in the hybrid Kashi Harit x Punjab Samrat ($P_3 \times P_6$) followed by Ambili x Pusa Vishwas ($P_1 \times P_7$) and Kashi Harit x Narendra Agrim ($P_3 \times P_4$). Earliness, in terms of days to first fruit harvest was observed by the hybrids Kashi Harit x Punjab Samrat ($P_3 \times P_6$), Narendra Upcar x Suvarna ($P_5 \times P_8$) and Kashi Harit x Narendra Agrim ($P_3 \times P_4$). The heterosis values for both type of heterosis were also significantly negative. Similar results were reported by Kumar and Sirohi (2002) in bottle gourd for the same trait. Number of primary branches per vine is an important trait by which growth and vigour of plants are measured. The hybrid Ambili x Kashi Harit ($P_1 \times P_3$) alone performed positive significant for relative heterosis and heterobeltiosis. Concomitant reports were also given by Kabilar (1999) in bitter gourd and Vidya *et al.* (2002) in pumpkin. Of the various yield components, fruit number per vine is the direct contributor and its heterosis contributes towards the higher yield (Yadav *et al.*, 1989). The hybrids Kashi Harit x Punjab Samrat ($P_3 \times P_6$) followed by Narendra Upcar x Suvarna ($P_5 \times P_8$) and Ambili x Narendra Upcar ($P_1 \times P_5$) exhibited high significant positive relative heterosis including another type of heterosis. Positive heterotic values for fruit number per vine had also been reported by Singh *et al.* (2000) in bitter gourd. Fruit weight also contributes much to fruit yield. As far as the fruit weight is concerned, preference is more for small to medium sized fruits. Among the 28 hybrids of the pumpkin, the hybrid Kashi Harit x Pusa Vishwas ($P_3 \times P_7$) showed the significant positive heterosis over the mid parent followed by the hybrid Kashi Harit x Punjab Samrat ($P_3 \times P_6$) and Narendra Upcar x Suvarna ($P_5 \times P_8$) showed the highest positive significant heterosis for both the type. Vidya *et al.* (2002) got the similar result for the same trait in pumpkin. For fruit size, the hybrid Anand Pumpkin-1 x Narendra Upcar ($P_2 \times P_5$) followed by Kashi Harit x Punjab Samrat ($P_3 \times P_6$) and Kashi Harit x Pusa Vishwas ($P_3 \times P_7$) showed the highest and significant value for both the type of heterosis. These results were supported by Nisha (1999) in pumpkin, where the hybrid $P_5 \times P_4$ showed significant heterosis. With respect to seed cavity size of

fruit, the significant positive relative heterosis and heterobeltiosis were observed by the hybrids Ambili x Suvarna ($P_1 \times P_8$) followed by Punjab Samrat x Suvarna ($P_6 \times P_8$) and Narendra Agrim x Pusa Vishwas ($P_4 \times P_7$) favorably. In case of 100 seed weight, among the 28 hybrids of the study, the cross Anand Pumpkin-1 x Punjab Samrat ($P_2 \times P_6$) showed significant positive values for both type of heterosis followed by Kashi Harit x Pusa Vishwas ($P_3 \times P_7$) and Narendra Upcar x Suvarna ($P_5 \times P_8$) showed significant positive values of relative heterosis and heterobeltiosis for 100 seed weight. The results were supported by Doijode and Sulladmath (1982) in pumpkin and Varghese and Rajan (1993) in snake gourd. In case of flesh thickness, the positive significant heterosis was observed by the hybrids Kashi Harit x Punjab Samrat ($P_3 \times P_6$) followed by Narendra Upcar x Suvarna ($P_5 \times P_8$) and Ambili x Suvarna ($P_1 \times P_8$) favorably. Concomitant reports were also given by Vidya *et al.* (2002) in pumpkin. Vine length is an important trait by which growth and vigour of plants are measured. The hybrid Ambili x Narendra Upcar ($P_1 \times P_5$), Kashi Harit x Punjab Samrat ($P_3 \times P_6$) and Punjab Samrat x Pusa Vishwas ($P_6 \times P_7$) showed positive significant heterosis for both relative heterosis and heterobeltiosis. Concomitant reports were also given by Kabilar (1999) in bitter gourd, Kumar and Sirohi (2002) in bottle gourd and Vidya *et al.* (2002) in pumpkin. With respect to yield per vine, the cross Kashi Harit x Punjab Samrat ($P_3 \times P_6$), Ambili x Narendra Upcar ($P_1 \times P_5$), Narendra Upcar x Suvarna ($P_5 \times P_8$) and Kashi Harit x Narendra Upcar ($P_3 \times P_5$) showed the positive significant for both the type of heterosis.

Fruit yield per vine being a complex trait and is a product of several basic component traits of yield. The improvement in heterosis for yield component may not necessarily be reflected in increased yield. Contrarily the increased fruit yield will definitely because of increase in one or more component traits Jha *et al.* (2009). In the present study the top performing F_1 hybrids for yield also showed significant heterosis either for days to first harvest or fruit weight along with some other yield component traits. Likewise, crosses showing heterosis for other yield component did not necessarily show heterosis for fruit yield. This showed that heterosis depends upon nicking of genes. Similar results have also been reported by Kumar and Sirohi (2002) in bottle gourd and Singh *et al.* (2012) in cucumber. The above findings indicated that some inbred has strong heterotic capability compared to other ones during hybridization process. This may be due to diverse parent and favorable cross combination. As the performance of hybrids developed upon the heterotic capability of the parents involved from economic point of view it will be useful to select and utilize the parental

inbreds with strong heterotic capability for important traits associated with yield in order to achieve higher fruit yield in F_1 hybrids through exploitation of heterosis Tamilselvi *et al.* (2015).

In case of hybrids evaluated by heterobeltiosis, the hybrid Kashi Harit x Punjab Samrat ($P_3 \times P_6$) was adjudged as the best hybrid as it excelled in exhibiting its superiority on more number of traits viz., earliness in terms of days to first female flower appearance, days to first fruit harvest, number of fruits per vine, flesh thickness and yield per vine. Next to this hybrid, Narendra Upcar x Suvarna ($P_5 \times P_8$) was adjudged as the next best one as the hybrid excelled in both the heterosis for the traits viz., earliness in terms of node number for first female flower appearance, fruit number per vine, flesh thickness and fruit yield per vine.

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Socio-Economic Profile of Farmers in Different Systems of Poultry Production

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Abstract

The study was conducted to determine the socio-economic status of farmers, the profitability and utilization of income under both organized and backyard systems of poultry production. Five districts were selected for the purpose of having a large number of poultry farmers. Data were collected from 20 respondents with the help of a systematic consultation strategy. The study area was full of middle-aged male farmers followed by youngsters. The majority of respondents are some of the most common followed by one in the background and the SC category. The educational conditions of most of the respondents were high and 10 + 2. The average family size in both the system and the background was 7 and they have a medium family size. The co-breed family was most present on most farms without regard to the poultry production system, as is the current rural social situation across the country and the majority of respondents were high and 10 + 2. In both poultry programs, respondents had livestock (including poultry) and agriculture as the main activity. Most formal poultry farmers aged 5 to 10 work on a poultry farm while informal poultry farmers have more than 10 years of experience.

Key words : Organized, backyard, respondent, poultry, farmers.

Introduction

Poultry farming has become the most lucrative and pre-eminence business in the developing world. It has a wide range of quick and large profits. In recent years, backyard production has placed great emphasis on stabilizing and improving rural livelihoods. On this farm, the birds are kept in a low-income and low-productive system and can be easily handled by housewives and children. Nowadays as there is growing concern about meeting the protein requirement of the individual 3rd person of India's rural population, chicken meat especially eggs have proven to be the best and cheapest solution to this.

Objective : To know the socio-economic status of poultry farmers in the Varanasi district of Uttar Pradesh.

Research Methodology

The study was conducted in the Varanasi district of Uttar Pradesh state. Following an exploratory research design, five villages near Varanasi were selected randomly. A sample of 20 farmers was selected randomly. Then the pre-tested interview schedule was used for the collection of data and the data was analyzed by using appropriate statistical methods viz. percentages and mean $\pm$ standard deviation.

Results and Discussion

Table-1 presents the socio-economic profile of the respondents covered in the present study. The

respondents were grouped into different categories based on the mean and standard deviation.

Age : Age can be defined as the length of time a person lives. Studies show that in the formal system of raising chickens 60 percent of respondents were in the middle age group (35-50 years) followed by a group of adults (over 50 years) and a group of young people (under 35 years old) accounting for about 30 percent and percent 10 in a row while in the backyard 70% were middle-aged people followed by young people (20%) and adults (10%). A similar effect was also reported by Kanwat *et al.* (2012) in their study of a measure of attitudes towards home adoption in Arunachal Pradesh, where most were middle-aged. But the findings of Mandal *et al.* (2003) contradict the results of current research. They found that most of the chicken owners were young.

Education : Education is the act or process of transmitting or acquiring common knowledge, developing the ability to think and reason. Looking at the results in Table 1 shows that in the formal segment the majority (40%) of respondents were high and 10 + 2, graduates and above (30%) followed by middle (20%), well-educated (10%), and illiterate category (0%). There are no illiterate people who respond to organized farming. On the other hand in poultry farms, most were illiterate and illiterate (30%) followed by educated people (20%), middle class and 10 + 2 per person (10%). system. A similar result was reported by Saha (2003) in a study of rural poultry production in the North 24 region of Parganas in West Bengal, where the majority of respondents had

Table-1 : Socio-personal profile of organised (n=10) and backyard poultry farmers (n=10).

S. No.	Variable	Variable	Organized (n=10)			Backyard (n=10)			Pooled N=20	
		Category	Mean SD	Freq- uency	%	Mean SD	Freq- uency	%	Freq- uency	%
1.	Age	Young (15-35 year)	41.6	1	10	37.9	2	20	3	15
		Middle (35-50 year)	8.97	6	60		7	70	13	65
		Old (>50 year)		3	30	6.64	1	10	4	20
2.	Education	Illiterate		0	0		3	30	3	15
		Functional literate		1	10		2	20	3	15
		Primary		0	0		3	30	3	15
		Middle		2	20		1	10	3	15
		High and 10=2		4	40		1	10	5	25
		Graduate and above		3	30		0	0	3	15
3.	Family size	Small (2-4)	4.5	4	40	3.5	0	0	4	20
		Medium (5-8)	0.79	4	40		7	70	11	55
		Large (>8)		2	20	0.46	3	30	5	25
4.	Family type	Joint		6	60		5	50	11	55
		Nuclear		4	40		5	50	9	45
5.	Family	(a) Poultry		7	70		0	0	7	35
		(b) Poultry+Agri.		3	30		5	50	8	40
		(c) Poultry+Agri.+Business		0	0		2	20	2	10
		(d) Poultry+Agri.+Service/Labour		0	0		3	30	3	15
6.	Experience in poultry rearing	< 2 year	6	1	10	9	0	0	1	5
		2-5 year	0.95	3	30		0	0	3	15
		5-10 year		4	40	0.53	5	50	9	45
		>10 year		2	20		5	50	7	35
7.	Gender	Male		8	80		7	70	15	75
		Female		2	20		3	30	5	25
8.	Caste	General		6	60		2	20	8	40
		ST		0	0		1	10	1	5
		SC		0	0		4	40	4	20
		OBC		4	40		3	30	7	35

read above the graduation rate (59.3%) and only 18.7 percent were illiterate.

This study reveals that the level of respondent education in the commercial system was higher than in the backyard system. Therefore in the back-end program, the illiteracy of poultry was considered a major limitation of the technical know-how for livestock including poultry production in the study area. Therefore, in order to increase poultry farming in the backyard, there is a need to make additional efforts to encourage respondents to adapt to new technologies. The information gap should be closed by providing education.

Family type and size : The role of the chicken owners in the family depends largely on the type and size of the

family. The size of the family usually indicates the number of helping hands. The time available to a family member depends largely on the number of members and the type of family. It is evident from the findings (Table-1) that in a formal and formal system 60 per cent and 50 per cent of families were united, and 40 per cent and 50 per cent were nuclear. The respondent family size was average (40%), followed by adults (40%) and young (20%) respectively. While i.e. in the backyard system (70%) belonged to a medium-sized family and 30% belonged to a large family. The average family size was associated with the chickens in a systematic and backyard poultry system. Similar results were observed by Singh and Jilani (2005) in a backyard poultry study in Garhwal, Himalayas. They

realize that most families belong to middle-class families. Saha (2003); Mandal *et al.* (2006) reported similar results.

Family occupation : The data revealed that the majority of respondents kept animals (including chickens) as the main activity in the systematic program (70%). In the case of the backyard chicken program, a good percentage of respondents (50%) had livestock (including chickens), agriculture as their second occupation. Only 30% of farmers who had animals (including poultry) + farmed as their main occupation in case they were planned.

Further research revealed that animal husbandry was subsidized with almost 72% of respondents and 14% working in agriculture as a subsidiary. These findings are consistent with those of Iqbaluddin (1996); Sharma (2000); Saha (2003) pointed out that farming was a versatile activity especially in rural India as it provided a part-time job with an annual income. Poultry farming in the yard was found to be a subsidy activity for all respondents to the informal process.

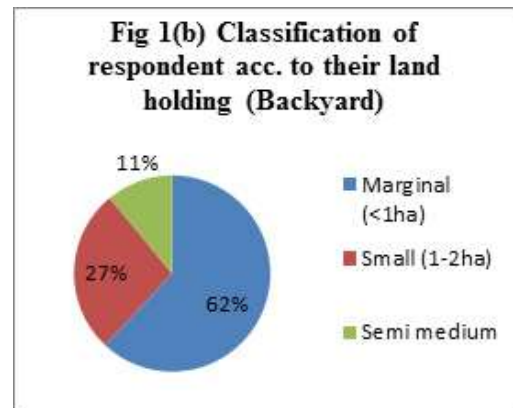
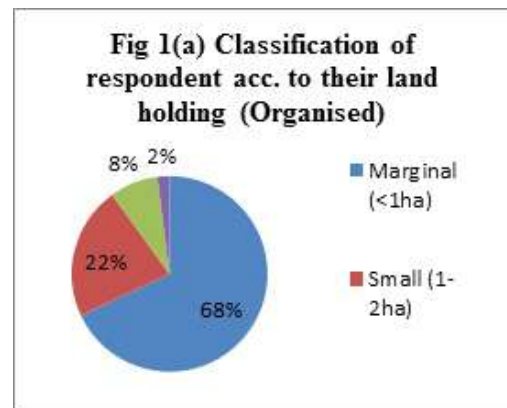
Experience in poultry farm : Table-1 shows the time in which chickens were raised by respondents. The majority of organized poultry farmers mean 40 percent have been poultry farmers for 5 to 10 years and 30 percent have 2-5 years experience and 20% of respondents have more than 10 years experience. On the other hand, the majority of backyard poultry farmers (50%) were 5 to 10 years old with more than 10 years of experience. It is clear from current research that poultry farming under the backyard system follows a rotating process as a comprehensive system and a rigid poultry production system, thus the findings of the current study can rightly be explained by the discovery of Saha (2003).

Gender : The majority of respondents (80%) in the organized system belonged to males and 20 per cent belonged to females. But in the case of the unorganized form which was mainly a backyard poultry farm majority of respondents 70 per cent were female and 30 per cent belonged to the female gender. It shows that in a commercial activity where ever the technology is involved women take a back seat. These results were also in accordance with the results recorded by Rai *et al.* (2000) while conducting a study on the performance of the backyard poultry, where they found that out of eighty farmers selected from eight villages, sixty-seven were women.

Caste : The study showed that most respondents in the organized system (60%) were in a general category and (40%) were in the general retrospective (OBC) category. In the backyard poultry (40%) was part of the Caste Schedule (SC) followed by 30 per cent of the reverse category (OBC) and 20 per cent of the standard category.

Similar results found in a study by Mandal *et al.* (2003) found that the majority (57.50%) of respondents in the Bareilly region of Uttar Pradesh were below the normal category followed by 21.67 percent in the SC category and 12.50% in the ST category.

Land holding : Fig.-1 (a) and (b) reveal that in both the systems of poultry rearing majority (organized 68 per cent and backyard 62 per cent) of the respondents fell under marginal land holding category followed by small (organized 22 per cent and backyard 27 per cent). None of the respondents either in organized or backyard system of poultry farming fell under landless as well as large land holding category.



This finding also got support from the study of Chatterje *et al.* (2004) who concluded that the farmers involved in backyard poultry rearing were generally marginal and small farmers in their study on the evaluation of Nicobari fowl under backyard island milieu. Mandal *et al.* (2006) reported the similar result.

Flock size : In the research data shown in (Table-2) that the majority of respondents (90%) of the planned category came from groups with a size of more than 3000 birds, about 10% were in the herd size group of 2000–3000 and none defendant in group 1st and 2nd. In the post-poultry system, most respondents (60%) came from the first group (up to 5 birds), 20% from the second group, 10

Table-2 : Classification of the respondents according to their flock size.

S. No.		Organized Broiler farm				Backyard poultry farm			
		Up to 1000	1000-2000	2000-3000	>3000	5 co/h/chi	5-10 co/h/chi	10-15 co/h/chi	>15 co/h/chi
1.	Actual no. of birds	0	0	1(10)	9(90)	6(60)	2(20)	1(10)	1(10)
		Desi/indigenous		Cross strain		Desi/indigenous		Cross strain	
		0		10		9(90)		1(10)	
2.	Guinea fowl	0		0		0.7(70)		0	
3.	Duck	0		0		3(30)		0	

percent from the 3rd group, and 10 percent from the fourth group. In a systematic way, all respondents kept broiler birds and respondents in a random poultry farming program kept unidentified colored birds. The in-house poultry program was supported by the findings of Panda and Singh (2000) who conducted research on domestic chickens in the remote Orissa region and found that the majority of respondents had 5 to 10 birds. A study by Mandal et al. (2003) found that the majority of respondents raised less than 10 birds.

Gross annual income from poultry : The study revealed (Table-3) that the majority of respondents in poultry farmers had incomes of between Rs. 42000 to 62000. Ignorant person 10% of the poultry responder with an annual income of more than Rs. 62000. It is also interesting to note here that 10% of respondents make poultry farming with an annual income <12000, which indicates that poultry farming is not limited to annual farmers' income.

Table-3 : Classification of the respondent according to their income (organized).

Income group	Income per annum	Frequency	Percentage
Very low	<12000	1	10
Low	12000-42000	3	30
Medium	42000-62000	5	50
High	>62000	1	10

Material possession (n=20) both organized and backyard : The findings (shown in Table-4) were that all respondents (both programs) had televisions followed by a motorcycle. They used it regularly. This clearly indicates that people are watching TV by enriching their knowledge of daily developments in poultry farming. 95% of respondents owned a motorcycle, which they used regularly to set up equipment and to contact the business and the market for dumping to harvest chickens at the right price. It can be concluded that scientific poultry farming controls the common use of the media especially T.V. to keep abreast of the latest information and to master the planning of various ideas and disposable chickens.

Table-4 : Classification of respondent according to their material possession.

S. No.	Materials	Possession		Uses	
		Freq- uency	%	Freq- uency	%
1.	TV	20	100	20	100
2.	Radio	2	10	1	5
3.	Motorcycle	19	95	18	90
4.	Tractor	4	20	3	15
5.	Power tiller	3	15	2	10
6.	Iron plough	6	30	1	5

Conclusions

The study will provide and understand the processes of poultry production on organized farms and behind the Varanasi region of the U.P. situation. This research will also help to effectively promote poultry production and will assist in generating information about the processes related to poultry production and the socioeconomic status of farmers under different programs.

Recommendations

The growth of the poultry industry will require strong research input from Government institutions on local issues. Currently little or no research is carried out on the problems of poultry farmers in this region. Given the importance of poultry farming in the Varanasi region and the need for business development in the sector.

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Soil Microbial and Enzymatic Responses as Influenced by Various Sources through Nano Nitrogen in Fodder Oats

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Abstract

The field experiment was conducted in Rabi season (2020) to study the influence of various sources of Nitrogen on soil microbial population and enzymatic activities. The experiment was laid out in the randomized block design with 6 treatment and combinations of four replication i.e. Absolute control, 100% RDN through Urea, 75% RDN + 25% N through Nano-N, 50% RDN + 50% N through Nano-N, 25% RDN + 75% N through Nano-N, 100% RDN through Nano-N. Application of 75% RDN + 25% N through Nano-N was found next better treatment and remained at par with 100% RDN through urea. The available N, P and K in soil, soil microbial activities (bacteria, fungi and Actinomycetes) were significantly increased by using 100% RDN through urea. Application of 75% RDN + 25% N through Nano-N was found statistically at par with application of 100% RDN through urea.

Key words : Microbial population, enzymatic activities, potassium, oats, nano nitrogen.

Introduction

Livestock is the backbone of India's economy in terms of Income, Employment, Equity, and Sustainability. It plays an essential role in the rural economy of India by providing employment, uniformly supplementing the family income. Livestock production is an integral and indispensable component of the farming system in India. Livestock is a main complementary component of Indian agriculture its accounting for 4.13 per cent of the national GDP and 25.6 per cent of agricultural GDP. The scarcity of feed and forage resources in the country has made the livestock suffer continuously with malnutrition, resulting in low production potential compared to many developed nations. The various challenges faced in current agriculture are to produce more food and fodder to feed the large population and equal importance to be given to maintain the soil health status and quality of produce. Like nitrogen and phosphorus, potassium is an essential macronutrient and a key factor controlling crop productivity. Its role is well documented in different physiological processes like photosynthesis, enzyme Catalysis, respiration, protein, and carbohydrates synthesis, translocation of photosynthetic, enabling their ability to resist environmental stress, pests, and diseases. The misconception of potassium richness in soil and faulty agronomical practices adopted by Indian farmers are the main reason for the continuous decline in the potassium status of the soil.

Therefore, an experiment was carried out to study the soil microbial and enzymatic responses under fodder oats as influenced by varying nitrogen management options to obtain higher productivity and improved soil properties.

Materials and Methods

Study site and weather : A field experiment (2020-21) was carried out at Research Farm of Agronomy Section, ICAR National Dairy Research Institute, Karnal, India (29°45' N latitude, 76°58' E longitude and an altitude of 245 m above mean sea level). This zone falls under the sub-tropical climatic zone and receives rainfall from both southwest and northeast monsoons. Karnal faces extremes of both high and low temperatures. During summer maximum temperature goes up to 45°C and in winter minimum temperature reaches near freezing point. The mean annual rainfall is about 707 mm of which major portion (about 574 mm) is received during the monsoon season (July to September) and rest during winter and spring seasons. The highest rainfall of 5.6 mm was recorded in 47th (16th November-22nd November) and 51st (14th -20th December 2020) standard week, and there was no rainfall in 40th-46th, 49th-50th and 2nd-3rd standard weeks of 2021 during the crop period. At the start of the experiment, soil samples were collected at 0-15 cm depth before preparing the field for sowing and harvesting crops using an auger. The composite soil samples were prepared by mixing, air dried, and crushed to pass through

Table-1 : Effect of nano nitrogen fertilizer on green fodder yield of oats.

Treatments	Green fodder yield (tha ⁻¹)		
	I Cut	II Cut	Total
T ₁ : Absolute control	23.99	17.41	41.40
T ₂ : 100% RDN through Urea	32.81	24.44	57.25
T ₃ : 75% RDN + 25% N through Nano-N	32.05	23.65	55.71
T ₄ : 50% RDN + 50% N through Nano-N	29.06	22.74	51.80
T ₅ : 25% RDN + 75% N through Nano-N	27.78	20.56	48.35
T ₆ : 100% RDN through Nano-N	27.13	19.78	46.91
SEm±	0.46	0.59	0.87
CD (P=0.05)	1.39	1.78	2.63

Table-2 : Effect of nano nitrogen fertilizer on dry fodder yield of oats.

Treatments	Dry fodder yield (tha ⁻¹)		
	I Cut	II Cut	Total
T ₁ : Absolute control	3.62	2.61	6.23
T ₂ : 100% RDN through Urea	5.34	3.92	9.26
T ₃ : 75% RDN + 25% N through Nano-N	5.15	3.70	8.86
T ₄ : 50% RDN + 50% N through Nano-N	4.63	3.47	8.10
T ₅ : 25% RDN + 75% N through Nano-N	4.30	3.14	7.44
T ₆ : 100% RDN through Nano-N	4.13	3.02	7.15
SEm±	0.12	0.12	0.18
CD (P=0.05)	0.36	0.35	0.56

a 2mm sieve and stored in sealed plastic jars before analysis. Soil bulk density, pH, EC, soil organic carbon (SOC), available N, P and K and microbial count (Bacteria, Actinomycetes, Fungi) were determined for 0-15 cm soil depths of each plot after and before the sowing of oats fodder crop. The soil was sandy clay loam (43.4% sand, 23.1% silt, and 33.4% clay) in texture having pH 7.70, electrical conductivity 0.25 dS/m, 6.3 g organic carbon/kg soil, 172.6 kg KMnO₄ oxidizable N/ha soil, 25.70 kg 0.5 N NaHCO₃ extractable P/ha soil and 185.4 kg 1.0 N NH₄OAc exchangeable K/ha soil in the top 15 cm soil. The initial bacterial count (CFU/g soil), fungal count (CFU/g soil), and actinomycetes count ($\times 10^{-3}$ CFU g⁻¹ soil) recorded in the experiment field were 33.1, 21.8, and 29.8, respectively.

Experimental design and treatments : The experiment was laid out in a *Randomized Block Design* with 6 treatment combinations with four replications. In this experiment, Nitrogen was applied to both of Urea and Nano nitrogen liquid with different doses through in the soil and foliar application method. It contained 10⁹ cfu/ml counts of potassium solubilizing bacteria. N was applied in Urea and Nano liquid form in three split doses. P₂O₅ was applied in SSP form as a basal dose. K was applied as MOP form through basal dose. The standard RDF (100%) dose is 120:40:40 NPK Kg/ha. These six treatment

combinations which was placed in four replications, among nutrients 1/3rd dose of nitrogen (Urea+ Nano-N), full dose of phosphorous and potassium was applied at the time of sowing through soil drenching, remaining half dose of nitrogen (Urea+ Nano-N) was applied 30 DAS as foliar spray and rest 1/3rd dose of nitrogen (Urea+ Nano-N) was applied after 1st cutting as foliar spray. The complete potassic fertilizer applied in different treatments is given in supporting information Table 1.0.

Forage yield : The crop was harvested two times for fodder purpose. The 1st harvesting/cutting was taken at 60 DAS from 8-10 cm above the ground level and the 2nd harvesting/cutting was taken at 45 days after the 1st cutting. Samples were weighed fresh from each respective plot, and representative samples were oven dried at 65°C for 72 hours for dry matter (DM) estimation. The dried samples were ground separately (Wiley mill) to pass through a 1 mm sieve and used for different chemical analyses. The ground samples were stored in polycarbonate bottles until analyzed.

Soil sampling and analysis : Soil samples were collected from two sites of each plot and at a depth of 0–15 cm. Soil samples from the first sampling were passed through a 2mm sieve and stored at four °C for estimation of soil microbial biomass carbon (SMBC), soil microbial population, alkaline phosphatase, and Dehydrogenase

Table-3 : Effect of nitrogen management on pH, EC and organic carbon of soil before sowing and after the harvest of oats fodder crops.

Treatments	pH	EC (dS m ⁻¹)	OC (%)
Initial Value	7.70	0.25	0.63
T ₁ : Absolute control	7.44	0.28	0.62
T ₂ : 100% RDN through Urea	7.31	0.26	0.65
T ₃ : 75% RDN + 25% N through Nano-N	7.35	0.27	0.64
T ₄ : 50% RDN + 50% N through Nano-N	7.33	0.27	0.65
T ₅ : 25% RDN + 75% N through Nano-N	7.40	0.26	0.64
T ₆ : 100% RDN through Nano-N	7.41	0.25	0.63
SEm±	0.09	0.01	0.02
CD (P=0.05)	NS	NS	NS

Table-4 : Effect of nano nitrogen fertilizer on available nitrogen, phosphorus and potassium of soil after the oats harvest.

Treatments	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
Initial value	172.6	25.70	185.4
T ₁ : Absolute control	169.0	25.72	184.6
T ₂ : 100% RDN through Urea	194.2	27.44	191.0
T ₃ : 75% RDN + 25% N through Nano-N	193.2	27.31	190.1
T ₄ : 50% RDN + 50% N through Nano-N	186.5	26.67	187.5
T ₅ : 25% RDN + 75% N through Nano-N	180.3	26.62	186.1
T ₆ : 100% RDN through Nano-N	178.3	26.06	187.4
SEm±	2.5	0.50	1.5
CD (P=0.05)	7.5	1.51	4.7

activity (DHA). The later soil samples were air dried, ground, and sieved on a 2mm mesh for chemical analysis (SOC and available N). The MBC ($\times 10^{-3}$ CFU g⁻¹ soil) content was determined by the dilution method. Numbers of colony forming cells of bacteria, fungi, Actinomycetes were determined by serial dilution pour plate method (Subbarao, 1986) and expressed in colony forming units (CFU) g⁻¹ dry soil. The population of different microorganisms viz., bacterial ($\times 10^{-3}$ CFU g⁻¹ soil), fungi ($\times 10^{-3}$ CFU g⁻¹ soil) and actinomycetes ($\times 10^{-3}$ CFU g⁻¹ soil) in the field soils were computed by using standard serial dilution plating techniques (Subbarao, 1986). Organic carbon was determined by rapid titration (Walkley & Black, 1934) and available soil N by the Alkaline Permanganate Method (Subbiah and Asija, 1956), available Phosphorus (Olsen's Method (Jackson, 1954) and available Potassium [Flame Photometer Method (Jackson, 1967)].

Statistical analysis : Statistical analysis was done using standard procedures of analysis of variance. Statistical analysis was carried out based on mean values obtained. Data were analyzed using analysis of variance (ANOVA). Analysis of variance of the experimental data was carried out as per Randomized Block Design. The 'F' test tested the significance of the difference. In case of significant F test in ANOVA with 5% significance level (P < 0.05), the means were compared using the least significant

difference (LSD) test at $\alpha = 0.05$. MS EXCEL was used to analyze the experimental data for its test of significance.. A five percent level of significance was used to test the significance of the results. The critical differences were calculated when the differences among treatments were significant in the 'F' test. In the remaining cases, only standard error of means was worked out. The data were analyzed in OPSTAT-CCSHAU, Hisar version.

Results and Discussion

Green and dry fodder yield : The total biomass (t/ha) produced at harvest is considered the economic yield in fodder crops, which produces a cumulative effect of all factors contributing to better growth and thereby resulted in higher yield per plant. It is one of the essential characters which shows the production potential of fodder crops. Data pertaining to the effect of nitrogen management on the yield potential of fodder oats crop presented in (Table-1 and 2). Results exhibited that the green fodder yield of oats was significantly influenced by the genetic potential and morphological arrangements.

Almost similar results were obtained by Abdel-Aziz *et al.*, (2018), Davarpanah *et al.*, (2017), indicated that both nitrogen sources significantly improved the green fodder yield (GFY) of oats over control at I as well as at II cut and their total. At I cut, application of 100% RDN

Table-5 : Effect of nano nitrogen fertilizer on soil microbial activities of oats.

Treatments	Total bacteria ($\times 10^{-6}$ CFU g ⁻¹ soil)	Total fungi ($\times 10^{-3}$ CFU g ⁻¹ soil)	Total Actinomycetes ($\times 10^{-4}$ CFU g ⁻¹ soil)
Initial Value	33.1	21.8	29.8
T ₁ : Absolute control	33.3	22.1	29.9
T ₂ : 100% RDN through Urea	37.9	24.4	33.0
T ₃ : 75% RDN + 25% N through Nano-N	37.1	24.2	32.6
T ₄ : 50% RDN + 50% N through Nano-N	35.9	23.3	31.8
T ₅ : 25% RDN + 75% N through Nano-N	34.6	22.7	30.5
T ₆ : 100% RDN through Nano-N	34.5	22.5	30.3
SEm±	0.4	0.2	0.3
CD (P=0.05)	1.1	0.6	0.9

through Urea (32.81 t/ha) and 75% RDN + 25% N through Nano-N (32.05 t/ha) resulted in significantly higher GFY over remaining N management practices. Further results revealed that at this cut, application of 50% RDN + 50% N through Nano-N (29.06 t/ha) showed at par GFY with 25% RDN + 75% N through Nano-N (27.78 t/ha) and observed significantly higher over 100% RDN through Nano-N (27.13 t/ha) and control (23.99 t/ha). Results revealed that application of N through both sources (Urea and Nano-N) either individual or in combination significantly enhanced DMY over control. Similar results were reported by El-Gewely *et al.*, (2020), Al-Juthery *et al.*, (2018), Davarpanah *et al.*, (2017). Further results revealed that application of 100% RDN through Urea (5.34, 3.92 and 9.26 t/ha) and 75% RDN + 25% N through Nano-N (5.15, 3.7 and 8.86 t/ha) had significantly higher DMY than rest of N management strategies at I cut, II cut and their total, respectively.

pH, EC (dS m⁻¹) and Organic carbon : A perusal of data containing pH, EC and organic carbon (OC %) in the soil before sowing and after the crop harvest is presented in Table-3. Data pertaining to soil pH as influenced by different N management practices are furnished in Table-3. Results revealed that different N management practices were failed to exert the effect of the significance level. Cultivation of oats reduced soil pH as compared to initial value. After the harvest of oats, a slightly lower value of pH was observed under 100% RDN through Urea treatment (7.31). Similar results were obtained by Panda *et al.*, (2020), Rani *et al.*, (2019). Application of different N management practices did not influence soil electrical conductivity (EC) (Table 2). Though, numerically a lower value of EC (0.25 dS/m) was recorded in 100% RDN through Nano-N and it was equal to initial EC. Similar results were obtained by Rani *et al.*, (2019). The data pertaining to organic carbon (OC) analyzed before sowing and after harvest of oats are presented in Table 2. Among different N management practices, application of 100%

RDN through Urea and 50% RDN + 50% N through Nano-N showed numerically equal OC (0.65%) and this was slightly higher than rest of N management practices. Similar results were obtained by Panda *et al.*, (2020) and Rajonee *et al.*, (2017).

Available N, available P and available K (kg/ha) : Data related to available N, available P and available K as influenced by different N management practices are presented in Table-4. A perusal of data revealed that available N, available P and available K significantly varied among different N management practices. Application of 100% RDN through Urea (194.2 kg/ha) being at par with 75% RDN + 25% N through Nano-N (193.2 kg/ha) had significantly higher available N compared to rest of the treatments. Further, results showed that 50% RDN + 50% N through Nano-N (180.3 kg/ha) was at par with 25% RDN + 75% N through Nano-N (178.3 kg/ha) and had higher available N compared to 100% RDN through Nano-N and control. With respect to available P, it was observed that application of 100% RDN through Urea (27.44 kg/ha) was at par with 75% RDN + 25% N through Nano-N, 50% RDN + 50% N through Nano-N, 25% RDN + 75% N through Nano-N and 100% RDN through Nano-N and noted considerably higher over control. Further results showed that application of 100% RDN through Urea (191.0 kg/ha) and 75% RDN + 25% N through Nano-N (190.1 kg/ha) remained at par with 50% RDN + 50% N through Nano-N and 100% RDN through Nano-N and noticed markedly higher over rest of treatments for available K. These results are in agreement with the earlier work done by Khalil *et al.*, (2019), Khan *et al.*, (2019) and Rajonee *et al.*, (2017).

Bacterial, fungal and Actinomycetes count in soil (CFU/g soil) : Application of 100% RDN through Urea (37.9 CFU/g soil) and 75% RDN + 25% N through Nano-N (37.1 CFU/g soil) followed by 50% RDN + 50% N through Nano-N (35.9 CFU/g soil) recorded significantly higher total bacterial counts compared to rest of the N

management strategies Table-5. Whereas, application of 100% RDN through Urea (24.4 CFU/g soil) was corroborated significantly the maximum fungal count amongst all N management strategies. Concerning Actinomycetes count in soil, application of 100% RDN through Urea (33 CFU/g soil) remained at par with 75% RDN + 25% N through Nano-N (32.6 CFU/g soil) and noted considerably higher over other practices. N fertilization might have helped in increasing the root biomass, which in turn improved the soil microbial population viz., total bacteria, fungi and Actinomycetes counts. These results are in agreement with the earlier work done by Khan *et al.*, (2019) and Rajonee *et al.*, (2017).

Conclusions

The soil pH, soil EC, soil organic carbon (SOC), were not reaching up to the level of significance while the values of available N, P and K (kg ha^{-1}) were significantly improved in 100% RDN through urea than other nitrogen sources. Furthermore, minimum available N, P and K in applied nitrogen sources were observed under absolute control.

The soil microbial activities (bacteria, fungi and Actinomycetes) were significantly enhanced by using 100% RDN through urea. While, 75% RDN + 25% N through Nano-N was found statistically at par with 100% RDN through urea.

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Performance of Castor Genotypes to Nipping and Different Levels of Nutrients on Dry Matter Production, Quality Parameters and Yield

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Abstract

A field experiment was conducted in kharif during 2016 and 2017 with castor (DCH -177 and DCH -519) on medium black clayey soil with alkaline in reaction at the Agricultural College Farm, UAS, Raichur with four levels of nutrients 75 per cent RDF with and without sulphur and 100 per cent RDF with and without sulphur in split-split plot design having three replications. Pooled mean of two years revealed that DCH-519 recorded significantly higher leaf area plant⁻¹ (56.63 dm² plant⁻¹), leaf area index (0.915) dry matter production (191.13 g plant⁻¹), oil yield (584.04 kg ha⁻¹), protein yield (355.21 kg ha⁻¹) and bean yield (1311 kg ha⁻¹) as compared to DCH-177. Among the row spacings, 120 cm without nipping recorded significantly higher dry matter production (198.69 g plant⁻¹) whereas bean yield (1700 kg ha⁻¹), oil yield (759.15 kg ha⁻¹) and protein yield (460.38 kg ha⁻¹) was significantly higher with a row spacing of 90 cm with nipping. Similarly 100 per cent RDF with sulphur recorded significantly higher dry matter production (192.29 g plant⁻¹), leaf area (56.96 dm² plant⁻¹), leaf area index (0.920), bean yield (1356 kg ha⁻¹), oil yield (617.65 kg ha⁻¹) and protein yield (373.70 kg ha⁻¹).

Key words : Leaf area, *Ricinus communis*, bean yield, nutrient levels.

Introduction

Castor is one of the important crop grown under rainfed area since last few years. Yield potentiality of castor, predominant and economically important which did not sustained owing to inadequate, erratic and uneven distribution of rainfall during crop growth periods and hence, ultimately, area under castor cultivation is increased due to its drought tolerant habit, wide adaptability to varying soil type and climate. However, average yield of castor is very low because of inferior fertility status of soil and fertilizer management. Therefore, a study was incorporated to find out optimum dose of nutrients and row spacing with nipping practices

Materials and Methods

The experiment was conducted at Agricultural College Farm, UAS, Raichur with thirty two treatments during *kharif* season of 2015-16 and 2016-17. The experiment consisted of two castor genotypes with different crop geometry with and without nipping practices along with 75% RDF with and without sulphur application and 100% RDF with and without sulphur application. Half of nitrogen, entire dose of phosphorus and potassium in the form of urea, diammonium phosphate (DAP) and muriate of potash (MOP) as 100% RDF and 75% RDF were applied as per treatments at 4-5 cm deep and 5 cm away from the seed as basal dose. Remaining 50 per cent dose of nitrogen in the form of urea was top dressed at 30 and 60

days after sowing (DAS). Gypsum application was done at 100 kg ha⁻¹ at 30 DAS in both the seasons.

Results and Discussion

Performance of castor genotypes : In the current investigation, castor hybrid DCH-519 recorded higher leaf area (56.63 dm² plant⁻¹), leaf area index (0.915), dry matter production (191.13), bean yield (1311 kg ha⁻¹), oil yield (584.04 kg ha⁻¹) and protein yield (355.21) over DCH 177 in pooled data. The higher yield could be attributed to higher dry matter production and cumulative effect of yield attributes. The genotype DCH-177 is a poor yielder because of its poor growth and canopy makeup. Similar results were reported by Govindan *et al.* (2002), Shifa (2011) and Sannappa *et al.* (2016). However oil and protein yields had significant variation among the genotypes. DCH-519 recorded higher oil and protein yields (584.04 and 355.21 kg ha⁻¹, respectively) compared to the genotype DCH-177. This might be due to inherent character of endosperm which has resulted in higher oil content which is also evidenced from genotype characteristics.

Row spacing and nipping : Among different row spacing, 120 cm x 60 cm without nipping (198.69 g plant⁻¹) recorded significantly higher plant total dry weight followed by 90 cm without nipping, 120 cm with nipping. Dry matter accumulations in different plant parts as well as other growth indices like LAI were significantly lower in periodical nipping off castor treatment as compared to

Table-1 : Leaf area, Leaf area index and dry matter production of castor genotypes as influenced by spacing with nipping practices and nutrition at harvest.

G x S x F		Leaf area (dm ² plant ⁻¹) at harvest				Leaf area index at harvest				Dry matter production (g plant ⁻¹) at harvest									
		F ₁	F ₂	F ₃	F ₄	G x S	F ₁	F ₂	F ₃	F ₄	G x S	F ₁	F ₂	F ₃	F ₄	G x S			
G ₁	S ₁	52.33	52.12	51.04	51.00	51.62	0.969	0.965	0.945	0.944	0.956	181.79	181.50	178.24	177.74	179.82			
	S ₂	58.53	58.50	56.71	56.65	57.60	1.084	1.083	1.050	1.049	1.066	192.18	191.60	187.94	187.77	189.87			
	S ₃	55.12	55.05	53.08	53.03	54.07	0.766	0.765	0.737	0.736	0.751	190.63	190.04	186.04	185.44	188.04			
	S ₄	60.61	60.56	59.67	59.56	60.10	0.842	0.841	0.829	0.827	0.835	199.47	199.03	196.07	195.29	197.46			
G ₂	S ₁	52.83	52.70	51.66	51.25	52.11	0.978	0.976	0.957	0.949	0.965	183.97	183.43	180.40	179.83	181.90			
	S ₂	58.78	58.64	58.15	58.00	58.39	1.089	1.086	1.077	1.074	1.082	193.94	193.40	190.45	189.49	191.82			
	S ₃	56.16	56.10	54.55	54.31	55.28	0.780	0.779	0.758	0.754	0.768	193.77	193.41	188.50	187.93	190.90			
	S ₄	61.35	61.25	60.31	60.13	60.76	0.852	0.851	0.838	0.835	0.844	202.69	202.15	197.78	197.10	199.93			
F		56.96	56.86	55.64	55.49		0.920	0.918	0.899	0.896		192.29	191.82	188.16	187.57				
		G x F				G x F	G x F				G	G x F				G			
G ₁	56.65	56.56	55.12	55.06	55.85	0.915	0.914	0.89	0.889	0.902	191.01	190.54	187.08	186.56	188.79				
G ₂	57.28	57.17	56.17	55.92	56.63	0.925	0.923	0.908	0.903	0.915	193.59	193.09	189.27	188.59	191.13				
		S x F				S	S x F				S	S x F				S			
S ₁	52.58	52.41	51.35	51.13	51.87	0.974	0.971	0.951	0.947	0.960	182.87	182.46	179.32	178.78	180.86				
S ₂	58.66	58.57	57.43	57.33	57.99	1.086	1.085	1.064	1.062	1.074	193.05	192.49	189.19	188.63	190.85				
S ₃	55.64	55.58	53.81	53.67	54.67	0.773	0.772	0.748	0.745	0.759	192.20	191.73	187.27	186.68	189.47				
S ₄	60.98	60.90	59.99	59.85	60.43	0.847	0.846	0.834	0.831	0.839	201.08	200.59	196.92	196.20	198.69				
Interactions		S.E.m.±				C.D. (0.05)				S.E.m. ±				C.D. (0.05)					
Genotype		0.10				0.59				0.002				0.13				0.79	
Spacing		0.09				0.27				0.002				0.23				0.70	
Nutrient		0.07				0.20				0.001				0.16				0.46	
G x S		0.18				NS				0.002				0.37				NS	
G x F		0.10				NS				0.002				0.23				NS	
S x F		0.14				0.39				0.003				0.32				NS	
G x S x F		0.19				NS				0.004				0.45				NS	
G ₁ – DCH-177		S ₁ – 90 cm x 60 cm with spacing								F ₁ – 100% RDF with sulphur									
G ₂ – DCH-519		S ₂ – 90 cm x 60 cm without nipping								F ₂ – 100% RDF without sulphur									
		S ₃ – 120 cm x 60 cm with nipping								F ₃ – 75% RDF with sulphur									
		S ₄ – 120 cm x 60 cm without nipping								F ₄ – 75% RDF without sulphur									

non-nipping plots. This might be due to reduced number of leaves and branches plant⁻¹ as a result of removal of axillary buds. Similar effect of nipping on castor growth parameters was also noted by Venkate Gowda *et al.* (2011), Shivaramu and Krishna Murthy (2008). leaf area and dry matter plant⁻¹ also increased significantly with 120 cm x 60 cm row spacing over 90 cm. This may probably be due to vigorous and profuse growth habit of castor. Being indeterminate plant, increased space availability for individual plant reduced competition for nutrients, light and water, resulted into increased growth of castor.

castor sown at 90 cm x 60 cm with nipping recorded significantly higher bean yield (1700 kg ha⁻¹). In the present study, the decrease in row spacing from 120 cm to 90 cm drastically decreased the bean yield plant⁻¹ because of acute competition for growth factors that even increased plant population could not compensate the loss in bean yield plant⁻¹.

Significantly higher oil content was recorded in periodical nipping of castor as compared to no-nipping. This treatment also recorded significantly higher oil yield. The oil yield is the resultant of oil content of seeds and seed yield of the crop. Higher oil content and higher seed yield of castor obtained from nipped treatments resulted in higher oil yield over non-nipping treatments. These results are in conformity with the findings of Venkate Gowda *et al.* (2011) and Shivaramu and Krishna Murthy (2008).

Nutrient management : Application of 100% RDF with sulphur recorded significantly higher leaf area (56.96 dm² plant⁻¹), leaf area index (0.920) and dry matter production (192.29 g plant⁻¹) as compared to 75% RDF. Increased levels of N, P and K might have resulted in more root proliferation and vigorous seedling growth, which in turn was useful for higher uptake of moisture and nutrients from soil reservoir. These findings are in close conformity with those of Hussaini *et al.* (2002) and Suryavanshi *et al.* (2008).

Application of 100 and 75% RDF with sulphur recorded significantly higher oil yield as compared to 100 and 75% RDF without sulphur. Increase in oil content by sulphur application might be attributed to involvement of sulphur in the biosynthesis of oil. Sulphur is involved in the formation of glucosides and glucosinolates and sulphhydryl-linkage and activation of enzymes, which aid in biochemical reaction within the plant. The higher oil yield by sulphur application was obviously because of higher seed yield and oil content. The results corroborate with the findings of Pavan Chandra Reddy and Suryanarayana Reddy (2001), Giri *et al.* (2003) and Patra *et al.* (2013).

Protein yield were significantly higher with 100%

RDF with sulphur application (373.70 kg ha⁻¹) The protein content was increased with increased NPK fertilization as a result protein yield was also increased with increase in bean yield. Nitrogen is a constituent of the proteins, nucleic acids and nucleotides which are essential to the metabolic function of a plant (Salisbury and Ross, 1994). This study confirms previous finding by Viola *et al.* (2001) and Maryam and Basalma (2012).

Interaction of genotypes, row spacing with nipping and different levels of nutrients : Bean yield, oil yield and protein yield was recorded significantly higher with a row spacing of 90 cm with nipping with the application of 100% RDF with sulphur (1783, 812.96 and 492.16 kg ha⁻¹) (Table 54, 58 and 60 this is because a plant population of 90 cm x 60 cm increased the number of spikes per plant and number of capsules per plant as a result of increase in the growth parameters like plant height, number of branches per plant which increased the bean yield as compared to a row spacing of 120 cm.

Oil and protein yield were Significantly increased with a row spacing of 90 cm and nipping with 100% RDF with sulphur because of the higher yield attributing parameters were achieved due to better growth and growth components, which helped in better uptake of nutrients and better translocation of photosynthates from source to sink lead to higher oil and protein yield.

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Effect of Different Nutrient Levels with Different Crop Geometry on Yield and Nutrient Uptake of Castor Genotypes

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Abstract

An experiment was carried out during the *Kharif* season of 2016 and 2017 at the Agricultural College Farm, UAS, Raichur, The soil of the experimental site was vertic inceptisols with low organic matter to study the optimum crop nitrogen, phosphorus, potassium and sulphur requirement of castor (*Ricinus communis* L.) under rainfed conditions. Pooled mean of two years revealed that genotype DCH-519 recorded significantly higher bean (1311 kg ha⁻¹) and stalk yield (2677 kg ha⁻¹) N, P, K and S uptake (42.84, 12.37, 67.14 kg ha⁻¹ and 6.92 ppm) by castor. Among the row spacings 90 cm with nipping recorded higher bean yield (1700 kg ha⁻¹) whereas stalk yield was highest with row spacings 90 cm without nipping (3325 kg ha⁻¹) and also N, P, K and S uptake was found to be higher with 90 cm without nipping (44.03, 12.98, 68.90 kg ha⁻¹ and 7.20 ppm). Among the different nutrient levels 100 % RDF with S recorded higher bean and stalk yield (1356 and 2754 kg ha⁻¹) N, P, K and S uptake (44.96, 13.40, 69.57 kg ha⁻¹ and 7.55 ppm).

Key words : Stalk yield, castor, nutrient levels, row spacing.

Introduction

Castor is one of the important non edible oil seed cash crop grown widely in rainfed areas of India. The productivity of this crop in rainfed environment quite often fluctuates due to vagaries of monsoon. The low productivity of rainfed castor is attributed to its cultivation under marginal soils having low available nitrogen. It is also attributed to the erratic rainfall and its distribution, use of non descriptive cultivars and poor management practices. Castor is exhaustive crop and responds well to the added fertilizers. In recent years it has been realized that, no single source of plant nutrients can meet the total nutrient need for modern agriculture, which is expected to take care of increasing human needs. For efficient production of castor, it is necessary to develop alternate source of materials that supply the nutrients steadily based on the crop demand simultaneously sustaining the soil health. Keeping these facts in view an experiment was conducted on sustaining castor productivity with promising genotypes, row spacing with nipping practices and different levels of nutrients.

Materials and Methods

A field experiment was conducted at the Agricultural College Farm, UAS, Raichur, during *kharif* season of 2015-16 and 2016-17 with thirty two treatments during *kharif* season of 2015-16 and 2016-17. The experiment consisted of two castor genotypes with different crop geometry with and without nipping practices along with 75% RDF with and without sulphur application and 100%

RDF with and without sulphur application. The land was ploughed once with mould-board plough and brought to fine tilth with two harrowing. Hand weeding was carried on bund side and paths whenever the weeds emerged in order to keep the experimental site clean. Nitrogen, phosphorus and potassium uptake was calculated for each treatment separately using the formula and expressed in kg ha⁻¹.

$$\text{Nutrient uptake} = \frac{\text{Nutrient Concentration (\%)}}{\text{Dry weight (kg ha}^{-1}\text{)}} \times 100$$

The recommended packages of practices were followed. The data recorded at different stages of crop was subjected to statistical analysis at 5 % probability.

Results and Discussion

Performance of castor genotypes : Hybrid DCH-519 recorded significantly higher bean (1311 kg ha⁻¹) and stalk yields (2677 kg ha⁻¹) compared to hybrid DCH-177 (1248 kg ha⁻¹ and 2558 kg ha⁻¹, respectively). The higher yield could be attributed to higher dry matter production and cumulative effect of yield attributes. Indeed, the yield of crop is a function of yield attributes like number of productive spikes plant⁻¹, mean spike length, number of capsules spike⁻¹ and test weight, which were higher in DCH-519 which ultimately resulted in higher bean and stalk yield. Castor genotypes exhibited a significant influence on N, P, K and S uptake in bean and stalk yield. Significantly higher total N, P, K and S uptake were recorded in genotype DCH-519 (42.84, 12.37, 67.14 kg NPK ha⁻¹ and 6.92 ppm S, respectively) as compared to

Table-1 : Bean yield, stalk yield, test weight and harvest index of castor genotypes as influenced by spacing with nipping practices and nutrition.

G x S x F		Bean Yield				Stalk Yield				Test weight				Harvest Index							
		F ₁	F ₂	F ₃	F ₄	G x S	F ₁	F ₂	F ₃	F ₄	G x S	F ₁	F ₂	F ₃	F ₄	G x S					
G ₁	S ₁	1742	1727	1620	1600	1672	2451	2415	2217	2191	2318	25.89	25.84	25.58	25.50	25.70	41.55	41.70	42.22	42.20	41.92
	S ₂	1149	1134	1028	1016	1081	3405	3371	3165	3116	3264	24.41	24.24	23.71	23.78	24.04	25.23	25.17	24.51	24.58	24.87
	S ₃	1458	1433	1294	1278	1366	1977	1942	1763	1728	1852	26.44	26.36	26.09	26.06	26.24	42.45	42.45	42.33	42.52	42.44
	S ₄	932	916	828	812	872	2936	2905	2693	2666	2800	25.24	25.08	24.75	24.63	24.93	24.10	23.97	23.52	23.35	23.73
G ₂	S ₁	1823	1800	1656	1632	1728	2576	2537	2334	2300	2437	26.00	25.95	25.79	25.67	25.85	41.44	41.51	41.51	41.50	41.49
	S ₂	1217	1200	1098	1082	1149	3523	3489	3284	3251	3386	24.55	24.49	24.05	23.88	24.24	25.68	25.59	25.04	24.97	25.32
	S ₃	1536	1517	1359	1333	1436	2114	2059	1868	1843	1971	26.80	26.61	26.29	26.19	26.47	42.07	42.42	42.10	41.96	42.14
	S ₄	988	969	889	867	928	3051	3018	2815	2782	2916	25.45	25.35	24.95	24.85	25.15	24.45	24.31	24.00	23.76	24.13
F		1356	1337	1221	1202		2754	2717	2517	2485		25.60	25.49	25.15	25.07		33.39	33.37	33.15	33.10	
G ₁		1320	1302	1192	1176	1248	2692	2658	2459	2425	2558	25.49	25.38	25.03	24.99	25.23	33.33	33.32	33.14	33.16	33.24
		1391	1371	1250	1228	1311	2816	2775	2575	2544	2677	25.70	25.60	25.27	25.15	25.43	33.41	33.46	33.16	33.05	33.27
S ₁		1783	1764	1638	1616	1700	2514	2476	2275	2246	2377	25.94	25.90	25.69	25.58	25.78	41.49	41.61	41.86	41.85	41.70
		1183	1167	1063	1049	1115	3464	3430	3224	3184	3325	24.48	24.36	23.88	23.83	24.14	25.45	25.38	24.78	24.77	25.10
		1497	1475	1326	1305	1401	2045	2000	1815	1785	1911	26.62	26.49	26.19	26.13	26.35	42.26	42.43	42.22	42.24	42.29
		960	943	859	840	900	2993	2961	2754	2724	2858	25.34	25.22	24.85	24.74	25.04	24.27	24.14	23.76	23.55	23.93
Interactions		S.E.m.±	C.D. (0.05)		S.E.m. ±		C.D. (0.05)		S.E.m. ±		C.D. (0.05)		S.E.m. ±		C.D. (0.05)						
Genotype		6	32		4		24		0.17		NS		0.06		NS						
Spacing		7	20		4		12		0.24		0.73		0.06		0.19						
Nutrient		6	15		2		6		0.24		NS		0.06		0.17						
G x S		12	NS		8		NS		0.41		NS		0.12		0.34						
G x F		8	NS		3		NS		0.35		NS		0.08		NS						
S x F		11	30		4		12		0.49		NS		0.12		0.33						
G x S x F		15	NS		6		NS		0.69		NS		0.17		NS						
G ₁ – DCH-177		F ₁ – 100% RDF with sulphur																			
G ₂ – DCH-519		F ₂ – 100% RDF without sulphur																			
		F ₃ – 75% RDF with sulphur																			
		F ₄ – 75% RDF without sulphur																			

Table-2 : Nitrogen, Phosphorus, Potassium and sulphur uptake by castor genotypes as influenced by spacing with nipping practices and nutrition.

G x S x F		Nitrogen uptake				Phosphorus uptake				Potassium uptake				Sulphur uptake												
		F ₁	F ₂	F ₃	F ₄	G x S	F ₁	F ₂	F ₃	F ₄	G x S	F ₁	F ₂	F ₃	F ₄	G x S	F ₁	F ₂	F ₃	F ₄	G x S					
G ₁	S ₁	44.44	44.17	39.78	39.62	42.00	13.10	13.00	10.77	10.72	11.90	69.10	69.03	63.10	63.01	66.06	7.37	6.08	7.36	6.05	6.71					
	S ₂	45.99	45.84	41.71	41.63	43.79	14.02	14.00	11.77	11.75	12.89	70.46	70.40	67.00	67.00	68.72	7.88	6.48	7.78	6.44	7.15					
	S ₃	43.39	43.34	38.06	37.54	40.58	12.47	12.40	10.08	9.92	11.22	67.96	67.89	61.83	61.67	64.84	7.13	5.85	7.05	5.83	6.47					
	S ₄	45.26	45.21	40.55	40.50	42.88	13.56	13.48	11.28	11.25	12.39	69.70	69.67	64.13	64.07	66.89	7.58	6.31	7.54	6.27	6.92					
G ₂	S ₁	44.73	44.65	40.20	40.17	42.44	13.32	13.25	11.15	11.02	12.18	69.44	69.36	63.70	63.56	66.51	7.45	6.18	7.43	6.12	6.79					
	S ₂	46.47	46.33	42.18	42.09	44.27	14.17	14.12	12.04	11.93	13.07	70.97	70.83	67.37	67.19	69.09	7.94	6.59	7.89	6.58	7.25					
	S ₃	43.83	43.71	38.91	38.83	41.32	12.77	12.62	10.44	10.38	11.55	68.72	68.39	62.55	62.33	65.50	7.31	5.97	7.25	5.93	6.61					
	S ₄	45.56	45.52	41.24	41.10	43.35	13.78	13.68	11.65	11.55	12.67	70.18	70.17	64.81	64.67	67.46	7.72	6.35	7.65	6.34	7.01					
F		44.96	44.85	40.33	40.18		13.40	13.32	11.15	11.06		69.57	69.47	64.31	64.19		7.55	6.23	7.49	6.20						
G ₁		G x F				G	G x F				G	G x F				G	G x F				G					
		44.77	44.64	40.02	39.82	42.31	13.29	13.22	10.97	10.91	12.10	69.30	69.25	64.02	63.94	66.63	7.49	6.18	7.43	6.15	6.81					
	G ₂	45.15	45.05	40.63	40.55	42.84	13.51	13.42	11.32	11.22	12.37	69.83	69.69	64.61	64.44	67.14	7.61	6.27	7.55	6.24	6.92					
		S x F				S	S x F				S	S x F				S	S x F				S					
S ₁		44.59	44.41	39.99	39.89	42.22	13.21	13.13	10.96	10.87	12.04	69.27	69.20	63.40	63.28	66.29	7.41	6.13	7.39	6.08	6.75					
	S ₂	46.23	46.09	41.94	41.86	44.03	14.10	14.06	11.90	11.84	12.98	70.72	70.62	67.19	67.09	68.90	7.91	6.54	7.84	6.51	7.20					
	S ₃	43.61	43.52	38.48	38.19	40.95	12.62	12.51	10.26	10.15	11.39	68.34	68.14	62.19	62.00	65.17	7.22	5.91	7.15	5.88	6.54					
	S ₄	45.41	45.36	40.89	40.80	43.12	13.67	13.58	11.47	11.40	12.53	69.94	69.92	64.47	64.37	67.17	7.65	6.33	7.59	6.30	6.97					
Interactions		S.E.m.±	C.D. (0.05)				S.E.m. ±				C.D. (0.05)				S.E.m. ±				C.D. (0.05)							
Genotype		0.24	1.49				0.08				0.47				0.16				0.97				0.27			
rightSpacing		0.23	0.70				0.07				0.21				0.17				0.53				0.12			
Nutrient		0.27	0.77				0.08				0.23				0.21				0.60				0.13			
G x S		0.47	NS				0.15				NS				0.33				NS				NS			
G x F		0.38	NS				0.11				NS				0.30				NS				NS			
S x F		0.54	NS				0.16				NS				0.42				1.20				NS			
G x S x F		0.76	NS				0.22				NS				0.59				NS				NS			
G ₁ – DCH-177		S ₁ – 90 cm x 60 cm with spacing																								
G ₂ – DCH-519		S ₂ – 90 cm x 60 cm without nipping																								
		S ₃ – 120 cm x 60 cm with nipping																								
		S ₄ – 120 cm x 60 cm without nipping																								
		F ₁ – 100% RDF with sulphur																								
		F ₂ – 100% RDF without sulphur																								
		F ₃ – 75% RDF with sulphur																								
		F ₄ – 75% RDF without sulphur																								

DCH-177 (42.31, 12.10, 66.63 kg NPK ha⁻¹ and 6.81 ppm S, respectively).

Effect of row spacings and nipping : Castor is perennial in nature with indeterminate growth habit. Hence, it puts forth lot of vegetative growth particularly under early sowing with numerous spikes viz., primary, secondary, tertiary and quaternary spikes etc., which leads to uneven source-sink relationship. Therefore, an attempt was made with different crop geometry to maintain few branches and spikes with controlled canopy growth through periodical nipping. Among the spacing with nipping practice, castor sown at 90 cm x 60 cm with nipping recorded significantly higher bean yield as compared to a row spacing of 120 cm with nipping, 90cm without nipping and 120 cm without nipping. Normally, the seed yield plant⁻¹ decreases with increase in plant density but decrease in seed yield will be compensated by increased plant population and the reverse was true with lower plant density. In the present study, the decrease in row spacing from 120 cm to 90 cm drastically decreased the bean yield plant⁻¹ because of acute competition for growth factors that even increased plant population could not compensate the loss in bean yield plant⁻¹. At wider spacing of 120 cm x 60 cm, though the bean yield plant⁻¹ was higher but the increased bean yield plant⁻¹ could not compensate the loss of plant population. Hence, a plant spacing of 90 cm x 60 cm with nipping was found optimum. Optimum plant spacing had reduced the competition between plants for moisture, nutrients, light and space and hence bean yield was increased. The results corroborate with the early findings of Raghavaiah and Sudhakara Babu (2000), Lakshmi and Reddy (2006) and Rana *et al.* (2006).

The spacing of 90 cm x 60 cm without nipping resulted in significantly higher total nutrient uptake (44.03, 12.98, 68.90 kg NPK ha⁻¹ and 7.20 ppm S, respectively) than row spacing of 120 cm without nipping, 90 cm and 120 cm with nipping. This might be due to higher crop biomass production at 90 cm x 60 cm spacing without nipping resulting in higher uptake. These findings are in close association with that of Singh (2003); Lakshmi and Reddy (2006) in castor crop. Nipping significantly influenced the uptake of nutrients. Higher uptake of NPK and S was noticed in non-nipping plots as compared to nipping plots.

Effect of nutrition : Higher bean and stalk yield was recorded in 100% RDF with sulphur (1356 and 2754 kg ha⁻¹, respectively) NPK fertilization from 75 to 100% RDF along with sulphur application increased the castor yield significantly because of increased availability of nutrients resulting into better growth of castor, which favourably influenced flowering and fruiting and might be the reason for higher bean yield. The results corroborate with the

findings of Goverdhan and Pooran (2002), Patel *et al.* (2005), Rana *et al.* (2006), Reddy *et al.* (2006), Venugopla *et al.* (2007) and Patel and Patel (2012) and Dodiya *et al.* (2016). Srivastava and Kumar (2015) reported that application of 20 kg sulphur ha⁻¹ through gypsum produced significantly higher seed yield (2577 kg ha⁻¹) compared to no sulphur application (control).

Castor fertilized with higher fertility level of 100% RDF with sulphur appreciably improved nitrogen, phosphorus and potash uptake of 44.96, 13.40, 69.57 kg NPK ha⁻¹ and 7.55 ppm S, respectively. The probable reason for increase in NPK and S uptake by castor is by bringing in improvement in nutritional environment in rhizosphere as well as plant system leading to absorption, uptake and translocation of nutrient in reproductive structure which leads to higher content and uptake. Similar findings were also reported by Shukla *et al.* (2013), Hadvani *et al.* (2010) and Samant (2015) also reported that application of RDF+ Sulphur @ 40 kg ha⁻¹ recorded the maximum uptake of N, P, K and S by seed and stalk followed by 50% RDF + Vermicompost @ 2 t ha⁻¹; 50% RDF + FYM @ 5 t ha⁻¹ and RDF.

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Behavioral Response of Ladybird Beetle (*Coccinella* sp.) in Y-tube Olfactometer to Headspace Volatiles Extracted from Okra, *Abelmoschus esculentus* (L.) Moench

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Abstract

Behavioral responses of Ladybird beetle *Coccinella septempunctata* Linn. and *Coccinella transversalis* Fab. was recorded against dichloromethane (DCM) extracted headspace volatiles from okra (undamaged plant, mechanically damaged plant, herbivore damaged plant, fresh fruits, mechanically damaged fruits, herbivore damaged fruits) by using Y-tube olfactometer. Both sexes of *Coccinella septempunctata* Linn., preferred headspace volatiles emitted from mechanically damaged plants; herbivore damaged plants and mechanically damaged fruits over the control. While, both sexes of *Coccinella transversalis* Fab., preferred headspace volatile blends from mechanically damaged plants. On the contrary, volatile blends from herbivore damaged fruits elicited significant behavioural responses from *C. transversalis* Fab. males while females not responded to it.

Key words : Y-tube olfactometer, Behavioral responses, *Coccinella septempunctata* Linn., *Coccinella transversalis* Fab.

Introduction

Ladybird beetles are one of the most important groups of the natural enemy complex of many horticultural and agricultural crop pests and inhabit in all types of terrestrial ecosystems (Omkar and Pervez 2000). Ladybird beetle belong to the order Coleoptera, suborder Polyphaga, super-family Cucujoidea and family Coccinellidae. Interestingly, family Coccinellidae comprises 6,000 described species worldwide, of which 90% are considered beneficial predators (Slipinski 2007). Thus, ladybird beetles have great economic importance as natural enemies; exhibit a predatory nature against many soft bodied insect pests viz., aphids, scale insects and mealy bugs, whiteflies, Thrips, jassids, psyllids, small larvae, insect eggs, and phytophagous mites. Many coccinellids have been used in both classical and augmentative biological control programmes and considered important in conservation biological control programmes (Ullah *et al.*, 2012; Kundoo and Khan 2017). As many as 72 insect species have been recorded on okra, among them shoot and fruit borer (*Earias* sp), fruit borer (*Helicoverpa armigera*) and some other sucking pests such as leafhoppers, aphids, mites and whitefly are major insect pests which causes significant crop losses (Srinivasa and Rajendra, 2003). The reduction in yield loss by insect pests demands heavy pesticide application at field level. Heavy pesticide application causes disturbances in the pest-natural enemy balance. Thus, to eliminate such problems, pest management tactics are needed, which incorporate more ecofriendly approaches. Plants often produce a blend of behavior modifying

volatile organic compounds to influence the natural enemies of herbivores. In the last few decades, there has been an increased interest in using these compounds to manipulate natural enemy behaviors to enhance biological control of insect pests in agricultural crops (James, 2003). Thus, the present experiment was conducted to record the behavioral response of Ladybird beetle *Coccinella septempunctata* and *C. transversalis* Fab. to headspace volatiles extracted from okra, *Abelmoschus esculentus* (L.) Moench by using Y-tube olfactometer.

Materials and Methods

Individual okra seeds (var. *Arka Anamika*) were grown in plastic pots (15×10 cm) filled with potting soil and any pesticide was not applied on these plants in polyhouse condition (30±5°C, 60% to 80% RH) at I.A.R.I., New Delhi. Headspace plant volatiles were collected from above ground portion of 30 days old ten intact individual potted plants (stem, branches, and leaves). Headspace volatile collection from different treatments (undamaged, mechanically damaged and herbivory damaged okra plant and its fruits) was completed by dynamic headspace collection system described by Tholl *et al.* (2006). Ten fourth instar *Earias vittella* caterpillars were released on individual okra plant and allowed to feed for 12 hrs before volatile collection started (Rodriguez-Saona *et al.*, 2011). Caterpillars (and their frass) were gently removed from the herbivory damaged okra plant during volatile collection without causing any possible mechanical damage to the okra plant, whereas from the herbivory damaged okra fruit samples caterpillars were not removed

Table-1 : Behavioral response of *Coccinella septempunctata* Linn. in Y-tube olfactometer to headspace volatiles.

S. N.	Odour Source	Male response (mean $\pm$ SE)			Female response (mean $\pm$ SE)		
		Source	Control	P value	Source	Control	P value
1.	Undamaged plant	14 $\pm$ 0.11 ^a	6 $\pm$ 0.11 ^a	0.07	9 $\pm$ 0.11 ^a	11 $\pm$ 0.11 ^a	0.66
2.	Mechanically damaged plant	15 $\pm$ 0.1 ^a	5 $\pm$ 0.1 ^b	0.02	17 $\pm$ 0.08 ^a	3 $\pm$ 0.08 ^b	0.0004
3.	Herbivore damaged plant	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004	15 $\pm$ 0.1 ^a	5 $\pm$ 0.1 ^b	0.0.02
4.	Fresh fruits	8 $\pm$ 0.11 ^a	12 $\pm$ 0.11 ^a	0.384	7 $\pm$ 0.11 ^a	13 $\pm$ 0.11 ^a	0.186
5.	Mechanically damaged fruits	15 $\pm$ 0.1 ^a	5 $\pm$ 0.1 ^b	0.0.02	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004
6.	Herbivore damaged fruits	14 $\pm$ 0.11 ^a	6 $\pm$ 0.11 ^b	0.07	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^b	0.186

*For each odour source, different letters indicate significant differences from control (Paired t test, N=20).

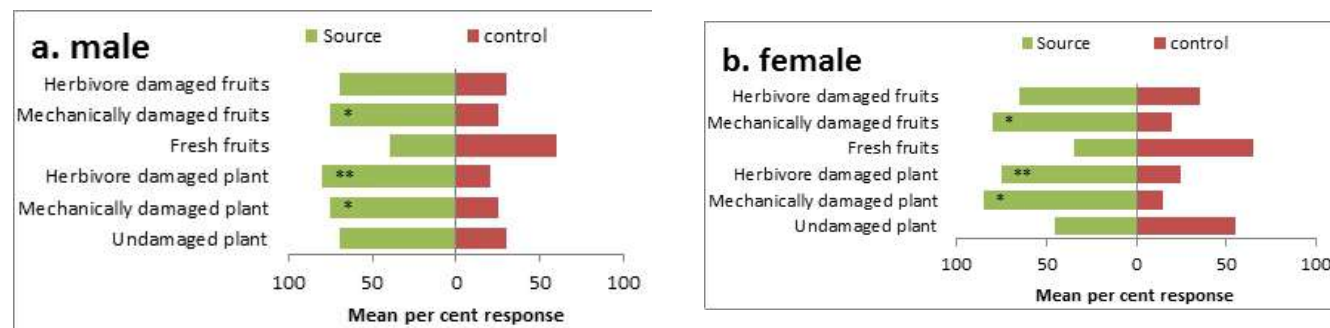


Fig-1 : Behavioral response (mean per cent response) of *Coccinella septempunctata* Linn. (a) male and (b) female in Y-tube olfactometer to headspace volatiles.

Asterisks indicate significant differences over the control (Paired t test: N = 20, *P = 0.05, **P = 0.01, ***P = 0.001, ****P = 0.0001).

because of possible mechanical damage to fruits caused by caterpillar removal. For mechanically damaged plant samples a single hole paper punch (4.5mm) was used to punch off 8 holes on each leaf of okra plant (Five leaves/plant) just before volatile collection and for mechanically damaged fruit samples fresh okra fruits were sliced in 1.5-2.0 cm pieces just before volatile collection. As a control, volatiles were collected from intact plant without any mechanical damage to plant and for fruit samples fresh fruits were used. Plant volatile collection was carried out in a day time (humidity: 75 $\pm$ 5 %, temperature: 25 $\pm$ 2°C). Volatiles were collected using a dynamic push-pull system. Porapak Q adsorbent-filtered air was pumped into the glass made volatile collection chamber at a flow rate of 1.5 L min⁻¹. At the same time, a portion of the air was pumped out of the volatile collection chamber with a second pump at a flow of 1 L min⁻¹. The outgoing air passed through a trap packed with 20 mg Porapak Q adsorbent (sigma-Aldrich) to retain the volatile compounds. Volatiles were collected after 12 hrs of herbivore release on the plants and fruits for 4 hrs. Volatile compounds were desorbed by eluting the filter twice with 200 L of dichloromethane (DCM) and used as test solution for behavioral bioassays.

Behavioral bioassay was conducted in a Y-tube olfactometer made up of transparent Plexiglas (3 cm ID; stem 10 cm, arms 8 cm; stem-arms angle 130°) with each arm connected to a glass tube holding the odor source.

Filtered air (1.0 liters/min) was drawn through the olfactometer by a pump. Whatman filter paper (2 $\times$ 2 cm) impregnated with 10 L of test solution, left to dry for 10s, and introduced into one of the glass tube was used as the odor source. On the other arm of olfactometer, glass tube held untreated filter paper (control) of the same size. The olfactometer was disconnected from the glass tube and thoroughly washed with water, rinsed in 70% ethanol, and dried in an oven at 120°C after every three runs. The apparatus was rotated 180° after five runs to exclude directional bias. Time to respond was standardized to record their maximum activity for test compound. Both Coccinellids were allowed for 15 min to respond to the test compound and each individual insect was used only once. Insect behavior was recorded and responses were considered positive when insects traveled at least 4 cm along arm connected to test compounds. All experiments were conducted in day light at 28 $\pm$ 2°C and 60% relative humidity. Adult male and females of *Coccinella sp.* were collected from experimental field (okra) at I.A.R.I. New Delhi.

Results and Discussion

Preliminary Y-tube olfactometer studies of, *Coccinella septempunctata* Linn. and *C. transversalis* Fab. indicated that dichloromethane did not elicit any response from these insects. The responses of *C. septempunctata* Linn., male and female to okra plant and fruit headspace

Table-2 : Behavioral responses of *Coccinella transversalis* Fab. in Y-tube olfactometer to headspace volatiles.

S.N.	Odour Source	Male response (mean $\pm$ SE)			Female response (mean $\pm$ SE)		
		Source	Control	P value	Source	Control	P value
1.	Undamaged plant	7 $\pm$ 0.11 ^a	13 $\pm$ 0.11 ^a	0.186	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00
2.	Mechanically damaged plant	15 $\pm$ 0.1 ^a	5 $\pm$ 0.1 ^b	0.02	16 $\pm$ 0.09 ^a	4 $\pm$ 0.09 ^b	0.004
3.	Herbivore damaged plant	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^b	0.186	13 $\pm$ 0.11 ^a	7 $\pm$ 0.11 ^b	0.186
4.	Fresh fruits	10 $\pm$ 0.11 ^a	10 $\pm$ 0.11 ^a	1.00	9 $\pm$ 0.11 ^a	11 $\pm$ 0.11 ^a	0.666
5.	Mechanically damaged fruits	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384
6.	Herbivore damaged fruits	15 $\pm$ 0.10 ^a	5 $\pm$ 0.10 ^b	0.02	12 $\pm$ 0.1 ^a	8 $\pm$ 0.1 ^a	0.384

*For each odour source, different letters indicate significant differences from control (Paired t test, N=20).

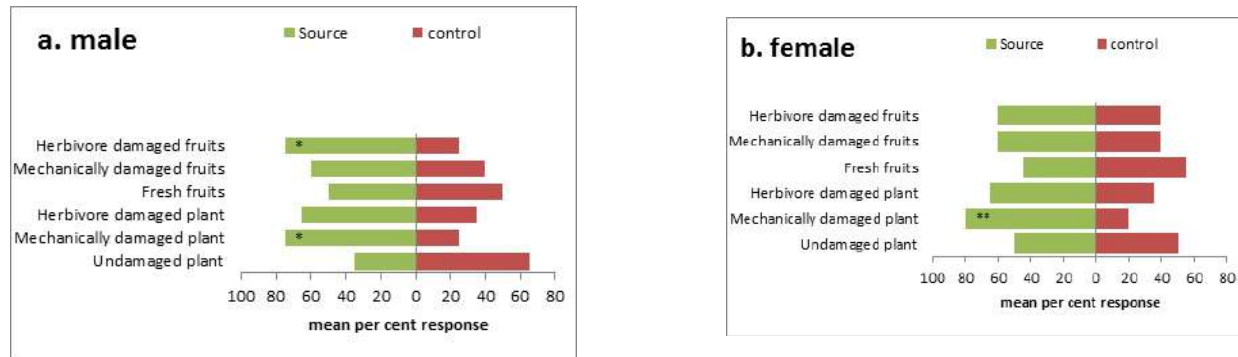


Fig.-2 : Behavioral response (mean per cent response) of *Coccinella transversalis* Fab. (a) male and (b) female in Y-tube olfactometer to headspace volatiles.

Asterisks indicate significant differences over the control (Paired t test: N = 20, *P = 0.05, **P = 0.01, ***P = 0.001, ****P = 0.0001).

volatiles are shown in Table-1. Both sexes of *C. septempunctata* Linn., preferred headspace volatiles emitted from mechanically damaged plants (N = 20, male P = 0.02; female P = 0.0004), herbivore damaged plants (N = 20, male P = 0.004; female P = 0.02) and mechanically damaged fruits (N = 20, male P = 0.02; female P = 0.004) over the control. Volatiles emanating from undamaged plants, fresh fruits and herbivore damaged fruits did not induce significant response in both sexes of *C. septempunctata* Linn. (fig.-1). Both sexes of *C. transversalis* Fab. preferred headspace volatile blends from mechanically damaged plants (N = 20, male P = 0.02; female P = 0.004). Whereas, only *C. transversalis* Fab., male responded to herbivore damaged fruits (N= 20, P = 0.02) over the control, which failed to elicit significant response in *C. transversalis* Fab., female (Table-2, fig.-2). Volatiles emanating from undamaged plants, herbivore damaged plants, fresh fruits and mechanically damaged fruits did not induce significant response in both sexes of *C. transversalis*. Our findings showed that, both sexes of *C. septempunctata* Linn., preferred headspace volatiles emitted from mechanically damaged plants, herbivore damaged plants and mechanically damaged fruits over the control. Volatiles emanating from undamaged plants, fresh fruits and herbivore damaged fruits did not induce significant response in both sexes of *C. septempunctata* Linn. (fig.-1). Similarly, both sexes of *C. transversalis* Fab., preferred headspace volatile blends from

mechanically damaged plants. Whereas, only *C. transversalis* male responded to herbivore damaged fruits over the control, which failed to elicit significant response in *C. transversalis* female (fig.-2). Volatiles emanating from undamaged plants, herbivore damaged plants, fresh fruits and mechanically damaged fruits did not induce significant response in both sexes of *C. transversalis*. There is evidence that herbivore-induced plant volatiles can be attractant stimuli for adult coccinellids (Han and Chen, 2000; Schaller and Nentwig, 2000; Ninkovic *et al.*, 2001; Zhu and Park, 2005; Girling and Hassall, 2008). Our findings are in close agreement with Reddy (2002) who reported higher attraction of *Chrysoperla carnea* to okra plant volatiles. Likewise, Zhu and Park (2005) reported that the extracts from aphid infested soybean plants elicited significant electrophysiological responses in *C. septempunctata* Linn. Similarly, *C. septempunctata* Linn. responded positively to volatiles from aphid-infested plants and from previously aphid-infested plants but not to volatiles from uninfested plants Ninkovic (2001). Tan and Liu (2014) reported *Coccinella septempunctata* L., was attracted to the volatiles emitted from tomato leaves infested with aphids. Conclusively, both sexes of *C. septempunctata* Linn., preferred headspace volatiles emitted from mechanically damaged plants; herbivore damaged plants and mechanically damaged fruits over the control. While, both sexes of *C. transversalis* preferred headspace volatile blends from mechanically damaged

plants. Whereas, only *C. transversalis* Fab., male responded to herbivore damaged fruits over the control, which failed to elicit significant response in *C. transversalis* Fab., female.

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Genetic Variability Assessment Using Metroglyph Analysis among Soybean Genotypes Based on Morpho-Physiological Traits

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Abstract

A study was conducted to understand genetic variability in Randomized Complete Block Design accommodating 30 soybean [*Glycine Max* (L.) Merrill] genotypes randomly in three replications. These genotypes were evaluated for eight traits: one phenological, six agro-morphological, and one physiological traits (from laboratory experiment) recorded and subjected to metroglyph analysis. Among all the studied cultivars, significant genetic variability was recorded for different agro-morphological characters. Metroglyph framed total seven groups: largest with eight and one were oligo-genotypic.

Introduction

Soybean, is globally oldest cultured plant. Historical evidences indicate its use for over 5000 yrs by human (Wang,1991). For which in Chinese literature evidences are available (Purcell *et al*, 2002). It Dates back to 1000 AD when soybean was introduced from China to India. Traditionally black-seeded soybean has been grown in north and north eastern regions of India and then spread to different part of the country. It belongs to genus *Glycine*, species *max*, family Leguminosae, sub-family papilionidae and tribe Phaseoleae. *Glycine* is derived from the Greek word *glykus* which means sweet (Hymowitz and Newell, 1981). Soybean has confused taxonomical history as it was described both as *Phaseolus max* and *dolichos soja* by Linnaeus initially. Merrill later in 1917 proposed name *Glycine max* which is now widely accepted. Genus *glycine* divided into 3 sections containing eleven species by Bentham (1865) that is *Leptolobium* includes 6 species of Australian origin; *Johnia* includes sole species of African and Asian origin. The sub genus *Glycine* consists of several (about 22) wild perennial species. Both the species *Glycine max* and *Glycine soja* hybridize readily. *Glycine max* (diploid) and *Glycine soja* (diploid), chromosome number 2n=40.

At present, soybean has acquired global importance, first ranked oilseed contributing 25% and 40% share (global and national level respectively) in oil seed production. Brazil, U.S.A and Argentina contributes 80% of world's soybean production. India is the fourth largest country in the world after United States of America, Brazil and Argentina regarding area but fifth regarding total production after China. In India, major soybean producing states are Madhya Pradesh, Maharashtra and Rajasthan. The productivity of soybean is quite low in our country as compare to top soybean

producing countries of the world which is probably due to narrow genetic base of the released varieties is the major reasons for low genetic yielding potential. Development of stable genotypes with enhanced seed yield is the most important goal of many soybean breeding programmes. The information on genetic diversity helps in selecting parents for development of new varieties, continuous evaluation of germplasm for important traits, which in earlier days was exclusively based on the available morphological data. (Shadakshari *et al.*, 2011). So to study genetic diversity and to select suitable selection criterion Metroglyph analysis method was used in this study.

Materials and Methods

The experimental plot was situated at the farm of Tirhut College of Agriculture, Dholi (25.5°N, 35.4° and 52.2m MSL) in Muzaffarpur District (North Bihar) located in eco-geographical region I Sub region IV of Bihar. This location is also characterized with high ground water as being surrounded by Gandak and Budhi Gandak.

Thirty entries (Table-1) including 3 checks, were sown to study the divergence during kharif 2019. Each plot consisted three rows of 3 meter length. The row to row and plant to plant distance was 45cm and 5cm, respectively. RCBD experiment trial laid out for 8 morpho-physiological traits viz., Days to first flowering (DFF), Plant height (PH), Pods per plant (P/P), Pod length (PL), Seed per Pod (S/P), Seed weight (SW), Vigour Index I(VI), Yield (GYPP).

Data for individual characters observed, replication-wise and mean data was used for statistical analyses. Metroglyph and Index score method proposed by Anderson (1957) were used for analysis of morpho-physiological characters. X and Y co-ordinates of hexagonal glyph represents Yield (GYPP) and Vigour

Table-1 : Pedigree record of all the genotypes under study.

S.N.	Genotype	Pedigree	Source
1.	SL 1074	PK1223 X SL(E) 14	PAU, Ludhiana, Punjab
2.	SL 1028	PK1223 X SL(E) 4	PAU, Ludhiana, Punjab
3.	SL 955	SL599 X PK1283	PAU, Ludhiana, Punjab
4.	SL 688	PK 416 X SL 317	PAU, Ludhiana, Punjab
5.	Pusa 9712	MUTANT OF DS-74	IARI, New Delhi
6.	JS 9305	Pedigree Selection (PS-73-22 as Cytoplasmic Donor)	JNKVV, Jabalpur, Madhya Pradesh
7.	Shalimar Soy-1	Selection from local landrace genotype AGR/538	CSKHPKV, Palampur, Himachal Pradesh
8.	RSC 1103	JS-335 X PK 1024	IGKV, Raipur, Chhattisgarh
9.	RSC 11-7	MACS 1336 X MAUS 504	IGKV, Raipur, Chhattisgarh
10.	RSC 11-17	JS 97-52 X JS 93-05	IGKV, Raipur, Chhattisgarh
11.	RSC 11-15	JS 335 X PS 1024	IGKV, Raipur, Chhattisgarh
12.	RSC 1052	NRC-37 X JS 335	IGKV, Raipur, Chhattisgarh
13.	RSC 1071	BRAGG X JS 335	IGKV, Raipur, Madhya Pradesh
14.	NRC-128	JS 97-52 X PBM-1-1-9-2-6-1	IISR, Indore, Madhya Pradesh
15.	NRC-132	JS 97-52 X PI 086023	IISR, Indore, Madhya Pradesh
16.	NRC-136	JS 97-52 X NRC-36	IISR, Indore, Madhya Pradesh
17.	NRC-137	JS 97-52 X NRC-37	IISR, Indore, Madhya Pradesh
18.	NRC 142	JS 97-52 X PI- 596540 X PI-542004 (through Marker Assisted Forward Breeding) Triple Cross	IISR, Indore, Madhya Pradesh
19.	PS-1572	derived by hybridisation	GBPUAT, Pantnagar, Uttarakhand
20.	PS-1347	PS 1024 X PK 472	GBPUAT, Pantnagar, Uttarakhand
21.	PS-1092 (PK-1052)	PK 327 X RK 416	GBPUAT, Pantnagar, Uttarakhand
22.	MACS-1493	EC 241780 X MACS 330	MACS, Pune, Maharashtra
23.	NRC-12 (Ahilya-2)	Induced Mutant of BRAGG	IISR, Indore, Madhya Pradesh
24.	NRCSL-1	JS 335 X SL 525	IISR, Indore, Madhya Pradesh
25.	VL Soya-94	VL Soya 59 X VS 2005-1	VPKAS, Almora, Uttarakhand
26.	AMS-2014	AMS 99-33 X H6P5	Amaravati, Maharashtra
27.	JS-20-116	JS-97-52 X JSM120	JNKVV, Jabalpur, Madhya Pradesh
28.	JS-335 (NC)	JS78-77 X JS71-05	JNKVV, Jabalpur, Madhya Pradesh
29.	JS-97-52 (NC)	PK-327 X L-129	JNKVV, Jabalpur, Madhya Pradesh
30.	RKS-18 (NC) (Pratap Soya-2)	MACS 450 X MONETTA	Kota, Rajasthan

index I (VI) respectively (Table 5). Rest of the traits were represented by rays in different direction on hexagon and hexagon in turn represents genotypes whereas variable ray length represents the range of the character i.e., A genotype having low range by short, medium range by medium and high range by long ray length (3). Index score was calculated by summation of values (1, 2 and 3) given to short, medium and long ray length respectively (Table-4).

Result and Discussion

On the basis of range and mean performance of each character, many genotypes found which were superior to the best check (Table-1) Total 7 groups has been constructed using morpho-physiological characters in scatter diagram (Table-5). Index score and signs used for

various characters are given in table-3. Group I represented by low yield and low vigour index I, included 8 genotypes most of them were medium for days to first flowering, genotypes 23 and 26 were high whereas 24 and 25 were low. For plant height most of the genotype among these 8 were low, 26 was medium whereas 23 and 24. Pods per plant was low among most of the genotypes except 7 and 26 which were high. Character pod length were high in genotype 7, 23,24 and medium in genotype 9, 25 whereas low in 8,10, 26. Seed per pod was low among most of the genotype whereas medium in 7,25 and low in 24. 100-seed weight character was found low in most of the genotypes except genotype 9 and 25 where it was found medium. Group II represented by low yield and medium vigour index comprises total 6 genotypes most of them were found low for days to first flowering, medium in

Table-2 : Range and mean performance of 30 soybean genotypes for 8 characters.

Characters	DFF	PH	P/P	PL	S/P	SW	V1	GYPP
Mean	43.289	65.167	78.756	3.328	2.797	7.179	2463.34	11.53
Range	40.000-47.000	42.667-92.667	62.399-105.041	2.400-4.400	1.773-3.887	4.500-11.197	1495.60-3503.70	6.54-21.00
Minimum	40.000	42.667	62.399	2.400	1.773	4.500	1495.60	6.54
Genotype	NRC 142	Shalimar Soy1	RSC 1103	AMS-2014	RSC 11-7 RSC 11-17	Shalimar Soy-1	VLS-94	RSC 11-17
Maximum	47.000	92.667	105.041	4.400	3.887	11.197	3503.70	21.00
Genotype	NRC-128	NRC-137	NRC-136	NRCSL-1	Pusa 9712	SL 1028	SL 955	NRC-136
No. of significantly Superior Genotypes (vis-à-vis best check)	4	4	6	6	6	1	3	5
Name(s) of Genotypes	NRC-142	NRC-137	NRC-136	NRCSL-1	Pusa 9712	SL-1028	SL-955	NRC-136
	PS-1092	MACS-1493	Shalimar Soy1	Shalimar Soy1	NRCSL-1		NRC-137	SL-955
	VLS-94	RSC-1071	SL-688	NRC-12	PS-1092		NRC-136	NRC-137
	SL-688	NRC-12	NRC-137	PS-1092	RSC 1071			MACS1493
			MACS-1493	PS-1572	SL 955			NRC-128
Best Check	JS-335	JS-9752	AMS-2014	PS -1347	PS-1572			
Min	40.00	42.67	62.40	2.40	1.77	4.50	1495.60	6.54
Max	47.00	92.67	105.04	4.40	3.89	11.20	3503.70	21.00
Range	7.00	50.00	42.64	2.00	2.11	6.70	2008.10	14.46
Range/3	2.33	16.67	14.21	0.67	0.70	2.23	669.37	4.82
Min+(Range/3)	42.33	59.33	76.61	3.07	2.48	6.73	2164.97	11.36
Min+(Range*2/3)	44.67	76.00	90.83	3.73	3.18	8.96	2834.33	16.18

genotype 5 and 12 whereas high in genotype 13. Character Plant height was found medium in most of the genotypes, low in genotype 12,18,20 and high in genotype 13. Character pods per plant was found medium among most of the genotype except genotype 18 and 30 which were found low for this character. Character pod length were found medium in most of the genotype whereas low in genotype 12 and high in genotype 20. Most of the genotype of this group were found medium for seed per pod character whereas genotype 5 and 13 were found low. Character 100-seed weight was low in most of the genotypes whereas high in genotype 5. Group III represented by low yield and high vigour index I comprises total 3 genotypes and all were found medium for days to first flowering as well for plant height. Character pods per plant was found medium among genotype 2 and 28, and low for genotype 19. Character pod length was found high in genotype 19 and low in genotype 2 as well in 28. Seed per pod was found high in genotype 19 and medium in genotype 2 as well in genotype 28. Character 100-seed weight was found medium in genotype 19 and high in 2 as well in 28. Bhargava et al. (2009) reported high 100 seed weight in *Chenopodium* species also. Group IV represented by medium yield and high vigour index I comprises total 2 genotypes and character days to first flowering was high

in genotype 14 and medium in genotype 27. Character plant height was medium in both the genotypes and pods per plant was low in both the genotype whereas pod length was low in genotype 14 and medium in 27. Character seed per pod was medium in genotype 14 and low in 27. 100-seed weight was low in both the genotypes. Group V represented by medium yield and medium vigour index I comprises total 6 genotypes and character days to first flowering was low in 7,21 and 29, medium in 6 whereas high in genotype 11 and 15. Character plant height was found medium in all the genotypes except genotype 15 in which plant height was low. Character pods per plant was low in 5,21 and 29, medium in genotype 6 and 11 whereas high in genotype 7. Character pod length was low in genotype 7, 6 and 15; medium in genotype 11 and 29 whereas high in genotype 21. Character seed per pod was medium in all the genotype except genotype 21 in which seed per pod was found high. Character 100-seed weight was medium in genotype 6,11 and 21; low in genotype 15 whereas high in genotype 29. Group VI represented by medium yield and low vigour index I comprises only 1 genotype and only days to first flowering character was found low rest others are all medium. Group VII represented by high yield and high vigour index I comprises 4 genotypes and character days to first flowering was found medium in all the

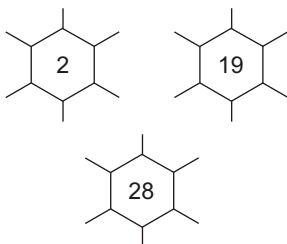
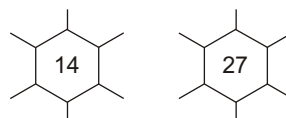
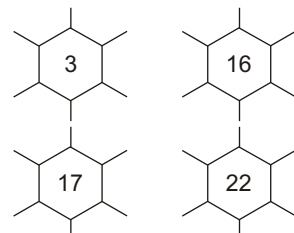
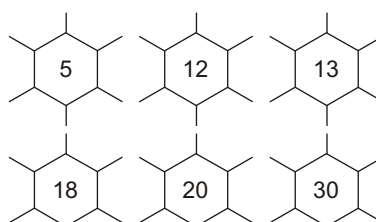
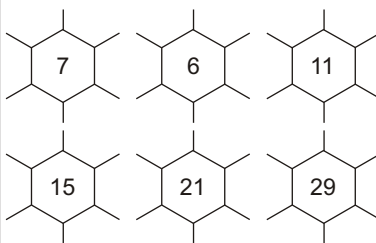
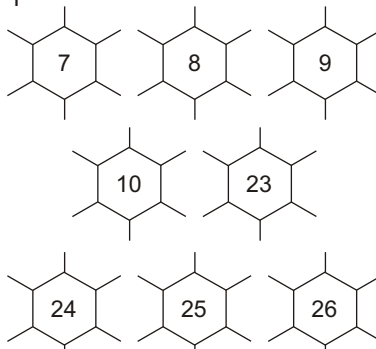
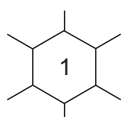
Table-3 : Categorisation of genotypes into low, medium and high range of each character with their symbols and sign.

Categories		DFF	PH	P/P	PL	S/P	SW	V1	GYPP	Ray Length
Low	Range	40-42.33	42.67-59.33	62.40-76.61	2.40-3.07	1.77-2.48	4.50-6.73	1495.60-2164.97	6.54-11.36	—
	Genotypes	1,4,18,20,21,24,25,29,30	5,7,8,9,10,15,25,30	8,9,10,14,15,18,19,21,23,24,25,27,29,30	2,3,4,6,8,10,12,14,15,26,28	8,9,10,16,17,23,26,27	7,8,10,12,13,14,15,17,18,20,23,24,26,27,30	1,7,8,9,10,23,24,25,26	2,5,7,8,9,10,12,13,18,19,20,23,24,25,26,28,30	
Medium	Range	42.33-44.67	59.33-76.00	76.61-90.83	3.07-3.73	2.48-3.18	6.73-8.96	2164.97-2834.33	11.36-16.18	—
	Genotypes	2,3,5,6,7,8,9,10,12,16,17,19,22,27,28	1,2,3,4,6,11,12,14,16,18,19,20,21,26,27,28,29	1,2,3,5,6,11,12,13,20,22,28	1,5,9,11,13,16,17,18,22,25,27,29,30	1,2,4,6,7,11,12,14,15,18,20,22,25,28,29,30	1,6,9,11,16,19,21,22,25	4,5,6,11,12,13,15,18,20,21,29,30	1,4,6,11,14,15,21,25,27,29	
High	Range	44.67-47.00	76.00-92.67	90.83-105.04	3.73-4.40	3.18-3.89	8.96-11.20	2834.33-3503.70	16.18-21.00	—
	Genotypes	11,13,14,15,23,26	13,17,22,23,29,24	4,7,16,17,26	7,19,20,21,23,24	3,5,13,19,21,24	2,3,4,5,28,29	2,3,14,16,17,19,22,27,28	3,16,17,22	
Ray Position								Y	X	

Table-4 : Index scores of all the genotypes with characters under study.

Genotypes	PH	P/P	PL	S/P	SW	V1	GYPP	Sum of scores
1. SL 1074	2	2	2	2	2	1	2	14
2. SL 1028	2	2	2	2	2	2	2	16
3. SL 955	2	2	1	3	3	3	3	19
4. SL 688	2	3	1	2	3	2	2	16
5. Pusa 9712	1	2	2	3	3	2	1	16
6. JS 9305	2	2	1	2	2	2	2	15
7. Shalimar soy-1	1	3	3	2	1	1	1	14
8. RSC 1103	1	1	1	1	1	1	1	9
9. RSC 11-7	1	1	2	1	2	1	1	11
10. RSC 11-17	1	1	1	1	1	1	1	9
11. RSC 11-15	2	2	2	2	2	2	2	17
12. RSC 1052	2	2	1	2	1	2	1	13
13. RSC 1071	3	2	2	3	1	2	1	17
14. NRC-128	2	1	1	2	1	3	2	15
15. NRC-132	1	1	1	2	1	2	2	13
16. NRC-136	2	3	2	1	2	3	3	18
17. NRC-137	3	3	2	1	1	3	3	18
18. NRC-142	2	1	2	2	1	2	1	12
19. PS-1572	2	1	3	3	2	3	1	17
20. PS-1347	2	2	3	2	1	2	1	14
21. PS-1092	2	1	3	3	2	2	2	16
22. MACS-1493	3	2	2	2	2	3	3	19
23. NRC-12	3	1	3	1	1	1	1	14
24. NRCSL-1	3	1	3	3	1	1	1	14
25. VLS-94	1	1	2	2	2	1	1	11
26. AMS-2014	2	3	1	1	1	1	1	13
27. JS-20-116	2	1	2	1	1	3	2	14
28. JS-335(NC)	2	2	1	2	3	3	1	16
29. JS-97-52(NC)	2	1	2	2	3	2	2	15
30. RKS-18(NC)	1	1	2	2	1	2	2	12

Table-5 : Scatter diagram of glyph-array arrangement using 30 soybean genotypes.

	Low	Medium	High X-axis (GYPP)
High	III 	IV 	VII 
Medium	II 	V 	
Low Y-Axis (VI)	I 	VI 	

genotypes. Punitha *et al.* (2010) also showed in their findings of metroglyph analysis in sorghum that group VI having three genotypes with high yield and moderate test weight. Similarly Bhargava *et al.* (2009) reported in *Chenopodium* species that group IV had three genotypes exhibiting high grain yield and medium to high primary branches/plant and plant height. Character plant height was found medium in genotype 3 and 16 whereas high in genotype 17 and 22. Character pods per plant was found medium in genotype 3 and 22 whereas high in genotype 16 and 17. Character pod length was found medium in 16, 17 and 22 whereas low in genotype 3. Character seed per pod was found low in 16 and 17; medium in 22 whereas low in genotype 3. 100-seed weight was low in genotype 17; medium in 16 and 22 whereas low in 3.

Similar study was conducted to assess genetic diversity by Chandra (1976) in *Linum* species, Dewan *et al.* (1992) in Indian mustard, Rashid *et al.* (2007) in basmati rice mutants, Chandra *et al.* (1997) in turmeric,

Laiju *et al.* (2002) in *Hordeum* species, Ghafoor and Ahmad (2005) in blackgram, Khan *et al.* (2007) in cotton and Bhargava *et al.* (2009) in *Chenopodium* species, Chandra *et al.* (2018) in Indian mustard genotypes.

The present study of soybean genotypes reflected lots of variability among these genotype for characters under study. This variability can be utilised in various breeding programme for crop improvement. On the basis of scatter diagram and index score, genotype SL-955, NRC-136 and MACS-1993 were found superior for among all the genotype under study.

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Potential Demand for Linseeds in Vidarbha

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Abstract

Linseed contents Omega-3, and its oil is used as consumption oil and in manufacturing of paints and varnishes, oilcloth, waterproof fabrics and linoleum and as edible oil. Linseed cake is used as animal feed and manure. It is also used in making paper and plastics. It is grown in the states of Madhya Pradesh, Uttar Pradesh, Bihar, Chhattisgarh, Maharashtra, Jharkhand, Orissa, Assam, West Bengal, Nagaland, Andhra Pradesh, Rajasthan, Himachal Pradesh, and Telangana. The demand for Linseed is need to be estimated. It will act as base for defining production planning. With this interest the topic of 'Potential Demand for Linseeds in Vidarbha' is selected for present paper. The data of 50 consumers is taken. Their consumption is estimated and consequently demand is estimated. The area and productions is used to estimated supply side of Linseeds. From the appraisal, it is found that the linseed consumption is 322.71 thousand tones. The Linseed oils consumption is 561.01 thousand tones and its value is Rs.1328.55 crores. So it can be said that Linseed production and processing can create Linseed industry of Rs Rs.1328.55 crores in Vidarbha. In other uses, linseed is used for Cakes, Alternative antibiotics, Drug carrier, Wound dressing (bandage), Antioxidant, Milled Fibres, (mukhwas), Shiv pooja (jawsachi math)/Padwa, Massage oil.

Key words : Linseeds, demand, supply.

Introduction

Linseed contents Omega-3 and its oil is used as consumption oil and in manufacturing of paints and varnishes, oilcloth, waterproof fabrics and linoleum and as edible oil. Linseed cake is used as animal feed and manure. It is also used in making paper and plastics. It is grown in the states of Madhya Pradesh, Uttar Pradesh, Bihar, Chhattisgarh, Maharashtra, Jharkhand, Orissa, Assam, West Bengal, Nagaland, Andhra Pradesh, Rajasthan, Himachal Pradesh, and Telangana. Omega-3 balances hormones of the human body. Even the consumption of non filter linseed oil is increased over the time. Now days, due to omega-3, it has gain strong importance in pharmaceutical sector. Linseed oils come in tablets form.

With intension to produce the demand oriented production of linseeds in Vidarbha, the present paper is selected.

Objectives : The objectives of Paper are as follows :

To estimate the consumers' demand of Linseeds and its processed products in Vidarbha.

To estimate supply of Linseeds in Vidarbha.

To estimate the gap between demand and supply for Linseeds and its processed products in Vidarbha.

To evaluate the potential for linseeds and its products in Vidarbha.

To evaluated potential marketing channels for marketing of linseeds and its products in Vidarbha.

Research Methodology

The Primary data of 50 consumers is collected randomly from Vidarbha. The Secondary data like data on area, production and productivity of linseeds is collected from Department of Agriculture, Maharashtra.

(A) Linseed Consumption is estimated on the basis of survey of 50 consumers i.e. average per head demand for raw linseeds and its processed products. The simple tabular method and weighted averages are used to estimate demand.

(B) The supply of linseeds is estimated on the basis of area, production and productivity of linseeds in Vidarbha by simple tabular analysis and growth rates.

(C) With the analysis of the first and second objectives, the data of demand and supply in Vidarbha is estimated. On the basis of this data the gap between demand and supply is estimated.

(D) The gap between demand and supply is estimated potential market for linseeds.

Results and Discussion

The data of 50 consumers is collected from Vidarbha randomly. The preliminary analysis of consumers' data is made to indentify demand. The potential and supply of Linseed is estimated.

Area and Production of Linseed in Vidarbha : The table number 1 represent the district-wise area of Linseed in Vidarbha of triennial average of year 2018-19, 2019-20 and 2020-21. As per the table, the area under Linseed in Vidarbha is 5007 hectares and the area under Linseed in Maharashtra is 6255 hectares. Highest area amongst the districts is the Bhandara i.e. 34.79 percent. It is followed by Gondia is 31.70 percent. Only Eastern Vidarbha has Linseed production. The share of Vidarbha in Maharashtra State in 80.05 percent.

Table-1 : District-wise share of Linseed Area in Vidarbha.

District	Area in 00 ha	Share in Vidarbha area
Akola	0	0.00
Amravati	0	0.00
Bhandara	17.42	34.79
Buldhana	0.00	0.00
Chandrapur	4.94	9.86
Gadchiroli	11.22	22.41
Gondia	15.87	31.70
Nagpur	0.27	0.54
Wardha	0.35	0.70
Washim	0.00	0.00
Yavatmal	0.00	0.00
Total Percentage		100.00
Total Area 00 ha		50.07
Total Percentage of Maharashtra		80.05
Total Area 00 ha of Maharashtra		62.55

(Area in triennial average of year 2018-19, 2019-20 and 2020-21).

The table number 2 shows that the change in Area, Yield and Production with the difference of 5 years. From the table, it is seen that the Linseeds' area and production of Vidarbha is declined to 13.27 and 23.13 percent in year 2020-21 respectively from the base year (2000-2001). While, the yield of Linseed is increased to 162.44 percent over the same period.

In case Maharashtra State, the area and production of Linseed is declined to 8.95 and 13.01 percent in year 2020-21 respectively from the base year (2000-2001). While, the yield of Linseed is increased to 145.42 percent over the same period.

Socio-economic features of Consumers in Vidarbha :

The table number 3 shows that the change in Socio-Economic features of Consumers in Vidarbha. The most of the selected consumers were belong to age group of 40-60 years i.e. 86 percent. The 70 percent of consumers have done post-graduation. The family members per family were 2.78 i.e. in round 3 members per family. Most of the consumer has family income more than 50 thousands.

Average Monthly Expenditure of Consumers in Vidarbha :

The table number 4 shows that the change in Average Monthly Expenditure of Consumers in Vidarbha. To get idea about the monthly expenditure of the consumers, the expenditure on food items, education, medicine are estimated. In monthly expenditure, 38.27 percent expenditure is shared by medical expenses. It is followed by cereals (16.81 percent), light bills (6.92

Table-2 : Change in Area, Yield and Production of Linseeds in Vidarbha and Maharashtra.

Year	Vidarbha					
	Area (00ha)	% change	Yield (kg/ha)	% change	Production (00 tons)	% change
2000-01	376.00	100.00	221.00	100.00	75.00	100.00
2005-06	472.00	125.53	277.75	125.68	132.00	176.00
2010-11	266.00	70.74	299.17	135.37	75.30	100.40
2015-16	130.15	34.61	237.00	107.24	35.24	46.99
2020-21	49.90	13.27	359.71	162.44	17.35	23.13
Maharashtra State						
	Area	% change	Yield	% change	Production	% change
2000-01	699.00	100.00	233.00	100.00	163.00	100.00
2005-06	650.00	92.99	285.00	122.32	185.00	113.50
2010-11	393.00	56.22	264.00	113.30	104.00	63.80
2015-16	163.00	23.32	237.00	101.72	39.00	23.93
2020-21	62.58	8.95	338.84	145.42	21.20	13.01

Indian production : 1,030 (00 tons)

Table-3 : Socio-Economic status of Linseed Consumers.

Particulars	Levels	Quantity	Percent share
Age distribution	20-40	7	14
	40-60	43	86
	Total	50	100
Education status	less than 12th	1	2
	Graduate	10	20
	Postgraduate	35	70
	Ph.D.	4	8
	Total	50	100
Family distribution	Female	48(1)	35
	Male	49(1)	35
	Children	42(1)	30
	Total	139	100
Average 3 persons per family			
Family Monthly Income (Rs.)	0-10000	2	4
	10001-20000	13	26
	20001-50000	18	36
	50001 and above	17	34
	Total	50	100

Table 4 : Average monthly expenditure of Linseed consumers on major items (Rs.).

S. No.	Items	Expenditure (Rs.)	Percent share
1.	Cereals	2774.90	16.81
2.	Oilseeds	943.70	5.72
3.	Pulses	824.29	4.99
4.	Tea/sugar	480.82	2.91
5.	Consumable oils	943.48	5.72
6.	Detergents	344.29	2.09
7.	Milk & milk products	1142.53	6.92
8.	Light Bill	1140.31	6.91
9.	Gas bill	792.08	4.80
10.	Education expenditure	6316.00	38.27
11.	Hospital & Medicine expenditure	801.67	4.86
12.	Total	16504.05	100.00

Table-5 : Linseed consumption per family.
(Average 2.78 members per family)

Consumption	Monthly	Annual	Per head annual demand
Linseeds consumption (kg)	0.33	3.9	1.40
Linseed consumption cost (Rs.)	44.80	537.6	193.38
Linseed oils' consumption (kg)	0.57	6.78	2.44
Linseed oils' consumption cost (Rs.)	89.00	1068.00	384.17
Overall total expenditure on consumption	133.80	1605.60	577.55

Table-6 : Annual Demand for Linseed and Linseed Oil in Vidarbha.

Consumption	Per head demand	Demand for Vidarbha
Linseeds consumption	1.40 kg	322.71 Thousand tones
Linseed consumption cost (Rs.)	193.38	444.84 Rs. cores
Linseed oils' consumption	2.44 kg	561.01 Thousand tones
Linseed oils' consumption cost (Rs.)	384.17	883.71 Rs. cores
Overall total expenditure on consumption	577.55	1328.55 Rs. cores

Note : Population of Vidarbha is 2,30,03,179 as per census of 2011.

Table- 7 : Share of population consumes Linseeds and Linseed oils.

Population consume linseed (%)	32
Population consume linseed Oil (%)	30
Awareness (%) about Omega-3 in Linseeds	48

Table-8 : Timely availability of Linseed in Market.

Response	Percentage
Yes	58
No	42

Table-9 : Reasons for non-availability on time.

Reason	Quantity	Percent share
No processing units	1	2
Village level	1	2
Less demand	6	12
Unawareness about nutritional value	1	2
Lower production	1	2

Table-10 : Application of Linseed and its processed products by consumers.

S. No.	Application	Quantity	Percent share in total sample
1.	Supportive Nutrition (chatani)	18	36
2.	Food oil	23	46
3.	Cakes	3	6
4.	Alternative antibiotics	2	4
5.	Drug carrier	5	10
6.	Wound dressing (bandage)	5	10
7.	Antioxidant	5	10
8.	Milled Fibres (mukhwass)	4	8
9.	Shiv pooja (jawsachi math)/ Padwa	1	2
10.	Massage oil	2	4

percent). The expenditure on oils and oilseeds is Rs. 9430 (5.72 percent) each.

The table number 5 specially indicates the Linseed consumption quantity and its expenditure. The linseed consumption is 1.40 kg per head. The Linseed oils consumption is 2.44 kg per head and its value is Rs.577.55 per head.

The linseed consumption is 322.71 thousand tones. The Linseed oils consumption is 561.01 thousand tones and its value is Rs.1328.55 crores. So it can be said that the Linseed production and Oil extraction has demand of 322.71 thousand tones linseed and 561.01 thousand tones linseed oil.

The table-7 shows that, out of the total sample, 32 percent consumers consumes linseeds and 30 percent consumers consume linseed oil. The 48 percent out of total sample are aware that the linseed content Omega-3..

The table 8 and 9, shows that the 42 percent consumer said that the linseed is not timely available in market and they quoted that the because of less demand, the linseed is not timely available.

Table number 10 shows that the linseed is used for making Cakes, as Alternative antibiotics, Drug carrier, Wound dressing(bandage), Antioxidant, Milled Fibres, (mukhwas), Shiv pooja(jawsachi math)/Padwa, Massage oil. But major use is as food oil.

Conclusions

The linseed consumption is 322.71 thousand tones. The Linseed oils consumption is 561.01 thousand tones and its value is Rs.1328.55 crores. So it can be said that Linseed production and processing can create Linseed industry of Rs Rs.1328.55 crores in Vidarbha. In other uses, linseed is used for Cakes, Alternative antibiotics, Drug carrier, Wound dressing(bandage), Antioxidant, Milled Fibres, (mukhwas), Shiv pooja(jawsachi math)/ Padwa, Massage oil.



Application of Support Vector Regression in Onion Forecasting

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Abstract

The study on the Forecasting of Monthly Prices of Onion in Major Markets of Maharashtra is selected with an objective estimate the better forecast for the monthly onion prices and test validity of model. For this Support Vector Regression is used to classify the data and fitting better non-linear line. With this the length of support vector can be obtained and it can be use to forecaste the price. For the study, around 14 market price data for are taken from Maharashtra. The data is collected in the form of model price per day from 2002 to 2012 from the website of agmarknet and further converted to monthly price. The prices forecasted by Polynomial and Sigmoid model of Support Vector Non-Linear Regression are very much closer with actual prices than ARIMA forecasted prices. Deviation declined much more between actual value and forecasted value. As the price of onion per quintal in actual market was Rs.298 in Lasalgaon market and forecasted price is Rs.313 and Rs.314. If the methodology by putting volatility and better optimisation can be tried, there are chances of better results. The result shows that if the data is classified by Support Vector Regression, the forecasted prices are better over other models. The validity of forecasting model is estimated by AIC, R Square and DW test. From the results of the model fitting, it can be concluded from above results that the model fitting is good in all market except two markets. The best fitted model is observed in Mumbai, Solapur, Nagpur and Pune sequentially.

Introduction

India is facing strong inflation in food price. Especially we can observe it in Fruits and Vegetables. Onion is one of the cash crops in Indian Agriculture. It is basic ingredient in Indian dishes. It is perishable and it is bulky stock to store. Onion production is around 14.56 million tons annually and second largest producer in the world after china. Kharif production is 40-50 percent and Rabi production is 50-60 percent. Area of onion in the country is 10 lakh hectares and productivity is 15.00 ton per hectare (Directorate of Onion and Garlic, 2011). Major onion producing State in the country is Maharashtra, Andhra Pradesh, Karnataka and Gujrat. Maharashtra produces shares 34 percent in Indian production. India exports onion 1.16 million tons to Gulf and Europe countries, Malaysia, Japan, Bangladesh and Shri-Lanka. India has pushed production through onion and garlic research centres and export through NAFED and different cooperatives. India started exports of onions since 1952 with 5000 tonnes per annum. Presently, it exports 12.86 percent of its production. It fetches foreign exchange for country.

Onion Prices has been always an issue of discussions. Shortage of onion supply in spot market leads to higher variation in prices. The higher prices of onion has major influenced the food inflation rate. The Competition Commission of India(CCI) had made enquiry in sudden raise in onion prices. Lasalgaon and its few

peripheral markets in Nasik and Ahmednagr have largest turnover of onions. It is hub of onions and specially make effect on the national prices. It is said that the decision of the Lasalgaon market traders are more responsible for raising onion prices. The government has made efforts to control the price and provide optimum supply. The government imported onions from neighbour countries viz; Pakistan and reduced import duties. A private trading company i.e. Hindustan trading imported Chinese onion. As the onion is basic ingredient in Indian dishes, its demand is less elastic. This year the onion prices has been down due to high 'Minimum Export Price' as compared to international prices. Therefore the prices generally observed in boom in the month of Nov, Dec and Jan, are at lower side. The Railway administration also responsible for stagnating the prices due to not making available the sufficient rakes at Nasik stations. The value of annual onion production is ranges around Rs. 200-1 lakh crores in Indian market.

It is very surprising that the prices of onion ranges from Rs.100(Min) to Rs. 8000 per quintal(Max). Looking to the price variation in onion prices and its annual volume of trade, the present study is selected with following objectives.

Objectives of study :

To classify the monthly price data of onion by kernel function.

To forecast the monthly onion prices.

To test the validity of the forecasting models' fitting.

Hypotheses : It is hypothesised that the onion monthly prices are forecasted better by Support Vector Regression/ Classification. Test will come true for most of the forecasted prices. It will guide the researcher in price study and different study related to onion. It will be also helpful to avoid risk as well as making future contract.

Research Methodology

Data and Market : To accomplish the objectives, the daily recorded data on prices and arrivals are collected from the period Jan 2002 to Dec 2017 from the government published website i.e. www.agmarknet.com. The data are collected on model price. For the study, around 14 market price data for onions is taken from Maharashtra. The onion data is collected for all markets in Maharashtra state, but the major markets which are showing time-series data are only selected for study. Those are as follows.

Table-1 : Major Markets in Maharashtra selected for study.

S. No.	Market	Number of additional sub-market
1.	Ahmednagar	
2.	Chandvad (Nasik)	
3.	Junnar (Ahmednagar)	Junnar (Otur) and Junnar (alphata)
4.	Lasalgaon (Nasik)	Lasalgaon (Niphad)
5.	Malegaon (Nasik)	
6.	Malegaon (Nasik)	Malegaon (Umarane)
7.	Mumbai	
8.	Nagpur	
9.	Newasa (Ahmednagar)	Newasa (Ghodegaon)
10.	Pimpalgaon (Nasik)	Pimpalgaon Baswant (Saykheda) (Nasik)
11.	Pune	
12.	Rahuri (Ahmednagar)	Rahuri(vambhori)
13.	Solapur	
14.	Yeola (Nasik)	

Major Markets are selected on the basis of arrivals in the market. It is observed that most of the onion markets are located in Ahmednagar and Nasik districts of Maharashtra State.

For the monthly price component, the daily price data is averaged on monthly basis by weighted average method.

Analytical Methods : The objective-wise methods used for analysis are given as below.: To classify the data by non linear Kernel Function.

The data of monthly price are converted to binary digit i.e. +1 or -1 on the basis of increment or decrement in price. The time is transformed to log for getting optimised function.

The Support Vector regression classifies the data in two or more classes by maximising the margin of the linearly or non-linearly fitted line by minimising the Loss function.

Support Vector Regression :

$$\text{Min } Z = 1/2w^T w + s_i$$

Subjected to

$$y_i(wx+b) + s_i = 1, s_i = 0$$

Where, w = weight, s = slack variable, = penalty to error and it greater than 0, t = number of hyperplanes of classes, y = class of the data /sign of margin score.

There are three Kernel Function, which classify data by non linear way. Kernel function is mapping function which converts the 2D data in to high dimension space without knowing the mapping function. Those are as follows.

$$(1) \text{ Polynomial} = (au^T v + b)^d$$

$$(2) \text{ Sigmoid} = \tanh(au^T v + b)$$

$$(3) \text{ Radial Basis Function (RBF)} = \exp(-a_i^2 |u - v_i|^2)$$

The u and v are two different vectors of different class or line, a,b,d are constants

After these estimated classified data, the different forecasting models can be applied. But as our result for the daily data are best by ARIMA than other models, the ARIMA model is applied for forecasting the classes of the data and length of the support vector.

ARIMA model : The Auto-regressive Integrated Moving Average model (ARIMA model) is fitted considering the significant lags from Auto-correlations (ACF) and Partial Autocorrelations (PACF).

ARIMA Model

$$P_t = a + b_1 P_{t-1} + b_2 P_{t-2} + \dots + b_n P_{t-n} + u_t + c_1 u_{t-1} + c_2 u_{t-2} + \dots + c_n u_{t-n}$$

$$\text{AR} \quad \text{MA}$$

P_t = Class of Price at current traded month

P_{t-1} = Class of Price at previous traded month (lag term)/season

a, b_1 , b_2 : Coefficients of lag price class term

u_t = Error term on current traded monthly price class

u_{t-1} = Error term of previous monthly(lag term) price class

Coefficients: c_1 , c_n of lag price term

The function is fitted on the basis of knowing stationary of the series. If the series is non-stationary, then it is integrated by differencing and made it stationary.

Once you know the forecasted length of the support

vector, you are able to know deviation from the fitted line and forecasted price can be estimated

Testing of validity of forecasting models' fitting : The model fitting is tested with three test i.e.

(a) Akaike's Information Criterion (AIC) : $AIC = (Dev + 2P)/N$ Dev=deviance, P=parameters, N is sample size. Smaller the value of AIC, better fitting of model.

(b) R Square : To test the variance of the result.

(c) Durbin-Watson statistic: It is a test statistic used to detect the presence of autocorrelation in the residuals.

$$d = \frac{\sum_{t=2}^T (e_t - e_{t-1})^2}{\sum_{t=1}^T e_t^2}$$

Du value for more than 100 sample is 1.56, 1.63, 1.69

Results and Discussion

The results regarding classification and forecasted monthly prices onion obtained from analysis are presented and discussed in this section subsequently.

First the data of all considered market is converted to binary codes on the basis of increased or decreased like +1 and -1.

The classified data is predicted/estimated for fitting new non-linear lines by Kernel Functions.

On another side the ACF and PACF Patterns are estimated for fitting the ARIMA model on estimated data as follows.

Table-1 : Fitting of Auto-regression, differencing and Moving averages (ARIMA) for Monthly prices of Onions.

S. No.	Market	Model
1.	Ahmednagar	2.1.1
2.	Chandvad	1.1.0
3.	Junner	2.1.3
4.	Junner Otur	3.1.2
5.	Lasalgaon	4.1.3
6.	Lasalgaon Niphad	1.1.0
7.	Malegaon	1.1.0
8.	Malegaon Umrane	1.1.1
9.	Mumbai	5.1.4
10.	Nagpur	5.1.4
11.	Newasa Ghodegaon	0.1.0
12.	Pimpalgaon	5.1.4
13.	Pune	5.1.5
14.	Rahuri	2.1.2
15.	Rahuri Vambori	1.1.0
16.	Solapur	2.1.1
17.	Vashi	2.1.1
18.	Yeola	2.1.0

The estimated binary code data are then forecasted on the basis of ARIMA model fitted. The example of forecasted binary data of Lasalgaon market is as follows.

Table-2 : Forecasted Value of Support Vector.

Month	Forecast Support Vector
1	0.899511
2	0.899512
3	0.899512
4	0.899513
5	0.899515
6	0.899517
7	0.899519
8	0.899523
9	0.899526
10	0.899530

Suppose the current month forecasted price is Rs. 348 per quintal. The predicted price for next month is height of the support vector i.e. 0.899511 multiplied by current month price (348).

Forecasted Price = $0.899511 \times 348 = 313$. This is much closed to actual price.

The all the forecasted prices are compared with actual value price and forecasted price by ARIMA.

It is observed that the Radial Basis Function type of Kernel Function is not suitable for prediction of onion data. While the prices forecasted by Polynomial and Sigmoid model are very much closer with actual prices than ARIMA prices. Deviation declined much more between actual value and forecasted value. As the price of onion per quintal in actual market was Rs.298 in Lasalgaon Market and forecasted price is Rs.313 and Rs.314. If we could modify more the methodology by putting volatility and better optimisation, we can give better results.

Validity of the model fitted ARIMA : The validity of the model is estimated by Akaike's Information Criterion (AIC) test, R Square and Durbin Watson Stat. The results are presented in table-4. As per the result obtained of the AIC Test, the lower value as compared to other markets is observed in Mumbai(13.50), Solapur (13.50), Nagpur, (13.51) and Pune(13.67). It indicates the better fitting of model in these markets.

The R square indicates that the prices are highly varying values are observed in Mumbai(0.84) , Nagpur (0.80) and Pune(0.78) markets. While Malegaon Umrane (-0.02) and Lasalgaon Niphad(0.12) has shown lowest value of R Square.

The results of the Durbin Watson Stat indicates that the actual DW estimates of the all markets except

Table-3 : Forecasted Price of Mixed Onions for next trading months.

Market	Actual Price for the next month	Forecasted Price by ARIMA	Forecasted Price by Polynomial SVM	Forecasted Price by Sigmoid SVM
Ahmednagar	NA	322.86	419	419
Chandvad	361.37	486.24	485	485
Junner	481.25	1252.91	991	991
Junner Otur	NA	1020.9	987	994
Lasalgaon	298.45	560.23	314	313
Lasalgaon Niphad	NA	318.16	312	251
Malegaon	NA	443.81	441	441
Malegaon Umrane	NA	940.42	312	312
Mumbai	NA	1093.1	969	975
Nagpur	714.47	858.88	700	810
Pimpalgaon	322.53	747.51	518	532
Pune	423.96	658.51	597	596
Rahuri	315.4	331.59	348	369
Rahuri Vambori	362.5	437.55	429	431
Solapur	NA	361.86	405	406
Vashi	542.86	448.15	514	768
Yeola	NA	563.36	571	571

Table-4 : Validity Testing of the Model fitting.

Market	Actual Price for the next month	Forecasted Price by ARIMA	AIC	R Sqr	DW Stat
Ahmednagar	NA	322.86	14.29	0.59	2.01
Chandvad	361.37	486.24	14.47	0.31	2.17
Junner	481.25	1252.91	14.34	0.68	2.01
Junner Otur	NA	1020.9	15.49	0.53	1.99
Lasalgaon	298.45	560.23	14.39	0.62	1.88
Lasalgaon Niphad	NA	318.16	14.67	0.12	2.00
Malegaon	NA	443.81	14.12	0.30	2.05
Malegaon Umrane	NA	940.42	15.00	-0.02	1.41
Mumbai	NA	1093.1	13.50	0.84	1.94
Nagpur	714.47	858.88	13.51	0.80	2.08
Pimpalgaon	322.53	747.51	13.78	0.75	1.90
Pune	423.96	658.51	13.67	0.78	1.97
Rahuri	315.4	331.59	13.72	0.50	1.99
Rahuri Vambori	362.5	437.55	14.18	0.36	1.52
Solapur	NA	361.86	13.50	0.37	2.17
Vashi	542.86	448.15	14.52	0.72	1.91
Yeola	NA	563.36	14.74	0.14	2.02

Malegaon Urmane and Rahuri Vambori are more than the Table Critical Values It reveals the we don't need to reject hypothesis. Model is fitted properly.

It can be concluded from above results that the model fitting is good in all market except two markets. The best fitted model is observed in Mumbai, Solapur, Nagpur and Pune sequentially.

Conclusions

The result shows that if the data is classified by Support Vector Regression, the forecasted prices are better over other models.

From results of validity testing , it can said that the model fitting is good in all market except two markets. The best fitted model is observed in Mumbai, Solapur, Nagpur and Pune sequentially.

Recommendation

Considering the efforts of on onion price forecasting following recommendation is made. For forecasting onion prices, the three steps will give best result i.e.

Price data is to be classified by Support Vector Regression

Volatility of onion prices is to be estimated by GARCH.

Forecast the prices by ARIMA Model with significant correlogram and merge effect of volatility."

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A Study on Butterflies Diversity in Barnawapara Sanctuary

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Abstract

A study to find out the diversity of butterflies at Barnawapara sanctuary, Balodabazar – Bhatapara (CG), was carried out over a period of two months from September 2021 to October 2021. A total of 33 butterfly species belonging to 5 families, namely, Nymphalidae consists of maximum number (18) of butterfly species followed by Pieridae (7), Papilionidae (4), Hesperidae (3) and Lycaenidae (1), were recorded during the study from two different habitats of sanctuary: open scrub, and dry deciduous habitat. The species namely, *Papilio demoleus* (Lime Swallowtail) represents highest percentage (12.52) of abundance followed by *Papilio polytes* (Common Mormon) (11.97), *Pachliopta aristolochiae* (Common Rose) (11.54), *Junonia atlites* (Gray Pansy) (10.62) and *Athyma perius* (Common Sergeant) (8.67) in the sanctuary. Different nectar and host plants present in the campus were recorded and butterflies approach to a particular nectar plant is visually observed in the sanctuary. Rich diversity among host plant is also seen in the sanctuary.

Introduction

Butterflies are the most beautiful creatures among the insect group. Among the insect groups butterflies comes under the large group called Lepidoptera. The development of butterflies is thought to be from moths and it is closely linked to the evolution of flowering plants. Butterflies depend on many host and nectar plants in their life time for evolution and development. Therefore, host or nectar plants availability and their reformation status study are essential in understanding the butterfly population in depth. Butterflies helps to advice climate change and environment decadence and are studied as living ecological components of broad importance. They play an important role in the food chain and act as valuable pollinators in the domestic environment. Butterflies are sensitive biota, and are severely affected by environmental shifts and changes in habitat structure. They respond to disturbances and changes in the habitat quality and landscape structure variations. Habitat enrichment has been found to play a great role in conserving butterfly species and their sufficiency. Throughout the world butterflies are seen huge in number (About 45,000 species) mainly in tropical region, which are classified into 6 different families (Ehrlich, 2000), however they are not found in Antarctica. India is known for its wealthy heritage of biological diversity, ranking among the top ten species-rich nations, showing high endemism (Dayananda, 2014). In India, about 1504 species of butterflies have been identified and documented (Kunte, 2000). In India, Western Ghats is considered as one of the most diversified areas containing a wide variety of species of butterflies (Umapati *et al.*, 2016), hosting 336 species, of which approximately 12%

are endemic to the area, and 59 species are legally protected in India (Nitin *et al.*, 2018). Our study area, Barnawapara sanctuary, is spread over an area of about 245 square km. The Jonk River, a tributary of the Mahanadi river, flows through the sanctuary, and is bisected by a number other of streams and rivulets, besides numerous watering holes. The tributaries of Mahanadi are the source of water here. Balamdehi River forms the western boundary and Jonk River forms the north-eastern boundary of the Sanctuary. It is a land mass of undulating terrain dotted with numerous low and high hillocks. With the above stated background, our study was carried out to calculate the abundance of butterflies as percentage compositions of the different families and to know the host / nector plant present in the Barnawapara sanctuary.

Materials and Methods

The study was conducted in Barnawapara sanctuary, Chhattisgarh located between the longitudes 80° 22'30" to 82° 37.30" E and latitudes 21° 18'45" to 21° 30.0"N in the district Balodabazar – Bhatapara of Chhattisgarh. from September 2021 to October 2021. The total area of sanctuary covers 244.66 Sqkm. The topography of the sanctuary is plain and undulating terrain. The elevation is varies up to 640 msl. The rivers Balmedhi, Jonk and Mahanadi are the life line river which runs along the sanctuary to fulfill the water scarcity of the sanctuary. The annual rainfall is 1200 mm and the climate is pleasant during the winter season between the months of November to February. The sanctuary contains major vegetation of Teak, Sal and Mixed forest. It holds good density of prey and predators to maintain the ecosystem. The Balar reservoir situated inside the sanctuary supports

Table-1 : Showing the Relative richness of butterflies present in the Barnawapara sanctuary.

S. No.	Common Name	Scientific Name	Status	Total no individuals sighted	Distribution of density pattern (%)
Family - Hesperidae					
01.	Grass Demon	<i>Udaspes folus</i>	Uncommon	2	0.12
02.	Common Small Flat	<i>Sarangesa dasahara</i>	Common	8	0.49
03.	Common Banded Awl	<i>Hasora chromus</i>	Common	17	1.04
Family – Lycaenidae					
04.	Tailless Lineblue	<i>Prosotas dubiosa</i>	Common	3	0.18
Family – Nymphalidae					
05.	Great Eggfly	<i>Hypolimnas bolina</i>	Common	25	1.53
06.	Lemon Pansy	<i>Junonia lemonias</i>	Common	24	1.47
07.	Peacock Pansy	<i>Junonia almanac</i>	Common	16	0.98
08.	Gray Pansy	<i>Junonia atlites</i>	Locally common	174	10.62
09.	Yellow Pansy	<i>Junonia hierta</i>	Common	8	0.49
10.	Angled Castor	<i>Ariadne Ariadne</i>	Uncommon	3	0.18
11.	Baronet	<i>Symphaedra nais</i>	Common	16	0.98
12.	Common Sergeant	<i>Athyma perius</i>	Locally Common	142	8.67
13.	Commander	<i>Moduza Procris</i>	Common	14	0.85
14.	Common Leopard	<i>Phalanta phalantha</i>	Common	27	1.65
15.	Tawny Coster	<i>Acraea terpsicore</i>	Common	18	1.10
16.	Common Bushbrown	<i>Mycalesis perseus</i>	Common	21	1.28
17.	Common evening Brown	<i>Melanitis leda</i>	Common	15	0.92
18.	Plain Tawny Rajah	<i>Charaxes psaphon</i>	Common	16	0.98
19.	Indian Nawab	<i>Charaxes bharata</i>	Locally Commo	119	7.26
20.	Common Indian Crow	<i>Euploea core</i>	Common	27	1.65
21.	Plain Tiger	<i>Danaus chrysippus</i>	Common	29	1.77
22.	Striped Tiger	<i>Danaus genutia</i>	Common	34	2.08
Family – Papilionidae					
23.	Blue Tiger	<i>Tirumala limniace</i>	Very common	127	7.75
24.	Common Rose	<i>Pachliopta aristolochiae</i>	Very common	189	11.54
25.	Lime Swallowtail	<i>Papilio demoleus</i>	Very common	205	12.52
26.	Common Mormon	<i>Papilio polytes</i>	Very common	196	11.97
Family – Pieridae					
27.	Indian Jezebel	<i>Delias eucharis</i>	Common	18	1.10
28.	Common Gull	<i>Cepora Nerissa</i>	Common	37	2.26
29.	Indian Wanderer	<i>Pareronia hippia</i>	Common	31	1.89
30.	Mottled Emigrant	<i>Catopsilia pyranthe</i>	Common	19	1.16
31.	Common Emigrant	<i>Catopsilia Pomona</i>	Common	12	0.73
32.	Common Grass Yellow	<i>Eurema hecabe</i>	Common	17	1.04
33.	Small Grass Yellow	<i>Eurema brigitta</i>	Common	29	1.77

number of wetland birds and fishes. This sanctuary promotes Ecotourism to create awareness to the public. To approach Barnawapara is two hours journey by road from Raipur while driving a joy of rid can not be unnoticed its 106 km. away from Raipur on N.H.53 on 78th km. Patewa is a small town where from Barnawapara can be approached after driving 28 km. on fair weather road. For our study, transects were divided into two habitats according to general landscape attributes and vegetation present there. The chief habitat types were as follows: (1)

open shrub and (2) dry deciduous for Butterfly Survey. The survey of butterfly was done using four main methods for survey are : (1) trapping and netting, (2) mark-recapture, (3) transects (Pollard walks), and (4) distance sampling as per the availabilities of butterflies . Butterflies were observed, captured, identified, and released immediately at the spot of capture. A butterfly net was used for this purpose.

The species of butterflies were identified by their physical feature as well as with the help of the book of

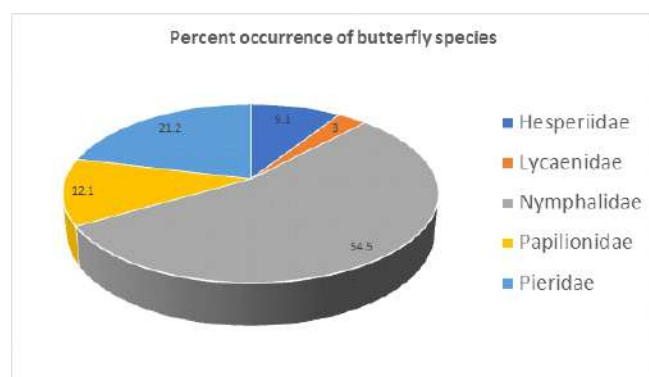


Table-2 : Number and percent division of butterflies species under different families present in the Barnawapara sanctuary.

S. No.	Family	Species	
		Number	Percentage
01	Hesperidae	03	9.1
02	Lycaenidae	01	3.0
03	Nymphalidae	18	54.5
04	Papilionidae	04	12.1
05	Pieridae	07	21.2

Fig-1 : Percent occurrence of butterfly species under

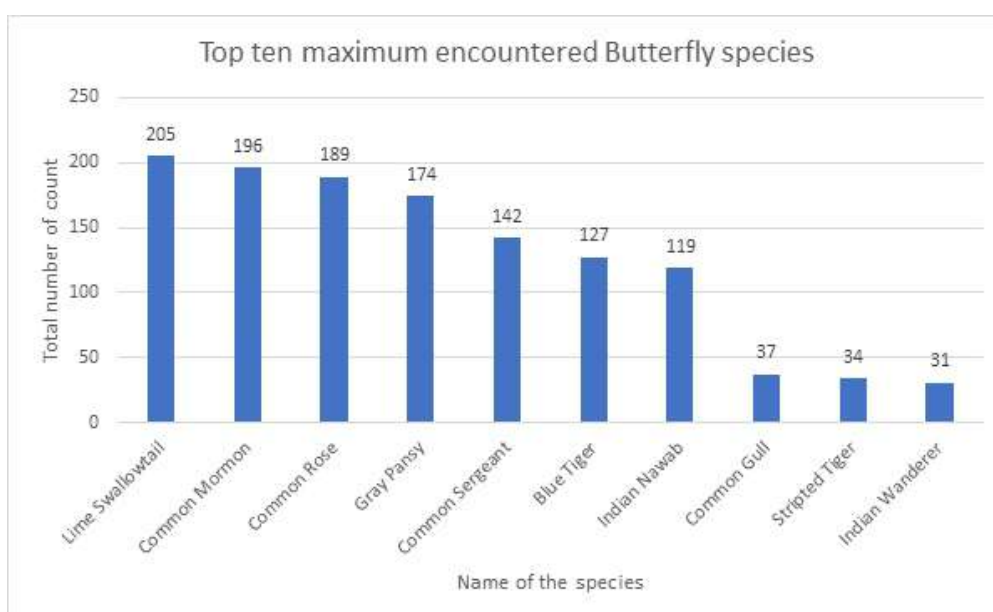


Fig-2 : Top ten maximum encountered Butterfly species.

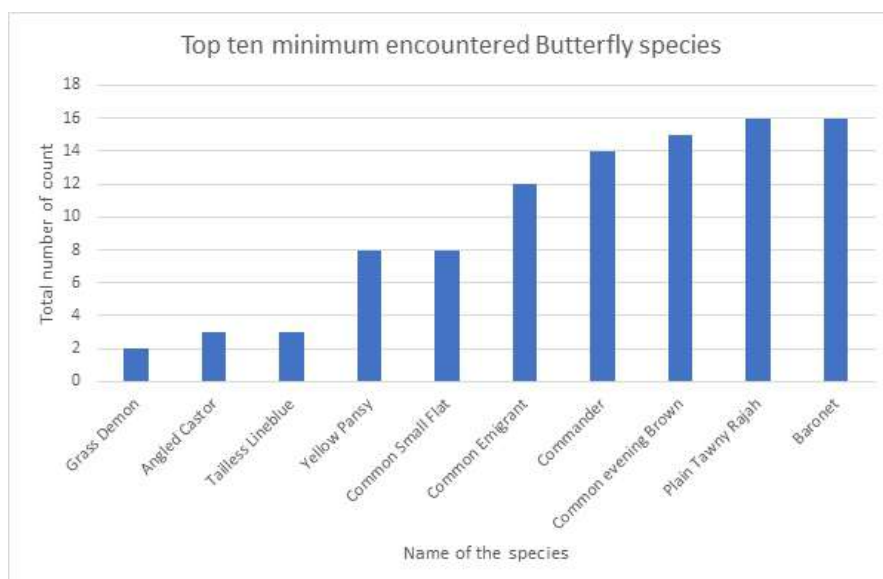


Fig-3 : Top ten minimum encountered Butterfly species.

Table-3 : List of host plants present in the Barnawapara sanctuary.

Sl. No.	Scientific Name	Butterflies Name
1.	<i>Acacia caesia</i>	Indian Nawab
2.	<i>Acacia catechu</i>	Indian Nawab
3.	<i>Acacia concinna</i>	Tailless Lineblue
4.	<i>Acacia sp.</i>	Indian Nawab
5.	<i>Adenia hondala</i>	Tawny Coster
6.	<i>Aedenium obesum</i>	Common Indian Crow
7.	<i>Aegle marmelos</i>	Lime Swallowtail
8.	<i>Aeschynomene americana</i>	Common Grass Yellow
9.	<i>Aeschynomene indica</i>	Common Grass Yellow
10.	<i>Albizia chinensis</i>	Indian Nawab
11.	<i>Albizia procera</i>	Common Grass Yellow
12.	<i>Albizia saman</i>	Common Grass Yellow
13.	<i>Alpinia calcarata</i>	Grass Demon
14.	<i>Alternanthera sessilis</i>	Great Eggfly
15.	<i>Angle marmelos</i>	Common Mormon
16.	<i>Aristolochia krisagathra</i>	Common Rose
17.	<i>Asclepias curassavica</i>	Blue Tiger
18.	<i>Asclepias curassavica</i>	Plain Tiger
19.	<i>Axonopus compressus</i>	Common evening Brown
20.	<i>Azadirachta indica</i>	Indian Jezebel
21.	<i>Bambusa arundinacea</i>	Common evening Brown
22.	<i>Barleria</i>	Gray Pansy
23.	<i>Barleria</i>	Peacock Pansy
24.	<i>Barleria cristata</i>	Yellow Pansy
25.	<i>Barleria cuspidate</i>	Yellow Pansy
26.	<i>Bauhinia racemosa</i>	Common Emigrant
27.	<i>Brachiaria mutica</i>	Common evening Brown
28.	<i>Butea monosperma</i>	Common Emigrant
29.	<i>Cadaba fruticose</i>	Commander
30.	<i>Caesalpinia pulcherrima</i>	Common Grass Yellow
31.	<i>Caesalpinia sappan</i>	Common Grass Yellow
32.	<i>Calliandra haematocephala</i>	Common Grass Yellow
33.	<i>Calotropis gigantea</i>	Plain Tiger
34.	<i>Calotropis procera</i>	Plain Tiger
35.	<i>Capparis sepiaria</i>	Common Gull
36.	<i>Capparis sp.</i>	Indian Wanderer
37.	<i>Capparis sp.</i>	Common Gull
38.	<i>Capparis zeylancia</i>	Indian Wanderer
39.	<i>Capparis zeylancia</i>	Common Gull
40.	<i>Carissa carandas</i>	Common Indian Crow
41.	<i>Carissa congesta</i>	Common Indian Crow
42.	<i>Carissa spinarum</i>	Common Emigrant
43.	<i>Carissa spinarum</i>	Mottled Emigrant
44.	<i>Cassia fistula</i>	Common Grass Yellow
45.	<i>Cassia fistula</i>	Common Emigrant
46.	<i>Cassia fistula</i>	Mottled Emigrant
47.	<i>Cassia renigera</i>	Mottled Emigrant
48.	<i>Cassia roxburghii</i>	Common Emigrant
49.	<i>Cassia sp.</i>	Small Grass Yellow
50.	<i>Chamaecrista klenii</i>	Common Grass Yellow
51.	<i>Chamaecrista mimosoides</i>	Small Grass Yellow
52.	<i>Chamaecrista mimosoides</i>	Common Grass Yellow
53.	<i>Chloroxylon swietenia</i>	Lime Swallowtail
54.	<i>Citrus aurantium</i>	Lime Swallowtail
55.	<i>Citrus latifolia</i>	Common Mormon
56.	<i>Citrus limon</i>	Common Mormon
57.	<i>Citrus limon</i>	Lime Swallowtail
58.	<i>Citrus medica</i>	Common Mormon
59.	<i>Citrus medica</i>	Lime Swallowtail
60.	<i>Citrus sp.</i>	Common Mormon
61.	<i>Colotropis gigantea</i>	Blue Tiger
62.	<i>Colotropis procera</i>	Blue Tiger
63.	<i>Cosmostigma racemosum</i>	Blue Tiger
64.	<i>Curcuma amada</i>	Grass Demon
65.	<i>Curcuma caesia</i>	Grass Demon

Table-3 : Contd...

Sl. No.	Scientific Name	Butterflies Name
66.	<i>Curcuma longa</i>	Grass Demon
67.	<i>Curcuma pseudomontana</i>	Grass Demon
68.	<i>Cytrolepsis buchanani</i>	Common Indian Crow
69.	<i>Dalbergia latifolia</i>	Plain Tawny Rajah
70.	<i>Delonix regia</i>	Common Grass Yellow
71.	<i>Dendrophthoe falcata</i>	Indian Jezebel
72.	<i>Diospyros melanoxylon</i>	Baronet
73.	<i>Echinochola sp.</i>	Common Bushbrown
74.	<i>Eleusine indica</i>	Common evening Brown
75.	<i>Ficus tsjahela</i>	Common Indian Crow
76.	<i>Flacourtia indica</i>	Common Leopard
77.	<i>Flacourtia montana</i>	Common Leopard
78.	<i>Glochidion ellipticum</i>	Common Sergeant
79.	<i>Grewia asiatica</i>	Baronet
80.	<i>Hemidesmus indicus</i>	Common Indian Crow
81.	<i>Holarrhena antidysenterica</i>	Common Indian Crow
82.	<i>Hygrophila auriculata</i>	Yellow Pansy
83.	<i>Hygrophila auriculata</i>	Gray Pansy
84.	<i>Hygrophila auriculata</i>	Peacock Pansy
85.	<i>Hygrophila auriculata</i>	Lemon Pansy
86.	<i>Hygrophila costata</i>	Lemon Pansy
87.	<i>Ichnocarpus frutescens</i>	Common Indian Crow
88.	<i>Limonia acidissima</i>	Lime Swallowtail
89.	<i>Milium tomentosa</i>	Plain Tawny Rajah
90.	<i>Millettia pinnata</i>	Common Banded Awl
91.	<i>Mimosa pudica</i>	Common Grass Yellow
92.	<i>Mitragyna parvifolia</i>	Commander
93.	<i>Murraya paniculata</i>	Common Mormon
94.	<i>Mussaenda erythrophylla</i>	Commander
95.	<i>Neolamarckia cadamba</i>	Commander
96.	<i>Nerium oleander</i>	Common Indian Crow
97.	<i>Oplismenus compositus</i>	Common Bushbrown
98.	<i>Oxystelma esculentum</i>	Striped Tiger
99.	<i>Paspalidium cf. geminatum</i>	Common evening Brown
100.	<i>Passiflora edulis</i>	Tawny Coster
101.	<i>Pennisetum setaceum</i>	Common evening Brown
102.	<i>Phyllanthus amarus</i>	Common Sergeant
103.	<i>Phyllanthus virgatus</i>	Common Sergeant
104.	<i>Portulaca oleracea</i>	Great Eggfly
105.	<i>Pterocarpus marsupium</i>	Plain Tawny Rajah
106.	<i>Pterospermum acerifolium</i>	Indian Jezebel
107.	<i>Salix terasperma</i>	Common Leopard
108.	<i>Senna alata</i>	Mottled Emigrant
109.	<i>Senna auriculata</i>	Mottled Emigrant
110.	<i>Senna occidentalis</i>	Mottled Emigrant
111.	<i>Senna sophora</i>	Mottled Emigrant
112.	<i>Senna tora</i>	Common Grass Yellow
113.	<i>Senna tora</i>	Common Emigrant
114.	<i>Senna tora</i>	Mottled Emigrant
115.	<i>Sesbania sesban</i>	Common Grass Yellow
116.	<i>Sida rhombifolia</i>	Great Eggfly
117.	<i>Sorghum halepensis</i>	Common evening Brown
118.	<i>Thottea siliquosa</i>	Common Rose
119.	<i>Thunbergia alata</i>	Grass Demon
120.	<i>Tragia involucrate</i>	Angled Castor
121.	<i>Turnera subulate</i>	Tawny Coster
122.	<i>Turnera ulmifolia</i>	Tawny Coster
123.	<i>Tylophora dalzellii</i>	Blue Tiger
124.	<i>Tylophora dalzellii</i>	Plain Tiger
125.	<i>Tylophora dalzellii</i>	Common Indian Crow
126.	<i>Vallis solanacea</i>	Blue Tiger
127.	<i>Wattakaka volubilis</i>	Blue Tiger
128.	<i>Zanthoxylum armatum</i>	Common Mormon
129.	<i>Zea mays</i>	Common evening Brown
130.	<i>Zinger montanum</i>	Grass Demon

Indian Butterflies, Butterflies of Peninsular India and checklists (Kunte, 2000). Butterflies species were continuously monitored for the feeding behaviour on *Vitex negundo*. Numbers of visits of each species at various timings was recorded and mean values were recorded.

Results and Discussion

A total of 33 butterfly species belonging to five families were recorded through visual observations of their wing color, patterns and also referring to field guides. The species namely, *Papilio demoleus* (Lime Swallowtail) represents highest percentage (12.52) of abundance followed by *Papilio polytes* (Common Mormon) (11.97), *Pachliopta aristolochiae* (Common Rose) (11.54), *Junonia atlites* (Gray Pansy) (10.62) and *Athyma perius* (Common Sergeant) (8.67) in the study area (Table 1). The Family Nymphalidae consists of maximum number (18) of butterfly species followed by Pieridae (7), Papilionidae (4), Hesperidae (3) and Lycaenidae (1) (Table 2) and their percent occurrence of butterfly species under different families were graphically represented (Fig.-1). The result of this survey at Barnawapara sanctuary shows that, the family Nymphalidae is abundant among the five families. The rich diversity of the butterflies in the sanctuary can be attributed to the floristic diversity of the sanctuary which provides suitable larval host plants, nectar plants and protection from predators. In two months duration from September to October, by adding up the total number of counts, it was seen that Lime Swallowtail was the most observed butterfly with a maximum count of 205 followed by Common Mormon (196), Common Rose (189), Gray Pansy (174) and Common Sergeant (142) (Fig.-2). Some rare butterflies such as Grass Demon was observed with a minimum count number of 2 followed by Angled Castor (3), Tailless Lineblue (3), Yellow Pansy (8) and Common Small Flat (8) (Fig.-3). This variation in the counts is mainly due to topical, availability of host plants and adaptability character of the butterflies. Uday kumar *et al.*, 2019 reported that, a total of 84 species of butterflies belonging to 6 families were recorded in which Nymphalidae contributed to maximum number of species (33). Higher abundance of Nymphalidae can be due to the presence of flowers belonging to families Fabaceae, Rutaceae, Euphorbiaceae, Compositae and Rubiaceae. Priya *et al.*, 2008, stated that, flowers belonging to families Euphorbiaceae, Compositae, Rubiaceae and

Verbinaceae can result in higher Nymphalid diversity. The host plants play a vital role in butterflies growth and development by providing food, especially caterpillars are fully dependent on host plants (Aneesh *et al.*, 2013). The diversity and richness of butterflies are dependent on availability of nectar and host plants. Different nectar and host plants present in the campus were recorded (Table-3) and butterflies approach to a particular nectar plant is visually observed in the sanctuary.

Conclusions

This study suggests that, butterfly diversity is high in the sanctuary and have a greater ecological magnitude, as various higher groups of organisms such as birds and some mammals diet on butterflies and their caterpillars, thus forming more than one link in the food net, hence there is a necessity to protect both butterflies and host plants for conserving the population. Maintaining high plant diversity and different types of habitats is a good option for the conservation of species in Barnawapara sanctuary.

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Effect of Boron and Lime on Growth and Yield of Mustard (*Brassica juncea* L.) under Acidic Soil of Jharkhand, India

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Abstract

An experiment was conducted to determine the suitable combination of boron (*i.e.*, 0.0, 1.0, 2.0 and 3.0 kg ha⁻¹) and lime (*i.e.*, 0/0, 1/5, 1/10 and 1/15 LR) during *Rabi* seasons of two years *i.e.*, 2017-18 and 2018-19 under acidic soil of agro climatic sub zone IVth of VIIth ACZ (Hill and plateau region) of Jharkhand. The significantly superior improvement was observed in number of branches and number of siliqua per plant in where lime was applied at the rate of 1/5 LR followed by @ 1/10 LR and @ 1/15 LR among the mean values of both years. In case of grain and straw yield, significantly increased with increasing boron application, in where significantly higher was observed @ 3.0 kg B ha⁻¹ followed by @ 2.0 kg B ha⁻¹ and @ 1.0 kg B ha⁻¹ application. The optimum improved in growth and yield of mustard was recorded from where boron application at the rate of 3.0 kg ha⁻¹ and lime application 1/5 LR. Hence we can be recommended that boron and lime play an important role in acidic soil of Jharkhand.

Key words : Mustard, acidic soil, boron, lime, growth and yield.

Introduction

Acid soils in the state of Jharkhand constitute more than 80 % of the total cultivated area. Acid soils support major crops of the state. But the yield of pulses, oil seeds and vegetables are far below than the national average. Soil acidity along with deficiency of boron and calcium are found limiting to the crop yield in these regions. Inadequate and imbalanced nutrition influences the yield and quality of crops. In oil crops like groundnut and mustard, boron requirement is high. It is essential for translocation of sugars, starches, nitrogen and sulphur. Lime is an important factor in the nutrition of mustard as the crop generally makes its best growth when the soil pH is 6.8- 7.0. Lime restricted boron fixation by raising pH towards neutrality which helped in increasing boron availability to the plants. Alone lime application decreased the hot water soluble boron in soil. Thus liming, in general, increased the boron retention capacity of soil as well as helps in total boron uptake.

The soils of agro climatic sub zone IVth of VIIth ACZ (Hill and Plateau region) of Ranchi in Jharkhand is generally sandy loam in texture and acidic reaction with pH range of 3.99-7.98 (Anonymous, 2015). Due to high rainfall in mid hills, leaching of nutrients and micronutrients is a common incidence leading to frequent deficiency of the elements like calcium and boron in soil. Therefore, it should be overcome to get sustained and

increased production. In order to formulate the correct dose of boron and lime for getting higher growth and yield in small and scattered land holding of Plateau region, the present investigation was studied on "Effect of boron and lime on growth and yield of mustard (*Brassica juncea* L.) under acidic soil of Jharkhand, India".

Materials and Methods

The experiment was laid down in Split Plot Design (SPD) and the respective treatments were applied to each plot. All the plots of the experiment received recommended applications of N, P, K and S fertilizers at the rate of 80, 60, 40 and 20 kg ha⁻¹, respectively. A basal dose of P, K and S was applied (60, 40 and 20 kg ha⁻¹) one day before sowing, while N was applied at 80 kg ha⁻¹ in three split doses *i.e.*, 40 kg N ha⁻¹ at basal, 20 kg N ha⁻¹ at top dressed (after 25 days of sowing) and remaining 20 kg N ha⁻¹ at siliqua initiation stage (50 DAS) to all the treatments. The N, P, K and S were applied through urea, single supper phosphate (SSP), potassium chloride (Muriate of potash) and elementary sulphur, respectively. The treatments were comprised of four levels of boron in the form of borax (0.0, 1.0, 2.0 and 3.0 kg B ha⁻¹) and four levels of calcium in the form of lime (0/0, 1/5, 1/10 and 1/15 LR) applied as basal in mustard variety Shivani. All the boron levels were applied through soil application. The plot size was 5m × 3.9m with adequate irrigation and drainage facility. Mustard was sown at the spacing of 30cm × 10cm. All the levels of Lime was applied in furrows

seven days before sowing and properly mixed with the soil. Required agronomic management practices were followed as per recommended package and practice. Then the mustard seedlings were allowed to grow till the harvest. After harvesting the grain and straw yields were recorded separately. The plants for data collection were randomly selected from middle rows of each unit plot avoiding border effects, except for the yield of mustard, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth and yield attributes as affected by different treatments of the experiment.

Growth yield attribute characteristics : At the end of the growing season (~95 days after sowing) samples of five selected plant were taken at random from each replication to determine the Plant height, No. of primary branches in plant⁻¹, No. of secondary branches in plant⁻¹, No. of siliqua plant⁻¹, Length of Siliqua and No. of Seeds Siliqua⁻¹. After harvesting of mustard plant the grain and straw yields were recorded separately from each plot

Harvest index : The harvest index was worked out from grain and straw yields using the formula given by Donald (1962) using following equation :

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where, Economic yield = grain yield; Biological yield = grain yield + straw yield

Statistical analysis : Statistical analyses of the results were statistically evaluated in the form of Analysis of Variance (ANOVA).

Results and Discussion

Effect of Boron on growth attributes characteristics of mustard during the *Rabi* season of both years *i.e.*, 2017-18 and 2018-19 : The present results indicated that all the growth characteristics (*i.e.*, plant height, No. of primary branches in plant⁻¹, No. of secondary branches in plant⁻¹, No. of siliqua plant⁻¹, Length of Siliqua and No. of Seeds Siliqua⁻¹) of mustard did not show any significant changes among the treatments during the *Rabi* season of both years *i.e.*, 2017-18 and 2018-19 (Table 1). Whereas apparently higher was observed in L₁B₃ followed by L₁B₂, L₁B₁ and L₁B₀, respectively.

Effect of lime on growth attributes characteristics of mustard during the *Rabi* season of both years *i.e.*, 2017-18 and 2018-19 : The present results indicated that all the growth characteristics of mustard did not show any significant changes among the treatments except No. of primary/secondary branches in plant⁻¹ and No. of siliqua plant⁻¹ during the *Rabi* season of both years *i.e.*, 2017-18 and 2018-19 (Table 2). During second year, the no. of

primary branches significantly higher increment was observed in L₁ (@ 1/5 LR) and L₂ (@ 1/10 LR) level of lime applications over the control (L₀). While in case of mean values of two years, significantly superior improvement was observed in L₁ and L₂ level of lime applications, in which about 25 % and 17 % increased over the control.

In respect of no. of siliqua per plant, the results indicated that significantly increase was observed among the all levels of lime applications over the control during the both years *i.e.*, 2017-18 and 2018-19 (Table 2). Whereas significantly higher no. of siliqua was observed in L₁ (@ 1/5 LR) (203.0 and 200.3) followed by L₂ (@ 1/10 LR) (181.3 and 180.5) and L₃ (1/15 LR) (165.5 and 156.8) level of lime applications, respectively first and second years. While mean values of both (1st and 2nd) years, significantly superior improvement was observed in L₁ (201.6) followed by L₂ (180.9) and L₃ (161.2) level of lime applications, in which about 38 %, 23% and 10 % increased over the control, respectively.

Effect of Boron application on grain and straw yield of mustard during the *Rabi* season of both years *i.e.*, 2017-18 and 2018-19 : As per the pooled data of two years (2017 and 2018), the highest grain yield was obtained under the boron application level at the rate of 3.0 kg ha⁻¹ (B₃) (21.91 q ha⁻¹) followed by 2.0 kg ha⁻¹ (B₂) (12.23 q ha⁻¹), 1.0 kg ha⁻¹ (B₁) (11.64 q ha⁻¹) and the least (10.95 q ha⁻¹) was recorded under control (B₀) (Table 3). The same trend was observed in 2017 wherein the grain yield varied from 8.29 q ha⁻¹ (B₀) to 9.84 q ha⁻¹ (B₃) and similar trend was also repeated in 2018, the grain yields varied from 13.60 q ha⁻¹ (B₀) to 15.97 q ha⁻¹ (B₃). Among the all B levels, only B₃ was bought significantly superior grain yields over the B₂, B₁ and B₀ (control).

Effect of Lime application on grain and straw yield of mustard during the *Rabi* season of both years *i.e.*, 2017-18 and 2018-19 : Grain and straw yields of mustard were influenced by the application of different levels of lime in soil (Table 4) but did not show any significant effect among the treatments in both years. Harvest index of two years did not show any significant effect among the treatments with boron and lime applications as compared to control.

Different levels of boron and lime applications gave the variable effects on plant height, number of primary branches plant⁻¹, number of secondary branches plant⁻¹, number of siliqua plant⁻¹, Length of Siliqua and number of Seeds Siliqua⁻¹ in mustard plant. The variation in growth attributes of mustard among the treatments may be due to application of boron and lime involved in transportation of sugar across cell membranes, cellular differentiation and development, nitrogen metabolism, active salt absorption, water retention etc. Lime restricted boron fixation by

Level	Plant height (cm)			No. of Primary Branches plant ⁻¹			No. of Secondary Branches plant ⁻¹			No. of Siliqua plant ⁻¹			Length of Siliqua			No. of Seeds Siliqua ⁻¹		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
B ₀	159.1	158.4	158.7	5.68	5.85	5.77	12.71	12.9	12.8	168.9	162.9	165.9	5.0	5.1	5.0	15.33	14.86	15.09
B ₁	161.5	160.3	160.9	5.87	5.98	5.92	12.83	13.1	13.0	171.5	169.0	170.2	5.1	5.1	5.1	15.43	15.00	15.22
B ₂	162.2	162.5	162.3	6.03	6.07	6.05	13.01	13.2	13.1	175.2	174.8	175.1	5.1	5.1	5.1	15.59	15.08	15.34
B ₃	163.5	163.4	163.5	6.08	6.18	6.13	13.65	13.6	13.6	181.2	176.8	179.0	5.1	5.1	5.1	15.70	15.34	15.53
SEm±	5.4	4.9	4.3	0.196	0.196	0.140	0.470	0.405	0.304	6.50	6.29	6.28	0.2	0.2	0.1	0.47	0.51	0.42
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	8.66	7.90	6.90	8.60	8.45	6.12	9.36	7.98	6.01	9.70	9.57	9.45	7.92	8.61	6.69	7.86	8.87	7.05

Level	Plant height(cm)			No. of Primary Branches plant ⁻¹			No. of Secondary Branches plant ⁻¹			No. of Siliqua plant ⁻¹			Length of Siliqua			No. of Seeds Siliqua ⁻¹		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
B ₀	156.0	157.1	156.5	5.35	5.23	5.29	11.50	12.07	11.79	147.0	146.0	146.5	4.8	4.9	4.8	14.68	14.01	14.36
B ₁	164.8	163.8	164.3	6.51	6.73	6.61	14.50	14.31	14.41	203.0	200.3	201.6	5.3	5.3	5.3	16.11	15.93	16.03
B ₂	163.2	162.3	162.7	6.07	6.35	6.21	13.63	13.43	13.55	181.3	180.5	180.9	5.2	5.2	5.2	15.89	15.61	15.76
B ₃	162.2	161.4	161.8	5.73	5.77	5.75	12.57	12.99	12.78	165.5	156.8	161.2	5.0	5.0	5.0	15.36	14.73	15.03
SEm±	5.43	5.30	3.80	0.203	0.192	0.138	0.301	0.412	0.241	5.00	4.17	3.54	0.19	0.22	0.14	0.77	0.60	0.27
CD at 5%	NS	NS	NS	NS	0.67	0.48	1.04	NS	0.84	17.31	14.44	12.25	NS	NS	NS	NS	NS	0.92
CV%	8.73	8.54	6.12	8.90	8.31	6.00	6.00	8.11	4.77	7.46	6.34	5.33	9.54	11.39	7.32	12.89	10.37	4.52

Table-3 : Effect of Boron application on grain and straw yield of mustard during the *Rabi* season of both years *i.e.*, 2017-18 and 2018-19.

Boron levels	Grain Yield (qha ⁻¹)			Straw Yield (qha ⁻¹)			Harvest Index (%)		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
B0	8.3	13.6	11.0	55.3	41.6	48.4	13.0	24.7	18.9
B1	8.9	14.4	11.6	60.3	42.9	51.6	12.9	25.2	19.0
B2	9.3	15.2	12.2	63.4	45.9	54.6	12.8	24.8	18.8
B3	9.84	15.97	12.91	66.92	44.40	55.66	12.83	26.48	19.66
SEm±	0.28	0.46	0.29	1.96	1.55	1.21	0.43	0.76	0.50
CD at 5%	0.81	1.35	0.85	5.71	NS	3.53	NS	NS	NS
CV %	7.97	8.14	6.31	8.28	9.21	5.98	8.62	7.77	6.85

Table-4 : Effect of lime application on grain and straw yield of mustard during the *Rabi* season of both years *i.e.*, 2017-18 and 2018-19.

Lime levels	Grain Yield (qha ⁻¹)			Straw Yield (qha ⁻¹)			Harvest Index (%)		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
L0	9.0	14.8	11.9	61.4	43.3	52.4	12.8	25.5	19.2
L1	9.1	14.7	11.9	61.1	43.3	52.2	12.9	25.4	19.1
L2	9.1	14.8	12.0	61.5	45.5	53.5	12.9	24.5	18.7
L3	9.1	14.8	12.0	61.8	42.6	52.2	12.9	25.8	19.3
SEm±	0.410	0.503	0.354	1.987	0.913	1.088	0.428	0.843	0.471
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	11.73	8.84	7.71	8.40	5.43	5.38	8.63	8.66	6.41

raising pH towards neutrality which helped in increasing boron availability to the plants the same result was found by Sharma (2002) and Jana (2004).

Present results also highlighted that comparatively more growth parameters of mustard was observed non significantly affect among the treatment, may be due to sloppy mountainous topography with high intensity of rainfall often causes extensive soil erosion and heavy losses of plant nutrients, particularly boron and calcium by runoff/leaching (Mandal *et al.*, 1991).

Present results also revealed that basal dose of boron was inductive to vegetative growth and seed yield in silique of mustard to a great extent because boron helps in photosynthesis and growth of meristematic tissues, carbohydrate and auxin metabolism, cell development and differentiation which ultimately increase vegetative growth. Increase in vegetative growth of different crops by boron application was reported by earlier workers Godvandan (1952), Dinger (1962), Venkataratnam (1961), Mishra (1992), and Sharma (1995).

Kumar *et al.* (2018) reported that the grain and straw yield of maize was increased with increasing levels of boron application in red and lateritic soil of Jharkhand, India. Our results also similar findings were observed that the grain and straw yield of mustard was increased with increasing levels of boron applications.

However, lesser grain yield was obtained in 2017

under all the levels of B application compared to corresponding grain yield obtained in 2018. The main reason of lesser grain yields in 2017 may be high leaching of B compared to in 2018. The pooled data also revealed that each incremental levels of B application contributed towards significantly higher yield over the control. Similar results have been reported by various workers (Asad *et al.*, 2000, Khan *et al.*, 2006 and Haldar *et al.*, 2007).

Lime is an important factor in the nutrition of mustard as the crop generally makes its best growth when the soil pH is 6.8-7.0. Lime restricted boron fixation by raising pH towards neutrality which helped in increasing boron availability to the plants. Alone lime application decreased the hot water soluble boron in soil. Thus liming, in general, increased the boron retention capacity of soil as well as helps in total boron uptake. Calcium, a constituent of lime also helps in the growth of meristematic tissues and the functioning of root tips (Sharma, 1995). Positive response of lime application for seed yield attributes has also been reported by Chaudhury and Debnath (2008) and Kushwaha *et al.* (2009).

Conclusions

On the basis of the results obtained in the present experiment, it may be concluded that the growth and yield of mustard was improved with boron and lime fertilization under acidic soil. Application of lime significantly increased the number of branches and silique of mustard and application of boron significantly increased the grain

and straw yield of mustard. Therefore, the application of boron in mustard may play a role in reducing B deficiency in soil and lime restricted boron fixation by raising pH towards neutrality which helped in increasing boron availability to the mustard plants. The optimum improved in growth and yield of mustard was recorded from where boron application at the rate of 3.0 kg ha⁻¹ and lime application 1/5 LR. Hence we can be recommended that boron and lime play an important role in acidic soil of Agro climatic sub zone IVth of VIIth ACZ (Hill and plateau region) of Jharkhand.

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Grouping of Kabuli Chickpea (*Cicer arietinum* L.) Genotypes Based on Plant Morphological Character

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Abstract

The present experiment was conducted at Pulses Research Station, Junagadh Agricultural University, Junagadh, to describe 42 chickpea genotypes using morphological features (stem, plant, seed and yield parameters), chemical tests and seed quality parameters. The genotypes were classified based on their flowering times; early in (15 genotypes) and medium (27 genotypes). The genotypes were divided into two groups based on their growth habits erect (3 genotype) and semi erect (39 genotypes). The genotypes were divided into three (small, medium and large) groups based on leaflet size medium (9 genotypes) and large (33 genotypes). The genotypes were divided into two groups based on peduncle length medium (2 genotypes) and long (40 genotypes). Based on plant height, the genotypes were grouped into three groups short in (11 genotypes), medium (31 genotypes) and tall in (1 genotype). Based on pod size, the genotypes were grouped into small (4 genotypes), medium (28 genotypes) and large (10 genotypes). Based on days to maturity, the genotypes were grouped into two groups early (26 genotypes) and medium (16 genotypes). Based on the number of branches per plant, the genotypes were grouped into high (7 genotypes), medium (33 genotypes) and low (2 genotypes). Number of pods per plant varied significantly among the genotypes number of pod per plant ranged from 17.79 (ICCV-171316) to 25.73 (ICCV-181302) with mean of 21.09. The first pod bearing node varied significantly among the forty-two genotypes and first pod bearing node ranged from 16.59 cm (ICCV-171316) to 28.14 cm (ICCV-171302) with the mean of 21.88 cm.

Key words : Chickpea, characterization, plant, morphology.

Introduction

Chickpea is a self-pollinated true diploid ($2n=2x=16$) crop. It is an ancient cool season food legume crop cultivated by man and has been found in Middle Eastern archaeological sites dated 7500–6800 BC (1). Its cultivation is mainly concentrated in semi-arid environments (2). (3) reported that Southwest Asia and the Mediterranean region being the primary centers of origin, with Ethiopia as the secondary centre. (4) suggested that Anatolia in Turkey was the area where chickpea was believed to have originated. Chickpea is popularly cultivated in sub-tropical and semi-arid to warm temperate regions under dry season.

Chickpea is the fourth largest grain legume crop in the world with a total production of 13.12 million tons from an area of 13.57 million hectare with productivity of 967 kg/ha. Major chickpea producing countries include India, Australia, Pakistan, Myanmar, Ethiopia, Turkey, Iran, Mexico, USA, Canada, Russian Federation and Tanzania (5). About 90 per cent of chickpea in the world is grown under rain fed conditions, where drought is one of the major constraints, limiting its production (6, 7). India is the largest producer of chickpea contributing more than 75 per cent of the world production. In India, during 2018-19,

chickpea was grown in an area of 9.67 million hectare with a production 10.09 million tonnes and productivity of 1043 kg/ha. Madhya Pradesh, Rajasthan, Maharashtra, Andhra Pradesh, Karnataka, Uttar Pradesh, Gujarat, Chhattisgarh and Jharkhand are the major chickpea producing states in the country. In Gujarat Chickpea was grown in area of 0.29 million hectare with a production 0.38 million tonnes and productivity of 1285 kg/ha in Gujarat during 2018-19 (5). For production of high-quality seed, plant morphological characteristics of each variety should be thoroughly understood, so that proper attention could be paid at critical stages of seed production to maintain identity and purity. But unfortunately, most of the currently used morphological characteristics do not fulfil all these criteria. Moreover, varietal characterization is assessed through field plot technique which is tedious, cumbersome, time consuming, seasonal dependent and may be affected by environment.

Materials and Methods

The field experiment was conducted at the Pulses Research Station, Junagadh Agricultural University, Junagadh during 2019-20 to characterize the 42 genotypes of chickpea (*Cicer arietinum* L.) viz., RVSSG-62, ICCV-181310, ICCV-171312, IPCK-175,

Table-1 : Identification and grouping of kabuli chickpea genotypes based on time of 50% flowering, growth habit and leaf let size (mm).

Genotypes	Time of 50% flowering	Group	Growth habit	Leaf let size (mm)	Group
RVSSG-62	60.55	Medium	Semi erect	15.99	Large
ICCV-181310	61.91	Medium	Semi erect	19.57	Large
ICCV-171312	63.43	Medium	Semi erect	19.63	Large
IPCK-175	60.09	Medium	Semi erect	15.69	Large
ICCV-171316	61.64	Medium	Semi erect	17.95	Large
VIHAR	64.63	Medium	Semi erect	14.79	Medium
IPCH -175	51.56	Early	Semi erect	17.95	Large
6 ICCV-181307	57.28	Early	Semi erect	21.21	Large
ICCV-181316	61.50	Medium	Semi erect	16.93	Large
PHULE-G-13315	56.06	Early	Semi erect	14.16	Medium
PG-220	63.53	Medium	Semi erect	14.17	Medium
ICCV-171703	51.15	Early	Semi erect	16.96	Large
HK-1534	54.69	Early	Semi erect	18.04	Large
ICCV-181313	62.73	Medium	Erect	17.90	Large
ICCV-181306	60.55	Medium	Semi erect	15.31	Large
ICCV-171309	65.86	Medium	Semi erect	18.25	Large
ICCV-2	61.23	Medium	Semi erect	15.90	Large
RKGK-13-159	60.72	Medium	Semi erect	14.94	Medium
ICCV-171310	55.24	Early	Semi erect	17.24	Large
NBEG-810	57.28	Early	Semi erect	18.05	Large
GJGK-1617	61.41	Medium	Semi erect	16.94	Large
ICCV-181311	60.82	Medium	Semi erect	18.1 2	Large
ICCV-181312	55.30	Early	Semi erect	18.25	Large
ICCV-181301	47.92	Early	Semi erect	15.96	Large
ICCV-171302	61.23	Medium	Erect	14.62	Medium
ICCV-181305	61.16	Medium	Erect	14.76	Medium
RVSIG-63	56.74	Early	Semi erect	18.02	Large
ICCV-181315	52.65	Early	Semi erect	17.62	Large
ICCV-181304	60.57	Medium	Semi erect	18.37	Large
ICCV-181302	55.10	Early	Semi erect	14.32	Medium
HK-13-103	56.06	Early	Semi erect	14.28	Medium
ICCV-171317	60.55	Medium	Semi erect	17.91	Large
DK-16-313	60.68	Medium	Semi erect	16.80	Large
ICCV-181303	61.91	Medium	Semi erect	14.49	Medium
DL-17-1306	63.29	Medium	Semi erect	15.92	Large
GKL-14306	60.11	Medium	Semi erect	20.29	Large
GJGK-1616	57.28	Early	Semi erect	18.47	Large
KAK-2	60.00	Medium	Semi erect	20.07	Large
RKGK-13-416	55.65	Early	Semi erect	18.62	Large
GNG-2404	60.86	Medium	Semi erect	16.70	Large
ICCV-171306	60.91	Medium	Semi erect	19.29	Large
ICCV-181318	60.14	Medium	Semi erect	18.26	Large
Mean	59.10			17.11	
S.Em ±	2.56			0.71	
C.D. at 5 %	7.31			2.02	
CV %	7.50			7.17	

Note	:	Time of 50% flowering	Note	:	Leaf let size
Early	:	< 60 days	Small	:	< 10 mm
Medium	:	60-80 days	Medium	:	10-15 mm
Late	:	> 80 days	Large	:	> 15 mm

Table-2 : Identification and grouping of kabuli chickpea genotypes based on peduncle length (mm) and plant height (cm).

Genotypes	Peduncle length (mm)	Group	Plant height (cm)	Group
RVSSG-62	17.38	Long	49.40	Medium
ICCV-181310	16.97	Long	43.18	Short
ICCV-171312	17.70	Long	46.88	Medium
IPCK-175	18.87	Long	46.07	Medium
ICCV-171316	17.33	Long	46.97	Medium
VIHAR	15.87	Long	50.18	Medium
IPCH -175	16.77	Long	47.85	Medium
ICCV-181307	9.83	Medium	52.90	Medium
ICCV-181316	17.57	Long	46.00	Medium
Phule-G-13315	16.33	Long	46.88	Medium
PG-220	16.00	Long	44.54	Short
ICCV-171703	16.10	Long	49.01	Medium
HK-1534	15.37	Long	45.61	Medium
ICCV-181313	16.47	Long	60.07	Tall
ICCV-181306	16.53	Long	43.66	Short
ICCV-171309	16.37	Long	46.39	Medium
ICCV-2	9.97	Medium	46.19	Medium
RKGK-13-159	17.40	Long	45.90	Medium
ICCV-171310	16.30	Long	43.28	Short
NBEG-810	14.50	Long	42.50	Short
GJGK-1617	15.70	Long	46.88	Medium
ICCV-181311	20.47	Long	40.55	Short
ICCV-181312	16.00	Long	50.28	Medium
ICCV-181301	20.30	Long	43.57	Short
ICCV-171302	21.33	Long	49.40	Medium
ICCV-181305	16.40	Long	47.95	Medium
RVSIG-63	16.43	Long	49.90	Medium
ICCV-181315	18.37	Long	47.85	Medium
ICCV-181304	16.83	Long	55.27	Medium
ICCV-181302	18.33	Long	46.39	Medium
HK-13-103	16.93	Long	48.14	Medium
ICCV-171317	18.13	Long	51.25	Medium
DK-16-313	15.90	Long	49.01	Medium
ICCV-181303	16.80	Long	44.93	Short
DL-17-1306	16.13	Long	48.72	Medium
GKL-14306	17.17	Long	47.26	Medium
GJGK-1616	18.30	Long	44.64	Short
KAK-2	18.40	Long	47.56	Medium
RKGK-13-416	19.50	Long	42.99	Short
GNG-2404	18.73	Long	45.04	Medium
ICCV-171306	18.93	Long	40.92	Short
ICCV-181318	18.30	Long	47.07	Medium
Mean	16.98		47.12	
S.Em ±	0.80		2.10	
C.D. at 5 %	2.30		6.00	
CV %	8.21		7.72	

Note : Peduncle length (mm)
 Early : (< 5 mm)
 Medium : (5-10 mm)
 Late : (> 10 mm)

Note : Plant height (cm)
 Small : (< 45 cm)
 Medium : (45-60 cm)
 Large : (> 60 cm)

Table-3 : Identification and grouping of kabuli chickpea genotypes based on pod size, days to maturity and number of branches per plant.

Genotypes	Pod size (mm)	Group	Days to maturity	Group	Number of branches per plant	Group
RVSSG-62	16.02	Medium	106.20	Early	4.49	medium
ICCV-181310	17.37	Medium	115.41	Medium	4.33	medium
ICCV-171312	17.10	Medium	114.29	Medium	3.69	low
IPCK-175	16.77	Medium	105.93	Early	4.74	medium
ICCV-171316	14.27	Small	115.11	Medium	4.66	medium
VIHAR	16.83	Medium	120.68	Medium	4.17	medium
IPCH -175	17.20	Medium	95.96	Early	4.66	medium
ICCV-181307	15.47	Medium	107.09	Early	4.69	medium
ICCV-181316	21.23	Large	114.62	Medium	4.68	medium
Phule-G-13315	15.20	Medium	106.66	Early	4.25	medium
PG-220	21.40	Large	110.32	Medium	4.49	medium
ICCV-171703	16.47	Medium	100.55	Early	5.46	high
HK-1534	17.20	Medium	103.70	Early	4.25	medium
ICCV-181313	16.73	Medium	117.01	Medium	5.14	high
ICCV-181306	17.93	Medium	112.77	Medium	4.74	medium
ICCV-171309	16.67	Medium	120.29	Medium	4.98	medium
ICCV-2	20.08	Large	113.83	Medium	4.25	medium
RKGK-13-159	15.00	Medium	100.48	Early	4.41	medium
ICCV-171310	20.50	Large	105.21	Early	4.49	medium
NBEG-810	16.97	Medium	106.46	Early	4.90	medium
GJGK-1617	21.70	Large	107.31	Early	5.14	high
ICCV-181311	17.57	Medium	115.26	Medium	4.33	medium
ICCV-181312	15.68	Medium	100.94	Early	4.33	medium
ICCV-181301	14.83	Small	93.63	Early	4.66	medium
ICCV-171302	16.93	Medium	102.00	Early	4.98	medium
ICCV-181305	17.57	Medium	110.96	Medium	5.14	high
RVSIG-63	21.50	Large	107.62	Early	4.90	medium
ICCV-181315	17.40	Medium	105.17	Early	5.54	high
ICCV-181304	21.37	Large	104.16	Early	4.66	medium
ICCV-181302	16.73	Medium	102.89	Early	4.58	medium
HK-13-103	15.43	Medium	104.57	Early	4.90	medium
ICCV-171317	22.27	Large	111.48	Medium	4.49	medium
DK-16-313	13.57	Small	115.33	Medium	4.66	medium
ICCV-181303	14.37	Small	110.36	Medium	4.82	medium
DL-17-1306	16.57	Medium	103.41	Early	4.74	medium
GKL-14306	16.77	Medium	106.53	Early	4.33	medium
GJGK-1616	16.97	Medium	106.46	Early	3.83	low
KAK-2	17.83	Medium	111.06	Medium	4.58	medium
RKGK-13-416	20.43	Large	109.08	Early	4.74	medium
GNG-2404	15.80	Medium	108.38	Early	5.79	high
ICCV-171306	21.30	Large	105.56	Early	4.90	medium
ICCV-181318	16.20	Medium	103.50	Early	5.58	high
Mean	17.50		108.05		4.69	
S.Em ±	0.79		4.79		0.32	
C.D. at 5 %	2.25		2.94		0.90	
CV %	7.79		7.68		11.68	

Note	:	Pod size	Note	:	Days to maturity	Note	:	No. of branches per plant
Small	:	<15 mm	Early	:	90-110 days	Low	:	1-2 branches
Medium	:	15-20 mm	Medium	:	110-130 days	Medium	:	3-4 branches
Large	:	>20 mm	Late	:	>130 days	High	:	> 4 branches

Table-4 : Identification and grouping of kabuli chickpea genotypes based on number of pods per plant and first pod bearing node.

Genotypes	Number of pod per plant	First pod bearing node (cm)
RVSSG-62	17.99	26.21
ICCV-181310	19.72	16.97
ICCV-171312	21.66	21.98
IPCK-175	19.32	18.13
ICCV-171316	17.79	16.59
VIHAR	18.19	27.57
IPCH-175	21.66	23.90
ICCV-181307	19.12	19.67
ICCV-181316	21.06	17.36
Phule-G-13315	19.79	25.06
PG-220	19.92	21.59
ICCV-171703	21.92	23.52
HK-1534	18.92	21.21
ICCV-181313	19.86	22.36
ICCV-181306	20.79	17.36
ICCV-171309	25.26	19.67
ICCV-2	23.46	18.90
RKKGK-13-159	19.92	19.67
ICCV-171310	20.66	19.28
NBEG-810	21.99	18.51
GJGK-1617	21.52	24.29
ICCV-181311	21.32	25.06
ICCV-181312	23.59	21.98
ICCV-181301	20.86	27.37
ICCV-171302	20.12	28.14
ICCV-181305	21.32	23.90
RVSIG-63	20.52	20.05
ICCV-181315	22.12	26.21
ICCV-181304	24.06	23.52
ICCV-181302	25.73	22.75
HK-13-103	21.52	21.98
ICCV-171317	22.72	21.21
DK-16-313	21.26	18.51
ICCV-181303	22.12	20.82
DL-17-1306	19.92	26.98
GKL-14306	20.59	21.59
GJGK-1616	21.26	25.83
KAK-2	20.12	21.21
RKKGK-13-416	20.59	20.82
GNG-2404	23.39	16.61
ICCV-171306	20.59	21.59
ICCV-181318	21.66	23.13
Mean	21.09	21.88
S.Em ±	1.33	1.03
C.D. at 5 %	3.79	2.94
CV %	10.90	8.15

ICCV 171316, VIHAR, IPCH-175, ICCV-181316, PHULE-G-13315, PG-220, ICCV-171703, HK-1534, ICCV-181313, ICCV-181306, ICCV-171309, ICCV-2, RKKGK-13-159, ICCV-171310, NBEG-810, GJGK-1617, ICCV-181311, ICCV-181312, ICCV-181301, ICCV-171302, ICCV-181305, RVSIG-63, ICCV-181315, ICCV-181304, ICCV-181302, HK-13-103, ICCV-171317,

ICCV-181303, DL-17-1306, GKL-14306, GJGK-1616, KAK-2, RKKGK-13-416, GNG-2404, ICCV-171306, ICCV-181318, based on plant morphological characters. The experiment was conducted as per randomized block design with three repetitions. The recommended agronomical and plant protection package of practices were followed for raising successful crop. The observations were recorded on 5 randomly selected plants for each replication at different crop growth stages. Data were collected on 10 morphological characters. The data obtained from field experiment conducted in RBD were analysed as per standard method suggested by (8).

Results and Discussion

Based on variation in physical characteristics, it was attempted to group the kabuli chickpea genotypes and identify each and every one of them through descriptors. Based on, plant morphological variation, 42 genotypes could be identified from each other (Table-1,2,3 and 4). Based on time of flowering, the genotypes were grouped as early (<60 days) in fifteen genotypes and medium (60-80 days) in twenty-seven genotypes. The flowering time ranged from 47.92 days (ICCV-181301) to 65.86 days (ICCV-171309) with mean of 59.10 days. Based on growth habit, the genotype were grouped in as erect in three genotypes and semi erect in thirty nine genotypes. On basis of leaf let size grouped in medium (10-15 mm) in nine genotypes and large (>15 mm) in thirty-three genotypes. The leaf let size ranged from 14.16 mm (PHULE-G-13315) to 21.21 mm (ICCV-181307) with mean of size 17.11 mm. Based on peduncle length, the genotypes were grouped as medium (5-10 mm) in two genotypes and long (>10 mm) in forty genotypes. The peduncle length ranged from 9.83 mm (ICCV-181307) to 21.33 mm (ICCV-171302) with a mean of 16.98 mm. Based on plant height, the genotypes were grouped as short (<45 cm) in eleven genotypes, medium (45-60 cm) in thirty genotypes and tall (>60 cm) in one genotype. The plant height ranged 40.55 cm (ICCV-181311) to 60.07 cm (ICCV-181313) with a mean of 47.12 cm. Based on pod size, the genotypes were grouped as small (<15 mm) in four genotypes, medium (15-20 mm) in twenty-eight genotypes and large (>20 mm) in ten genotypes. The pod size ranged 13.57 mm (DK-16-313) to 22.27 mm (ICCV-171317) with mean of 17.50 mm. Based on days to maturity, the genotypes were grouped as early (90-110 days) in twenty-six genotypes and medium (110-130 days) in sixteen genotypes. The days to maturity ranged to 93.63 days (ICCV-181301) to 120.68 days (VIHAR) with mean of 108.05 days. Based on number of branches per plant, the genotypes were grouped as low (3-4) in two genotypes, medium (4-5) in thirty-six genotypes and high (5-6) in four genotypes. The number of branches per plant

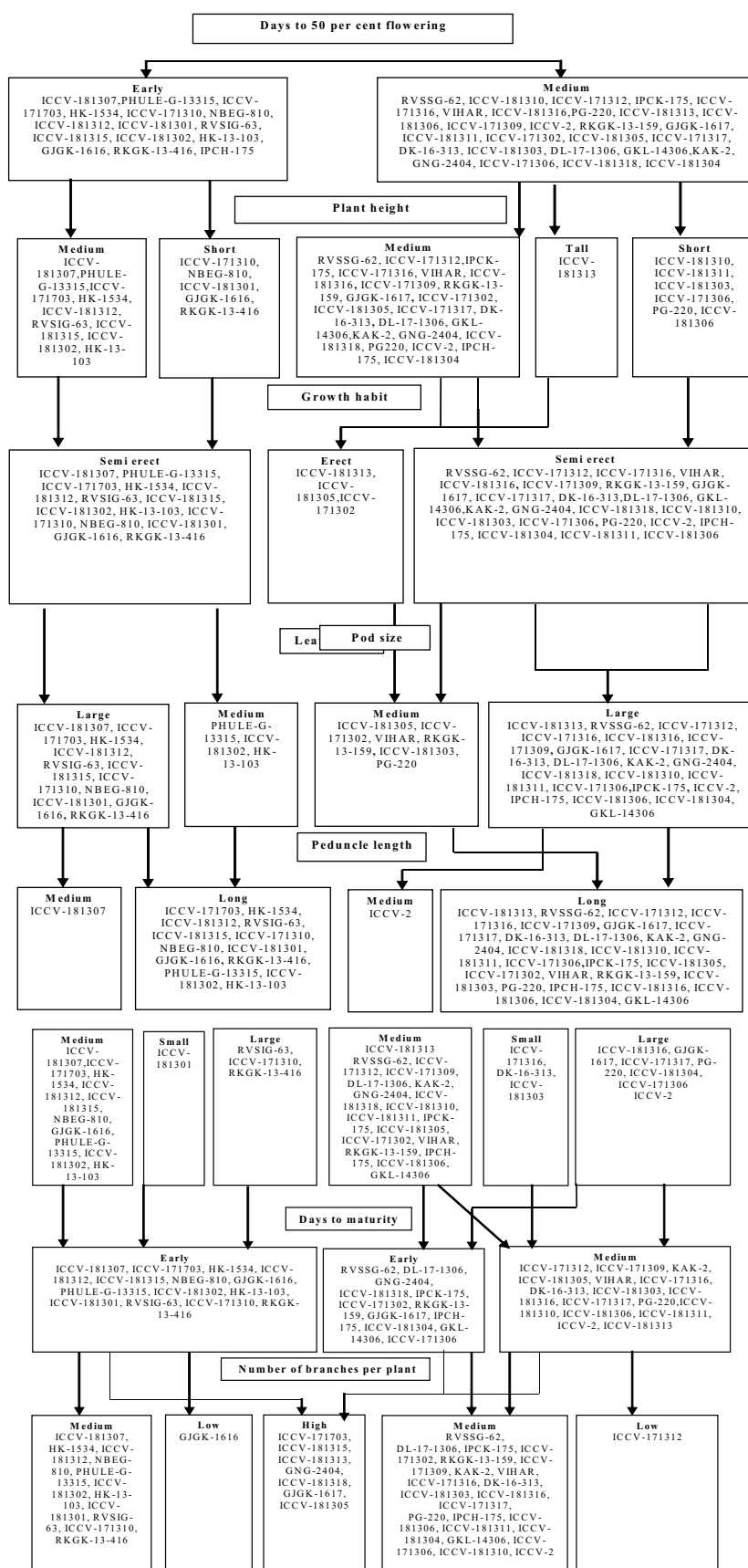


Figure-1 : Kabuli chickpea genotypes identification keys on the basis of plant morphological characters.

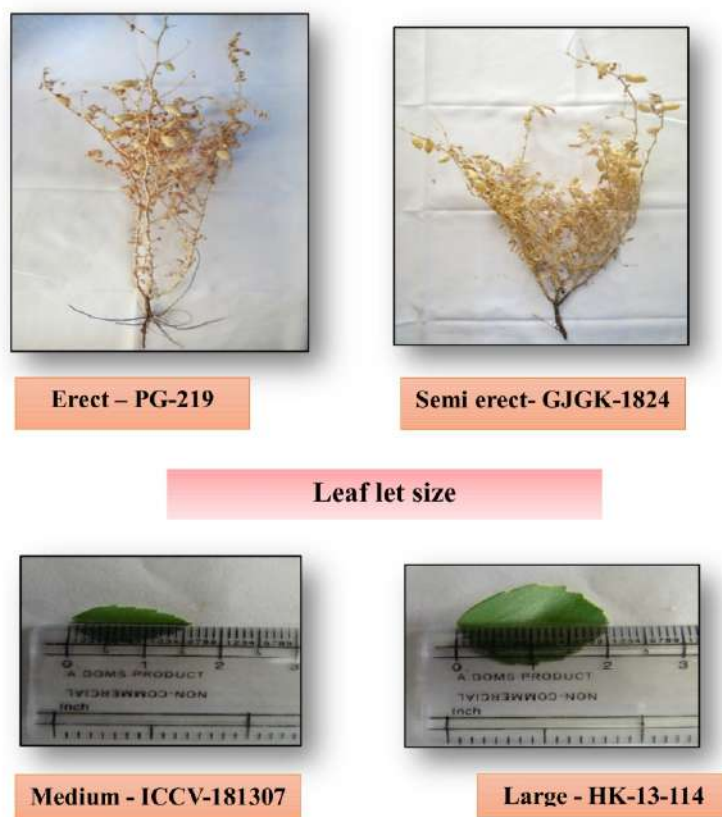


Figure-2 : Growth habit and leaf let size of kabuli chickpea

ranged 3.69 (ICCV-171312) to 5.79 (GNG-2404) with mean 4.69. Number of pod per plant varied significantly among the forty-two genotypes and number of pod per plant ranged from 17.79 (ICCV-171316) to 25.73 (ICCV-181302) with mean of 21.09. The first pod bearing node varied significantly among the forty-two genotypes and first pod bearing node ranged from 16.59 cm (ICCV-171316) to 28.14 cm (ICCV-171302) with mean 21.88 cm.

The plant morphological characteristics helped in identifying and grouping of the genotypes identification keys are presented in figure-1. The genotypes viz, HK-1534, ICCV-181312, having similar morphological character early time of flowering, medium plant height, semi-erect growth habit, large leaf let size, long peduncle length, large pod size, early days to maturity and medium number of branches per plant. The genotype ICCV-171703 differed from above genotypes with respect to high number of branches.

The genotypes RVSSG-63, was depicted medium

time of flowering, medium plant height, semi erect growth habit, large leaf let size, long peduncle length, medium pod size, early days to maturity and medium number of branches per plant, while the genotype ICCV-10113 varied from above genotypes with respect to early time of flowering and early days to maturity. ICCV-181302 varied in early time of flowering and medium leaf let size.

The genotypes ICCV-171310, RKGK-13-416 had short plant height, semi-erect growth habit, large leaf let size, long peduncle length, large pod size, early days to maturity and medium number of branches, while the genotype NBEG-810, ICCV-181301, varied from above genotypes with respect to medium and small pod size and GJGK-1616 had low number of branches.

The genotypes ICCV-181307 and PHULE-G-13315, ICCV-181315 had early time of flowering, medium plant height, semi-erect growth habit, large leaf let size, medium pod size, early days to maturity and medium number of branches, only one-character differed in medium and long peduncle length. Genotype

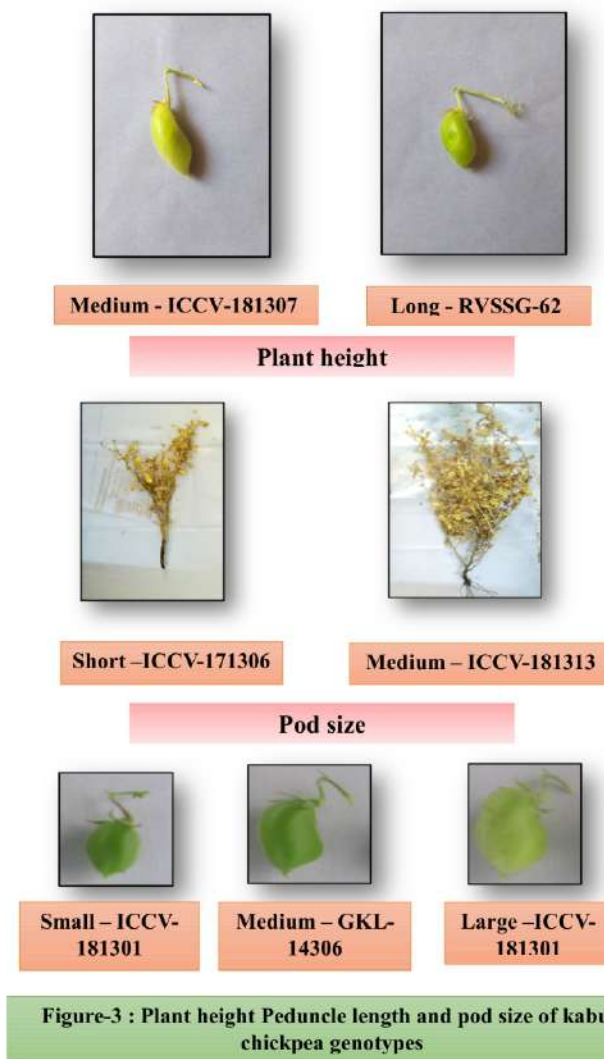


Figure-3 : Plant height Peduncle length and pod size of kabuli chickpea genotypes

ICCV-181315 varied in high number of branches, while the genotype ICCV-171703 varied from above genotypes with respect to long peduncle length and low numbers of branches per plant.

The genotypes ICCV-171312, ICCV-181310 had medium time of flowering, short plant height, semi-erect growth habit, large leaf let size, long peduncle length, medium pod size, medium days to maturity and medium number of branches.

The genotypes DK-16-313 and ICCV-171316 had medium time of flowering, medium plant height, semi-erect growth habit, large leaf let size, long peduncle length, small pod size, medium days to maturity and medium number of branches, while the genotype ICCV-181316 and ICCV-171317 varied from above genotype with respect to large pod size.

The genotypes KAK-2, VIHAR and ICCV-171309 had medium time of flowering, medium plant height, semi-erect growth habit, large leaf let size, long peduncle

length, medium pod size, medium days to maturity and medium number of branches, while the genotype, GNG-2404, GKL-14306 and RVSSG-62 varied from above genotype with respect to early days to maturity.

The genotypes RKGK-13-159 had medium time of flowering, medium plant height, semi-erect growth habit, medium leaf let size, long peduncle length, medium pod size, early days to maturity and medium number of branches, while the genotype DL-17-1306 varied from above genotype with respect to large number of leaf let size.

The genotypes GJGK-1617 had medium time of flowering, medium plant height, semi-erect growth habit, large leaf let size, long peduncle length, large pod size, early days to maturity and medium number of branches.

The genotypes ICCV-171302 had medium time of flowering, medium plant height, erect growth habit, medium leaf let size, long peduncle length, medium pod size, early days to maturity and medium number of

branches, while the genotype ICCV-181305 varied from above genotype with respect to medium days to maturity and high number of branches.

The genotypes ICCV-171306 had medium time of flowering, short plant height, semi-erect growth habit, large leaf let size, long peduncle length, large pod size, early days to maturity and medium number of branches, while the genotype ICCV-181304 varied from above genotype with respect to medium plant height.

The genotypes ICCV-181303 and PG-220 had medium time of flowering, short plant height, semi-erect growth habit, medium leaf let size, long peduncle length, small pod size, medium days to maturity and medium number of branches.

The genotypes ICCV-181306 and ICCV-181311 had medium time of flowering, short plant height, semi-erect growth habit, large leaf let size, long peduncle length, medium pod size, medium days to maturity and medium number of branches.

The genotypes ICCV-181318 had medium time of flowering, medium plant height, semi-erect growth habit, large leaf let size, long peduncle length, medium pod size, early days to maturity and high number of branches. While the genotype, ICCV-181313 varied from above genotype with respect to tall plant height and erect growth habit.

The genotypes ICCV-2 had medium time of flowering, medium plant height, semi-erect growth habit; large leaf let size, medium peduncle length, medium pod size, medium days to maturity and medium number of branches.

The genotypes IPCK-175 had medium time of flowering, medium plant height, semi-erect growth habit, large leaf let size, long peduncle length, medium pod size, early days to maturity and medium number of branches.

Similar findings and grouping of genotypes based on plant morphological characters were made by (9, 10, 11) in chickpea.

Conclusions

From the above discussion, it can be stated that the assessment of genetic purity is an important criterion in seed production programme. Therefore, simple and reliable techniques need to be developed for genetic purity

assessment and variety characterization. The identified morphological characteristics of chickpea genotypes could be utilized in DUS testing, seed production programme and genetic purity testing. The result of chemical test is useful in identifying and grouping of chickpea genotypes and also in genetic purity testing.

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Study of Variability Parameters for Yield and its Attributes to Identify Elite Genotypes of Barley (*Hordeum vulgare* L.)

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Abstract

The field experiment under present investigation was conducted during Rabi 2019-2020 at Agriculture research farm of B.R.D.P.G. College (Campus), Deoria UP. The experiment was conducted to evaluate the correlation and path coefficient for grain yield and its contributing traits in 38 barley genotypes in normal soil under timely sown in Randomized block design in three replications. The observation was recorded on fourteen metric traits viz., days to 50% flowering, flag leaf area (cm²), length of spike (cm), peduncle length (cm), plant height (cm), days to maturity, number of productive tillers per plant, number of spikelets per spike, number of grains per spike, grains weight per spike (g), 1000 grain weight (g), biological yield plant (g), harvest index (%), grain yield per plant (g). The analysis of variance revealed that the variance due to genotypes (treatment) were significant for all the traits under study. The highest variance due to genotypes with highest variance due to phenotypes was observed for number of grains per spike (i.e., 39.90 and 44.12 respectively) followed by plant height (39.78 and 43.94 respectively). The higher values of GCV were noticed for flag leaf area (cm²) (23.08), grain yield per plant (g) (20.40) and biological yield per plant (g) (19.88); while higher values of PCV were noticed for flag leaf area (cm²) (23.44), grain yield per plant (g) (20.64) and biological yield per plant (g) (20.25). High estimates of heritability (>75%) were observed for grain yield per plant (97.96), flag leaf area (96.92), biological yield (96.40), number of productive tillers per plant (95.53), number of Grain per spike (90.42), length of spike (90.14), number of spikelets per spike (89.36), Peduncle length (87.16), harvest index (84.19), and day to 50% flowering (80.49). High estimates of genetic advance in per cent over mean was found for Flag leaf area (46.80) and Grain yield per plant (41.53) and biological yield per plant (40.21).

Key words : Barley, *Hordeum vulgare*, grain yield, heritability, variability and genetic advance.

Introduction

Barley (*Hordeum vulgare* L.) is considered one of the fourth cereal grains after rice, wheat and maize in the world. It is a staple food of the people in Tibet, Nepal and Bhutan. In European countries it is used only as breakfast food. Only 10% of barley is used as Human food, while 50% of barley is used in brewing industries as a raw material. However, the 20% of barley is used for livestock feed. The most important uses of barley in India are as grain feed to livestock and poultry, as malt for manufacture for beer and other liquors like whisky, brandy etc. As a food barley flour is used in preparing 'Chapatis'. Grain is roasted and ground and used as 'sattu'. Grain is also broken and toughly ground into 'pearl' barley to be used in soup. Barley grain contains 11.5 percent albuminoids, 74 percent carbohydrates, 1.3 percent crude fiber and 1.5 percent ash and small quantities of B-complex vitamins, including thiamine (B1), Riboflavin (B2), nicotinic acid and pyridoxine (B6), as well as pantothenic acid, biotin, folic acid and vitamin E (5-6 g./100g.) [Mac Gregor and Fincher 1993]. These components provide valuable nutrient required by human s and also domestic animals.

The availability of genetic variability is the basic pre-requisite for genetic improvement through systematic breeding programme for developing barley varieties. Indigenous and exotic germplasms are the backbone of successful breeding programming for improving yield and yield contributing traits. Nature always favours the plant having much variability in terms of provenances and adaptation across the year and locations. It is true that more diverse plants have greater chances of obtaining high heterotic crosses and broad variability in segregating generations during genetic improvement.

Heritability measures the transmission of the character in the particular environment. High heritability means the trait has less influence of environment. Thus, it acts as a basis for selection. High heritability coupled with high genetic advance indicates that the character is governed by additive gene action. Such studies were reported by different workers (Trehen *et al.* 1970 a), Cecarelli *et al.* 1972, Chauhan *et al.* 1988, Vimal and Vishwakarma 1998, Yadav *et al.* 2004.

Materials and Methods

Field Location : The field experiment under present

Table-1 : Analysis of variance of randomized block design for 14 characters of wheat genotypes.

S. No.	Characters	Source of variance		
		Replication df (2)	Treatment df (41)	Error df (82)
1.	Days to 50% flowering	9.43	54.46**	4.07
2.	Flag leaf area (cm ²)	1.07	64.51**	0.68
3.	Spike length (cm)	0.12	3.25**	0.11
4.	Peduncle length (cm)	2.01	56.89**	2.66
5.	Plant height (cm)	4.69	123.51**	4.16
6.	Days to maturity	2.25	20.89**	2.18
7.	No. of productive tillers per plant	0.03	3.21**	0.05
8.	No. of spikelets per spike	0.19	18.85**	0.72
9.	No. of grains per spike (g)	1.89	123.92**	4.22
10.	Grain weight per spike (g)	1.57	0.31**	0.01
11.	1000 grain weight (g)	5.68	16.37**	1.73
12.	Biological yield per plant (g)	0.31	97.57**	1.20
13.	Harvest Index (%)	0.19	32.23**	1.90
14.	Grain yield per plant (g)	0.66	17.15**	0.14

*, **Significant at 5% and 1% Probability level.

investigation was conducted during *Rabi* 2019-20 at Agriculture Research farm of Baba Raghav Das Post Graduate College, Deoria (U.P.). Geographically, the College is located in the east part of Uttar Pradesh, India. The site of experiment is located at 26.5°N latitude, 83.79°E longitude and 68 meter (223 feet) above the mean sea level. The climate of district Deoria is semi-arid with hot summer and cold winter nearly 80% of total rain fall is received during the monsoon (only up to September) with a few showers in the winter.

Experimental details : The experiment was conducted to evaluate 38 barley genotypes and four checks in normal soil under irrigated conditions following Randomized Block Design in three replications. Each variety consisted of two rows of 2 m length with spacing of 5 cm between plant to plant and 22.5 cm between row to row. All other recommended cultural practices were followed to raise good crops.

Generation of data : Observations on 5 randomly selected competitive plants from each of the advanced lines in each of the replication were recorded for 14 quantitative traits namely days to 50% flowering, flag leaf area (cm²), length of spike (cm), peduncle length (cm), plant height (cm), days to maturity, number of productive tillers per plant, number of spikelets per spike, number of grains per spike, grains weight per spike (g), 1000 grain weight (g), biological yield plant (g), harvest index (%), grain yield per plant (g). The mean data after computing for each character was subjected to standard method of analysis of variance following Panse and Sukhatme, 1988, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were estimated by the

formula as suggested by Burton, 1952, heritability in broad sense (h^2) was estimated by the formula as suggested by Lush, 1949 and genetic advance and genetic advance as per cent of mean by following Johnson *et al.*, 1955a.

Results and Discussion

The result of analysis of variance for Randomized Block Design of experiment involving 38 barley germplasm in three replication and four check was done for each of the 14 characters. The mean square due to replication, treatment and error for all 14 characters are presented in Table-1. The variance due to replications were non-significant for all of the characters at 5% and 1% probability level at 2 df. However, the variance due to treatments were highly significant at 1% probability level at 41 df for all the traits. The character Day to maturity (123.67-134.00) showed highest range, while the minimum range was observed in case of grain yield per spike (1.57-2.78) and second minimum range was observed in case of number of productive (4.07-8.57) The other parameters with high range of variation were plant height (78.39-101.79), days to 50% flowering (72.00-88.33), and number of grains per spike (40.95-71.35), and peduncle length (33.20-52.59).

The highest variance due to genotypes with highest variance due to phenotypes was observed for number of grains per spike i.e. (39.90 and 44.12 respectively) followed by plant height (39.78 and 43.94 respectively). Phenotypic and genotypic variance and phenotypic and genotypic coefficient of variation were computed for 14 characters. The phenotypic and genotypic variances are influenced by unit of measurement of different traits.

Table-2 : Range, mean, genotypic and phenotypic coefficient variation, heritability and genetic advance in percent over mean for 14 characters of barley genotypes.

Genotypes	Range			Variance							
	Mean	Min	Max	Heritability (%)	GA	GA% mean	% CONTRI	GCV (%)	PCV (%)	var (g)	var (p)
Day to 50% flowering	79.05	72.00	88.33	80.49	7.57	9.58	10.12	5.18	5.78	16.80	20.87
Flag leaf Area (cm ²)	19.99	8.83	29.64	96.92	9.35	46.80	6.58	23.08	23.44	21.28	21.95
Length of Spike (cm)	8.18	6.62	10.67	90.14	2.00	24.43	6.46	12.49	13.15	1.04	1.16
Peduncle length (cm)	39.88	33.20	52.59	87.16	8.18	20.50	7.66	10.66	11.42	18.07	20.74
Plant Height (cm)	90.77	78.39	101.79	90.53	12.36	13.62	8.86	6.95	7.30	39.78	43.94
Day to Maturity	128.10	123.67	134.00	74.09	4.43	3.46	10.74	1.95	2.26	6.23	8.42
No. of Productive Tillers	5.47	4.07	8.57	95.53	2.07	37.78	7.29	18.76	19.20	1.05	1.10
No of Spikelet per spike	22.42	17.25	32.25	89.36	4.79	21.35	6.48	10.96	11.60	6.04	6.76
No. of grain per spike	55.65	40.95	71.35	90.42	12.37	22.23	5.02	11.35	11.94	39.90	44.12
Grain weight / spike (g)	2.15	1.57	2.78	93.85	0.63	29.43	5.77	14.75	15.22	0.10	0.11
1000 grain weight (g)	39.95	34.81	48.44	73.79	3.91	9.78	7.41	5.53	6.44	4.88	6.61
Biological Yield / plant (g)	28.51	18.08	45.09	96.40	11.46	40.21	4.96	19.88	20.25	32.12	33.32
Harvest Index (%)	41.01	34.44	47.38	84.19	6.01	14.65	8.69	7.75	8.45	10.11	12.01
Grain yield /plant (g)	11.68	7.08	17.04	97.67	4.85	41.53	3.96	20.40	20.64	5.67	5.81

Therefore, these parameters were made unit free by estimating phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). As GCV represents the heritable genetic component of the total variation, it would be more appropriate to use this parameter for comparing variability of different characters in the present investigation. Relatively higher values of GCV were noticed for flag leaf area (cm)² (23.08), grain yield per plant (g) (20.40) and biological yield per plant (g) (19.88) while higher values of PCV were noticed for flag leaf area (cm)² (23.44), grain yield per plant (g) (20.64) and biological yield per plant (g) (20.25). The low value of GCV along with low values of PCV were recorded for days to maturity (1.95 and 2.26), days to 50% flowering (5.18 and 5.78), 100 grain weight (5.53 and 6.44) and harvest index (7.75 and 8.45 respectively). Difference between GCV and PCV values for the mentioned characters was very broad indicating influence of the environment on the expression of the traits.

The estimate of heritability can be utilized for the prediction of genetic gain, which indicates the genetic improvement that would result from the selection of best individual. Hence, estimate of heritability is an essential pre-requisite for formation of an effective selection method for genetic improvement. High estimates of heritability (>75%) were observed for grain yield per plant (97.96), flag leaf area (96.92), biological yield (96.40), number of productive tillers per plant (95.53), number of Grain per spike (90.42), length of spike (90.14), number of spikelets per spike (89.36), Peduncle length (87.16), harvest index (84.19), and day to 50% flowering (80.49). Moderate heritability (50-75%) was recorded for Day to maturity (74.09), and 1000 Grain weight (73.79), indicating that a plant breeder can concentrate on these traits to exploit effective selection for genetic improvement.

Genetic advance is the improvement in the mean genotypic value of selected individual over the parental population. High heritability accompanied with high genetic advance indicates that the heritability is due to additive genetic effect and selection may be effective, while high heritability coupled with low genetic advance indicates the predominance of non-additive gene action, while low heritability is exhibited due to influence of environmental interactions rather than genotypic selection for such characters may not be rewarding. High estimates of genetic advance in per cent over mean was found for Flag leaf area (46.80) and Grain yield per plant (41.53) and biological yield per plant (40.21). Rest of the characters showed low to moderate genetic advance in per cent over mean. The estimates of broad sense heritability (h²) and genetic advance in per cent over mean (GA) for different characters are given in Table-2.

Conclusions

The study revealed that the grain yield per plant, biological yield per plant, number of grains per spike and harvest index are important selection parameters. Hence a breeder can concentrate more on these traits while planning for a breeding program.

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Effect of Heat Susceptibility Index on Yield and its Components in Bread Wheat (*Triticum aestivum* L. em. Thell.) over Environments

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Abstract

Heat susceptibility index was analysed using a half diallel of ten parents in bread wheat (*Triticum aestivum* L. em. Thell.). Based on HSI the parents Raj 4120, WH 1021 and Raj 4079 and the crosses, Raj 4079 x DBW 17, Raj 4120 x WH 1021 and Raj 4120 x DBW 17 were least affected under late sown (E3). Therefore, these genotypes may be used in the future breeding programme to develop a heat-tolerant wheat variety suitable for warmer areas to maximize production.

Key words : wheat, heat susceptibility index.

Introduction

Wheat was one of the first domesticated food crops and for 8000 years has been the basic staple food of the major civilizations of Europe, West Asia and North Africa. Today, wheat is grown on more land area than any other commercial crop and continues to be the most important food grain source for humans. Its production leads all crops, including rice, maize and potatoes. Wheat is one of the ancient grain crops consumed as primary food by human beings since the dawn of civilization. Among different wheat species, *T. aestivum*, the bread wheat (hexaploid) has the major share of cultivation and *T. durum* or durum wheat (tetraploid) is the second species in some parts of the world. However, *T. dicoccum* is also cultivated in some parts of the world. Global wheat production is expected to reach a new record of 780 million tonnes in 2021, according to a preliminary forecast issued March 4 by the Food and Agriculture Organization of the United Nations. (Anonymous, 2021). China is the largest producer of wheat producer wheat production from about 11% area under wheat. The major wheat-producing countries are India, the United States of America, Russia and Australia. These five countries together contribute more than half of the global wheat production. Less developed countries grow about 110 million hectares and produce about 307 million tons. During the last four decades of the 20th century global wheat production is doubled from 3 to 6 billion mark. Globally, demand for wheat by the year 2021 is forecasted around 950 million tons to meet future demands imposed by population and prosperity growth. This target may be achieved only, if global wheat production is increases 2.5% per annum. This must be achieved under reduced water availability, a scenario

global warming stricter end-use quality characteristics, and evolving pathogen and pest populations. Most of the production growth must occur in developing countries where wheat will be consumed. Breeding wheat cultivars with increased grain yield potential, enhanced water-use efficiency, heat tolerance, end-use quality, and durable resistance to important diseases and pests can contribute to meet at least half of the desired production increases. The remaining half must come through better agronomic and soil management practices and incentive policies.

The cultivation of wheat is limited by the temperature at both ends of the cropping season, and high-temperature stress has a harm productivity. The present-day rice-wheat cropping system, keeping in view of monsoonal irregularities has compelled wheat crops to be subjected to rapidly ascending temperatures coupled with hot, dry winds during the post-anthesis stage, especially during grain development. These unfavourable environments terminate grain growth prematurely and reduce yield considerably. It has already been established that high-temperature stress can be a significant factor in reducing yield and quality of wheat (Stone and Nicolas, 1995); also reported at mean temperature greater than 15-18°C following anthesis can result in decrease in grain weight at maturity. Breeding program for heat tolerance is an integral component of wheat breeding program at both national and international level (Acevedo et al. 1990). These programs will not only help spread to non-traditional warmer areas besides, optimizing and optimise tropical environments under the present situation of multiple-cropping system. Approximately, 3.0 million hectare area on north hectares of western plains zone is exposed to heat stress, which at grain filling stage the synthesis and mobilization of photosynthates and results

Table-1 : Mean of Parents, their F₁s & F₂s for various characters in normal (E₂) and late sown condition (E₃) for 12 characters of Bread Wheat.

Particulars	Days to Heading		Days to Maturity		Plant Height (cm)		Tillers per Plant		Flag Leaf Area (cm ²)		Spike Area (cm ²)	
	E ₂	E ₃	E ₂	E ₃	E ₂	E ₃	E ₂	E ₃	E ₂	E ₃	E ₂	E ₃
Parents	83.09	72.27	123.00	114.93	81.86	69.73	7.25	5.84	23.24	16.64	39.68	35.35
F ₁ s	83.09	71.00	122.40	116.33	80.51	65.23	7.52	5.75	24.84	18.20	41.68	37.20
F ₂ s	80.39	68.36	120.02	114.41	76.31	60.43	6.98	5.08	22.61	17.16	40.54	35.84

Particulars	Spikelets per Spike		Grains per Spike		Grain Yield per Spike(g)		1000-Grain weight(g)		Harvest Index (%)		Grain Yield per Plant (g)	
	E ₂	E ₃	E ₂	E ₃	E ₂	E ₃	E ₂	E ₃	E ₂	E ₃	E ₂	E ₃
Parents	15.17	14.04	42.53	39.54	2.41	1.89	39.50	36.54	43.35	38.19	16.59	11.96
F ₁ s	14.93	13.78	43.81	40.39	2.47	1.84	41.43	37.80	42.72	38.64	21.87	13.56
F ₂ s	14.41	13.17	42.49	39.32	2.27	1.67	40.45	36.84	40.63	36.59	19.78	12.13

in shrivelling of the grains. Hence, there is an urgent need for the introduction of terminal high temperature stress in India to meet the projected target of production of wheat i.e., wheat production, 2020 AD. Modern varieties of wheat varieties to control cultural practices, but they are generally not highly tolerant to extreme environmental stresses, such as high temperature. The varieties of one region are generally not suitable for the unsuitable separate breeding objectives will be needed for each situation (Rajaram 1988). Since plant tolerance to temperature stress is heritable, selection and breeding can be used to improve. The objective of the present study was to select a suitable parent and desirable cross combinations for future breeding programme to develop new set of wheat varieties suitable for heat stress environment to maximize the production in warmer areas.

Materials and Methods

The present investigation aimed to gather information on the genetic basis of yield and its contributing traits in ten diverse genotypes of bread wheat genotype (*Triticum aestivum* L. em. Thell.) viz., Raj 4083, Raj 4037, Raj 4079, Raj 4120, Raj 4238, PBW 343, DBW 17, DBW 621, HD 2967 and WH1021 selected from the germplasm maintained at Rajasthan Agriculture Research Institute, Durgapur, Jaipur, on the basis of based on genetic diversity for major yield components. These selected genotypes were planted at Rajasthan Agriculture Research Institute, Durgapur, Jaipur, for hybridization in diallel fashion excluding reciprocals. The final experiment was laid out in a randomized block design with three replications in 2015. The experiment plot comprised two rows each of parent and F₁ and six row of F₂ of 3 meter length. Row to row and plant to plant spacing was maintained at 30 cm and 10 cm. Recommended uniform agronomical practices were followed for raising the crop in all the three environments. Observations were recorded on twenty randomly selected competitive plants of each

parent and F₁'s and sixty plants in F₂'s in every replication for following traits viz., days to heading, days to maturity, plant height (cm), tillers per plant, flag leaf area, spike area (cm²), spikelet's per spike, grains per spike, grain yield per spike, 1000-grain weight (g), harvest index (%) and grain yield per plant (g). In case of maturity traits (days to heading and days to maturity), the data was recorded on the whole plot basis. The mean of each plot used for statistical analysis. The data were first subjected to the usual analysis followed for a randomized block design for individual environment as suggested by Panse and Sukhatme, 1985. The combining ability analysis was done following Griffing's method 2, Model I (1956).

Results and Discussion

The heat susceptibility index (HSI) was estimated for each character based on E₂ vs. E₃. Heat susceptibility indices of various parents, their F₁s and F₂s for different characters based on E₃, are presented in Table-1. The mean of parent, F₁s and F₂s for different characters decreased under E₃ environment (late sown) in comparison to E₂ environment (normal sown) [Table-1]. The results are in agreement with Singh and Ahmad (1997), Nagrajan and Rane (2002), Rashid et al., (2004), Vivek Raj and Bharadwaj (2004) and Ved Prakash (2007).

Perusal of Table-2 showed that parent PBW343, Raj4238 and Raj4120 for days to heading; WH 1021, DBW 17 and Raj 4037, Raj 4079 and HD 2967 for plant height; WH 1021, DBW 17 and Raj 4120 for tillers per plant; Raj 4238, HD 2967 and DBW 17 for flag leaf area; WH 1021, HD 2967 and DBW 621 for spike area; PBW 343, Raj 4238 and HD 2967 for spikelet's per spike; WH 1021, Raj 4238 and Raj 4120 for grains per spike; Raj 4083, Raj 4079 and Raj 4120 for grain yield per plant; DBW 17, WH 1021 and Raj 4079 for 1000-grain weight; Raj 4238, Raj 4037 and Raj 4083 for harvest index and Raj 4120, WH 1021 and PBW 343 for grain yield per plant were least affected under late sown conditions (E₃). An

Table-2 : Heat susceptibility indices for various characters in E₃ in comparison to E₂ in wheat.

S.No.	Parents/Crosses	Days to headi	Days to maturity	Plant height	Tillers per plan	Flag leaf area (cm ²)	Spike area (cm ²)	Spikelets per spike	Grains per spike	Grain Yield per spike (g)	1000-Grain weight	Harvest index (%)	Grain yield per plant (g)
Parents													
1.	Raj4083	1.11	1.18	1.04	0.96	0.87	1.33	1.15	1.63	0.61	1.11	0.67	1.11
2.	Raj4037	1.12	0.84	0.54	1.17	1.04	0.80	1.06	1.59	1.14	1.00	0.61	1.26
3.	Raj4079	0.99	1.13	0.91	1.09	0.98	1.19	0.93	0.75	0.81	0.90	1.52	0.95
4.	Raj4120	0.98	0.85	1.01	0.81	1.17	1.13	1.38	0.63	0.81	1.05	1.07	0.68
5.	Raj4238	0.96	1.00	1.09	1.05	0.22	1.27	0.70	0.28	1.00	1.10	0.59	0.94
6.	PBW343	0.73	1.02	1.11	1.14	1.28	1.39	0.63	1.08	0.90	1.07	0.84	0.90
7.	DBW17	1.17	0.77	1.15	0.62	0.86	0.78	0.93	1.66	1.26	0.28	1.27	0.98
8.	DBW621	1.15	1.70	0.94	1.20	1.31	0.79	1.22	1.59	0.92	1.00	0.95	1.08
9.	HD2967	0.67	1.30	1.00	1.42	0.70	0.59	0.85	0.88	1.09	0.99	0.86	1.20
10.	WH1021	1.12	0.13	1.16	0.15	0.88	0.72	1.09	0.06	1.21	0.83	1.44	0.72
F₁s													
11.	Raj4083xRaj4037	0.63	0.98	0.83	0.78	1.22	0.49	1.34	1.65	0.90	0.62	1.01	1.07
12.	Raj4083xRaj4079	0.85	1.36	0.88	0.96	1.12	0.27	1.11	0.97	1.23	1.66	1.34	1.12
13.	Raj4083xRaj4120	1.17	1.08	0.96	0.90	1.20	0.28	1.20	1.00	0.69	1.43	1.18	0.84
14.	Raj4083xRaj4238	0.65	0.73	0.84	1.17	1.10	1.01	1.00	0.82	0.66	0.75	1.03	0.91
15.	Raj4083xPBW343	0.65	0.56	0.85	0.94	0.92	0.83	0.72	0.64	0.89	0.84	1.05	1.02
16.	Raj 4083xDBW17	1.02	0.87	0.85	0.95	1.38	1.32	0.63	0.84	1.09	0.85	1.05	0.96
17.	Raj 4083xDBW621	1.02	0.60	0.89	1.25	0.61	1.53	-0.03	1.06	1.14	1.66	1.08	0.92
18.	Raj4083xHD 2967	0.56	0.62	0.96	1.10	1.21	0.53	1.46	1.24	0.98	0.88	0.85	0.98
19.	Raj4083 xWH1021	0.92	0.89	0.94	1.09	1.04	1.08	2.12	0.06	1.09	0.92	0.29	1.19
20.	Raj4037xRaj4079	0.94	0.57	1.00	0.92	1.12	-0.06	1.26	1.17	1.04	1.07	0.81	0.96
21.	Raj4037xRaj4120	0.88	0.96	1.00	1.05	0.69	0.97	1.14	1.19	0.96	1.10	0.80	1.01
22.	Raj4037xRaj4238	0.63	1.00	1.09	1.02	1.31	0.83	1.08	1.12	0.94	0.80	0.50	1.07
23.	Raj4037xPBW343	0.88	0.60	1.00	1.11	1.22	0.97	1.38	0.83	0.98	0.81	0.21	0.93
24.	Raj 4037xDBW17	1.06	0.76	0.88	1.03	0.96	0.41	0.54	0.98	1.04	0.83	0.91	0.92
25.	Raj 4037xDBW621	1.02	1.04	1.08	1.13	1.10	0.42	1.07	1.49	0.94	0.43	1.16	0.95
26.	Raj4037xHD 2967	0.74	1.18	0.93	0.86	1.48	1.01	0.77	1.01	0.97	0.65	1.65	0.96
27.	Raj4037 xWH1021	0.93	0.51	0.78	0.96	1.07	0.25	1.54	0.93	1.04	1.06	1.12	0.87
28.	Raj4079xRaj4120	0.93	0.68	0.97	1.06	1.40	1.00	1.07	1.04	1.14	1.71	0.69	0.99
29.	Raj4079xRaj4238	0.89	1.06	1.17	1.05	1.11	1.01	1.09	0.93	0.97	0.80	0.78	1.06
30.	Raj4079xPBW343	1.04	1.14	1.33	1.06	0.72	0.44	0.62	0.86	1.06	0.93	0.88	1.07
31.	Raj 4079xDBW17	1.02	0.86	1.29	0.78	0.67	1.00	0.25	0.80	0.90	0.72	0.66	0.89
32.	Raj 4079xDBW621	0.93	0.98	1.28	0.55	1.32	0.58	1.02	1.40	1.05	1.61	1.05	0.93
33.	Raj4079xHD 2967	1.16	1.21	1.21	1.12	0.82	1.00	1.22	1.31	1.05	0.78	0.51	1.09
34.	Raj4079 xWH1021	1.00	0.78	1.23	0.56	0.33	0.76	1.23	1.25	1.10	0.71	1.23	0.95
35.	Raj4120xRaj4238	1.19	0.77	1.11	1.30	0.95	1.60	1.01	0.73	0.98	1.13	0.54	1.14
36.	Raj4120xPBW343	1.25	0.77	0.93	0.81	0.82	0.86	0.79	1.07	0.98	1.01	1.03	0.94
37.	Raj 4120xDBW17	0.54	0.71	1.08	0.31	1.18	0.59	0.97	0.94	0.93	1.11	1.00	0.65
38.	Raj 4120xDBW621	1.03	0.83	1.08	1.22	0.81	0.94	0.86	1.20	0.68	1.22	0.75	0.96
39.	Raj4120xHD 2967	1.21	1.19	0.95	1.25	0.94	0.67	1.36	1.03	1.00	0.97	0.87	1.06
40.	Raj4120 xWH1021	1.17	0.51	0.98	0.60	0.57	2.25	0.40	0.96	1.13	0.45	0.90	0.82
41.	Raj4238xPBW343	0.96	1.46	1.10	1.32	0.88	2.26	0.93	1.17	0.90	1.35	0.55	1.21
42.	Raj 4238xDBW17	0.95	1.10	1.16	1.17	0.96	1.81	0.77	1.07	1.06	0.86	1.17	1.04
43.	Raj 4238xDBW621	1.05	0.98	1.21	1.19	0.76	1.46	0.90	1.17	0.81	1.18	1.11	1.05
44.	Raj4238xHD 2967	1.12	1.17	1.15	1.20	0.80	1.56	1.67	0.81	1.08	1.04	0.97	1.08
45.	Raj4238 xWH1021	1.18	1.11	0.93	1.25	0.73	1.50	1.21	0.88	1.04	0.79	1.42	0.88
46.	PBW343 xDBW17	0.84	1.89	1.11	0.63	0.95	1.18	1.14	0.66	1.17	1.25	1.24	1.02
47.	PBW343xDBW621	0.84	1.14	0.87	1.09	0.84	0.67	1.01	0.65	0.82	1.26	1.15	1.00
48.	PBW343xHD2967	1.30	1.43	1.06	1.04	1.20	1.06	1.31	1.42	0.94	1.16	1.51	1.02
49.	PBW343xWH1021	1.31	1.37	0.85	0.68	1.45	1.19	0.64	0.73	1.16	0.00	1.21	1.08
50.	DBW17xDBW 621	1.26	1.44	0.98	1.10	0.78	1.12	0.19	0.52	1.10	1.28	1.36	1.08
51.	DBW17xHD2967	1.39	1.03	0.88	1.01	0.69	0.72	0.47	1.34	0.92	0.82	1.06	0.89
52.	DBW17xWH1021	1.06	1.15	0.71	0.68	0.97	1.46	0.80	1.02	1.05	1.00	1.73	0.83
53.	DBW621xHD2967	1.11	1.49	0.81	1.27	0.92	0.91	1.15	1.12	1.10	1.24	1.13	1.15
54.	DBW621xWH1021	1.20	1.31	0.92	1.00	1.16	1.55	0.82	0.78	1.12	0.81	1.04	1.10
55.	HD2967xWH1021	1.47	0.93	0.81	0.74	1.09	0.77	1.26	1.10	1.04	1.23	1.30	1.10

Table-2 : Contd....

S.No.	Parents/Crosses	Days to headi	Days to maturity	Plant height	Tillers per plant	Flag leaf area (cm ²)	Spike area (cm ²)	Spikelets per spike	Grains per spike	Grain Yield per spike (g)	1000-Grain weight	Harvest index (%)	Grain yield per plant (g)
F₁s													
56.	Raj4083xRaj4037	0.71	1.24	0.93	0.72	1.11	0.70	1.36	1.47	0.89	0.78	0.76	0.83
57.	Raj4083xRaj4079	0.77	1.16	0.74	0.66	0.94	0.27	0.74	0.79	1.30	1.58	1.28	0.97
58.	Raj4083xRaj4120	1.16	1.27	0.88	0.65	0.37	0.19	1.28	1.34	0.87	1.76	1.11	0.94
59.	Raj4083xRaj4238	0.72	0.78	0.88	0.63	1.01	0.85	0.69	1.08	0.63	0.89	1.11	0.75
60.	Raj4083xPBW343	0.75	0.60	0.89	0.91	0.90	0.83	0.56	0.87	0.69	1.00	1.09	0.97
61.	Raj 4083xDBW17	1.05	0.94	0.85	0.87	1.08	1.31	1.14	1.19	1.05	0.80	1.07	0.95
62.	Raj 4083xDBW621	1.07	0.78	0.92	1.00	-0.11	1.39	1.18	0.88	0.99	2.03	1.05	0.78
63.	Raj4083xHD 2967	0.60	0.49	1.04	1.06	0.79	0.46	1.05	1.33	0.80	0.82	0.87	0.94
64.	Raj4083 xWH1021	0.90	0.78	0.93	1.00	0.83	1.04	1.20	0.99	1.00	0.87	0.33	0.81
65.	Raj4037xRaj4079	0.97	0.31	0.91	0.69	1.06	0.20	1.67	0.80	0.86	1.15	0.88	0.86
66.	Raj4037xRaj4120	0.77	1.02	0.87	0.84	0.81	0.78	1.50	1.61	1.33	1.10	0.89	1.07
67.	Raj4037xRaj4238	0.68	0.78	1.15	1.22	1.33	0.61	1.03	0.98	0.78	0.93	0.37	1.05
68.	Raj4037xPBW343	0.85	1.11	1.01	1.05	0.89	0.84	0.85	0.69	0.95	0.70	0.25	0.93
69.	Raj 4037xDBW17	0.34	0.83	0.92	0.92	0.94	0.35	1.02	0.82	1.07	0.69	0.72	1.03
70.	Raj 4037xDBW621	1.06	0.95	1.16	1.15	0.68	0.50	1.08	1.13	1.02	0.38	0.99	0.87
71.	Raj4037xHD 2967	0.89	1.27	0.90	1.21	1.20	0.99	1.37	1.27	0.95	0.84	1.64	1.11
72.	Raj4037 xWH1021	1.01	0.49	0.82	0.92	1.30	0.27	1.21	0.79	1.22	1.01	1.12	1.02
73.	Raj4079xRaj4120	1.06	0.61	0.99	0.93	1.08	0.87	0.58	1.13	1.03	1.24	0.70	1.01
74.	Raj4079xRaj4238	1.15	1.20	1.25	1.35	1.09	0.98	1.03	0.81	1.03	0.88	0.81	0.98
75.	Raj4079xPBW343	1.02	1.18	1.31	0.90	0.42	0.43	0.77	1.17	0.90	0.93	0.88	1.03
76.	Raj 4079xDBW17	1.09	0.98	1.29	0.89	0.67	0.88	0.91	0.87	1.07	0.65	0.66	0.97
77.	Raj 4079xDBW621	1.09	1.23	1.28	0.46	0.40	0.69	1.04	0.96	0.95	1.64	1.08	0.71
78.	Raj4079xHD 2967	1.10	1.00	1.18	0.96	1.30	0.88	1.12	0.93	0.86	0.76	0.62	0.92
79.	Raj4079 xWH1021	1.04	0.90	1.25	0.48	0.76	0.84	0.94	0.94	1.15	0.73	1.24	0.87
80.	Raj4120xRaj4238	1.18	0.84	1.07	1.37	1.18	1.87	1.44	0.48	1.15	1.14	0.58	1.27
81.	Raj4120xPBW343	1.22	0.89	0.94	0.90	0.55	0.79	0.99	0.37	1.07	0.94	1.01	1.00
82.	Raj 4120xDBW17	0.50	0.88	1.04	0.58	1.03	0.97	1.04	1.13	1.03	1.09	1.10	0.93
83.	Raj 4120xDBW621	1.06	0.72	1.11	1.21	1.03	0.89	1.07	0.79	0.86	1.26	0.76	1.13
84.	Raj4120xHD 2967	1.19	1.24	0.97	1.29	1.25	0.56	1.10	0.96	0.92	1.01	0.94	1.11
85.	Raj4120 xWH1021	1.12	0.61	0.97	1.29	0.95	2.33	0.76	0.94	0.93	0.41	0.90	1.00
86.	Raj4238xPBW343	0.98	1.30	0.96	1.50	1.47	2.35	1.15	0.97	1.03	1.42	0.54	1.22
87.	Raj 4238xDBW17	0.93	1.25	1.16	1.16	1.46	1.64	0.67	1.05	0.92	0.80	1.09	1.06
88.	Raj 4238xDBW621	1.10	1.00	1.21	1.24	1.06	1.34	0.53	1.30	0.84	1.07	0.98	1.12
89.	Raj4238xHD 2967	1.15	1.11	1.21	1.08	1.48	1.53	1.19	1.21	0.99	1.25	1.08	1.06
90.	Raj4238 xWH1021	1.10	1.01	0.93	1.10	0.96	1.49	0.92	1.50	1.17	0.86	1.42	1.10
91.	PBW343 xDBW17	0.98	1.72	1.08	0.88	0.95	1.27	0.74	1.08	0.85	1.36	1.31	1.05
92.	PBW343xDBW621	0.81	1.11	0.89	1.06	0.91	0.71	0.45	0.82	0.97	1.42	1.19	1.10
93.	PBW343 xHD2967	1.18	1.21	0.91	1.06	1.01	1.14	1.21	1.29	0.90	1.10	1.44	1.03
94.	PBW343xWH1021	1.23	1.35	0.85	0.90	1.11	1.51	1.08	1.18	1.11	0.54	1.01	0.90
95.	DBW17xDBW 621	1.28	1.29	0.94	1.22	0.80	1.31	0.52	0.56	1.16	1.27	1.37	1.15
96.	DBW17xHD 2967	1.37	1.12	0.75	0.92	1.20	0.84	0.52	0.83	1.21	0.69	1.53	0.91
97.	DBW17xWH1021	1.00	1.18	0.76	0.79	1.25	1.13	0.76	0.70	1.03	0.76	1.69	0.95
98.	DBW621 xHD2967	1.07	1.22	0.97	1.21	1.05	0.95	0.94	1.04	1.00	0.17	1.09	1.16
99.	DBW621xWH1021	1.18	1.07	1.00	0.97	1.24	1.17	0.59	0.90	1.14	0.85	1.03	1.07
100.	HD2967xWH1021	1.43	0.89	0.85	1.06	1.06	1.11	1.55	1.19	1.21	1.15	1.34	1.14

hIS : <0.5 Highly heat tolerant, 0.51-0.75 Heat tolerant, 0.76-1.00 Moderately heat tolerant, 1.0 Susceptible to heat stress.

Table-3 : Heat Stress intensity (D-value) for various characters in parents, F₁ and F₂ in Bread Wheat.

Particulars	Days to Heading	Days to Maturity	Plant Height (cm)	Tillers per Plant	Flag Leaf Area (cm ²)	Spike Area (cm ²)
	D value	D value	D value	D value	D value	D value
Parents	0.13	0.07	0.19	0.24	0.28	0.11
F ₁ s	0.15	0.05	0.19	0.24	0.27	0.11
F ₂ s	0.15	0.05	0.21	0.27	0.15	0.12

Particulars	Spikelet's per Spike	Grains per Spike	Grain Yield per Spike(g)	1000-Grain weight(g)	Harvest Index (%)	Grain Yield Per Plant(g)
	D value	D value	D value	D value	D value	D value
Parents	0.07	0.07	0.22	0.08	0.12	0.28
F ₁ s	0.08	0.08	0.25	0.09	0.10	0.38
F ₂ s	0.09	0.07	0.26	0.09	0.10	0.39

overall appraisal indicated that Raj 4120, WH 1021 and PBW 343 were found to be good parents for grain yield per plant based on heat susceptibility index (HSI). Among the F₁ crosses, Raj 4120 x DBW 17, Raj 4037, Raj 4083 x Raj 4238 and Raj 4083 x PBW 343 for days to heading; Raj 4120 x WH 1021, Raj 4083 x PBW 343 and Raj 4083 x DBW 621 for days to maturity; DBW 17 x WH 1021, Raj 4037 x DBW 17 and HD 2967 x WH 1021 for plant height; Raj 4120 x DBW 17, Raj 4079 x DBW 17 and Raj 4079 x WH 1021 for tillers per plant; Raj 4120 x WH 1021, Raj 4079 x DBW 17 and Raj 4238 x HD 2967 for flag leaf area; Raj 4037 x Raj 4079, Raj 4083 x Raj 4079 and Raj 4037 x DBW 17 for spike area; Raj 4083 x DBW 621, Raj 4079 x DBW 17 and Raj 4037 x DBW 17 for spikelet's per spike; Raj 4083 x WH 1021, DBW 17 x DBW 621 and Raj 4083 x PBW 343 for grain per spike; Raj 4083 x Raj 4238, Raj 4120 x DBW 621 and Raj 4238 x DBW 621 for grain yield per spike; Raj 4120 x WH 1021, Raj 4083 x Raj 4037 and Raj 4079 x WH 1021 for 1000-grain weight; Raj 4037 x PBW 343, Raj 4083 x WH 1021 and Raj 4083 x Raj 4037 for harvest index and Raj 4120 x DBW 17, Raj 4120 x WH 1021 and DBW 17 x WH 1021 were least affected under late sown condition (E3). In general Raj 4079 x DBW 17, Raj 4120 x WH 1021 and Raj 4120 x DBW 17 were found good general combiner for grain yield per plant based on heat susceptibility index. Among the F₂ crosses, Raj 4037 x DBW 17, Raj 4120 x DBW 17 and Raj 4083 x HD 2967 for days to heading; Raj 4083 x HD 2967, Raj 4037 x Raj 4079 and Raj 4079 x Raj 4120 for days to maturity; Raj 4083 x Raj 4079, Raj 4083 x DBW 17 and Raj 4037 x WH 1021 for plant height; Raj 4079 x DBW 621, Raj 4083 x Raj 4238 and Raj 4083 x Raj 4120 for tillers per plant; Raj 4079 x DBW 621, Raj 4079 x PBW 343 and Raj 4120 x PBW 343 for flag leaf area; Raj 4083 x Raj 4120, Raj 4083 x Raj 4079 and Raj 4037 x WH 1021 for spike area; PBW 343 x DBW 621, DBW 17 x DBW 621, DBW 17 x HD 2967 and Raj 4238 x DBW 621 for spikelet's per spike; Raj 4120 x Raj 4238, Raj 4120 x PBW 343 and DBW 17 x DBW 621 for grains per spike; Raj 4083 x Raj 4238, Raj 4037 x Raj

4238 and Raj 4083 x HD 2967 for grain yield per spike; Raj 4037 x DBW 621, Raj 4120 x WH 1021 and PBW 343 x WH 1021 for 1000-grain weight; Raj 4037 x PBW 343, Raj 4083 x WH 1021 and Raj 4037 x Raj 4238 for harvest index and Raj 4079 x DBW 621, Raj 4083 x Raj 4238 and Raj 4083 x WH 1021 for grain yield per plant were least affected under late sown condition (E3). In general, the crosses Raj 4079 x DBW 17, Raj 4120 x PBW 343 and Raj 4083 x WH 1021 were found to be good F₂ crosses for grain yield per plant based on HSI.

In order to determine relative tolerance, the heat susceptibility index [Table 2] was estimated for various characters. Based upon the value and direction of desirability, ranking was done for different genotype. Hence, as highly heat tolerant (HSI < 0.50), Heat tolerant (HSI: 0.51-0.75), moderately heat tolerant (HSI: 0.76-1.0) and heat susceptible (HSI > 1.00). An overall appraisal revealed the parent, The Raj 4120 and WH 1021; F₁ crosses Raj 4079 x DBW 17, Raj 4120 x WH 1021 and Raj 4120 x DBW 17 and F₂ cross Raj 4079 x DBW 17, Raj 4120 x PBW 343 and Raj 4083 x WH 1021 for grain yield per plant were least affected under late sown condition. High grain yield of a genotype under late sown condition indicated the presence of genes for heat tolerance. Comparison across the generations indicated that the crosses Raj 4083 x DBW 17 and Raj 4083 x WH 1021 immersed as highly heat tolerant in F₁ and heat tolerant in F₂ for grain yield per plant.

If we considered D value i.e. heat stress intensity [Table-3] it was revealed that days to heading, days to maturity, spikelet's per spike, grains per spike, 1000 grain weight, spike area and harvest index were less affected by late sown condition, while grain yield per spike, harvest index, tillers per plant and grain yield per plant and flag leaf area highly suffered under E3 environment. This indicated that grain yield depends on harvest index and per spike. Comparison across the generations indicated that the crosses Raj 4079 x DBW 17, Raj 4120 x

PBW 343 and Raj 4083 x WH 1021 were good under late sown condition (E3). Heat stress intensity (D value) [Table 3] related that days to maturity, spikelet's per spike, grains per spike, 1000-grain weight and spike area were less affected by late sown condition (E3), while plant height, flag leaf area, tillers per plant, grain yield per spike and grain yield per plant highly suffered under late sown condition (E3).

Similar result, were also reported by Blum et al., (1997), Ved Prakash (2007), Singh et al., (2011) and Ram et al., (2014) emphasized that selection for high biomass yield should bring about positive improvement in grain yield and 1000- grain weight. Thus, Biomass yield could be improved by plant height. In the present investigation, plant height significantly contributed to biomass because less plant height (D=0.09, 0.15 and 0.17 for parents, F1s and F2s respectively) in the E3 environment. Thus, selection for biomass yield is one of the most important ways to improve the productivity under late sown condition.

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Incidence of Stem Rot of Rice (*Sclerotium oryzae* Catt.) in Major Rice Growing Regions of Andhra Pradesh, Telangana and Tamil Nadu

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Abstract

A survey of stem rot of rice disease was carried out and incidence was assessed in major rice growing areas of Andhra Pradesh, Telangana and Tamil Nadu during *Kharif* 2019. Incidence of disease was varied among the locations. In Andhra Pradesh the incidence varied from 0.00 per cent to 12.92 per cent with highest mean per cent disease incidence of 12.92 per cent which was recorded in Karapa mandal of East Godavari district and lowest mean per cent disease incidence (2.70 %) was recorded in Chennur mandal of Y.S.R Kadapa district of Andhra Pradesh. In Telangana the incidence varied from 1.02 per cent to 4.39 per cent with highest mean per cent disease incidence of 4.39 per cent was recorded in Gollapalli mandal of Jagityal district and lowest mean per cent disease incidence (1.02 %) was recorded in Munagala mandal of Suryapet district. In Tamil Nadu the incidence varied from 0.00 per cent to 4.11 per cent with highest mean per cent disease incidence of 4.11 per cent was recorded in Kumbakonam block of Thanjavur district and the lowest incidence of 0.00 per cent was recorded in Devakottai block of Sivagangai district of Tamil Nadu. Incidence was observed among all the prominent cultivars belongs to their particular region. The output of present study regarding incidence of disease will help in the prioritizing the research and extension work in the management of the disease.

Key words : Incidence, rice, *Sclerotium oryzae*, stem rot.

Introduction

Cereals are one of the important foods for growing population of human. Approximately 50 per cent of consumed calories by the whole population of humans depend on wheat, rice and maize, as an important component of food security rice contributes to a major proportion of dietary calories (21% of energy and 15% of protein) for the population in developing countries (Gnanamanickam, 2009). Rice serves as a staple food for more than two-thirds of the world's population. It is the second most cereal crop cultivated around the world and serves as the important food source for Asian countries (Zibae, 2013).

Rice production is affected by a number of biotic and abiotic factors, widespread cultivation of few high-yielding nitrogen-responsive varieties with narrow genetic base replacing the mosaic of local land races and traditional crop varieties has resulted in unabated spread and epidemic development (Keneni *et al.* 2012). Recently, the intensity and profile of rice diseases has been impacted by changes in several climatic parameters, especially temperature, relative humidity and rainfall pattern,

changes in cropping pattern and intensity, increased use of inputs, changes in varietal composition in a particular region and widespread cultivation of few selected high-yielding varieties (narrow genetic base) (Laha *et al.*, 2017). Diseases once considered minor are becoming major constraints in rice production. One of those diseases is stem rot incited by *Sclerotium oryzae* causing substantial quantitative and qualitative losses due to increased lodging, smaller panicles, production of light chalky grains and poor milling quality particularly in waterlogged areas. About 1–5 per cent grain deterioration and 18 per cent yield loss was reported due to fungal invasion mostly by *Magnaporthe salvinii* in rice in almost all rice producing countries of the world. Grain yield losses up to 50 per cent, 75 per cent and 80 per cent have been reported from Vietnam, the United States and Philippines, respectively (Ou, 1985). Other estimates of grain yield loss include 27–30 per cent in Iraq (Al-Heeti and El-Bahadli 1982), 6–53 per cent in China (Li *et al.*, 1984) and 10–30 per cent in Australia (Cothier and Nicol, 1999). In India, annual losses of 5–15 per cent have been estimated with a maximum of 80 per cent (Paracer and Luthra, 1944). This disease was also reported to be the

Table-1 : Incidence of stem rot of rice in major growing states of Southern India.

State	District	Mandal/Block	Cropping sequence	Variety	Latitude	Longitude	Range of per cent disease incidence	Mean per cent disease incidence (%)
Andhra Pradesh	East Godavari	Ramachandrapuram	Paddy-paddy	MTU7029	16.892394	82.138213	8.82-8.93	8.88
		Karapa	Paddy-paddy	MTU7029	16.857899	82.174592	12.53-13.30	12.92
		Pedapudi	Paddy-paddy	MTU7029	16.947382	82.120527	7.61-7.73	7.69
		Undi	Paddy-paddy	MTU1121	16.575580	81.483700	8.73-8.82	8.63
	West Godavari	Akividu	Paddy-paddy	MTU1061	16.585362	81.440357	11.91-12.61	12.29
		Kalla	Paddy-paddy	MTU1061	16.566131	81.485895	5.52-5.81	5.81
		Penumantra	Paddy-paddy	MTU7029	16.630841	81.745666	8.62-8.85	8.74
	Kurnool	Velugodu	Paddy-pulses	BPT5204	15.733388	78.565198	2.53-3.57	2.84
		Pamulapadu	Paddy-pulses	NLR34449	15.836549	78.525798	2.18-3.45	2.82
		Nandyal	Paddy-pulses	NKR34449	15.479498	78.449265	4.83-5.32	5.08
	YSR Kadapa	Khazipet	Paddy-pulses	NLR34449	14.644158	78.778837	3.65-3.72	3.69
		Chennur	Paddy-pulses	NLR34449	14.560661	78.778761	2.59-2.81	2.70
	Nellore	Buchireddypalem	Paddy-paddy	BPT5204	14.505863	79.902212	4.37-5.12	4.72
		Kovur	Paddy-paddy	NLR34449	14.520680	79.986310	4.19-4.21	4.20
		Atmakur	Paddy-paddy	NLR34449	14.617649	79.922749	3.93-4.20	4.00
Telangana	Jogulamba Gadwal	Rajoli	Paddy-pulses	BPT5204	15.895930	77.828299	1.73-2.37	2.05
		Itikyall	Paddy-pulses	RNR15048	16.127595	77.891530	1.87-2.13	2.00
	Jagityal	Gollapalli	Paddy-pulses	RNR15048	18.769457	79.076165	3.79-4.99	4.39
		Dharmagiri	Paddy-pulses	RNR15048	19.009414	79.053736	3.35-3.74	3.55
Tamil Nadu	Suryapet	Munagala	Paddy-paddy	BPT5204	17.029710	79.881048	0.66-1.37	1.02
		Kumaratchi	Paddy-pulses	DRR Dhan 42	11.364198	79.711264	1.31-3.73	2.52
		Melbhuvanagiri	Paddy-pulses	Swarna Sub I	11.450115	79.601200	3.35-3.58	3.47
		Virudhachalam	Paddy-pulses	Co51	11.631748	79.248370	1.60-1.82	1.71
	Tiruvarur	Nannilam	Paddy-pulses	ADT38	10.969302	79.657052	1.74-2.80	2.25
		Papanasam	Paddy-pulses	ADT38	11.102016	79.561573	1.89-3.93	2.91
	Thanjavur	Kumbakonam	Paddy-pulses	ADT38	10.873971	79.168080	4.00-4.21	4.11
		Sivagangai	Paddy-pulses	MDU5	9.975725	78.935335	0.00-0.00	0.00

major constraint for paddy cultivation in Telangana in recent years (Gopika *et al.*, 2016, Prameela *et al.*, 2021).

The disease appears in the form of small irregular black lesions on the outer leaf sheath near the water level at mid-tillering stage. As the season advances, the lesions enlarge and the fungus moves inward, producing lesions on the inner leaf sheaths. Subsequently, the fungus infects the culms, resulting in partial or complete rotting and premature lodging of the crop. Severely infected plants bear partially filled or unfilled grains. Dark greyish mycelium may be found within the sheath and culm, which is converted into numerous small, round and black sclerotia near maturity serves as the initial source of inoculum (Ferreria and Webster, 1976)

The information on its distribution and potential yield loss is available from Northern and North eastern India, but from rice growing regions of Southern India is limited. Therefore, present investigation was undertaken to study the disease incidence in different rice growing regions of Andhra Pradesh, Telangana and Tamil Nadu.

Materials and Methods

Roving survey was conducted in different rice ecosystems, viz., irrigated, rainfed, tank fed, bore wells,

low lying and upland ecosystems during *Kharif* 2019 in major rice growing areas of Andhra Pradesh, Telangana and Tamil Nadu. Prominent rice growing areas were chosen for assessment of disease, per cent disease incidence (PDI), stage of the crop, variety grown, cropping pattern were recorded. Samples showing typical symptoms of stem rot disease were collected in butter paper covers to avoid saprophytic contamination, brought to the plant pathology laboratory of ICAR- Indian Institute of Rice Research and stored for further studies. Observations were recorded in four one-meter square areas randomly in each field by walking diagonally starting from South west corner. The disease in observed fields was expressed as per cent disease incidence (PDI).

Potato dextrose agar (PDA) medium was used for isolation and maintenance of fungal pathogens associated with stem rot disease of rice. The plants showing typical symptoms of stem rot collected during the survey were used for isolation of pathogen. Pathogens from the test samples were isolated by tissue segment method (Rangaswami and Mahadevan, 1999). The infected stem portion was surface sterilized with one per cent sodium hypochlorite followed by rinsing with three changes of sterile distilled water, air dried in the laminar

Table-2 : Mean percent stem rot incidence among rice cultivars of Andhra Pradesh, Telangana and Tamil Nadu.

zVariety	Range of per cent disease incidence	Mean per cent disease Incidence (%)
MTU7029	7.61-12.92	9.70
MTU1121	8.34-8.73	8.63
MTU1061	5.52-12.61	9.05
BPT5204	0.66-5.12	2.88
NLR34449	2.18-5.32	3.79
RNR15048	1.87-4.99	3.31
DRR Dhan 42	1.31-3.73	2.52
Swarna Sub I	3.35-3.58	3.47
Co51	1.60-1.82	1.71
ADT38	1.74-2.80	2.25
MDU5	0.00-0.00	0.00

and finally, the sterilized portions were made into small bits and plated on PDA. The plates were incubated at $28\pm 2^{\circ}\text{C}$ and observed for the growth of the pathogens. The pathogen culture was purified by hyphal tip method and maintained on PDA slants by periodical transfer throughout the present investigation. Identification of the fungi isolated was done by comparing them with available published literature and manual (Barnett, 1962).

Results and Discussion

A roving survey was conducted from milk stage to mature grain stage of rice among different cropping systems for the incidence of stem rot disease during *khariif*-2019 in major rice growing areas of Andhra Pradesh, Telangana and Tamil Nadu (Figure-1, Table-1). The results on the disease incidence revealed that, among the five districts surveyed in Andhra Pradesh the mean per cent disease incidence (PDI) varied from 0.00 per cent to 12.92 per cent. The highest mean per cent disease incidence (PDI) of 9.53 per cent was recorded in East Godavari district. It was followed by West Godavari, Nellore, Kurnool and Y.S.R Kadapa with mean PDI of 8.95, 4.31 and 3.58 per cent respectively. The lowest mean stem rot disease incidence of 3.20 per cent was recorded in Y.S.R Kadapa district. The highest stem rot incidence of 12.92 per cent was recorded in Karapa mandal of East Godavari in a range of 12.53 to 13.30 per cent followed by 12.29 per cent in Akividu mandal of West Godavari in a range of 11.91 to 12.61 per cent, Ramachandrapuram mandal (8.88 % PDI with 8.82 to 8.93 % range) of East Godavari, Penumantra mandal (8.74 % PDI with 8.62 to 8.85 % range) of West Godavari and Undi mandal (8.63 % PDI with 8.73 to 8.82 % range) of East Godavari district. The lowest incidence was recorded in Chennur (2.70 % PDI with 2.59 to 2.81 % range) of Y.S.R Kadapa followed by Pamulapadu (2.82 % PDI with 2.18 to 3.45 % range), Velugodu (2.84 % PDI with 2.53 to 3.57 % range) of

Kurnool and Khazipet (3.69 % PDI with 3.65 to 3.72 % range) of Y.S.R Kadapa.

The results on the disease incidence revealed that, among the three districts surveyed in Telangana the mean per cent disease incidence (PDI) was varied from 1.02 per cent to 4.39 per cent. The highest mean per cent disease incidence (PDI) of 2.03 per cent was recorded in Jogulamba Gadwal district followed by Jagityal (2.00 %). The lowest mean stem rot disease incidence of 1.02 per cent was recorded in Suryapet district. The highest stem rot incidence of 4.39 per cent with a range of 3.79 to 4.99 per cent was recorded in Gollapalli mandal of Jagityal district followed by Dharmagiri (3.55 PDI with 3.35 to 3.74 % range) of Jagityal district. The lowest incidence of 1.02 per cent was recorded in Munagala mandal of Suryapet with a range of 0.66 to 1.37 per cent followed by Itikyal (2.00 % PDI with 0.66 to 1.37 % range) of Jogulamba Gadwal and Rajoli (2.05 % PDI with 1.73 to 2.37 % range) of Jogulamba Gadwal district.

The results on the disease incidence revealed that, among the four districts surveyed in Tamil Nadu the mean per cent disease was varied from 0.00 per cent to 4.11 per cent. The highest mean per cent disease incidence (PDI) of 3.51 per cent was recorded in Thanjavur district followed by Cuddalore (2.57%) and Tiruvarur (2.25%). The highest stem rot incidence of 4.11 per cent with a range of 4.00-4.21 was recorded in Kumbakonam block of Thanjavur district followed by Melbhuvanagiri block (3.47 % PDI with 3.35 to 3.58 % range) of Cuddalore and Papanasam block (2.91 % with 1.89 to 3.93 % range) of Thanjavur district. The lowest mean stem rot disease incidence of 0.00 per cent was recorded in Devakottai block of Sivagangai district followed by Virudhachalam block (1.71 % PDI with 1.60 to 1.82 % range) of Cuddalore and Nannilam block (2.25 % PDI with 1.74 to 2.80 % range) of Tiruvarur district.

Stem rot incidence was highly varied among the cultivars when compared with the locations. The highest mean incidence of 9.70 per cent with a range of 7.61 to 12.92 per cent was observed in cultivar MTU-7029. This was followed by MTU1061 (9.05 %) in a range of 5.52 to 12.61 per cent and MTU1121 (8.63 %) in a range of 8.34 to 8.73 per cent. The lowest mean incidence was recorded in MDU5 (0.00 %) followed by Co51 (1.71 %) and ADT 38 (2.25 %). The ascending order of the remaining cultivars regarding the mean disease incidence was recorded as DRR Dhan 42 (2.52 %) ? BPT 5204 (2.88 %) ? RNR 15048 (3.31 %) ? Swarna Sub I (3.47 %) ? NLR 34449 (3.79 %) (Table-2). The crop sequence played an important role in reducing stem rot incidence as maximum stem rot incidence of 7.17 per cent was recorded in paddy-paddy sequence when compared to the minimum



Black lesions on the stem near waterline

Sclerotia inside the culm

Figure-1 : Symptoms of stem rot of.

stem rot incidence of .88 per cent in paddy-pulses sequence. A total of 36 *Sclerotium oryzae* isolates were isolated from the disease samples collected during the survey.

The present results on the incidence of stem rot disease in different agro climatic zones of Andhra Pradesh, Telangana and Tamil Nadu are in accordance with Pramesh *et al* (2017) and who surveyed for the incidence of stem rot in different rice growing taluks of North-eastern Karnataka and reported the mean disease incidence of 12.35 to 29.55 per cent during *Kharif* 2014 and it was 4.78 to 14.33 per cent during *Kharif* 2015, the incidence was present in all cultivated varieties. In the same way Gopika and Jagadeeshwar (2017) surveyed for stem rot incidence in Khammam and Warangal districts of Telangana and reported that incidence was varied from field to field (0 to 15%) and from location to location. Production oriented survey for the occurrence of stem rot of rice conducted by ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad in different states of India, Andhra Pradesh (IIRR, Production oriented survey reports, 2004, 2006, 2007, 2008) varied from 0 to 15 per cent.

Stem rot disease of rice is an emerging threat for rice cultivation in India. It has been reported in late 1990s from North Eastern India (Singh and Devi, 1999) and later from other rice growing states of the country (Kumar *et al.*, 2003; Pramesh and Guruprasad, 2014; Sumitra *et al.*, 2014; Chethana and Kumar, 2019). The disease is favoured by high N fertilizers (Keim and Webster, 1974a), low potassium, high relative humidity, high temperature and water logging conditions. The disease is more in early planted crop because of high temperature and relative humidity coinciding with the susceptible stage of the crop. Stem rot is more serious in fields that have been in

continuous rice for several years. Wounding of plants caused by lodging, insect attack or other factors directly effects the incidence of disease in the field (Hsieh, 1966; Ike and Watanabe, 1953 and Kobari, 1961). Plants are most susceptible to initial infection at the inter-node elongation stage and infection at this stage usually results in the most severe infection.

The intensity and geographical spread of stem rot disease has significantly increased over the years in certain rice growing regions of India. During 1981-1990, the disease was more or less sporadic and was recorded in low to moderate intensities but not severe intensity in some areas in Andhra Pradesh (undivided) and Haryana. During 1991-2000, the disease spread to states like Assam, Bihar, Gujarat, Himachal Pradesh and some regions of West Bengal. Severe occurrence of the disease was recorded from Kullu district in Himachal Pradesh during 1991 and from Ferozepur district of Punjab in 1991. During 2001-2014, the spread and intensity of the disease drastically increased in Andhra Pradesh (undivided) and Haryana with many reports of its increased severity. The disease also spread in low to moderate form in other states like Punjab, Uttar Pradesh and West Bengal. The disease is not much prevalent in Karnataka. However, in the year 2012, the disease was reported in severe form from districts of Bellary, Raichur and Koppal (Laha *et al.*, 2016). Konthoujam and Chhetry (2005) reported that the disease is wide spread in mono cropped rice growing regions of Manipur and may eventually become endemic and wide spread sooner or later. Erratic rainfall, especially late season rainfall leading to watery stagnation, cyclonic condition causing lodging or injury to the plants, increase in the minimum temperature, changes in varietal profile, monocropping and increased application of fertilizers especially nitrogen

could be some of the probable reasons for its increased occurrence.

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Impact of Conservation Tillage on Different Soil Properties – A Review

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Abstract

Human efforts to produce more food to feed an ever-growing population have degraded the sustainability of the environment and consequently the agricultural production systems. Tillage is one of the most fundamental components of agricultural production systems since it affects soil processes, characteristics and crop growth, all of which have an impact on agricultural sustainability. However, conventional tillage in the form of intensive tillage has exacerbated soil erosion, poor physical soil properties, degraded fertility of the soil and contributed to climate change by causing loss of soil organic carbon. Meanwhile, conservation tillage comes out as an effective approach to prevent soil degradation and promote soil fertility and has been adopted widely throughout the world. Zero tillage (ZT), minimum tillage, ridge tillage, mulch tillage and contour tillage are all examples of conservation tillage. As compared to intensive tillage-based systems, no-till has generally enhanced soil physical qualities. The presence of crop residue mulch and dearth of soil disturbance in case of the no-tillage system may increase aggregation, saturated hydraulic conductivity, and reduce runoff, which are important parts of the soil-plant-water continuum and also help to increase soil organic matter (SOM) content. All these benefits related to minimum tillage and residue cover in turn help to make soil biologically active and improve its fertility. This review article provides an insight into conservation tillage and its impacts on soil properties, including some constraints faced for its adoption.

Key words : Conservation tillage, crop residues, intensive tillage, soil properties.

Introduction

Tillage may be defined as the mechanical manipulation of soil for crop production and it has a great impact on soil qualities like water conservation, temperature, infiltration, and evapotranspiration. This indicates that ploughing affects the soil to produce a crop, and hence has an environmental impact (Busari *et al.*, 2015). With the use of heavy machinery for agricultural output, soil quality is changing regularly. As a result, we need to find a long-term tillage solution. It has been observed that conventional tillage (CT) affects soil properties in a negative way. As a result, we must anticipate conservation tillage (CST). The conservation tillage, along with certain harmonizing strategies like covering the soil and crop diversification (Corsi *et al.*, 2012), has emerged as a viable alternative for ensuring sustainable food production while also maintaining integrity of environment. Lal (1990) defines conservation tillage as a seedbed preparation approach that incorporates the presence of residue mulch and an increase in surface roughness as critical criteria. CST is an environmentally friendly method of managing soil surface and seedbed preparation. Reduced erosion of soil, improved soil-water conservation and fewer tillage operations are all reasons for CST's popularity. It

preserves or increases yields, preserving soil and water while increasing profit margins. CST's beneficial impacts, on the other hand, may take many years to manifest. Different from either continuous CT or continuous CST, the transition period from CT to CST may display unusual features. Due to the variable tillage intensities and infiltration features, tillage techniques alter soil physical attributes in diverse ways. Surface residues left behind from ZT systems help to regulate temperature and moisture changes while reducing evaporation and runoff (Blevins and Frye, 1993). Additionally, the adoption of the ZT system creates a new ecosystem. Conversion from CT to ZT often enhances available water capacity, infiltration rate and discharge, while lowering costs. The goal of this review is to investigate the effects of CST on soil properties to provide farmers and other land users with information on how to use the CST system to achieve sustainable crop yields while minimizing negative impacts on the soil and environment.

Types of Conservation Tillage

The Conservation Tillage Information Center (CTIC) defines conservation tillage as any tillage and planting method that covers 30 % or more of the soil surface with crop residue after planting in order to reduce water erosion. ZT, minimum tillage, ridge tillage, mulch tillage

and contour tillage are all examples of CST. The term “no-tillage (NT)” refers to the practice of leaving the soil untouched from harvest through planting, except plant nutrition application (Singh and Kaur, 2012). Any tillage technique that disturbs less than 25 % of the row width by planting equipment is termed a NT system. Farmers have benefited from lower costs, higher yields and more revenue, as well as improved soil health and environmental purity. Herbicides are the most common method of weed management however, cultivation can be utilized in an emergency. The soil is prepared or tilled in mulch tillage so that plant wastes or other detritus cover the surface as much as possible. Planting crops in rows along both sides or on top of ridges produced at the start of the cropping season is known as ridge tillage. When tillage is done at a right angle to the slope’s direction, it is known as contour tillage. Reduced tillage is a seedbed preparation technique that leaves 15 to 30 % residue cover after planting, or 500 to 1000 kg ha⁻¹ of small grain residue equivalent, for the critical wind erosion phase.

Effect of Conservation Tillage on Soil Properties

Soil Physical Properties

The soil physical properties are influenced by surface as well as internal drainage, clay composition and quantity, climate, physiography, motor traffic, and soil & crop management strategies. NT systems, according to Lal (1997), have better soil physical attributes than tillage based systems. Many studies have revealed that NT greatly increases saturated as well as unsaturated hydraulic conductivity due to the continuity of pores or water flow via a small number of large holes. CST, particularly NT, has been demonstrated to work successfully in well-drained soils having light to medium texture and low SOM content (Liao *et al.*, 2021; Nebo *et al.*, 2020).

Soil structure and Soil aggregation

Improved soil fertility, increased agronomic production, improved porosity and decreased erodibility all require a favourable soil structure and strong aggregate stability. Soil aggregation is a critical component of soil fertility, production and the global carbon cycle. Root growth, water and carbon cycling, and erosion resistance are all influenced by soil aggregation. In the plots under CT and ZT, Bhattacharyya *et al.* (2006) found that the volume proportion of macropores (effective pore diameter > 30 mm) and pores drained freely with gravity (effective pore diameter > 150 mm) was non-significant. They also found that the ZT plots had a greater volume percentage of transmission pores (150–30 mm) in the 0–15 cm soil layer than the CT plots. The ZT plots were found to have a greater proportion of smaller storage holes (30–0.5 mm)

than the CT plots. He *et al.* (2009) discovered that CST plot soils had more macro-aggregates (13–37%) throughout the soil profile than those from regular tillage plots. In CT soils, the percentage of micro-aggregates was 25–59 % higher. Tillage-induced SOC changes and soil faunal activity must be examined concerning the impact of tillage practices on soil structural features. Increased SOC content in the ZT system’s surface layer may result in improved aggregate stability. Many elongated desiccation fractures were seen on the surface of the CT plot, but none were apparent on the CST plot (Wahl *et al.*, 2004). This could be attributed to the fact that the CST plots had a larger surface covering of plant/crop residues and a higher water retention due to a higher number of medium-sized pores.

Bulk density and Compaction

Bulk density (BD) is known soil physical metric that is commonly used to determine the compactness of the soil. Bhattacharyya *et al.* (2006) investigated the impact of tillage on soil characteristics in the Indian Himalayan rice-wheat system. They observed that following rice harvest, zero-tilled plots were more compact, while after wheat harvest, compaction levels were lower at both soil depths (0-15 cm and 15-30 cm). Soil BD assessed after the rice crop was greater in the ZT plots than the CT plots in the 0–15 cm soil depth, but it was non-significant in the CT plots after wheat harvest (Singh and Kaur, 2012). The non-disturbance of the soil matrix, which resulted in less total porosity than tilled plots, may explain the much greater value of soil BD following rice harvest in the surface soil layer under ZT plots. When compared to CT and reduced tillage soils, BD in the upper layer of NT soils increased, resulting in a decrease in the number of coarse pores, and resistance did not change with increasing soil depth under NT, whereas resistance decreased with increasing soil depth under ploughing in the upper soil zone (Tebrugge and During, 1999). In contrast to this lower BD, some researchers have discovered that practicing NT over CT with time reduces BD (Zhang *et al.*, 2009; Jabro *et al.*, 2021). Higher SOM content and better aggregation owing to agricultural residue retention, boosted soil organic carbon and biotic activity which might explain the lower BD in NT system.

Soil hydraulic conductivity and infiltration

Through lowering surface sealing and decreasing velocity of runoff, residue mulch or partial inclusion in soil by CST has also been proven to promote infiltration. K_{sat} was higher after wheat harvest than after rice harvest (Bhattacharyya *et al.*, 2006). The rise in K_{sat} following wheat harvest might be attributable to a reorganization of soil pores and the formation of more continuous macropores in the investigated soil depths. After rice and

wheat harvest, the laboratory computed K_{sat} values in the 0–15 cm soil depth under the ZT system were higher than those in the tilled plots. Tillage in the surface soil layer induced the disintegration of soil aggregates and the reduction of non-capillary pores, resulting in a decrease in K_{sat} . In this situation, the activity and abundance of soil organisms may have also played a role in pore continuity. Because there were more soil fauna and previous crop root canals in the ZT system, the pores were more continuous. Hydraulic conductivity has been shown to improve up to eight-fold in ZT stubble maintained treatments compared to treatments where stubble was burned away.

Soil aeration/air permeability

Air permeability is a measurement of how easily air convection occurs through the soil in response to pressure gradients. Air turbulence above the soil surface can create pressure gradients, allowing air to move through tilled soil layers, particularly if the pores are larger than 5 mm (Kimball and Lemon, 1971). Only if there is a continuous network of air-filled pores, there will be airflow. In NT, air permeability decreases when soil BD increases immediately under the tillage depth (Rasmussen, 1999). The physical behavior of the soil, root penetration and water transport are all influenced by its porosity. The soil porosity of various tillage treatments is now one of the hotspots in tillage research. Long-term NT crop production techniques, according to Golabi *et al.* (1995), improve aeration porosity (equivalent pore diameter > 60 mm) and total porosity of the soil. The favourable effect of SOM provided by low tillage and residue cover is most likely responsible for the increase in soil porosity under CST. Increased porosity is particularly significant for crop development since it has the potential to improve soil aeration and root growth. CST can impact soil porosity in the top 0–10 cm of the soil layer, increasing soil porosity from wheat sowing through overwintering, while loosening the soil by fall tillage. The enhanced porosity on the CST plots was mostly attributable to increased macroporosity and mesoporosity (He *et al.*, 2009). In CST plots, macroporosity and mesoporosity were 14 percent (significant at P 0.05 level) and 4.6 percent higher, respectively, in the 0–10 cm soil layer, whereas microporosity was 5.9% lower than standard tillage plots.

Soil strength and stability

The term 'strength' refers to the amount of stress (force per unit area) that soil can withstand before irreversibly deforming. The capacity to maintain a cohesive structure in the presence of free water is referred to as 'stability.' If soil is to maintain its structure in the face of forced forces, it must have strength and stability. These imposed stressors might be natural, such as the impact of

raindrops, or human, such as those caused by automobile traffic. A problem with soil is that it can't be too strong otherwise, plant roots and other creatures won't be able to penetrate. At all three sites, Hill *et al.* (1990) reported that soil strength increased with decreased matric potential for both tillage techniques. At each given matric potential, NT soils exhibited stronger soil strengths, and the absolute difference between the two tillage methods grew as the matric potential at each site decreased. For a particular matric potential, the relative soil-strength disparities (ratio of NT to CT) declined as the matric potential fell (Yu *et al.*, 2020).

Soil temperature

Low soil-surface temperatures caused by agricultural residue deposition (Gupta *et al.*, 1989) can stymie emergence and seedling development in NT systems. CST resulted in lower maximum soil temperatures than CT, especially during the first 4–6 weeks following planting (Singh *et al.*, 2019). Mean soil temperature was similar amongst tillage systems in the advanced stages of both crops. In the early stages of maize and wheat growth, the mean soil temperature was lower under NT, negatively influencing the early corn and wheat growth (Fabrizzi *et al.*, 2005). The highest soil temperature in CT was greater than NT, while the lowest soil temperature in both tillage regimes was identical. The thermal amplitude of NT was smaller than CT. The variations in soil temperature across tillage regimes were caused by the buildup of soil surface residue. The crop residues' strong sun reflectance and low heat conductivity avoid temperature rise under NT. Due to changes in maximum temperature, the thermal amplitude was lower under NT, even though the lowest temperature was comparable in both NT and CT. Surface residues in ZT systems help to keep the temperature down (Blevins and Frye, 1993). Lower soil temperature during CST has been linked to higher water content in the topsoil and more plant remains on the soil surface, resulting in less evaporation (Rasmussen, 1999).

Soil moisture content

During no-till, the soil water content of the surface soil (0–7.5 cm) was substantially greater than under CT (Alhameid *et al.*, 2019). NT system left more plant residues on the soil surface, resulting in reduced evapotranspiration, increased soil water content in the top (0–10 cm) soil layer, and less runoff (Rasmussen, 1999). Surface residues leftover from a ZT method help to regulate moisture changes, reducing evaporation and runoff (Blevins and Frye, 1993). According to Lopez-Fando *et al.* (2007), paraplow had a substantial effect on the soil volumetric moisture content of the surface layer. In November and February 2003, zone tillage increased soil moisture content across NT and CT at the 0–50, 50–100,

and 100–200 mm depths, but there was no obvious effect in June 2003. According to Fabrizzi *et al.* (2005), NT enhanced soil water storage during the critical corn growth stage, as well as for the majority of the wheat growing season. In a three-year NT experiment having silt loam soils on the Baishang Plateau in Hebei province, Rong (2004) found that NT enhanced soil water content by 4% (0–20 cm) and spring wheat production by 3% when compared to CT. He *et al.* (2009) reported that average soil water storage in the 0–30 cm layer on CST plots (59 mm) was nearly 10% higher than on standard tillage plots (54 mm) during the experiment period. Soil water storage in CST plots rose by 8 mm on average during the drought years of 2003, 2006, and 2007.

Soil erosion

The topsoil is the principal source of fertility in many soils. Soil erosion is the loss of the top layer of soil due to water, air, and other forces (Klik and Rosner, 2020). Direct loss of soil fertility occurs when surface-applied fertilisers or accessible plant nutrients adhering to soil particles are removed. Because of crop residue cover and improved aggregate stability under ZT, conversion from CT to ZT reduced erosion and prevented surface sealing, protecting soil fertility (Rasmussen, 1999). The most popular definition of CST is any tillage and planting strategy that keeps at least 30% of the soil surface covered with residues after planting to prevent water erosion. When wind erosion is a major problem, the system must keep a flat small grain residue equivalent of 1.1 Mg ha⁻¹ on the surface during the crucial wind erosion period. A year-round CST method typically entails lowering the number of passes over the field and tillage intensity, as well as avoiding ploughing (soil inversion) that absorbs residues into the soil mass (Chaudhary *et al.*, 1985). CT & NT in particular causes changes in the distribution of organic pools in the soil. CST technology improve water conservation by reducing evaporation losses and preventing soil loss by providing protective crop residue cover on the soil surface (Selvakumar and Sivakumar, 2021).

Soil Chemical properties

According to Lal (1997), the surface layer chemical characteristics of the NT technique are often better than those of extensively tilled soil.

Soil nitrogen, phosphorus, potassium

Tillage and crop rotation had no significant effects on inorganic soil NO₃-N, but crop rotation x soil depth and tillage x soil depth interactions had significant effect (Ashraf *et al.* 1999). The interaction of crop rotation x soil depth was unsurprising and it was produced by a smaller quantity of nitrogen (N) in the 0- 30 cm depth in barley in

1992 than in other crops. N in the CST treatment's surface layers may have been immobilized owing to residue breakdown since higher residue remained on the soil surface (Doran, 1980). Increased surface residue-induced N immobilisation is a short-term problem that can be easily solved by adding extra N during the CST establishment phase. Variations in SOC values collected after the first growing season demonstrated that the CT systems had much lower SOC concentration in the top layer (0–50 mm) than the NT and ZT systems (Lopez-Fando *et al.*, 2007). SOC variations were most likely due to the reduced tillage intensity associated with NT and ZT. Available N, P and K all followed the same pattern as SOC. After the first growing season, P and K stocks were higher under NT and ZT in terms of available nutrients, but this effect was not seen at the conclusion of the second year (Fabrizzi *et al.*, 2005).

Soil pH

Although soil pH was lower in NT systems than CT, the tillage method has been demonstrated to have no effect on soil pH (Rasmussen, 1999; Rahman *et al.*, 2008). Yadav *et al.* (2021) reported that the pH of NT soil was considerably lower (p 0.05) than conventionally tilled soil at 4 locations for at least one sampling depth. These NT samples had a pH of 5.0 to 5.6 (0.01M CaCl₂), which was 0.2 to 0.4 pH units lesser than the CT samples. NT in Kentucky had a pH of 6.0 on the surface (0-7.5 cm) soil, which was much higher than CT (pH 5.7) (Doran, 1980). This increase was due to a higher surface concentration of lime with NT than with CT, due to the application of 6.72 metric tons ha⁻¹ of agricultural limestone on the surface. The nitrification of surface-applied N fertilizer is the primary cause of acidification. The best strategy to prevent soil from acidification is returning crop residues to the soil and crop residue application elevated pH considerably (Karlen *et al.*, 1994).

Soil organic carbon content

CST strategies have been demonstrated to preserve higher levels of SOM than regular tillage systems, particularly at the surface (D'az-Zorita and Grove, 2002). Water-soluble carbon is one kind of TOC that makes up a minor percentage of total TOC in soil. However, it is widely acknowledged that this fraction has an impact on biological activity in the soil. CST soil gathers agricultural residues and, as a result, increases organic carbon in the soil, with a focus on the most superficial layer. The organic C and Kjeldahl N contents of surface soil (0-7.5 cm) with NT were 1.25 and 1.20 (25 and 20%) times greater than traditionally tilled soil, respectively (Doran, 1980). In contrast, in CT treatment, frequent and extensive tillage and residue removal led to considerable SOM loss. The short-term (10-year) impacts of SOC management is

complicated and vary depending on soil variables such as climate, soil texture, cropping system, and crop residue type, as well as the management itself (Munoz *et al.*, 2007). In terms of available nutrients, P and K stocks were higher under NT and ZT after the first growing season, but this effect was not noticeable at the end of the second year. The greater levels of C and N under NT were consistent with prior observations on these plots as well as those observed by other researchers in a variety of locales (Jat *et al.*, 2019; Hati *et al.*, 2021).

Soil organic matter content

In short-term field studies, it may be difficult to detect changes in SOM as a result of new management practices (Alvarez and Alvarez, 2000). After four years in semi-arid Inner Mongolia, Qin *et al.* (2007) found that SOM and accessible P and K were up to 10% greater under NT than regular tillage down to 10 cm deep. According to He *et al.* (2009), the average SOM in the 0–5 cm soil layer for the three CST treatments (NT, ST, and RT) was 17.9 g kg⁻¹, which was significantly greater than the 14.3 g kg⁻¹ recorded on the CT plot. In the deeper layers, the SOM difference between CST and CT decreased, but was remained substantial at 20 cm depth. NT and shallow-tilled plots have greater SOM contents than traditionally tilled plots, according to Gosai *et al.* (2009). Plant residues left over the soil surface during yearly NT, may aid to enhance organic matter in the topsoil.

Soil Biological properties

It is undeniable that the improvement in soil aeration increase the growth of the aerobes responsible for organic matter mineralization and so extensive tillage reduces soil humus content (Rasmussen, 1999). Much greater earthworm population in NT soil than in ploughed soil. Surface-feeding earthworms were more active as a result of the reduced tillage (Demetrio *et al.*, 2020). CST appears to be the most viable long-term alternative to traditional agriculture for addressing CT's negative agro-environmental effects, such as soil biodiversity loss. However, under diverse tillage techniques, soil biological characteristics have received very little research (Madejo'n *et al.*, 2007). CST would be beneficial since it would increase SOM and fertility while also improving soil microbial functioning.

Soil Microbial biomass

Soil microbial parameters including microbial biomass and soil enzymes have been utilized to forecast soil biological conditions and the influence of agricultural management on soil quality (Eivazi *et al.*, 2003). Researchers reported a considerable increase in overall soil microbial biomass and activity due to the application of NT to previously tilled soils in long-term studies (fourteen years) (Melero *et al.*,

2009; Li *et al.*, 2018). DHA has been considered as a sensitive biomarker of microbial activity changes since it depends on the metabolic status of the soil biota (Parit *et al.*, 2019). Because DHA employs oxygen and other chemicals as terminal electron acceptors, the oxidative capability of the whole soil microflora should be reflected in this enzyme. DHA similarly responded to tillage treatments as soil organic C, rising under CST and indicating improved soil oxidative capacity (Kumar *et al.*, 2018). For all soil profiles studied, the greatest levels of protease were reported in minimal tillage and NT practiced areas. found that the connections between microbial populations and tillage were quite similar to the associations between soil water, C, and N levels. NT soil has much greater microbial populations at the surface (0-7.5 cm) than traditionally tilled soil. NT soil had 1.35 and 1.57 times (35 and 57 percent) greater total aerobic and facultative anaerobe counts, respectively than conventionally tilled soil (Gupta *et al.*, 2022).

Constraints

Implementation of CST depends on the region's climatic characteristics, soil properties, levels of crop residues, and types of cropping systems. Few constraints include difficulty in control of weeds, specific and suitable machinery, soil specificity and other requirements for cropping systems. Reasons for non-adoption of CST system are summarized as follows :-

- (a) Dearth of information on CST
- (b) No or few farms are practicing CST which could serve as a demonstration.
- (c) Little knowledge of extension workers about the system.
- (d) Higher costs of implements used in CST systems.
- (e) Inputs and credits are unavailable due to a lack of access (for purchase of CST implements).
- (f) Preventing risks (fear of failure or wrong application of the new technique in the absence of guidance phase).

Conclusions

Intensive tillage continues to degrade soils, endangering food security and the livelihoods of millions of agricultural families throughout the world. CST appears to be a realistic strategy for protecting soils from the negative consequences of intense tillage while also having good effects on soil physicochemical and biological features, according to our review. However, because these effects are site-specific and have a long-term effect, research of long-term trials is required for a better understanding.

Furthermore, various flaws have resulted in a lower adoption of CT. As a result, socio-economic concerns should always be taken into account when choosing one practice over another. Government cost-share schemes for CST equipment adjustments and purchases should be adopted.

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Effect of Plant Growth Regulators on Fruit Retention, Productivity and Biochemical Constituents in Guava (*Psidium guajava* L.) Fruits

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Abstract

Plant growth hormones influence fruit size, diameter and shape, appearance and biochemical constituents etc. Growth regulators like SA, GA₃ and NAA affect flower and fruit setting, cell growth, apical dominance, geotropism and photoperiod. The pre-harvest sprays of growth regulators and minerals are the new practices adopted nowadays for higher fruit production and improved fruit quality. The present investigation was conducted at Fruit Research Station, Imalia, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, (M.P.) during 2020-21. The studies was carried out 7 treatments with 3 growth regulators (GA₃, NAA and Salicylic Acid) in two concentrations (100 and 150 ppm) of each. The investigation was conducted on 8 years old guava plants in Randomized Block Design with four replications. On the basis of results in the present investigation found that yield attributes are significantly influenced by the application of Salicylic Acid 100 ppm and GA₃ 150 ppm. Application of Salicylic Acid @ 100 ppm obtained maximum number of flower/shoot, fruit set %, No. of fruits/plant, yield per plant, minimum days taken to harvest of fruits and all biochemical quality attributes viz maximum T.S.S., Ascorbic acid, total Sugar, reducing Sugar, non reducing Sugar and minimum Acidity percent also recorded under 100 ppm Salicylic Acid. Maximum fruit length, fruit width, fruit weight, fruit volume, pulp percentage and pulp weight was recorded under application of GA₃ @150 ppm.

Key words : GA₃, guava, NAA and salicylic acid.

Introduction

Guava (*Psidium guajava* L.) is the important fruit crop across India, belongs to the myrtaceae family. Its origin is tropical America, although cultivation has expanded to almost all the tropical and subtropical countries and become especially important in India (Samson, 1980). Guava fruit is the rich and cheap source of vitamin C and pectin (Agnihotri, 1962). In India it is cultivated since early 17th century. Guava is the fourth most widely grown fruit crop in India, guava cultivation in 2019-20 was recorded 292,000 hectares of land across the country with production 43, 61,000 metric tonnes (Anonymous, 2019-20). India is the major producer of guava fruit in the world and it shares about 45 % of total production of guava. Guava can be consumed fresh or can be processed into juice, nectar, pulp, jam, jelly, and slices in syrup, fruit bar or dehydrated products, as well as being used as an additive to other fruit juices or pulps (Kuldeep *et al.*, 2019). It is a rich source of vitamin C (260 mg/100 g) which is the second after amla (600 mg/100 g) (Bhooriya *et al.*, 2020).

Due to its wider edapho-climatic adaptability in diverse soils and diverse agro-climatic regions, low cost of the cultivation, prolific bearing and being highly

remunerative with nutraceutical values and biomass, it has gained tremendous popularity among the fruit growers. (Meena *et al.*, 2020).

Plant growth regulators are plant hormone enhancers or disrupters which are man-made or naturally derived (Kumar, 2012). There is a lot of information that show how plant growth regulators encourage the biochemical changes in plants, which in induce vegetative and reproductive responses. Plant growth hormones play a key role in guava production and productivity by influencing various plant processes like germination, rooting, flowering, improving fruit set, decreasing fruit drop, fruit growth and yield of guava. Plant growth hormones also influence fruit size, diameter and shape, appearance and biochemical traits. Growth regulators like SA, GA₃ and NAA affect flower and fruit setting, cell growth, apical dominance, geotropism and photoperiod. The pre-harvest sprays of growth regulators and minerals are the new practices adopted nowadays for higher fruit production and improved fruit quality (Dutta and Banik, 2005).

Many works have been carried out with different growth regulators in guava but not standardize the region specific because climatic conditions are varies to

locations. So the present investigation was formulated in Jabalpur region.

Materials and Methods

The present investigation was conducted at Fruit Research Station, Imalia, Department of Horticulture at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, (M.P.) during 2020-21 and 2021-22. The investigation was conducted on 8 years old guava plants planted at 3 X 3 m apart under square system of planting. In order to assess the effects of various growth parameters, all the plants were subjected to uniform cultural practices during the period of experimentation. The experiment was laid out in Randomized Block Design with four replications with a unit of four plants in each replication of a treatment.

The studies was carried out 7 treatments with 3 growth regulators in two concentrations (100 and 150 ppm) includes control are used in the investigation. The treatments includes T₁ (Control), T₂ (100 ppm GA₃), T₃ (150ppm GA₃), T₄ (NAA 100 ppm), T₅ (NAA 150 ppm), T₆ (Salicylic Acid 100 ppm) and T₇ (Salicylic Acid 150 ppm) were prepared by dissolving the required amount of respective growth regulators. The required amount of different growth regulator was weighed with the help of electronic balance for the preparation of solution. After dissolving them in 10ml of 99% absolute ethyl alcohol, the solution was replaced in volumetric flask, when lukewarm distilled water was added to it we get clear solution of growth regulators. This was used as stock solution and from this the solution of desirable concentration were made by adding water. As these PGR are photosensitive, the containers of these solutions were kept away from light and covered with black paper.

Harvesting of fruit was done at full maturity stage to local market. The maturity of fruit was judged on the basis of visual means by using skin colour, size, and computation method. Observation were recoded different yield parameters and quality parameters. Yield parameters such as flower per shoot, fruit set percent, fruit retention percent, number of fruits direction wise (East, West, North and South), number of fruits per shoot, number of fruits per plant, yield per plant (kg), days taken to harvest of fruits, fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm³), pulp weight (g), peel weight (g) and pulp percent and quality parameters includes T.S.S. Ascorbic acid (mg/100g), total Sugar, reducing Sugar, non reducing Sugar and Acidity percentage among the treatments.

Results and Discussion

The results of the present investigation indicated that, the different yield parameters and biochemical quality of

guava fruits significantly influenced the foliar application of various growth regulators.

The maximum number of flower/shoot (7.24), fruit set % (85.14), No.of fruits/ plant (82.50), yield per plant (20.65), minimum days taken to harvest of fruits (119) was recorded in T₆ (Salicylic Acid 100 ppm). Increased vegetative growth may be to responsible for the rise in fruit yield. Increased auxin production and subsequent translocation from source to sink could explain the entire rise in yield and yield attributing factors. The use of exogenous plant growth regulators regulates the flow of assimilates and nutrients essential for fruit growth (Treharne *et al.*, 1985). Maximum fruit retention % (84.76) was recorded under T₅ (NAA 150 ppm). The present results revealed that NAA increase the fruit retention may be due to auxin is well known as inhibitors for abscissic acid and ethylene which cause fruit drop (Ram, 1983). There is correlation between fruit drop and endogenous NAA status and existence of high level of internal auxin that prevent fruit drop. Since high level of endogenous hormones might help in building up endogenous hormone at appropriate level potent to enough reduces the fruit drop (Lenka *et al.*, 2019).

The maximum fruit length (7.40 cm), fruit width (7.83 cm), fruit weight (250.08 g) and fruit volume (261.29) was recorded in the treatment (T₃) GA₃ 150 ppm and it was significantly superior over rest of the treatments. The application of gibberellic acid, which may have a beneficial influence on an increase in auxin concentration, could be responsible for the increased fruit length and width in this treatment. The increase in fruit length could potentially be owing to more photosynthates being accumulated due to a superior source-sink ratio, in which more carbohydrates are synthesized in the leaf and translocated to the fruit at various phases of fruit development.

Certain horticultural cultural methods, such as the addition of plant growth hormones, have been shown to have an impact on the size, volume and quality of the fruits (Guardiola, 1992). In the clementine orange, gibberellic acid (GA₃) has been demonstrated to boost fruit set and growth (Van Rensburg *et al.*, 1996). Spraying GA₃ on cherry cherries boosted the size and weight of the fruit, according to Choi *et al.* (2002).

Maximum pulp percentage (97.73%), pulp weight (255.65 g) with GA₃ 150 ppm (T₃) which are significantly superior over rest of the treatment. Gibberellins are plant growth regulators that are known to promote physiological responses in plants and alter source-sink metabolism by affecting photosynthesis and sink creation, resulting in increased biomass and pulp weight.

Table-1 : Effect of foliar spray of various growth regulators on flower per shoot, fruit set (%), fruit retention (%), No. of fruit/plant, yield/ plant (kg) and days taken to harvest of fruits.

Treat. Symb.	Treatments	Flower/ shoot	fruit set (%)	fruit retention (%)	No.of fruits/ plant	Yield/ plant (kg)	Days taken to harvest of fruits
T ₁	Control (water)	5.00	40.50	57.95	61.36	10.44	124.10
T ₂	GA ₃ 100 ppm	5.29	70.24	67.46	80.25	18.64	121.12
T ₃	GA ₃ 150 ppm	5.68	76.46	72.88	82.00	20.17	120.00
T ₄	NAA 100 ppm	5.84	77.00	78.21	77.50	16.89	120.13
T ₅	NAA 150 ppm	6.18	77.34	84.76	82.00	18.99	119.28
T ₆	Salicylic Acid 100 ppm	7.24	85.14	76.15	82.50	20.65	119.00
T ₇	Salicylic Acid 150 ppm	5.67	76.65	71.30	77.25	16.73	119.75
	SEm ±	0.216	2.161	0.779	3.228	1.117	1.475
	C.D. at 5% level	0.642	6.421	2.316	9.590	3.319	4.381

Table-2 : Effect of foliar spray of various growth regulators on fruit length (cm), fruit width (cm), fruit volume, fruit weight (g), fruit volume (cm³), pulp weight (g) and (pulp%).

Treat. Symb.	Treatments	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Fruit volume (cm ³)	Pulp weight (g)	Pulp percent
T ₁	Control (water)	5.80	6.24	169.66	186.37	175.17	93.35
T ₂	GA ₃ 100 ppm	7.18	7.70	236.63	245.30	238.70	97.21
T ₃	GA ₃ 150 ppm	7.40	7.83	250.08	261.29	255.65	97.73
T ₄	NAA 100 ppm	6.65	7.17	217.50	227.32	218.52	95.95
T ₅	NAA 150 ppm	7.10	7.33	228.31	234.29	227.19	96.89
T ₆	Salicylic Acid 100 ppm	7.35	7.77	244.12	251.42	245.21	97.46
T ₇	Salicylic Acid 150 ppm	6.55	7.11	216.18	222.58	214.37	96.20
	SEm ±	0.210	0.194	8.257	5.777	5.841	0.147
	C.D. at 5% level	0.623	0.576	24.533	17.165	17.354	0.437

Table-3 : Effect of foliar spray of various growth regulators on biochemical quality of Guava fruit.

Treat. Symb	Treatments	T.S.S. (°Brix)	Ascorbic acid (mg/100g)	Total Sugar	Reducing Sugar (%)	Non reducing Sugar (%)	Acidity %
T ₁	Control (water)	11.31	181.64	8.46	4.91	3.55	0.39
T ₂	GA ₃ 100 ppm	12.29	216.44	9.83	5.51	4.32	0.34
T ₃	GA ₃ 150 ppm	12.44	226.64	10.51	5.79	4.72	0.33
T ₄	NAA 100 ppm	11.64	203.67	9.41	5.07	4.35	0.36
T ₅	NAA 150 ppm	11.86	206.97	9.47	5.28	4.18	0.35
T ₆	SA 100 ppm	13.84	244.31	10.74	5.94	4.81	0.29
T ₇	SA 100 ppm	13.49	232.55	10.65	5.86	4.79	0.31
	SEm ±	0.185	6.145	0.196	0.158	0.210	0.007
	C.D. at 5%	0.549	18.257	0.582	0.470	0.624	0.021

It is clear from the results that the maximum T.S.S. (13.84 °Brix), Ascorbic acid (244.31 mg/100g), total Sugar (10.75 %), reducing Sugar (5.94 %), non reducing Sugar (4.81 %) and minimum Acidity (0.29%) was recorded in the the treatment Salicylic acid 100 ppm (T₆) and it was significantly superior over rest of the treatments. In the present investigation, the increase of TSS due to the breakdown of complex polymer into simple substances by hydrolytic enzymes and also due to rapid mobilization of sugars and other soluble solids to developing fruits. Higher T.S.S. induced by calcium treatments may be due to lesser utilization of sugars in metabolic processes as a result of reduced respiration

(Gupta et al., 1980). Plant growth regulators like salicylic acid different concentrations augmented quality parameters i.e. TSS, Acidity, TSS- Acid ratio, ascorbic acid. These have been reported to divert more solids towards developing fruits and might have also enhanced the conversion of complex polysaccharides into simple sugars. Similar findings reported by Iqbal *et al.* (2009) in guava and Dutta *et al.* (2008) in carambola.

Conclusios

On the basis of results found in the present investigation it is concluded that in case of yield attributes application of Salicylic Acid 100ppm followed by GA₃ 150 ppm found beneficial.

Application of Salicylic Acid @ 100 ppm obtained maximum number of flower/shoot, fruit set %, No. of fruits/plant, yield per plant, minimum days taken to harvest of fruits and all biochemical quality attributes maximum T.S.S., Ascorbic acid, total Sugar, reducing Sugar, non reducing Sugar and minimum Acidity percent also recorded in 100 ppm Salicylic Acid.

Maximum fruit length, fruit width, fruit weight, fruit volume, pulp percentage and pulp weight was recorded under application of GA₃ @ 150 ppm.

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Constraints Analysis under Different Farming Systems in the Hills of Himachal Pradesh

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Abstract

The present study examined the constraints experienced by the farmers under existing farming systems in the hills of Himachal Pradesh. A sample of 240 farmers was selected through stratified multistage random sampling technique. The collected data was analyzed using Garrett's ranking technique and further, chi-square test was used to test the significant difference of the problem/constraints among selected districts of the study area. The results of the study revealed that lack of subsidy for inputs, lack of processing facilities and lack of training or extension services were the main infrastructural constraints faced by the farmers of study area. Further, high cost of inputs, high cost of production, and labour scarcity were the major production constraints, and among marketing constraints, lack of regulated markets was ranked first by the farmers followed by price fluctuations and non-remunerative prices, respectively. Monkeys/wild animals/stray animals' menace, higher insect/pests/disease attack and lower risk-taking capacity of the farmers were the major miscellaneous constraints in the study area. The overall results indicate that providing subsidies on inputs, short-term training activities, field demonstrations, regulated markets and establishing cold storage facilities in the study area could help the farmers in more income generations and improving their standard of living.

Key words : Multistage random sampling, garrett's ranking technique, regulated markets.

Introduction

Himachal Pradesh, the North-Western and Himalayan State of the country has been endowed with a wide range of agro-climatic conditions, due to which there is a wide scope to cultivate various field and fruit crops in different agro-climatic zones of the State. The agriculture is the main occupation of the people of the State and the dependency on agriculture/ horticulture is eminent as it provides direct employment to about 71 per cent of the total population. During 2017-18, the share of primary sectors which include agriculture, forestry, fishing and mining & quarrying was 13.73 per cent in State Domestic Product (Anonymous, 2019). In spite of an increase in food production in the state, the agriculture has the disadvantage of small holdings as the average holding size in the state is about one hectare. Distribution of land holdings shows that 87.95 per cent of the total holdings are of marginal and small and about 11.71 per cent and 0.34 per cent of holdings are owned by medium and large farmers, respectively (Anonymous, 2011). Like whole country, Himachal too has almost reached a plateau in so far as cultivable land is concerned.

Himachal Pradesh has a deeply fissured topography, with mountain ranges and valleys of varying slopes and sizes due to which farmers face many constraints in farming. Yadav *et al.*, (2016) identified

marketing linkages, difficulty in getting loan, high cost and non-availability of quality inputs on time, lack of entrepreneurship development oriented, trainings, low price of produce, lack of storage and irrigation facilities and stray animal's menace as the major constraints faced by the farmers of Mandi district of Himachal Pradesh. Similarly, Kumar and Sharma (2019) revealed that high cost of plant protection chemicals, problem of stray animals, shortage of skilled labour, high wage rates and high transportation charges were the major constraints faced by the farmers of Kangra district of Himachal Pradesh. Therefore, it is very difficult to enhance the livelihoods of hill farmers of the State unless agriculture is supplemented by other farm components such as livestock, horticulture etc. In this context, the farming system approach is seen as a potential way of raising and stabilizing productivity and profitability levels and thereby improving the livelihood security of the farmers (Anonymous, 2005). The farming system approach is a result of a complex interaction among a number of enterprises/ components in which the available resources are utilized in such a manner for raising and stabilizing productivity and profitability levels of the farmers and thereby, increasing their livelihood security. It requires involvement of various farm enterprises, viz., agriculture, horticulture, soil conservation, forestry, fisheries, animal husbandry, apiculture etc. (Ansari *et al.*, 2013). The

primary objective of the farming system is to improve the economic conditions of individual farm through increase in productivity, profitability, food and nutritional security, generation of income round the year through suitable modifications, intensification, diversification, environmental security and incorporation of the appropriate sequence of crops and/or enterprises and production techniques keeping in view the latest technology, constraints imposed by resources, social taboos and the environment (Kumar *et al.*, 2011; Kumar *et al.*, 2013 and Behera, 2019).

The per capita availability of land has declined in the state and as a result it would be increasingly difficult to produce enough food for meeting the requirements of growing population. Since, there is no further scope for horizontal expansion of land for cultivation of farm enterprises; the emphasis has to be on increasing productivity levels besides, diversification towards high value crops. A number of authors have studies about the farming system constraints at various places (Sharma *et al.*, 2008; Ponnusamy, 2010; Saikumar *et al.*, 2013; Yadav *et al.*, 2014; Shrey *et al.*, 2015 and Meshram *et al.*, 2020) who revealed that the productivity of farming systems is largely affected by the various constraints/problems faced by the farmers in different farming components. Keeping all these factors in view, the present study was conducted to study, understand and analyze the various farming systems' constraints encountered by the farmers in the hills of Himachal Pradesh. Moreover, if the farming systems' constraints in the study area are identified and feasible suggestions are made to overcome these constraints, then it can help to increase the income of the farmers and improve their livelihood security.

Materials and Methods

The farming systems' constraints are recognized as the difficulties/problems experienced by the farmers which restrict or limit the activity and/or performance of a particular farming system. The present study examined the farming system constraints in all four agro-climatic zones of the hills of Himachal Pradesh viz. Zone-I (Sub-montane and low hills sub-tropical), Zone-II (Mid-hills sub-humid), Zone-III (High hills temperate wet) and Zone-IV (High hills temperate dry). Stratified multistage random sampling technique was used to select the sample size. The study area was stratified into four strata according to the agro-climatic zones of the State. At the first stage of sampling, one district from each agro-climatic zone viz. Una district from Zone-I, Mandi district from Zone-II, Shimla district from Zone-III and Kinnaur district from Zone-IV was selected on the basis of maximum cultivated area in that particular zone. At the second

stage, a complete list of blocks in the selected districts was prepared and two blocks from each selected district were selected on the basis of maximum cultivated area. At the third stage, 3 gram panchayats from each selected block were selected randomly. Thus, 24 Gram panchayats were selected from 8 blocks. Further, 10 farmers from each gram panchayat were selected randomly at the fourth stage of sampling to constitute a sample size of 240 farmers in total. The sample of 240 farmers comprised of 60 farmers from each selected district of respective zone. The primary data from sampled households were collected through personal interview method with the help of well-designed pre-tested schedule. All the information has been collected through field visits during 2018-2019. The required secondary data related to the present study were collected from various publications and government departments like agriculture, horticulture, directorate of economics and statistics, land records, books, journals, reports etc.

The collected data have been analyzed through Garrett's Ranking technique (Dhanavandan, 2016). The prime advantage of this technique over simple frequency distribution is that the constraints are arranged based on their severity from the point of view of farmers (Zalkuwi *et al.*, 2015). As per this method, the farmers were asked to assign the rank for each category of the constraints proposed to them. The per cent position for each rank was calculated with the help of the following formula :

$$\text{Per cent position} = \frac{R_{ij} - 0.50}{N_j} \times 100$$

Where,

R_{ij} = Rank given for the i th factor by the j^{th} respondent

N_j = Number of factor ranked by the j^{th} respondent

The percent position was converted into scores by referring to the table (Garrett ranking conversion table) given by Garrett and Woodworth (1969). Then, the scores of the individual respondents were added together and divided by the total number of respondents for whom scores were added. These mean scores for all the factors were arranged in descending order and the most influencing factors were identified through the ranks assigned as the factors having the highest mean value score was considered to be the most severe problem faced by the farmers in the study area.

Further, in order to test the significant difference of the problem/constraints among selected districts, Chi-Square test was used. The details of Chi-Square (χ^2) test are given below :

$$\chi^2 = \sum_{i=1}^4 \frac{(O_i - E_i)^2}{E_i} \sim \chi^2_{(L-1)df}$$

Table-1 : Infrastructural constraints experienced by the farmers in the study area.

Sr. No.	Particulars	Una (Zone-I)		Mandi (Zone-II)		Shimla (Zone-III)		Kinnaur (Zone-IV)		Overall	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1.	Non-availability of package of practices	39.65	8	42.77	7	48.50	5	43.88	8	43.70	8
2.	Fragmentation of landholdings	34.48	9	42.55	8	56.70	2	57.52	1	47.81	7
3.	Lack of training or extension services	60.52	2	50.17	4	47.92	7	50.17	6	52.19	4
4.	Lack of field demonstrations	54.30	4	48.55	6	48.33	6	52.60	4	50.95	5
5.	Lack of veterinary services	39.85	7	42.23	9	43.47	9	40.52	9	41.52	9
6.	Lack of processing facilities	60.37	3	57.12	3	49.92	4	54.37	2	55.44	2
7.	Lack of cold storage facilities	46.58	6	59.38	1	58.03	1	54.03	3	54.51	3
8.	Lack of finance or credit facilities	53.12	5	48.67	5	45.78	8	44.97	7	48.13	6
9.	lack of subsidy for inputs	61.13	1	58.57	2	51.35	3	51.95	5	55.75	1

Table-2 : Production constraints experienced by the farmers in the study area.

Sr. No.	Particulars	Una (Zone-I)		Mandi (Zone-II)		Shimla (Zone-III)		Kinnaur (Zone-IV)		Overall	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1.	Non-availability of good quality seeds/planting material	56.98	5	55.22	4	44.92	8	49.07	7	51.55	5
2.	Non-availability of chemicals/ pesticides/fertilizers on time	46.88	7	47.92	7	50.42	6	53.90	3	49.78	7
3.	High cost of inputs	61.50	1	56.77	3	58.08	3	53.73	4	57.52	1
4.	Lack of knowledge about seed treatment	57.37	4	44.53	8	47.13	7	44.82	8	48.46	8
5.	Lack of irrigation facilities	44.45	8	36.93	9	58.43	2	61.17	1	50.25	6
6.	Labour scarcity	59.52	3	59.02	2	55.93	4	53.00	6	56.87	3
7.	High wage rate	55.90	6	59.42	1	53.83	5	57.55	2	56.68	4
8.	Improved breeds of livestock not available	29.40	9	33.60	10	36.25	10	33.18	10	33.11	10
9.	Shortage of fodder	27.27	10	53.70	6	37.52	9	41.10	9	39.90	9
10.	High cost of production	60.93	2	54.95	5	58.98	1	53.08	5	56.99	2

Where,

O = Observed values

E = Expected values

L = Number of selected districts

Results and Discussion

Existing farming systems in the study area : The farmers of the study area practice Crops + Vegetables + Fruits + Dairy (C+V+F+D), Crops + Fruits + Dairy (C+F+D), Crops + Vegetables + Dairy (C+V+D), Vegetables + Fruits + Dairy (V+F+D), Crops+ Dairy (C+D) and Fruits + Dairy farming systems. Among these farming systems, C+V+F+D exists in all the selected districts and is the major farming system of Una (40%), Mandi (53%) and Shimla (45%) districts of Zone-I, II and III, respectively. C+F+D farming system was also found in all the selected districts and was major farming system in Kinnaur district of Zone-IV as 52 per cent of the farmers were practicing the same followed by C+V+F+D (40%). Out of the total farmers selected from Una district of Zone-I, 24 per cent were practicing C+D farming system followed by C+V+D (18%) and C+F+D (18%). Similarly, in Mandi district of Zone-II, 35 per cent farmers were

practicing C+V+D followed by C+D (9%) and C+F+D (3%) farming system. It was also found that V+F+D and F+D farming systems were practiced only in Shimla (40%) and Kinnaur (8%) districts, respectively. Overall, the major farming system in the study area was C+V+F+D practiced by 45 per cent of the total sample size followed by C+F+D (20%), C+V+D (15%), V+F+D (10%), C+D (8%) and F+D (2%), respectively.

Constraints faced by the farmers : The data collected through personal interview method revealed that a number of constraints are faced by the farmers in practicing existing farming systems in the study area. These problems and constraints have been grouped into four categories namely infrastructural, production, marketing and miscellaneous constraints.

Infrastructural constraints : The results related to infrastructural constraints experienced by the sampled farmers in existing farming systems in the study area have been presented in Table-1. The table depicted that lack of subsidy for inputs was the most severe problem of farmers and was ranked first by the farmers in Una district of Zone-I with average Garrett score of 61.13.

followed by lack of training or extension services (60.52) and lack of processing facilities (60.37). Similarly,

Table-3 : Marketing constraints experienced by the farmers in the study area.

Sr. No.	Particulars	Una (Zone-I)		Mandi (Zone-II)		Shimla (Zone-III)		Kinnaur (Zone-IV)		Overall	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1.	Lack of regulated markets	67.47	1	61.42	1	51.87	5	53.52	5	58.57	1
2.	Lack of packing material	46.68	8	40.50	10	42.02	10	42.60	10	42.95	10
3.	Transportation facility not available/ costly	35.43	10	52.55	6	50.55	7	59.87	2	49.60	8
4.	Vehicles not available in time	28.67	11	31.53	11	30.57	11	29.12	11	29.97	11
5.	Labour scarcity	59.33	3	57.67	2	52.50	4	43.20	9	53.18	4
6.	Lack of market intelligence	54.07	4	44.33	9	48.90	8	49.18	8	49.12	9
7.	Non remunerative prices	61.92	2	54.45	3	52.78	3	50.55	7	54.93	3
8.	Price fluctuations	53.18	5	53.12	5	66.30	1	60.70	1	58.33	2
9.	High commission charges	49.57	7	53.70	4	46.85	9	51.45	6	50.39	7
10.	Delay in payments	50.00	6	49.38	8	56.58	2	53.73	4	52.43	5
11.	High marketing cost	43.90	9	51.68	7	51.42	6	56.25	3	50.81	6

Table-4 : Miscellaneous constraints experienced by the farmers in the study area.

Sr. No	Particulars	Una (Zone-I)		Mandi (Zone-II)		Shimla (Zone-III)		Kinnaur (Zone-IV)		Overall	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
1.	Monkeys/wild animals/stray animals' menace	57.90	1	56.05	2	56.25	1	55.55	2	56.44	1
2.	Higher insect/pests /disease attack	56.37	2	58.93	1	53.82	2	55.97	1	56.27	2
3.	Lack of know-how	40.73	4	40.53	4	42.83	4	42.35	4	41.61	4
4.	Lower risk-taking capacity	44.52	3	44.28	3	47.10	3	46.13	3	45.51	3

in Mandi and Shimla districts of Zone-II and III, lack of cold storage facilities was the most prominent problem with average Garrett score of 59.38 and 58.03, respectively. In Kinnaur district of Zone-IV, fragmentation of land holding (57.52) was found to be the major infrastructural constraints and was ranked first followed by lack of processing facilities (54.37) and lack of cold storage facilities (54.03). Overall, lack of subsidy for inputs (55.75) was ranked first by the farmers and found to be the major infrastructural constraint in the study area followed by lack of processing facilities (55.44), lack of cold storage facilities (54.51), lack of training or extension services (52.19) and lack of field demonstrations (50.95). These results are supported by the findings of Kumar *et al.*, 2011; Saikumar *et al.*, 2013 and Meshram *et al.*, 2020.

Production constraints : The various production constraints (Table-2) revealed that high cost of inputs, high cost of production and labour scarcity were the major farming problems in Una district of Zone-I and was ranked first, second and third with average Garrett score of 61.50, 60.93 and 59.52, respectively. Similarly, in Mandi district of Zone-II, high wage rate (59.42), labour scarcity (59.02) and high cost of inputs (56.77) were severe problems. In Shimla district of Zone-III, high cost of production (58.98), lack of irrigation facilities (58.43) and high cost of inputs (58.08) were the most severe constraints, while lack of irrigation facilities (61.17) was the prominent production constraint in Kinnaur district of Zone-IV followed by high wage rate (57.55) and non-availability of chemicals/pesticides/ fertilizers on time (53.90). Overall, in the study

area, high cost of inputs (57.52) was the most prominent production constraints and was ranked first by the farmers followed by high cost of production (56.99), labour scarcity (56.87), high wage rate (56.68) and non-availability of good quality seeds/planting material (51.55). These results are in close conformity with the results of Kumar *et al.*, 2011; Saikumar *et al.*, 2013; Bhutia *et al.*, 2017 and Meshram *et al.*, 2020.

Marketing constraints : It can be seen from the Table-3 that in Una district of Zone-I, lack of regulated markets (67.47) was the major marketing constraint and ranked first by the farmers followed by non-remunerative prices (61.92) and labour scarcity (59.33). The farmers of Mandi district of Zone-II also ranked lack of regulated markets (61.42) as the major constraints followed by labour scarcity (57.67) and non-remunerative prices (54.45). In Shimla and Kinnaur districts of Zone-III and IV, price fluctuation was ranked first with average Garrett value of 66.30 and 60.70, respectively which implied that price fluctuations was the most severe problem in these two districts. Overall, lack of regulated markets with average Garrett value of 58.57 was the most prominent marketing constraint and ranked first by the farmers in the study area followed by price fluctuations (58.33), non-remunerative prices (54.93), labour scarcity (53.18) and delay in payments (52.43). These results are similar with those of Kumar *et al.*, 2011; Saikumar *et al.*, 2013; Ponnusamy & Devi, 2017 and Meshram *et al.*, 2020.

Miscellaneous constraints : As far as miscellaneous constraints are concerned, monkeys/wild animals/stray

Table-5 : Test of significance of constraints experienced by the farmers in the study area.

Sr. No.	Particulars	Chi-square
A. Infrastructural Constraints		
1	Non-availability of package of practices	0.92
2	Fragmentation of land-holdings	7.92**
3	Lack of training or extension services	1.84
4	Lack of field demonstrations	0.52
5	Lack of veterinary services	0.19
6	Lack of processing facilities	1.06
7	Lack of cold storage facilities	1.82
8	Lack of finance or credit facilities	0.84
9	lack of subsidy for inputs	1.27
B. Production Constraints		
1	Non-availability of good quality seeds/planting material	1.81
2	Non-availability of chemicals/pesticides/ fertilizers on time	0.59
3	High cost of inputs	0.54
4	Lack of knowledge about seed treatment	2.27
5	Lack of irrigation facilities	7.90**
6	Labour scarcity	0.48
7	High wage rate	0.30
8	Improved breeds of livestock not available	0.72
9	Shortage of fodder	8.95**
10	High cost of production	0.68
C. Marketing Constraints		
1	Lack of regulated markets	2.69
2	Lack of packing material	0.49
3	Transportation facility not available/costly	6.36*
4	Vehicles not available in time	0.17
5	Labour scarcity	2.97
6	Lack of market intelligence	0.97
7	Non remunerative prices	1.33
8	Price fluctuations	2.11
9	High commission charges	0.50
10	Delay in payments	0.65
11	High marketing cost	1.54
D. Miscellaneous Constraints		
1	Monkeys/wild animals/stray animals' menace	0.06
2	Higher insect/pests /disease attack	0.23
3	Lack of know-how	0.10
4	Lower risk-taking capacity	0.12

animals' menace was ranked first by the farmers of Una and Shimla districts with average Garrett value of 57.90 and 56.25, respectively followed by higher insect/pests /disease attack. While, in Mandi and Kinnaur districts, higher insect/pests /disease attack was ranked first by the farmers with average Garrett value of 58.93 and 55.97, respectively followed by monkeys/wild animals/stray animals' menace. Overall, it was found that under miscellaneous constraints, monkeys/wild animals/stray animals' menace was ranked first followed by higher insect/pests /disease attack, lower risk taking capacity of the farmers and lack of know-how with average Garrett scores of 56.44, 56.27, 45.51 and 41.61, respectively.

These results are in close conformity with the results of Sharma *et al.*, 2006.

Test of significance of problems faced by kinnow growers in the study area : The results of chi-square analysis presented in Table-5 revealed that among various categories of constraints, fragmentation of land holding (7.92), lack of irrigation facilities (7.90), shortage of fodder (8.95) and non-availability/costly transportation facility (6.36) were found to be different among selected districts of respective zones as revealed by their statistically significant chi-square values.

Conclusions

This study analyzed the constraints/problems faced by the hill farmers of Himachal Pradesh under different farming systems. On an overall level, lack of subsidy for inputs, lack of processing facilities, lack of training or extension services, high cost of inputs, high cost of production, labour scarcity, lack of regulated markets, price fluctuations, non-remunerative prices, monkeys/wild animals/stray animals' menace and higher insect/pests /disease attack were the major farming system constraints in the study area. It can be concluded that increasing cold storage facilities, regulated markets, short-term training activities and field demonstrations under proper supervision can help the farmers of the study area to enhance their skills for maximizing net income and improve livelihood security.

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Effect of Various Nutrient Sources and Irrigation Levels on Availability of Nutrients and their Uptake under Protected Cultivation of Cucumber

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Abstract

The effect of various nutrient sources (chemical and bio fertilizers along with cow urine) and drip irrigation levels was studied on soil and plant nutrient status and their uptake under protected cultivation of cucumber during summer season. The experiment was conducted in a randomized block design (RBD) with 11 treatments and 3 replication comprising of two drip irrigation levels viz., I_2 (IW/CPE= 0.4) and I_4 (IW/CPE = 0.8), five fertigation levels and one farmers' practice. The treatment with hundred percent of RDF (1/3N, Full P&K as basal) 2/3N through fertigation + Azo + PSB + 5 per cent cow urine along with fertigation (4 lt m^{-2}) resulted in higher N, P and K uptake as compared to other treatments and found that cow urine at 5 per cent concentration resulted in higher K uptake. While comparing the other treatments, it is found that treatments with addition of PSB recorded higher P uptake than the treatments without application of PSB. The available N and P of surface soil was statistically at par for both the irrigation levels, while among different fertigation treatments, the T_4 resulted in the highest available nitrogen and phosphorus in soil. The overall results indicated that combined application of bio-fertilizers and chemical fertilizers has positive effect on soil and plant nutrient status and their uptake due to addition of nutrients through different sources and saving of at least 50% of water, hence can be exploited as a sustainable approach under integrated nutrient management.

Key words : Cucumber, bio fertilizer, nutrient uptake, drip irrigation, polyhouse.

Introduction

The Indian cucumber (*Cucumis sativus* L.) is widely planted throughout the country, owing to its immature fruit. It is a low-calorie diet that is high in B vitamins. It is a vegetable diuretic plant because it contains 95% water, which helps to keep the body clean and free of toxins. It also lowers cancer risk, removes uric acid, and its skin, which is abundant in fibre and potassium and magnesium, aids in blood pressure regulation and nutritional function. It is, nevertheless, a frost-tolerant cultivar that, as a seasonal vegetable, is thermophilic and thrives best in high light, humidity, fertiliser, and temperature (above 20 °C). Cucumbers are best grown in the fall and winter. Parthenocarpic fruits are common cucumber hybrids that can be grown in the off-season under protected conditions due to their ability to set fruit without pollination or fertilisation even at low temperatures (Monisha et al., 2014), allowing for more efficient use of land, water, nutrients, and other resources. Protected agriculture, also known as "Controlled Environment Agriculture (CEA)," is a high-yielding, environmentally friendly, and water and land-conserving cultivation method (Jensen., 2002). Despite possessing the world's biggest irrigation network, India's irrigation efficiency is less than 40% (Imamsaheb et al., 2014), necessitating the development and implementation of more effective irrigation systems. 80-85 percent of field capacity is the ideal soil moisture content

for cucumber development and fruiting. Its high water requirements are due to its bulky and robust above-ground component, which evaporates a huge amount of water, and its poorly formed root system, which has limited absorption capacity and substantial fertiliser leaching losses. Drip irrigation is a sophisticated irrigation technology in which water is delivered drop by drop on a continuous basis through a closed network of plastic pipes at frequent intervals near the root zone for crop consumption. It reduces water losses caused by deep percolation, evaporation, and runoff. It may save 40 to 70 percent of water while also increasing crop productivity by 20 to 100 percent (Reddy and Reddy, 2003).

The use of both inorganic and organic fertilisers in a balanced proportion, as well as fertiliser delivery by drip irrigation (fertigation), not only improves water utilisation but also boosts nutrient use efficiency. Solaimalai et al. (2005) found that the fertigation approach had greater nutrient usage efficiency (90%) than the standard methods (40-60%). Excessive use of inorganic fertilisers has negative impacts on fruit quality, as well as harmful effects on soil and biological dynamics, water, and environmental conditions. In these circumstances, bio-fertilizers have emerged as viable nutrient providers or mobilizers in a variety of horticulture crops, allowing them to fulfil the ever-increasing demands of the rising population.

Considering the scope of the crop growth behavior of cucumber under differential moisture regimes and fertigation levels, many accounts of effect of irrigation amount, intervals and frequencies have been found (Moujabber *et al.*, 2002; Yuan *et al.*, 2006; Wang *et al.*, 2009). However, an effect of incorporation of cow urine and bio-fertilizers in fertigation scheduling has not been studied so far. Hence the objective of present paper is to study the effects of cow urine and bio-fertilizers based fertigation schedule at varying levels of drip irrigation on available soil nutrient status and plant uptake of cucumber under protected condition.

Materials and Methods

The experiment was conducted during the year 2015-16 on cucumber cv. Hilton on 21st March in naturally ventilated polyhouse at the Experimental Farm of CSK HPKV, Palampur (32° 6' N latitude and 76° 3' E longitude) at an elevation of 1290 m above mean sea level of Kangra district of Himachal Pradesh and represents the mid hills sub humid agro climatic zone of Himachal Pradesh in North Western Himalayas and the research farm lies in Wet Temperature Zone according to Thornwaite's classification (Aggarwal *et al.* 1978). The average annual rainfall of the place is about 2500 mm. The soil of experimental site was clay loam and rich in clay content with accumulation of sesquioxides (Verma 1979). The soil was low in available soil nitrogen, high in available phosphorus and medium in available potassium (209.5, 42.50 and 278.3 kg ha⁻¹) at 0.0-15 cm and (201.4, 39.10 and 270.6 kg ha⁻¹) at 15 to 30 cm, respectively.

Preparatory tillage was done with manual labour. Raised strips were laid out as per plan before transplanting and were made with dimensions of 3.0 m length and 0.4 m width. The drip irrigation system was installed in a naturally ventilated polyhouse of 15 x 7 m size. The polyhouse was divided into two parts and each part was provided with 12 m long main line. Each main line was connected with 18 laterals at 45 cm distance and each lateral was 3 m long having 8 online drippers at 30 cm spacing. The average discharge rate from each dripper was 3 lt h⁻¹.

The treatments comprised two irrigation (I₂ and I₄ designated as 2 lt m⁻² and 4 lt m⁻² daily, respectively) and five fertigation levels; (F₁) 50 % of recommended NPK doses 1/3rd N and full P, K applied as basal and 2/3rd N through fertigation+ *Azotobacter* (Azo)+PSB and 5 % cow-urine, (F₂) 100 % of recommended NPK doses 1/3rd N and full P, K applied as basal and 2/3rd N through fertigation+ *Azotobacter* (Azo)+ PSB and 5 %cow-urine, (F₃) 50 % of recommended NPK doses 1/4th N, P and K applied as basal and 3/4th NPK through fertigation+

Azotobacter (Azo)+PSB and 5 %cow-urine, (F₄) 100% of recommended NPK doses 1/4th N, P and K applied as basal and 3/4th NPK through fertigation+ *Azotobacter* (Azo) + PSB and 5% cow-urine, (F₅) 100% of recommended NPK doses of fertilizer applied through water soluble fertilizers (RDF=100:50:60) along with Farmers' practice (FYM @ 1 kg m⁻² + 10 g m⁻² IFFCO (12:32:16) + 2g lt-1 of 19:19:19 at 15 days intervals and drip irrigation applied at rates 2 lt m⁻² daily). The eleven treatment combinations (T₁ - F₁I₂, T₂ - F₁I₄, T₃-F₂I₂, T₄- F₂I₄, T₅-F₃I₂, T₆-F₃I₄, T₇-F₄I₂, T₈-F₄I₄, T₉-F₅I₂, T₁₀-F₅I₄, T₁₁- Farmers' Practice) were imposed in a completely randomized design replicated three times.

The soil samples were collected from 0.0-15 and 15 to 30 cm depth at the start and end of the experiment, for analyzing various chemical properties of soil like available nitrogen, phosphorus and potassium. The plant samples were collected from all the plots at harvest. These samples were oven dried at 60 to 70 °C till constant weight was recorded. The plant samples were digested with di-acid and concentration of nitrogen, phosphorus and potassium were estimated by modified Kjeldhal's method, vanadomolybdate yellow colour method with the help of spectrophotometer at 470 nm and flame photometer, respectively (Jackson 1973). The uptake of nitrogen, phosphorus and potassium in fruit and stover were calculated using the following formula (Pomares and Pratt 1987).

Nutrient uptake (g m⁻²) = Nutrient concentration x oven dried biomass (g m⁻²)

Result and Discussion

Plant nutrient uptake : The nutrient uptake by fruit and halum was determined separately at harvest and are given in table-2. The plant samples were collected from all the plots at harvest. These samples were oven dried at 60 to 70°C till constant weight was recorded.

Nitrogen uptake : The highest N uptake by fruit, halum and total uptake (fruit + halum) was recorded in treatment T₄ with irrigation level I₄ (58.5, 65.8 and 124.4 kg ha⁻¹) followed by T₃ with irrigation level I₂ (54.8, 64.7 and 119.5 kg ha⁻¹), respectively. The nitrogen uptake by halum in treatment T₄ and T₃ was statistically at par, whereas, uptake by fruit was significantly different. The higher uptake in I₄ may be due to higher soil water content, better root and shoot growth and marketable yield. Similar results were reported by Ibriki and Buyuk (2002) where the irrigation levels significantly affected leaf N, P and K contents in drip fertigated plants. Among different fertigation treatments, significantly higher N uptake was recorded by fruit (58.5 kg ha⁻¹) in T₄ followed by T₃ (54.8 kg ha⁻¹), T₈ (52.0 kg ha⁻¹) and T₇ (50.1 kg ha⁻¹). The higher N

Table-1 :

Parameter	Method	Reference
Available nitrogen	Alkaline permanganate	Subbiah and Asija (1956)
Available phosphorus	Sodium bicarbonate extraction (pH 8.5) method	Olsen <i>et al.</i> (1954)
Available potassium	Neutral normal ammonium acetate extraction	Black (1965)

Table-2 : Effect of drip irrigation and different fertilization treatments on nutrient uptake of cucumber (kg ha⁻¹).

Treatments		N uptake			P uptake			K uptake		
		Fruit	Halum	Total	Fruit	Halum	Total	Fruit	Halum	Total
T ₁	F ₁ I ₂ (2 lt m ⁻² daily)	43.3	44.9	88.2	9.46	12.63	22.10	31.1	42.5	73.6
T ₂	F ₁ I ₄ (4 lt m ⁻² daily)	46.6	47.8	94.4	10.96	15.03	25.99	37.2	44.0	81.3
T ₃	F ₂ I ₂ (2 lt m ⁻² daily)	54.8	64.7	119.5	15.66	20.14	35.80	43.2	65.6	108.8
T ₄	F ₂ I ₄ (4 lt m ⁻² daily)	58.5	65.8	124.4	18.17	22.92	41.09	47.9	68.1	116.0
T ₅	F ₃ I ₂ (2 lt m ⁻² daily)	33.4	39.7	73.1	8.75	12.19	20.94	29.4	45.2	74.6
T ₆	F ₃ I ₄ (4 lt m ⁻² daily)	35.0	40.8	75.8	9.91	14.42	24.33	39.1	43.1	82.2
T ₇	F ₄ I ₂ (2 lt m ⁻² daily)	50.1	50.0	100.1	12.26	17.27	29.54	39.4	60.9	100.3
T ₈	F ₄ I ₄ (4 lt m ⁻² daily)	52.0	53.9	105.9	14.14	19.41	33.55	39.8	62.1	101.9
T ₉	F ₅ I ₂ (2 lt m ⁻² daily)	40.0	47.7	87.7	10.71	14.19	24.90	40.4	47.0	87.5
T ₁₀	F ₅ I ₄ (4 lt m ⁻² daily)	43.8	50.1	93.9	12.36	16.20	28.57	39.3	49.5	88.8
T ₁₁	FP (2 lt m ⁻² daily)	30.7	33.1	63.8	7.18	10.91	18.09	30.1	52.2	82.3
	SE(m±)	0.9	1.6	1.8	0.86	1.04	1.42	1.5	1.7	2.3
	CD(P=0.05)	2.9	4.8	5.2	2.53	3.08	4.20	4.3	4.9	6.8

uptake by halum was recorded in treatment T₄ (65.8 kg ha⁻¹) which was statistically at par with treatment T₃ (64.7 kg ha⁻¹) and significant higher among all other treatments. The total N uptake for different fertigation treatments was higher in T₄ (124.4 kg ha⁻¹) followed by T₃ (119.5 kg ha⁻¹) and T₈ (105.9 kg ha⁻¹). The higher N uptake may be due to the better utilization of applied nitrogen through combined fertigation treatment and conventional application as a basal dose leading to better root and shoot growth. Similar results were reported by Ahlfoos *et al.* (2005) where the fertigation was not needed during the first 3-4 weeks after planting when nutrient uptake was low. The N uptake by fruit and halum were lowest under farmers' practice *i.e.*, 30.7 and 33.1 kg ha⁻¹, respectively.

Phosphorus uptake : The phosphorus uptake for different irrigation levels, different fertigation treatments was higher by halum as compare to fruit. The P uptake by fruit under treatment T₄ (18.17 kg ha⁻¹) was significantly superior over all other treatments. Among different fertigation treatments, significantly higher P uptake was recorded by fruit (18.17 kg ha⁻¹) in T₄ followed by T₃ (15.40 kg ha⁻¹), T₈ (14.14 kg ha⁻¹) and T₁₀ (12.36 kg ha⁻¹). The higher P uptake by halum was recorded in treatment T₄ (22.92 kg ha⁻¹) which was statistically at par with treatment T₃ (20.14 kg ha⁻¹) and significantly higher among all other treatments. The higher P uptake may be due to the better utilization of applied phosphorus through phosphorus solubilize bacteria and combined fertigation treatment, increase availability by application of bio-fertilizers and conventional application as a basal dose leading to better root and shoot growth. Similar result were reported by Kanwar and Paliyal (2004) that the incorporation of P₂O₅

along with organic manures (FYM and vermicompost) concluded that grain yield and P-uptake of chick pea was maximum at 50 kg P₂O₅ ha⁻¹ applied along with FYM or vermicompost. Similarly, Backiyavathy and Vijayakumar (2006) recorded higher Ca and P uptake by applying 75 per cent of recommended dose of NPK and vermicompost @ 5 t ha⁻¹ in fodder crops of maize and cowpea. Biocompost and vermicompost when treated with cow urine and bio-fertilizers gave higher phosphorus concentration at every interval as compared to unfortified compost during both the years as reported by Paul (2015).

Potassium uptake : The potassium uptake for different irrigation levels and fertigation treatments, highest K uptake by fruit, halum and total uptake (fruit + halum) was recorded in treatment T₄ with irrigation level I₄ (47.9, 68.1 and 116.0 kg ha⁻¹) in comparison to T₃ with irrigation level I₂ (43.2, 65.6 and 108.8 kg ha⁻¹), respectively. The potassium uptake observed by halum under treatment T₄ which was statistically at par with treatment T₃ and in fruit it was significantly higher comparing with T₃. This may be due to the application of high fertilizer dose through the combined fertigation treatments and conventional fertilizer application as basal dose. Feleafele *et al.* (2014) also reported similar findings where the application of starter fertilizer combined with 125 per cent of recommended NPK resulted in the highest significant mean values for the leaf's P and K content.

Soil nutrient status

Available nitrogen

(i) **Surface soil :** A perusal of the data presented in table-3, shows the effect of drip based irrigation, different

Table-3 : Effect of drip irrigation and fertigation on soil nitrogen status at harvest (kg ha⁻¹).

Treatments	Irrigation level	Available Nitrogen (kg ha ⁻¹)	
		0.0-0.15 m	0.15-0.30 m
T ₁	F ₁ I ₂ (2 lt m ⁻² daily)	201.8	196.2
T ₂	F ₁ I ₄ (4 lt m ⁻² daily)	197.4	191.8
T ₃	F ₂ I ₂ (2 lt m ⁻² daily)	217.1	215.4
T ₄	F ₂ I ₄ (4 lt m ⁻² daily)	223.1	217.8
T ₅	F ₃ I ₂ (2 lt m ⁻² daily)	197.8	192.5
T ₆	F ₃ I ₄ (4 lt m ⁻² daily)	199.0	195.1
T ₇	F ₄ I ₂ (2 lt m ⁻² daily)	217.0	211.7
T ₈	F ₄ I ₄ (4 lt m ⁻² daily)	220.7	209.2
T ₉	F ₅ I ₂ (2 lt m ⁻² daily)	210.7	207.1
T ₁₀	F ₅ I ₄ (4 lt m ⁻² daily)	217.7	212.4
T ₁₁	FP (2 lt m ⁻² daily)	192.8	188.6
	SE(m±)	2.3	1.7
	CD(P=0.05)	6.7	5.1

Table-4 : Effect of drip irrigation and fertigation on soil phosphorus status at harvest (kg ha⁻¹).

Treatments	Irrigation level	Available Phosphorus	
		0.0-0.15 m	0.15-0.30 m
T ₁	F ₁ I ₂ (2 lt m ⁻² daily)	44.4	37.9
T ₂	F ₁ I ₄ (4 lt m ⁻² daily)	46.1	41.1
T ₃	F ₂ I ₂ (2 lt m ⁻² daily)	48.7	45.2
T ₄	F ₂ I ₄ (4 lt m ⁻² daily)	51.4	48.9
T ₅	F ₃ I ₂ (2 lt m ⁻² daily)	41.9	35.7
T ₆	F ₃ I ₄ (4 lt m ⁻² daily)	44.0	36.8
T ₇	F ₄ I ₂ (2 lt m ⁻² daily)	47.8	44.2
T ₈	F ₄ I ₄ (4 lt m ⁻² daily)	50.8	47.7
T ₉	F ₅ I ₂ (2 lt m ⁻² daily)	44.9	39.2
T ₁₀	F ₅ I ₄ (4 lt m ⁻² daily)	47.6	41.6
T ₁₁	FP (2 lt m ⁻² daily)	41.4	38.3
	SE(m±)	0.7	1.0
	CD(P=0.05)	2.0	3.0

fertigation treatments with bio-fertilizer, cow urine and organic nutrient source on available nitrogen status. It indicated that available nitrogen status varied between 192.8 kg ha⁻¹ to 223.1 kg ha⁻¹. The maximum available nitrogen (223.1 kg ha⁻¹) was recorded under the treatment (T₄) where 100 per cent RDF (1/3N, full P&K as basal) 2/3N through fertigation + cow urine + bio-fertilizers through fertigation was applied and minimum (192.8 kg ha⁻¹) in T₁₁ under farmers' practice. There was a significant difference in available N found under different treatments. Amongst the treatment T₄ were found statistically at par with treatment T₃, T₇, T₈, T₁₀ and significantly superior over rest of the treatments. Available nitrogen status was increased in all the respective treatments from the initial status of the soil except treatments (T₁, T₂, T₅, T₆ and T₁₁) on surface soil (0-0.15 m) samples.

Soil available nitrogen status was statistically at par in I₄ and I₂ irrigation level treatments. The higher soil available nitrogen status might be due to the application of more water availability. The favorable soil conditions viz. organic carbon, porosity, water holding capacity etc. might have helped in the mineralization of soil nitrogen

leading to build up of higher available nitrogen. Application of FYM when treated with cow urine in which nitrogen is in amide form that increases nitrification and bio-fertilizer gave higher available nitrogen. The highest available nitrogen was recorded in 100 per cent RDF with 1/3rd basal application than the rest of the organic and bio-fertilizer source of the nutrients applied in all other treatment except T₉, T₁₀ and T₁₁. It might be due to the reason that cow urine and bio-fertilizer increased the nitrogen content of soil that enhanced the soil available nitrogen status on surface soil samples.

When compared to initial available nitrogen content, except T₁, T₅ and T₆, all the treatments showed significantly lower available content than initial. This might be due to the fact that in T₁ 50 per cent RDF at 1/3rd was applied with irrigation level I₂. In T₅ and T₆ 50 per cent RDF at 1/4th were applied with irrigation level I₂ and I₄ which was low in nitrogen content.

(ii) **Subsurface soil** : A perusal of the data regarding available nitrogen status has been presented in 3. The data revealed that available nitrogen status varied

Table-5 : Effect of drip irrigation and fertigation on soil potassium status at harvest (kg ha⁻¹).

Treatments	Irrigation level	Available Potassium	
		0.0-0.15 m	0.15-0.30 m
T ₁	F ₁ I ₂ (2 lt m ⁻² daily)	277.7	269.1
T ₂	F ₁ I ₄ (4 lt m ⁻² daily)	276.1	268.6
T ₃	F ₂ I ₂ (2 lt m ⁻² daily)	270.7	263.3
T ₄	F ₂ I ₄ (4 lt m ⁻² daily)	267.2	259.8
T ₅	F ₃ I ₂ (2 lt m ⁻² daily)	278.1	269.8
T ₆	F ₃ I ₄ (4 lt m ⁻² daily)	277.3	268.8
T ₇	F ₄ I ₂ (2 lt m ⁻² daily)	276.4	267.8
T ₈	F ₄ I ₄ (4 lt m ⁻² daily)	273.3	263.8
T ₉	F ₅ I ₂ (2 lt m ⁻² daily)	277.4	268.9
T ₁₀	F ₅ I ₄ (4 lt m ⁻² daily)	275.4	264.9
T ₁₁	FP (2 lt m ⁻² daily)	279.8	270.2
	SE (m±)	1.4	1.4
	CD (P=0.05)	4.2	4.1

between 188.6 kg ha⁻¹ to 217.8 kg ha⁻¹ among all the treatments. The maximum nitrogen content (217.8 kg ha⁻¹) was recorded under the treatment T₄ where 100 per cent RDF (1/3N, full P&K as basal) 2/3N through fertigation + cow urine + bio-fertilizers were applied and minimum (188.6 kg ha⁻¹) in T₁₁ under farmers' practice. The significant differences were found under different treatments. Amongst the treatment T₄ were found statistically at par with treatment T₃ and significantly superior over all the other treatments. Available nitrogen status was increased in all the respective treatments from the initial status of the soil except treatments (T₁, T₂, T₅, T₆ and T₁₁) on subsurface (0.15-0.30 m) soil samples.

Similar trend was recorded in subsurface soil samples as compared to the surface soil samples. The available nitrogen status of subsurface soil samples was decreased as compared to surface soil samples might be due to the reason that the presence of less organic matter and microbial activities and mineralization processes in the lower layers.

When compared to initial nitrogen content, the treatments T₁, T₂, T₅, T₆ and T₁₁ gave numerically lower nitrogen content than initial. This might be due to the fact that treatment T₁, T₂, T₅, T₆ and T₁₁ were low dose of RDF fertilizer. Similar results were reported by Sharma and Subehia (2003), Prasad *et al.* (2010), Urkurkar *et al.* (2010) and Thakur *et al.* (2011).

Available phosphorus

(i) Surface soil : The data presented in the table-4 shows the effect of drip irrigation, fertigation, inorganic and organic nutrient with bio-fertilizers sources on available phosphorus content of soil. The data revealed that the maximum 51.4 kg ha⁻¹ available phosphorus content was recorded under the treatment (T₄) 100 per cent RDF (1/3N, full P&K as basal) 2/3 N through fertigation + bio-fertilizer + cow urine and minimum under farmers'

practice (T₁₁) 41.4 kg ha⁻¹. In all the treatments, treatment T₄ was found significantly better except T₈. Furthermore, amongst other treatments, treatment T₈ was found significantly superior than all other treatments except T₄.

The available phosphorus (P) was higher in all the irrigation level I₄ as comparing to irrigation level I₂. In different fertigation treatments, the available phosphorus was maximum in T₄ (51.4 kg ha⁻¹) followed by T₈ (50.8 kg ha⁻¹), T₃ (48.7 kg ha⁻¹) and T₇ (47.8 kg ha⁻¹). Similar results were reported by Ibricki and Buyuk (2002), Ahlfos *et al.* (2005), Amer *et al.* (2009) and Chand (2014).

Soil available phosphorus status was improved numerically and significantly in all the I₄ treatments as compared to I₂ treatments. The higher soil available phosphorus status in soil might be due to better physical condition, during decomposition release of organic acids which in turn helped in releasing phosphorus through solubilizing action of native phosphorus in the soil by application of phosphorus solubilizing bacteria. The organic matter also forms a cover on sesquioxides and makes them inactive and thus reduces the phosphate fixing capacity of the soil, which ultimately, helps in release of ample quantity of phosphorus. In current study the farmyard manure and bio-fertilizers contributed appreciable amount of phosphorus. Therefore, their application contributes an appreciable additional amount of phosphorus to the soil released on their decomposition.

The application of FYM treated with cow urine and bio-fertilizers gave numerically higher soil available phosphorus status in surface soil samples. This might be due to the fact that fortification increased nitrogen content and as nitrogen and phosphorus have synergistic effect on each other, the phosphorus content also increased. This also might be due to the fact that the fortification was also done with phosphate solubilizing microorganisms which help in solubilizing the unavailable phosphorus and

making it available. Similar results were reported by Verma et al. (2005), Urkurkar et al. (2010), Thakur et al. (2011) and Tandon (1987).

(i) Subsurface soil : With the increase in depth the soil available phosphorus content was decreased. The data indicated in the table 4 shows that the highest (48.9 kg ha⁻¹) soil available phosphorus content was recorded under the treatment T₄ and lowest (37.9 kg ha⁻¹) under the treatment (T₁). In all treatments, treatment T₈ was found significantly better among all the treatments except treatment T₄. The treatments T₅, T₆ and T₁₁ decreased its content from the initial status of the soil on subsurface (0.15-0.30 m) soil samples.

Similar trend was recorded in subsurface soil samples as compared to the surface soil samples. The available phosphorus content of subsurface soil samples was lower as compared to surface soil samples and this might be due to the presence of less organic matter and microbial activities and mineralization processes. Similar results were reported by Verma *et al.* (2005), Urkurkar *et al.* (2010), Thakur *et al.* (2011) and Tandon (1987).

Available potassium

(i) Surface soil : Table-5 shows the effect of both the irrigation levels I₂ and I₄, different fertigation treatments with bio-fertilizer, cow urine and organic nutrient source on available potassium status of soil. It indicates that available potassium status varied between 267.2 kg ha⁻¹ to 279.8 kg ha⁻¹. The maximum available potassium status (279.8 kg ha⁻¹) was recorded under the treatment (T₁₁) and minimum (267.2 kg ha⁻¹) in (T₄). There was a significant difference under different treatments. Available potassium status was less in all the respective treatments except farmers' practice from the initial status of the soil on surface soil (0-0.15 m) samples.

Soil available potassium status decreased numerically in all the treatments of irrigation level I₄ as compared to irrigation level I₂ treatments. The higher soil available potassium status under low irrigation level might be due to better physical condition and proper moisture availability at field capacity, Increase in available potassium due to addition of organic source of nutrients and cow urine may be ascribed to the reduction of potassium fixation and release of potassium due to interaction of organic matter with clay, besides the direct potassium addition to the pool of soil.

The application of cow urine and FYM gave numerically higher soil available potassium status on surface soil samples application of bio-fertilizer and FYM with other sources of nutrients enhanced the soil available potassium status as compared to inorganic fertilizer, this might be due to the reason that with high K per cent in cow

urine it provide more potassium concentration to the soil than chemical fertilizers that enhance the soil available potassium status on surface soil samples.

(ii) Subsurface soil : A perusal of the data regarding available potassium status has been presented in table-5. The data revealed that available potassium status varied between 259.8 kg ha⁻¹ to 270.2 kg ha⁻¹ among all the treatments. The maximum potassium (270.2 kg ha⁻¹) was recorded under the treatment (T₁₁) and minimum (259.8 kg ha⁻¹) under T₄. Soil available potassium status was reduced when the depth was increased in all the different respective treatments in subsurface soil samples.

Similar trend was recorded in subsurface soil samples as compared to the surface soil samples. The decrease in available potassium status of subsurface soil samples as compared to surface soil samples might be due to the reason that the presence of less organic matter and microbial activities and mineralization processes. Similar results were reported by Urkurkar et al. (2010).

Conclusions

Hundred percent of RDF (1/3N, Full P&K as basal) 2/3N through fertigation + Azo + PSB + 5 per cent cow urine along with fertigation (4 lt m⁻²) resulted in higher N, P and K uptake as compared to other treatments. The uptake of NPK nutrients was significantly influenced by the integrated nutrient management practices during both the years. The plants recorded higher total nitrogen uptake, which was on par with T₆, T₄, T₁ and T₇ respectively in different vine parts. This could be attributed to better availability of nutrients when plants received in combination of inorganic, organic and biofertilizers. While comparing the treatments with cow urine (T₁-T₈) and treatments without cow urine (T₉-T₁₁), it is found that cow urine at 5 per cent concentration resulted in higher K uptake. The biomass carbon increased from its initial value in all the sources of nutrients applied. The application of organic source of nutrients, make soil micro flora and fauna more active that result in an increase of the biomass carbon showing the potential of using bio-fertilizers and cow urine in fertigation schedule. While comparing the treatments, it is found that treatments with PSB addition resulted in higher phosphatase activity and P uptake than the treatments without PSB addition.

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Varietal Susceptibility of Okra [*Abelmoschus esculentus* (L.) Moench] against Major Sucking Insect Pests

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Abstract

The experiment was conducted to screen out eleven varieties of okra for their varietal susceptibility and none of the varieties was found completely free from the attack of major sucking insect pests of okra. The varieties, Varsha Uphar and Arka Anamika were found to be least susceptible against leaf hopper population; while Hisar Unnat, Arka Abhay, Pusa Makhamali, Hisar Naveen, Parbhani Kranti, Sagun, Pusa Sawani and Kashi Mohini were categorized as moderately susceptible and variety Aprajita as highly susceptible. Whitefly, *Bemisia tabaci* was also observed as second major sucking pest of okra in present investigation. The varieties, Varsha Uphar and Arka Anamika were ranked as least susceptible to whitefly. The varieties Hisar Unnat, Arka Abhay, Pusa Makhamali, Hisar Naveen, Parbhani Kranti, Sagun and Pusa Sawani were ranked as moderately susceptible, however, Kashi Mohini and Aprajita were ranked as highly susceptible to whitefly.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] commonly known as *bhindi* or lady's finger (family: Malvaceae) is a popular fruit vegetable crop and said to be originated from Africa. It is an important summer and rainy season vegetable crop grown throughout the world. Okra fruit is nutritionally very rich with a caloric value of 35. It is one of the important cash crop paying high returns to the growers. However, this crop is also known to harbor many insect pests and diseases which require special attention to combat with at proper time and manner. The crop right from germination to harvesting is attacked by about 72 species of insect pests (Rao and Rajendran, 2003). The major insect pests are shoot and fruit borer, *Earias insulana* (Boisd.), *Earias vittella* (Boisd.); leaf hopper, *Amrasca biguttula biguttula* (Ishida); leaf roller, *Sylepta derogata* Fab; whitefly, *Bemisia tabaci* (Genn.); Aphid, *Aphis gossypii* Glov. and mite, *Tetranychus cinnabarinus* (Boisd.) (Dangi and Ameta, 2005; Meena and Kanwat, 2005). The leaf hopper, *A. biguttula biguttula* sucks the cell sap from lower surface of the leaves and injects toxic substance in it, resulting in yellowing and curling of leaf margins and stunted plant growth. The severe infestation causes burning of leaves which fall down latter, this results 40-60 per cent decrease in yield (Narke and Suryawanshi, 1987). The whitefly also sucks the cell sap from the leaves which lowered vitality of the plants. It excretes honeydew on which sooty mold develops, which interferes with the process of normal photosynthesis. Consequently, the growth of plant is adversely affected. This insect transmits

viral diseases and acts as vector of 'yellow veins mosaic' virus in the plants (Nath *et al.*, 1992). Due to high population of the pest, the vitality of plant is greatly reduced. The leaf acquires curly appearance, and fall down latter ultimately resulting in decreased yield. The use of insecticides have undoubtedly resulted in the maximum production of food grain for the world food supply, but the proliferation of insecticides and their unilateral utilization have created many problems such as development of resistance in insect pests to insecticides, resurgence of insect pests, outbreak of secondary insect pests, insecticidal residues etc. Development of insecticide resistance in insect pests is now one of the major problems in pest management. It causes unexpected crop losses to the growers. The heavy dependence on highly toxic insecticides leads to produce toxicity hazards to environment so there is need to identify the varieties based on their preference/ non preference to a particular pest. The resistant varieties of crops offer insect pest management at no additional cost.

Materials and Methods

The experiment was laid out in simple randomized block design (RBD) with eleven treatments, each replicated thrice. The plot size was kept 3.0 x 2.25 m² keeping row to row and plant to plant distance of 45 and 30 cm, respectively. All the okra varieties used in the experiment were sown on 5th July, 2013 and 2014. Eleven varieties of okra were screened for their relative susceptibility to major insect pests and considered as treatments. The populations of major sucking insect pests were recorded

Table-1 : Relative susceptibility of okra varieties against leaf hopper (kharif, 2013).

S.No.	Variety	Mean leaf hopper population / three leaves*												Mean
		04.08.13	11.08.13	18.08.13	25.08.13	01.09.13	08.09.13	15.09.13	22.09.13	29.09.13	06.10.13	13.10.13	20.10.13	
1.	Arka Abhay	0.80 (1.14)	1.20 (1.30)	2.00 (1.58)	2.40 (1.70)	6.00 (2.55)	9.80 (3.21)	13.00 (3.67)	7.00 (2.74)	3.80 (2.07)	3.40 (1.97)	1.80 (1.52)	1.00 (1.22)	4.35 (2.20)
2.	Hisar Unnat	0.40 (0.95)	0.80 (1.14)	1.60 (1.45)	2.20 (1.64)	5.80 (2.51)	8.40 (2.98)	11.60 (3.48)	6.80 (2.70)	3.20 (1.92)	2.80 (1.82)	1.60 (1.45)	0.80 (1.14)	3.83 (2.08)
3.	Kashi Mohini (VRO-3)	2.00 (1.58)	3.00 (1.87)	4.40 (2.21)	5.20 (2.39)	12.80 (3.65)	17.60 (4.25)	19.60 (4.48)	11.40 (3.45)	6.80 (2.70)	4.40 (2.21)	3.60 (2.02)	2.80 (1.82)	7.80 (2.88)
4.	Varsha Uphar	0.20 (0.84)	0.40 (0.95)	1.60 (1.45)	3.60 (2.02)	5.00 (2.35)	6.40 (2.63)	5.00 (2.35)	3.40 (1.97)	2.00 (1.58)	1.20 (1.30)	0.40 (0.95)	0.20 (0.84)	2.45 (1.72)
5.	Pusa Sawani	1.80 (1.52)	2.80 (1.82)	4.40 (2.21)	5.80 (2.51)	13.20 (3.70)	16.40 (4.11)	18.80 (4.39)	13.00 (3.67)	7.40 (2.81)	4.20 (2.17)	3.60 (2.02)	2.00 (1.58)	7.78 (2.88)
6.	Aprajita	2.20 (1.64)	3.20 (1.92)	4.60 (2.26)	6.20 (2.59)	13.20 (3.70)	17.80 (4.28)	21.60 (4.70)	14.00 (3.81)	7.80 (2.88)	5.00 (2.35)	3.80 (2.07)	3.00 (1.87)	8.53 (3.01)
7.	Parbhani Kranti	1.20 (1.30)	2.40 (1.70)	3.60 (2.02)	4.80 (2.30)	10.60 (3.33)	14.20 (3.83)	17.00 (4.18)	10.40 (3.30)	6.40 (2.63)	3.80 (2.07)	3.20 (1.92)	1.40 (1.38)	6.58 (2.66)
8.	Hisar Naveen	1.20 (1.30)	1.80 (1.52)	2.80 (1.82)	3.60 (2.02)	9.60 (3.18)	13.80 (3.78)	15.20 (3.96)	8.60 (3.02)	5.00 (2.35)	3.60 (2.02)	3.00 (1.87)	1.40 (1.38)	5.80 (2.51)
9.	Sagun	1.40 (1.38)	2.60 (1.76)	4.80 (2.30)	5.80 (2.51)	13.00 (3.67)	15.00 (3.94)	18.40 (4.35)	12.40 (3.59)	6.80 (2.70)	4.20 (2.17)	3.40 (1.97)	1.80 (1.52)	7.47 (2.82)
10.	Arka Anamika	0.20 (0.84)	0.60 (1.05)	1.80 (1.52)	4.40 (2.21)	5.30 (2.41)	8.00 (2.92)	7.00 (2.74)	4.40 (2.21)	2.20 (1.64)	1.00 (1.22)	0.80 (1.14)	0.40 (0.95)	3.01 (1.87)
11.	Pusa Makhamali	1.00 (1.22)	1.40 (1.38)	2.20 (1.64)	2.80 (1.82)	6.00 (2.55)	11.20 (3.42)	13.80 (3.78)	7.40 (2.81)	5.00 (2.35)	3.60 (2.02)	2.70 (1.79)	1.20 (1.30)	4.86 (2.31)
	S.E.m. ±	0.07	0.09	0.11	0.13	0.17	0.20	0.22	0.16	0.13	0.12	0.10	0.09	0.13
	CD (P=0.05)	0.21	0.26	0.32	0.38	0.52	0.61	0.64	0.48	0.4	0.35	0.3	0.26	0.39

*Mean of three replications,

Figures in the parentheses are $\sqrt{X}$ 0.5 values**Table-2 : Relative susceptibility of okra varieties against leaf hopper (kharif, 2014).**

S. No.	Varieties	Mean leaf hopper population/ three leaves*												Mean
		05.08.14	12.08.14	19.08.14	26.08.14	02.09.14	09.09.14	16.09.14	23.09.14	30.09.14	07.10.14	14.10.14	21.10.14	
1.	Arka Abhay	1.00 (1.22)	1.60 (1.45)	2.20 (1.64)	2.80 (1.82)	7.40 (2.81)	10.80 (3.36)	15.60 (4.01)	7.20 (2.77)	4.60 (2.26)	3.60 (2.02)	2.20 (1.64)	1.20 (1.30)	5.02 (2.35)
2.	Hisar Unnat	0.80 (1.14)	1.20 (1.30)	1.80 (1.52)	2.40 (1.70)	6.80 (2.70)	9.80 (3.21)	12.00 (3.54)	6.40 (2.63)	4.60 (2.26)	2.80 (1.82)	1.80 (1.52)	1.20 (1.30)	4.30 (2.19)
3.	Kashi Mohini (VRO-3)	2.00 (1.58)	2.80 (1.82)	5.60 (2.47)	6.20 (2.59)	14.20 (3.83)	18.20 (4.32)	22.80 (4.83)	15.20 (3.96)	8.60 (3.02)	5.40 (2.43)	3.00 (1.87)	2.80 (1.82)	8.90 (3.07)
4.	Varsha Uphar	0.40 (0.95)	0.80 (1.14)	1.80 (1.52)	2.00 (1.58)	5.80 (2.51)	7.60 (2.85)	7.60 (2.85)	5.20 (2.39)	3.80 (2.07)	2.00 (1.58)	1.40 (1.38)	0.80 (1.14)	3.27 (1.94)
5.	Pusa Sawani	1.80 (1.52)	2.80 (1.82)	5.20 (2.39)	6.00 (2.55)	14.00 (3.81)	16.60 (4.14)	21.80 (4.72)	13.80 (3.78)	8.20 (2.95)	4.60 (2.26)	2.60 (1.76)	2.00 (1.58)	8.28 (2.96)
6.	Aprajita	2.40 (1.70)	3.00 (1.87)	5.60 (2.47)	6.80 (2.70)	15.80 (4.04)	18.60 (4.37)	24.60 (5.01)	14.40 (3.86)	9.40 (3.15)	5.20 (2.39)	3.20 (1.92)	3.00 (1.87)	9.33 (3.14)
7.	Parbhani Kranti	1.20 (1.30)	2.40 (1.70)	3.60 (2.02)	4.40 (2.21)	10.60 (3.33)	16.00 (4.06)	19.80 (4.51)	11.00 (3.39)	7.20 (2.77)	3.80 (2.07)	2.20 (1.64)	1.80 (1.52)	7.00 (2.74)
8.	Hisar Naveen	1.20 (1.30)	2.00 (1.58)	2.80 (1.82)	3.20 (1.92)	6.40 (2.63)	13.00 (3.67)	17.60 (4.25)	8.40 (2.98)	5.20 (2.39)	3.60 (2.02)	2.60 (1.76)	1.60 (1.45)	5.63 (2.48)
9.	Sagun	1.40 (1.38)	2.60 (1.76)	4.80 (2.30)	5.60 (2.47)	13.00 (3.67)	16.20 (4.09)	20.00 (4.53)	13.40 (3.73)	6.80 (2.70)	3.80 (2.07)	2.40 (1.70)	2.00 (1.58)	7.67 (2.86)
10.	Arka Anamika	0.80 (1.14)	1.00 (1.22)	1.80 (1.52)	2.20 (1.64)	6.00 (2.55)	8.20 (2.95)	9.40 (3.15)	5.80 (2.51)	4.00 (2.12)	2.20 (1.64)	2.00 (1.58)	1.00 (1.22)	3.70 (2.05)
11.	Pusa Makhamali	1.00 (1.22)	1.80 (1.52)	2.40 (1.70)	3.00 (1.87)	8.20 (2.95)	11.00 (3.39)	16.20 (4.09)	8.20 (2.95)	5.20 (2.39)	3.60 (2.02)	2.40 (1.70)	1.40 (1.38)	5.37 (2.42)
	S.Em. ±	0.07	0.09	0.11	0.13	0.17	0.20	0.24	0.18	0.15	0.13	0.10	0.08	0.14
	CD (P=0.05)	0.22	0.27	0.34	0.39	0.51	0.60	0.70	0.55	0.44	0.38	0.31	0.23	0.41

*Mean of three replications

Figures in the parentheses are $\sqrt{X}$ 0.5 values

Table-3 : Relative susceptibility of okra varieties against leaf hopper (Pooled, *kharif*, 2013 and 2014).

S. No.	Varieties	Mean leaf hopper population/ three leaves*												Mean
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1.	Arka Abhay	0.90 (1.18)	1.40 (1.38)	2.10 (1.61)	2.60 (1.76)	6.70 (2.68)	10.30 (3.29)	14.30 (3.85)	7.10 (2.76)	4.20 (2.17)	3.50 (2.00)	2.00 (1.58)	1.10 (1.26)	4.68 (2.28)
2.	Hisar Unnat	0.60 (1.05)	1.00 (1.22)	1.70 (1.48)	2.30 (1.67)	6.30 (2.61)	9.10 (3.10)	11.80 (3.51)	6.60 (2.66)	3.90 (2.10)	2.80 (1.82)	1.70 (1.48)	1.00 (1.22)	4.07 (2.14)
3.	Kashi Mohini (VRO-3)	2.00 (1.58)	2.90 (1.84)	5.00 (2.35)	5.70 (2.49)	13.50 (3.74)	17.90 (4.29)	21.20 (4.66)	13.30 (3.71)	7.70 (2.86)	4.90 (2.32)	3.30 (1.95)	2.80 (1.82)	8.35 (2.97)
4.	Varsha Uphar	0.30 (0.89)	0.60 (1.05)	1.70 (1.48)	2.80 (1.82)	5.40 (2.43)	7.00 (2.74)	6.30 (2.61)	4.30 (2.19)	2.90 (1.84)	1.60 (1.45)	0.90 (1.18)	0.50 (1.00)	2.86 (1.83)
5.	Pusa Sawani	1.80 (1.52)	2.80 (1.82)	4.80 (2.30)	5.90 (2.53)	13.60 (3.75)	16.50 (4.12)	20.30 (4.56)	13.40 (3.73)	7.80 (2.88)	4.40 (2.21)	3.10 (1.90)	2.00 (1.58)	8.03 (2.92)
6.	Aprajita	2.30 (1.67)	3.10 (1.90)	5.10 (2.37)	6.50 (2.65)	14.50 (3.87)	18.20 (4.32)	23.10 (4.86)	14.20 (3.83)	8.60 (3.02)	5.10 (2.37)	3.50 (2.00)	3.00 (1.87)	8.93 (3.07)
7.	Parbhani Kranti	1.20 (1.30)	2.40 (1.70)	3.60 (2.02)	4.60 (2.26)	10.60 (3.33)	15.10 (3.95)	18.40 (4.35)	10.70 (3.35)	6.80 (2.70)	3.80 (2.07)	2.70 (1.79)	1.60 (1.45)	6.79 (2.70)
8.	Hisar Naveen	1.20 (1.30)	1.90 (1.55)	2.80 (1.82)	3.40 (1.97)	8.00 (2.92)	13.40 (3.73)	16.40 (4.11)	8.50 (3.00)	5.10 (2.37)	3.60 (2.02)	2.80 (1.82)	1.50 (1.41)	5.72 (2.49)
9.	Sagun	1.40 (1.38)	2.60 (1.76)	4.80 (2.30)	5.70 (2.49)	13.00 (3.67)	15.60 (4.01)	19.20 (4.44)	12.90 (3.66)	6.80 (2.70)	4.00 (2.12)	2.90 (1.84)	1.90 (1.55)	7.57 (2.84)
10.	Arka Anamika	0.50 (1.00)	0.80 (1.14)	1.80 (1.52)	3.30 (1.95)	5.65 (2.48)	8.10 (2.93)	8.20 (2.95)	5.10 (2.37)	3.10 (1.90)	1.60 (1.45)	1.40 (1.38)	0.70 (1.10)	3.35 (1.96)
11.	Pusa Makhamali	1.00 (1.22)	1.60 (1.45)	2.30 (1.67)	2.90 (1.84)	7.10 (2.76)	11.10 (3.41)	15.00 (3.94)	7.80 (2.88)	5.10 (2.37)	3.60 (2.02)	2.55 (1.75)	1.30 (1.34)	5.11 (2.37)
	S.Em. ±	0.07	0.09	0.11	0.13	0.17	0.20	0.23	0.17	0.14	0.13	0.10	0.09	0.14
	CD (P=0.05)	0.22	0.27	0.33	0.39	0.52	0.61	0.67	0.52	0.42	0.37	0.31	0.25	0.40

Mean of three replications

Figures in the parentheses are $\sqrt{X} \pm 0.5$ values**Table-4 : Categorization of susceptibility of different okra varieties against leaf hopper (Kharif, 2013 and 2014).**

S. No.	Leaf hopper population/ three leaves	Category	Name of varieties
1.	Below 10.47	Less susceptible	Varsha Uphar, Arka Anamika
2.	10.47 to 21.21	Moderately susceptible	Hisar Unnat, Arka Abhay, Pusha Makhamali, Hisar Naveen, Parbhani Kranti, Sagun, Pusa Sawani, Kashi Mohini (VRO-3).
3.	Above 21.21	Highly susceptible	Aprajita

Peak population of pooled mean (X) = 15.84 Standard deviation () = 5.37

at weekly interval right from germination to harvesting of the crop. The varieties were allowed to have a natural infestation. For recording the observations, the crop was left for having the natural infestation. The population of sucking insect pests (leaf hopper and whitefly) were counted in early morning hours (before 8 AM) of the day when they remain less active. Five plants were randomly selected and tagged in each plot and the populations of leaf hopper and whitefly were counted visually (absolute counting) (Thakkar and Rote, 2001; Sharma and Sinha, 2009). The observations were recorded on three leaves, i.e. one each from top, middle and bottom of every tagged plant. All the stages of nymphs and adults of these pests were taken into account while counting. The leaf hopper and whitefly on upper surface of leaves were counted first and then on lower surface by gentle turning, taking all possible care not to disturb them.

The observations recorded on population of sucking insect pests (leaf hopper and whitefly) were transformed into $\sqrt{X + 0.5}$ values and subjected to analysis of variance separately for the year of 2013, 2014 and pooled. On the basis of critical difference between mean populations, susceptibility to these insect pests were determined.

The varieties of okra were categorized on the basis of mean peak population of insect pests by using following formula :

$$X \pm$$

Where,

X = Mean of peak population / infestation

= Standard deviation for insect population / infestation

The categories were made as (i) least susceptible, (ii) moderately susceptible and (iii) highly susceptible.

Table-5 : Relative susceptibility of okra varieties against whitefly (*kharif*, 2013)

S. No.	Varieties	Mean whitefly population/three leaves*												Mean
		03.08.13	10.08.13	17.08.13	24.08.13	31.08.13	07.09.13	14.09.13	21.09.13	28.09.13	05.10.13	12.10.13	19.10.13	
1.	Arka Abhay	0.40 (0.95)	2.20 (1.64)	2.80 (1.82)	3.60 (2.02)	6.00 (2.55)	8.80 (3.05)	10.00 (3.24)	12.00 (3.54)	8.64 (3.02)	5.84 (2.52)	4.80 (2.30)	2.40 (1.70)	5.62 (2.47)
2.	Hisar Unnat	0.00 (0.71)	1.60 (1.45)	2.58 (1.75)	3.20 (1.92)	5.66 (2.48)	8.26 (2.96)	9.60 (3.18)	10.66 (3.34)	7.60 (2.85)	4.88 (2.32)	4.30 (2.19)	2.00 (1.58)	5.03 (2.35)
3.	Kashi Mohini (VRO-3)	2.40 (1.70)	3.30 (1.95)	6.80 (2.70)	8.00 (2.92)	15.60 (4.01)	18.00 (4.30)	21.34 (4.67)	24.68 (5.02)	16.34 (4.10)	12.78 (3.64)	8.48 (3.00)	4.84 (2.31)	11.88 (3.52)
4.	Varsha Uphar	0.00 (0.71)	0.40 (0.95)	1.20 (1.30)	1.60 (1.45)	2.40 (1.70)	3.20 (1.92)	5.20 (2.39)	4.40 (2.21)	4.00 (2.12)	2.80 (1.82)	1.70 (1.48)	0.90 (1.18)	2.32 (1.68)
5.	Pusa Sawani	2.30 (1.67)	3.20 (1.92)	6.50 (2.65)	7.60 (2.85)	12.70 (3.63)	16.66 (4.14)	18.44 (4.35)	20.92 (4.63)	14.40 (3.86)	10.88 (3.37)	7.60 (2.85)	4.20 (2.17)	10.45 (3.31)
6.	Aprajita	2.44 (1.71)	3.72 (2.05)	7.20 (2.77)	8.90 (3.07)	16.00 (4.06)	21.60 (4.70)	23.20 (4.87)	27.92 (5.33)	19.24 (4.44)	15.52 (4.00)	9.60 (3.18)	5.20 (2.39)	13.38 (3.73)
7.	Parbhani Kranti	1.60 (1.45)	2.80 (1.82)	3.90 (2.10)	5.12 (2.37)	7.92 (2.90)	12.40 (3.59)	15.34 (3.98)	17.34 (4.22)	11.60 (3.48)	8.40 (2.98)	5.70 (2.49)	3.20 (1.92)	7.94 (2.91)
8.	Hisar Naveen	1.12 (1.27)	2.52 (1.74)	3.20 (1.92)	4.40 (2.21)	7.20 (2.77)	11.60 (3.48)	13.20 (3.70)	15.20 (3.96)	9.52 (3.17)	7.46 (2.82)	5.20 (2.39)	2.86 (1.83)	6.96 (2.73)
9.	Sagun	2.00 (1.58)	2.90 (1.84)	5.60 (2.47)	5.82 (2.51)	11.60 (3.48)	14.98 (3.93)	16.40 (4.11)	18.40 (4.35)	13.72 (3.77)	10.00 (3.24)	6.70 (2.68)	3.66 (2.04)	9.32 (3.13)
10.	Arka Anamika	0.00 (0.71)	0.90 (1.18)	2.00 (1.58)	2.66 (1.78)	4.00 (2.12)	6.38 (2.62)	7.82 (2.88)	8.00 (2.92)	5.30 (2.41)	3.60 (2.02)	2.80 (1.82)	1.84 (1.53)	3.78 (2.07)
11.	Pusa Makhamali	0.80 (1.14)	2.40 (1.70)	2.94 (1.85)	4.30 (2.19)	7.34 (2.80)	9.52 (3.17)	10.50 (3.32)	12.90 (3.66)	8.80 (3.05)	6.44 (2.63)	4.86 (2.32)	2.66 (1.78)	6.12 (2.57)
	S.Em. $\pm$	0.07	0.10	0.12	0.14	0.19	0.22	0.24	0.25	0.21	0.19	0.16	0.11	0.17
	CD (P=0.05)	0.20	0.31	0.37	0.42	0.57	0.66	0.70	0.74	0.62	0.56	0.47	0.33	0.50

*Mean of three replications

Figures in the parentheses are $\sqrt{X}$ 0.5 valuesTable-6 : Relative susceptibility of okra varieties against whitefly (*kharif*, 2014).

S. No.	Varieties	Mean whitefly population/ three leaves*												Mean
		05.08.14	12.08.14	19.08.14	26.08.14	02.09.14	09.09.14	16.09.14	23.09.14	30.09.14	06.10.14	13.10.14	20.10.14	
1.	Arka Abhay	0.80 (1.14)	1.34 (1.36)	2.80 (1.82)	3.10 (1.90)	3.34 (1.96)	6.50 (2.65)	8.20 (2.95)	10.50 (3.32)	12.66 (3.63)	10.66 (3.34)	9.20 (3.11)	3.84 (2.08)	6.08 (2.56)
2.	Hisar Unnat	0.52 (1.01)	0.80 (1.14)	2.30 (1.67)	2.80 (1.82)	2.84 (1.83)	5.34 (2.42)	6.90 (2.72)	7.60 (2.85)	9.60 (3.18)	7.00 (2.74)	4.72 (2.28)	2.36 (1.69)	4.40 (2.21)
3.	Kashi Mohini (VRO-3)	2.86 (1.83)	3.52 (2.00)	6.00 (2.55)	7.60 (2.85)	11.34 (3.44)	15.20 (3.96)	20.00 (4.53)	21.60 (4.70)	27.20 (5.26)	20.00 (4.53)	15.20 (3.96)	8.34 (2.97)	13.24 (3.71)
4.	Varsha Uphar	0.00 (0.71)	0.40 (0.95)	0.80 (1.14)	1.66 (1.47)	2.30 (1.67)	2.70 (1.79)	3.34 (1.96)	4.66 (2.27)	6.20 (2.59)	4.44 (2.22)	2.36 (1.69)	1.34 (1.36)	2.52 (1.74)
5.	Pusa Sawani	2.30 (1.67)	3.20 (1.92)	4.86 (2.32)	5.34 (2.42)	10.00 (3.24)	14.50 (3.87)	19.64 (4.49)	20.54 (4.59)	24.00 (4.95)	19.84 (4.51)	13.62 (3.76)	7.20 (2.77)	12.09 (3.55)
6.	Aprajita	3.84 (2.08)	4.00 (2.12)	6.40 (2.63)	8.50 (3.00)	12.58 (3.62)	16.00 (4.06)	20.40 (4.57)	23.34 (4.88)	29.70 (5.50)	24.48 (5.00)	20.40 (4.57)	16.80 (4.16)	15.54 (4.00)
7.	Parbhani Kranti	1.66 (1.47)	2.30 (1.67)	3.60 (2.02)	4.40 (2.21)	6.80 (2.70)	9.34 (3.14)	14.90 (3.92)	15.34 (3.98)	18.20 (4.32)	15.46 (3.99)	10.80 (3.36)	5.14 (2.37)	9.00 (3.08)
8.	Hisar Naveen	1.20 (1.30)	1.84 (1.53)	3.34 (1.96)	4.00 (2.12)	6.66 (2.68)	8.00 (2.92)	12.80 (3.65)	14.00 (3.81)	14.74 (3.90)	13.34 (3.72)	10.38 (3.30)	4.80 (2.30)	7.93 (2.90)
9.	Sagun	2.00 (1.58)	2.66 (1.78)	3.90 (2.10)	4.90 (2.32)	7.66 (2.86)	12.30 (3.58)	16.66 (4.14)	19.64 (4.49)	20.50 (4.58)	17.30 (4.22)	12.58 (3.62)	6.00 (2.55)	10.51 (3.32)
10.	Arka Anamika	0.00 (0.71)	0.50 (1.00)	2.00 (1.58)	2.44 (1.71)	2.80 (1.82)	4.00 (2.12)	6.00 (2.55)	6.70 (2.68)	8.70 (3.03)	6.50 (2.65)	2.92 (1.85)	1.84 (1.53)	3.70 (2.05)
11.	Pusa Makhamali	1.10 (1.26)	1.60 (1.45)	2.90 (1.84)	3.30 (1.95)	5.60 (2.47)	6.90 (2.72)	10.66 (3.34)	12.66 (3.63)	13.34 (3.72)	11.60 (3.48)	9.26 (3.12)	4.00 (2.12)	6.91 (2.72)
	S.Em. $\pm$	0.07	0.09	0.13	0.14	0.17	0.20	0.23	0.24	0.26	0.23	0.21	0.15	0.18
	CD (P=0.05)	0.22	0.27	0.38	0.41	0.52	0.59	0.67	0.72	0.78	0.68	0.62	0.44	0.53

*Mean of three replications

Figures in the parentheses are $\sqrt{X}$ 0.5 values

Table-7 : Relative susceptibility of okra varieties against whitefly (Pooled, *kharif*, 2013 and 2014).

S. No.	Varieties	Mean whitefly population/ three leaves*												Mean
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1.	Arka Abhay	0.60 (1.05)	1.77 (1.51)	2.80 (1.82)	3.35 (1.96)	4.67 (2.27)	7.65 (2.85)	9.10 (3.10)	11.25 (3.43)	10.65 (3.34)	8.25 (2.96)	7.00 (2.74)	3.12 (1.90)	5.85 (2.52)
2.	Hisar Unnat	0.26 (0.87)	1.20 (1.30)	2.44 (1.71)	3.00 (1.87)	4.25 (2.18)	6.80 (2.70)	8.25 (2.96)	9.13 (3.10)	8.60 (3.02)	5.94 (2.54)	4.51 (2.24)	2.18 (1.64)	4.71 (2.28)
3.	Kashi Mohini (VRO-3)	2.63 (1.77)	3.41 (1.98)	6.40 (2.63)	7.80 (2.88)	13.47 (3.74)	16.60 (4.14)	20.67 (4.60)	23.14 (4.86)	21.77 (4.72)	16.39 (4.11)	11.84 (3.51)	6.59 (2.66)	12.56 (3.61)
4.	Varsha Uphar	0.00 (0.71)	0.40 (0.95)	1.00 (1.22)	1.63 (1.46)	2.35 (1.69)	2.95 (1.86)	4.27 (2.18)	4.53 (2.24)	5.10 (2.37)	3.62 (2.03)	2.03 (1.59)	1.12 (1.27)	2.42 (1.71)
5.	Pusa Sawani	2.30 (1.67)	3.20 (1.92)	5.68 (2.49)	6.47 (2.64)	11.35 (3.44)	15.58 (4.01)	19.04 (4.42)	20.73 (4.61)	19.20 (4.44)	15.36 (3.98)	10.61 (3.33)	5.70 (2.49)	11.27 (3.43)
6.	Aprajita	3.14 (1.91)	3.86 (2.09)	6.80 (2.70)	8.70 (3.03)	14.29 (3.85)	18.80 (4.39)	21.80 (4.72)	25.63 (5.11)	24.47 (5.00)	20.00 (4.53)	15.00 (3.94)	11.00 (3.39)	14.46 (3.87)
7.	Parbhani Kranti	1.63 (1.46)	2.55 (1.75)	3.75 (2.06)	4.76 (2.29)	7.36 (2.80)	10.87 (3.37)	15.12 (3.95)	16.34 (4.10)	14.90 (3.92)	11.93 (3.53)	8.25 (2.96)	4.17 (2.16)	8.47 (2.99)
8.	Hisar Naveen	1.16 (1.29)	2.18 (1.64)	3.27 (1.94)	4.20 (2.17)	6.93 (2.73)	9.80 (3.21)	13.00 (3.67)	14.60 (3.89)	12.13 (3.55)	10.40 (3.30)	7.79 (2.88)	3.83 (2.08)	7.44 (2.82)
9.	Sagun	2.00 (1.58)	2.78 (1.81)	4.75 (2.29)	5.36 (2.42)	9.63 (3.18)	13.64 (3.76)	16.53 (4.13)	19.02 (4.42)	17.11 (4.20)	13.65 (3.76)	9.64 (3.18)	4.83 (2.31)	9.91 (3.23)
10.	Arka Anamika	0.00 (0.71)	0.70 (1.10)	2.00 (1.58)	2.55 (1.75)	3.40 (1.97)	5.19 (2.39)	6.91 (2.72)	7.35 (2.80)	7.00 (2.74)	5.05 (2.36)	2.86 (1.83)	1.84 (1.53)	3.74 (2.06)
11.	Pusa Makhamali	0.95 (1.20)	2.00 (1.58)	2.92 (1.85)	3.80 (2.07)	6.47 (2.64)	8.21 (2.95)	10.58 (3.33)	12.78 (3.64)	11.07 (3.40)	9.02 (3.09)	7.06 (2.75)	3.33 (1.96)	6.52 (2.65)
	S.Em. $\pm$	0.07	0.10	0.12	0.14	0.18	0.21	0.23	0.25	0.24	0.21	0.18	0.13	0.17
	CD (P=0.05)	0.21	0.29	0.38	0.42	0.55	0.63	0.69	0.73	0.70	0.62	0.55	0.39	0.51

* Mean of three replications

Figures in the parentheses are $\sqrt{X}$ 0.5 valuesTable-8 : Categorization of susceptibility of different okra varieties against whitefly (*Kharif*, 2013 and 2014).

S. No.	Whitefly population/ three leaves	Categories	Name of varieties
1.	Below 8.23	Least susceptible	Varsha Uphar, Arka Anamika,
2.	8.23 to 21.67	Moderately susceptible	Hisar Unnat, Arka Abhay, Pusa Makhamali, Hisar Naveen, Parbhani Kranti, Sagun, Pusa Sawani
3.	Above 21.67	Highly susceptible	Kashi Mohini (VRO-3), Aprajita

Peak population of pooled mean (X) = 14.95

Standard deviation () = 6.72

Results and Discussion

Leaf hopper, *A. biguttula biguttula* : The observations of leaf hopper population commenced from (first week of August) to disappearance of population (third week of October) during both the years, Table-1,2. It is worthwhile to mention that none of the tested varieties was found immune to the leaf hopper infestation. The minimum population of leaf hopper was recorded on Varsha Uphar (0.30/ three leaves), whereas, it was maximum on Aprajita (2.30/ three leaves) (Table-3). This trend continued till peak population was observed in the third week of September during both the years, (VII observation). Based on pooled data of 2013 and 2014 varieties, Varsha Uphar and Arka Anamika harbored minimum leaf hopper population of 6.30/ three leaves and 8.20/ three leaves, respectively and stood at par with each other in their

degree of infestation, whereas, Aprajita, Kashi Mohini, Pusa Sawani, Sagun and Parbhani Kranti harboured maximum population (18.40 to 23.10/ three leaves) and remained statistically at par to each other. The other varieties ranked in middle order of susceptibility.

Based on statistical categorization, the varieties Varsha Uphar and Arka Anamika were found to be least susceptible, while Hisar Unnat, Arka Abhay, Pusa Makhamali, Hisar Naveen, Parbhani Kranti, Sagun, Pusa Sawani and Kashi Mohini were categorized as moderately susceptible, and variety Aprajita as highly susceptible to leaf hopper (Table-4). Srinivasa and Sugeetha (2001) reported variety Parbhani Kranti as most preferred by the leaf hopper, partially supported the present result. Bhat *et al.* (2007) screened okra genotypes and reported Arka Anamika, Pusa Sawani as less preferred, Varsha Uphar and Arka Abhay moderately preferred while Parbhani

Kranti and Sagun were more preferred by *A. biguttula biguttula*. Iqbal et al. (2008) reported Pusa Sawani as comparatively susceptible variety partially in agreement with present findings. The difference may probably be due to the difference in climatic conditions, soil types and intensity of pest population in different locations. In the present investigation, variety Aprajita was found highly susceptible to leaf hopper. The work on the varieties Aprajita, Hisar Naveen and Pusa Makhamali screened in the present investigation have not been traced in the literature; therefore, the performance of these could not be compared and discussed.

Whitefly, *B. tabaci* : The population of whitefly started in the first week of August during both the years on all the varieties except Varsha Uphar and Arka Anamika and increased gradually after second week of August and reached to its peak in the pooled data of VIII observation during the study period after that the population showed decreasing trend (Table-5,6).

The mean whitefly population at all the intervals ranged from 2.42 to 14.46/ three leaves. The minimum whitefly population was observed on Varsha Uphar (2.42/ three leaves) and Arka Anamika (3.74/ three leaves), whereas, maximum on Aprajita (14.46/ three leaves), Kashi Mohini (12.56/ three leaves) and Pusa Sawani (11.27/ three leaves) (Table-7). The non-significant difference existed between latter three varieties. The rest of the varieties, viz., Hisar Unnat, Arka Abhay, Pusa Makhamali, Hisar Naveen, Parbhani Kranti and Sagun harbored whitefly population ranging from 4.71 to 9.91/ three leaves and ranked in the middle order of infestation.

The varieties, Versha Uphar and Arka Anamika were ranked as least susceptible. The varieties Hisar Unnat, Arka Abhay, Pusa Makhamali, Hisar Naveen, Parbhani Kranti, Sagun and Pusa Sawani were ranked as moderately susceptible, however, Kashi Mohini and Aprajita were ranked as highly susceptible against whitefly (Table-8). The present findings got support from the findings of Patni (2000), Bairwa and Kanwat (2001), Bhat et al. (2007) who reported Arka Abhay, Arka Anamika, Pusa Sawani and Prabhani Kranti as moderately susceptible. Anitha and Nandihalli (2007) reported Arka Anamika as least susceptible variety to whitefly, corroborated with the present findings. Gonde et al. (2013) reported varieties Kashi Mohani (VRO3) and VRO4 harbored lowest infestation of whitefly, partially corroborated with the present findings. The difference may probably be due to the difference in climatic conditions, soil types, intensity of insect pest population at different locations. In the present investigation, variety Aprajita was found highly susceptible to whitefly. The work on the varieties Aprajita, Hisar Naveen and Pusa

Makhamali screened in the present investigation have not been traced in the literature; therefore, the performance of these could not be compared and discussed.

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The Impact of Various Irrigation Schedules on the Growth and Yield of Rabi Onion (*Allium cepa* L.)

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Abstract

The present study was conducted to find out the water use efficiency and marketable yield of onion bulb on research farm, Maharajpur, college of agriculture, Jawaharlal Nehru Agriculture University, Jabalpur (MP) in 2019-20. The experiment was carried out in a split plot design (SPT). IW/CPE ratio 0.8 (IW/CPE ratio of 0.8), Critical stages (bulb formation and pre maturity), 75 % ASM, and 50 % ASM are the four treatments. The study revealed that the bulb yield production increased with an increase in irrigation levels. The results of the experiment showed that the irrigation scheduling had significantly affected all the studied parameters. The maximum Plant height (cm) and number of leaves per plant was recorded in the 75 % ASM at 30, 60 and 90 DAT (Plant height 28.02, 45.26, 58.37 cm and minimum 25.99, 42.08, 54.38 cm and number of leaves 4.01, 5.95, 7.65 and minimum leaves 3.80, 5.51 and 6.97, respectively). Neck thickness (cm), Equatorial diameter (cm), Polar diameter (cm), Average bulb weight /plant (g), Total bulb yield (t/ha) and Marketable bulb yield (t/ha) was recorded in 75 % ASM (1.74 cm, 5.17 cm, 5.18 cm, 37.87 g, 22.44 t/ha, 21.46 t/ha and minimum 1.59 cm, 4.17 cm, 4.17 cm, 33.48 g, 20.58 t/ha, 19.51 t/ha, respectively).

Key word : Irrigation scheduling, IW/CPE ratio, onion, growth, critical stages, ASM.

Introduction

The onion (*Allium cepa* L.) ($2n = 16$) belongs to the Alliaceae family and is one of the most important bulbous vegetable crops. considered to have originated in central Asia. India is the second largest producer of onions in the world, next to China, but the productivity of onions in India is very low, i.e., 14.21 tons/ha, as compared to China and other countries like Egypt, the Netherlands, Iran, etc. In India, it is being grown on an area of 1.43 m ha with a production of an average of 26.15 MT and the productivity is 16.18 tonnes per hectare, which is quite low (DAC&FW 2019-20). The major onion producing states are Maharashtra, Madhya Pradesh, Karnataka, Rajasthan, Gujarat, Bihar, Andhra Pradesh, Haryana, West Bengal, Uttar Pradesh, and Chhattisgarh in the country. These states account for almost 90% of the total onion production in the country. (SDH&A2020). Irrigation scheduling is a critical management input to ensure adequate soil moisture for optimum plant growth, yield, quantity, water use efficiency, and economic return. Irrigation scheduling, which determines the timing and amount of irrigation water, is governed by many complex factors, but microclimate plays the most vital role.

Materials and Methods

The investigation was carried out during the Rabi season (Dec-May) 2019-20 at Maharajpur Vegetable Research Farm, Department of Horticulture, JNKVV, Jabalpur (MP), India. The climate of the Jabalpur region is typically sub-humid, characterized by hot, dry summers and cool, dry winters. The mean annual rainfall of Jabalpur is 962 mm and ranges from 1000 to 1500 mm. The soil of the experimental field is sandy clay loam in texture, medium in organic carbon (0.58%), available nitrogen (218.00 kg N ha⁻¹) and phosphorus (12.22 kg P₂O₅ ha⁻¹) but high in available potassium (289 kg K₂O ha⁻¹). The soil was nearly neutral in reaction (6.6pH) and the concentration of soluble salts (0.15 ds m⁻¹) was below the harmful limit. The treatment consisted of four. These approaches are based on climatologically based approaches plant indices and soil moisture regime approaches. Methods were IW/CPE ratio of 0.8 critical stages (bulb formation and pre-maturity), 75% ASM and 50% ASM. CPE was computed as the sum of the daily evaporation of a USWB class-A open pan. The pan was located adjacent to the metrological observatory in Jabalpur. An integrated approach to SPAC is essential for an ideal irrigation schedule.

Pan evaporation (E_{pan}) is used to determine the

amount of irrigation water to be applied in the ratio of irrigation water (IW) and cumulative pan evaporation (CPE) from USWB Class A pan, usually known as IW/CPE ratio method. IW/CPE ratio of 1.0 indicates scheduling irrigation with quantity of irrigation water equal to that lost in evaporation.

Cumulative pan evaporation (CPE) :

IW/CPE by using following formula :

$$CPE = \frac{IW}{\text{Ratio}}$$

Where, CPE = cumulative pan evaporation, IW = Irrigation water depth Ratio = given ratio.

Critical stages, any plant character, related directly or indirectly to plant water deficit which responds readily to integrated influence of soil, water, plant and evaporative demand of the atmosphere may serve as a criterion for timing of irrigation to crops, in this research field critical stages of bulb formation found in 30 DAT to pre-maturity of bulb 15 days before harvesting in season 2019-20.

75% ASM and 50% ASM, in these methods, soil moisture content is estimated to know the deficit in available soil moisture at which it is proposed to irrigate on predetermined soil moisture content to bring the soil to field capacity. Soil moisture content is estimated either by direct gravimetric method or indirect measurement such as tensiometers, resistance blocks, neutron probe etc.

Field capacity :

It is calculated by formula.

$$fc = \frac{M_{fc} - M_{bi}}{100} \times BD \times D_s$$

Where, FC = Field capacity, M_{fc} = soil moisture content % at field capacity, M_{bi} = soil moisture content % before irrigation, BD = soil bulk density, D_s = depth of soil (cm) considered

Oven drying method (Gravimetric method to determinate soil moisture) : The soil sample is dried in hot air oven at 105°C until constant weight is obtained and dry weight of the sample is recorded.

$$\text{Moisture content} = \frac{\text{Wet weight} - \text{dry weight}}{\text{dry weight}} \times 100$$

Growth Parameters : The five plants were randomly selected in each plot and data were collected at four days interval. Plant height and numbers of leaves per plant was recorded.

Yield Parameters : Neck thickness (cm), Equatorial

diameter (cm), Polar diameter (cm) were measured using Vernier caliper at the narrowest point of the bulb and widest point of the bulb respectively were counted from selected plants.

Average bulb weight /plant (g) to calculate the weight of bulb in each plot, five plants were randomly selected and weighed on electronic balance.

Total bulb yield (t/ha) and Marketable bulb yield (t/ha) was calculated by the following formulas :

$$\text{Total bulb yield (t/ha)} = \frac{\text{bulb yield (kg / plot)} \times 10,000}{\text{net area of plot (m}^2\text{)} \times 10 \times 100}$$

$$\text{Marketable bulb yield (t/ha)} = \frac{(W_1 - W_2) \times 10,000}{\text{net area of plot (m}^2\text{)} \times 10 \times 100}$$

Where, W_1 = Total bulb wt. per net plot, W_2 = Unmarketable bulb wt. per net plot.

Results and Discussion

The results recorded that significant differences were recorded in the different growth and yield parameters. The plant height was significantly affected at 60 and 90 DAT by irrigation scheduling whereas, the maximum plant height was recorded in 75 % ASM (45.26 and 58.37 cm, respectively) but 75 % ASM was found at par with IW/CPE ratio 0.8 (44.27 and 56.79 cm, respectively) followed by Critical stages (bulb formation and pre maturity) and minimum plant height was recorded in 50 % ASM (42.08 and 54.38 cm, respectively) at 60 and 90 DAT. The plant height increasing when the adequate soil moisture was applicated in the field and it is directly related turgid pressure that's are contained by the water in the plant cells which is the main reason for plant growth Doorenbos J and Pruitt WO (1977), Vaux HJ and Pruitt WO (1983), Zheng *et al.*, (2013) and El-Noemani AA *et al.*, (2009).

The maximum number of Leaves per plant was recorded in 75 % ASM (7.65) but 75 % ASM was found at par with IW/CPE ratio 0.8 (7.24) and Critical stages (bulb formation and pre maturity) (7.17) and minimum Number of Leaves per plant was recorded in 50 % ASM (6.97) at 90 DAT. This all the number of leaves related finding are supported by the perversely studded researchers viz., Wakchaure *et al.* (2018), Kumar *et al* (2007) Metwally (2011), Enchalew *et al.*, (2016) and Bagali *et al* (2012). The study shoes the number of leaves are directly affected by the amount of water applied at available soil moisture and applied irrigation water for the plant growth.

The neck thickness (table-2) was significantly

Table-1 : Different irrigation schedules have an effect on the growth of rabi onion (*Allium cepa* L.).

Treatment	Plant height (cm)			Number of leaves per plant		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
IW/CPE ratio 0.8	27.04	44.27	56.79	3.96	5.72	7.24
Critical stages	26.06	43.21	55.69	3.87	5.65	7.17
75% ASM	28.02	45.26	58.37	4.01	5.95	7.65
50% ASM	25.99	42.08	54.38	3.80	5.51	6.97
SEM $\pm$	0.70	0.46	0.72	0.06	0.15	0.15
CD at 5%	NS	1.58	2.51	NS	NS	0.54

Critical stages (bulb formation and pre maturity)

Table-2 : Effect of different irrigation scheduling in yield attributes on Rabi onion (*Allium cepa* L.)

Treatment	Neck thickness (cm)	Equatorial diameter (cm)	Polar diameter (cm)	Average bulb weight / plant (g)	Total bulb yield (t/ha)	Marketable bulb yield (t/ha)
IW/CPE ratio 0.8	1.61	4.20	4.76	35.54	21.50	20.39
Critical stages	1.61	4.17	4.17	34.11	20.94	19.75
75% ASM	1.74	5.17	5.18	37.87	22.44	21.46
50% ASM	1.59	4.17	4.40	33.48	20.58	19.51
SEM $\pm$	0.03	0.21	0.15	0.34	0.35	0.17
CD at 5%	0.09	0.74	0.53	1.16	1.21	0.59

Critical stages (bulb formation and pre maturity)

differentiated in different treatments. Neck thickness affected by the irrigation scheduling at harvesting the maximum neck thickness was recorded in 75 % ASM (1.74 cm) followed by IW/CPE ratio 0.8 and Critical stages (bulb formation and pre maturity) (1.61 cm respectively) and the minimum neck thickness was recorded in 50 % ASM (1.59 cm) at harvesting stage of crop these findings are supported by the R.M. Sujeewa *et al.*, (2020).

The equatorial and polar diameter was significantly affected by the irrigation scheduling the maximum equatorial and polar diameter was recorded in 75 % ASM (5.17 and 5.18 cm respectively) but the equatorial diameter IW/CPE ratio 0.8 (4.20 cm) was followed by the 75 % ASM and the minimum equatorial and polar diameter was recorded in 50 % ASM (4.17 and 4.40 cm respectively) at harvesting stage of crop. The result was supported by Paul JC *et al.*, (2013) Yenus (2013), Kenneth *et al.* (2017) and Kumar *et al.* (2007b), who indicated that water stress at the development and bulb formation stages of growth of onion significantly affected the size of onion bulbs.

The average bulb weight (table 2) of significantly influences due to irrigation scheduling at harvesting stage of onion crop, whereas, the maximum average bulb weight was recorded in 75 % ASM (37.87 g) followed by IW/CPE ratio 0.8 (35.54 g) and proved significantly superior effect on all remaining treatments and the minimum average bulb weight was recorded in 50 % ASM (33.48 g) at harvesting stage of onion crop.

The total bulb yield (t/ha.) was significantly influenced by the irrigation scheduling, whereas, the maximum total bulb yield was recorded in 75 % ASM (22.44 t/ha) but 75 % ASM was found at par with IW/CPE ratio 0.8 (21.50 t/ha) and proved significantly superior over all other treatments and proved superior and minimum total bulb yield was recorded in the 50 % ASM (20.58 t/ha) at harvest.

Marketable bulb yield significantly influences due to irrigation scheduling at harvesting stage of onion crop whereas, the maximum marketable bulb yield was recorded in 75 % ASM (21.46 t/ha) followed by IW/CPE ratio 0.8 (20.39 t/ha) and proved significantly superior over all other remaining treatments and minimum marketable bulb yield was recorded in 50 % ASM (19.51 t/ha) at harvesting stage. According to Tsegaye *et al.* (2016), David *et al.* (2016), Pelter *et al.* (2004), Martýn de Santa Olalla *et al.* (2004) and Dirirsa *et al.* (2017) higher marketable bulbs of onion at higher irrigation levels might be due to the increase in the formation of growth measurements causing faster synthesis and transportation of photosynthates from source to sinks.

Conclusion

Based on the obtained results of the effect of different water application schedules on the growth and yield of onions, it was concluded that irrigation scheduling had significantly affected all the studied parameters. To achieve a high production potential for onions, appropriate soil moisture should be maintained during

the entire growing season. High marketable yields of bulbs in 75 % ASM(21.46 t/ha) suggested that the crop water requirement of onions in maximum irrigation applied during the crop growth period as per requirement, can maintain appropriate soil moisture during the entire crop growing season. It is therefore recommended for onion farmers to adopt it if they want to achieve maximum growth, yield, and optimum utilization of irrigation water per unit area.

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Industrial By-Products Potential for Improving Problematic Soils

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Abstract

Due to huge population, global food demands have been increasing day by day on-the-one-hand, and the continual shrinkage of productive lands and freshwater on the other, there is a growing pressure to bring marginal and problematic soil into cultivation. So, it is necessary to ameliorate these problematic soils. Chemically the problematic soils are acid soil, sodic soil, saline soil and calcareous soil. Limestone and gypsum are most common materials used soil amendments in problematic soils but small and marginal farmers of India could not afford to purchase lime and gypsum because of their relatively high cost and limited availability. On the other hand rapid rate of industrialization has accelerated soil and water pollution around the industrial units due to unscientific methods of discharge of waste materials on land or into water bodies. Since industrialization and pollution go together problem of disposal of industrial wastes assume paramount importance. The industrial waste of some industry like steel, paper mill, sugar etc. can be used in amelioration of these problematic soils. Pressmud – a sugar industry waste and spent wash, a byproduct of distilleries–could be efficient ameliorants in alleviating the sodicity stress with appreciable reductions in soil pH and ESP in salt-affected. Soil properties like pH, EC, organic carbon, exchangeable sodium percentage (ESP), contents of cations and anions were improved significantly under combination of pressmud and gypsum (improved practice) than only gypsum. Adding an appropriate amount of FGDG can effectively improve saline-alkaline (coastal saline) soil. After the application of FGDG, the physicochemical properties of the soil can be significantly improved, the bulk density, pH, ESP and EX-Na⁺ content can be reduced, and the porosity can be significantly increased. For the amelioration of acid soils, the paper mill sludge and basic slag were found to be useful to enhance the soil pH, nutrient uptake, biomass, leaf area and yield of different crops significantly when it was applied up to 50% LR from the above results we can conclude that the industrial by product in alone or in combination with other organic like FYM and inorganic like gypsum, lime can be used for amelioration of problematic soils.

Key words : Industrial byproduct, FGD gypsum, sodicity, FYM, pH, EC

Introduction

In face of increasing global food demands on-the-one-hand, and the continual shrinkage of productive lands and freshwater on the other, there is a growing pressure to bring marginal lands into cultivation. Development of soil acidity, salinity and sodicity problems caused by both natural and anthropogenic processes is recognized to be a major driver of land degradation globally (Meena *et al.*, 2019; Wicke *et al.*, 2011). It is estimated that only salt affected soils eventually affect about 1,125 million hectares (million ha) of land in arid and semiarid regions (Hossain, 2019), resulting in annual economic losses of about \$US27.5 billion (Qadir *et al.*, 2014). In India, about 6.74 million ha is salt affected, with predominance in certain areas including the agriculturally important Indo-Gangetic basin (Mandal, Sharma, & Singh, 2009). Of this, a nearly 3.77 million ha is dominated by sodic soils is responsible for the annual loss of about 11.2 million tons of farm production valued at US\$ 2.3 billion (Sharma *et al.*, 2015) and acid soils occupy about 49 m ha area, of which 26 m ha has pH below 5.5 and 23 m ha has pH between 5.6 and 6.5 (Panda, 1979). Due to huge population and

limited arable land resources it is necessary to ameliorate the problematic soil. Limestone is the most common liming material used to ameliorate acid soil while gypsum is most commonly known and used calcium compound for amelioration of salt affected soil, but small and marginal farmers of India could not afford to purchase lime and gypsum in the form of pure because of their relatively high cost and limited availability. On the other hand, rapid rate of industrialization has accelerated soil and water pollution around the industrial units due to unscientific methods of discharge of waste materials on land or into water bodies. If the waste material was to be directly disposed of without any utilization or treatment, a vast area of land would be required. Such an approach will be a waste of valuable land resources and represents a potential threat of secondary pollution to the environment. Because industrialization and pollution go hand in hand, the problem of industrial waste disposal becomes critical.

The amelioration of saline-alkali soil using industrial by product would make use of tens of millions tons of these product, thereby boosting the application of industrial by product and the development of the pollution-control industry. Furthermore, the vast majority

of barren saline-alkali soils that have been improved with the industrial byproduct would be viable for growing agricultural products, which would be beneficial to both agricultural development and local ecosystem improvement. For salt affected soil industrial by product like pressmud, spent wash, flue gas desulfurization (FGD) gypsum, fly ash, phosphogypsum etc. can be used in place of gypsum. These by-products are formed in huge amount in industrial process. These products contain high amount of calcium carbonate as well as organic matter which also supply essential nutrient to soil. For acid soil reclamation industrial by product like basic slag from steel industry and paper mill sludge from paper industry etc. can be used for amelioration. The objective of this study is to investigate the effect of these industrial by product on the problematic soils.

Problematic soils and its type : The soils which possess characteristics that make them uneconomical for the cultivation of crops without adopting proper reclamation measures are known as problem soils. There is following types of problematic soils.

1. Physical problem soils
2. Chemical Problem soils
3. Biological Problem soils
4. Nutritional problem soils as a result of above constraints

In this section we will discuss about the chemical problem soils which are further divided into following types.

Saline soils-Saline soils defined as soils having a conductivity of the saturation extract greater than 4 dS m⁻¹ and an exchangeable sodium percentage less than 15. Formerly these soils were called white alkali soils because of surface crust of white salts.

Alkali / Sodic soils-Alkali or sodic soil is defined as a soil having a conductivity of the saturation extract less than 4 dS m⁻¹ and an exchangeable sodium percentage greater than 15. Most alkali soils, particularly in the arid and semi-arid regions.

Saline-alkali/sodic soils-Saline-alkali / sodic soil is defined as a soil having a conductivity of the saturation extract greater than 4 dS m⁻¹ and an exchangeable sodium percentage greater than 15. The pH is variable and usually above 8.5 depending on the relative amounts of exchangeable sodium and soluble salts. When soils dominated by exchangeable sodium, the pH will be more than 8.5 and when soils dominated by soluble salts, the pH will be less than 8.5.

Acid soils - Soil acidity refers to presence of higher

concentration of H⁺ in soil solution and at exchange sites. They are characterized by low soil pH and with low base saturation. In acid soil regions (ASR) precipitation exceeds the evapo-transpiration and hence leaching is predominant causing loss of bases from the soil. When the process of weathering is drastic, the subsoil and in many cases, the whole profile becomes acidic. Acid soils occupy approximately 60% of the earth land area and are arise under humid climate conditions from carbonaceous less soil forming rocks in all thermal belts of the earth.

Acid Sulphate soils - Acid sulphate are drained coastal wetland soils that have become acid (pH<4) due to oxidation of the pyritic minerals in the soil. Undrained soils containing pyrites need not be acid and they are called potential acid sulphate soils. Soil with sufficient sulphides (FeS₂ and others) to become strongly acidic when drained are termed acid sulphate soils or as the Dutch refer to those soils cat clays. Generally acid sulphate soils are found in coastal areas where the land is inundated by salt water. In India, acid sulphate soil is, mostly found in Kerala, Orissa, Andhra Pradesh, Tamil Nadu and West Bengal.

Calcareous soil - Calcareous soil that contains enough free calcium carbonate (CaCO₃) and give effervescence visibly releasing CO₂ gas when treated with dilute 0.1N hydrochloric acid. The pH of calcareous soil is > 8.5 and it is also regarded as an alkaline (Basic) soil.

Industrial by-products in ameliorating problematic soils : The methods generally used to ameliorate chemical problem soils are chemical amendments alone or in combination with organic amendments like farmyard manure (FYM), compost, and crop-based interventions Of these, chemical amendments like gypsum (CaSO₄.2H₂O) (sodic soil), liming material (acid soil) have been used most extensively for the reclamation but it is very costly because of its requirement in large quantity and high market price. To reduce the burden on these natural resources, the industrial by product can be used for reclamation of problematic soil like :

Pressmud
Spent wash
Basic slag
Paper mill sludge
Fly ash
Phosphogypsum
Flue gas desulfurized gypsum

Table-1 : Changes in soil properties with different sodicity levels (S1–S4) and reclamation practices (EP and IP) after 3 years of cultivation with rice-wheat cropping system.

Soil parameter	EP (existing practice)				IP (improved practice)			
	S1	S2	S3	S4	S1	S2	S3	
pH	8.5±0.14	9.0±0.11	9.4±0.16	9.6±0.16	8.5±0.11	8.5±0.12	9.2±0.15	9.4±0.21
EC (dS/m)	0.60±0.10	0.76±0.12	1.32±0.10	1.41±0.12	0.63±0.15	0.76±0.21	1.36±0.31	1.41±0.32
OC (%)	0.26±0.02	0.20±0.02	0.14±0.03	0.12±0.02	0.32±0.04	0.26±0.09	0.21±0.06	0.14±0.04
ESP	21.5±1.23	30.4±2.42	42.6±2.51	51.4±3.28	16.2±1.01	24.2±1.32	28.8±2.28	38.6±1.68
Na ⁺ (meq/l)	2.30±0.06	3.20±0.08	3.60±0.12	3.80±0.21	1.40±0.23	2.10±0.18	3.20±0.23	3.00±0.24
Ca ⁺⁺ (meq/l)	2.50±0.21	1.83±0.32	1.80±0.24	1.41±0.16	1.83±0.31	1.53±0.12	1.84±0.20	2.10±0.22
Mg ⁺⁺ (meq/l)	2.30±0.13	1.74±0.16	2.10±0.12	1.10±0.16	1.10±0.15	1.20±0.20	2.13±0.21	1.20±0.20

Table-2 : Effect of addition PM and G on pH, EC, Soluble cations and ESP of soil study.

Treatments	PM%	Gg/kg	pH	ECe (dS/m)	Soluble cations			ESP %
					Ca ⁺⁺	Mg ⁺⁺	Na ⁺	
T1 (CTRL)	PM1=0	G1=0	8.33	14.25	22.33	14.33	88.66	13.43
T2	PM1=0	G2=2.5	8.24	11.83	38	23	43	9.78
T3	PM1=0	G3=5	8.21	10.85	43.66	23.33	38.66	8.85
T4	PM2=2.5	G1=0	8.17	10.05	32.66	17.66	49.33	9.55
T5	PM2=2.5	G2=2.5	8.11	9.51	35.66	21.33	26.33	8.33
T6	PM2=2.5	G3=5	8.03	8.82	40.33	21	17.66	8.23
T7	PM3=5	G1=0	8.07	9.86	33.33	21.33	43.66	9.44
T8	PM3=5	G2=2.5	8.02	9.16	38.33	23	22.33	8.11
T9	PM3=5	G3=5	7.9	8.53	41.66	22.33	14.33	7.71
T10	PM4=10	G1=0	8.06	9.63	36.33	21.33	37.66	9.1
T11	PM4=10	G2=2.5	7.96	8.86	40.66	23.33	21	8.02
T12	PM4=10	G3=5	7.78	7.65	47	24	11.33	6.55

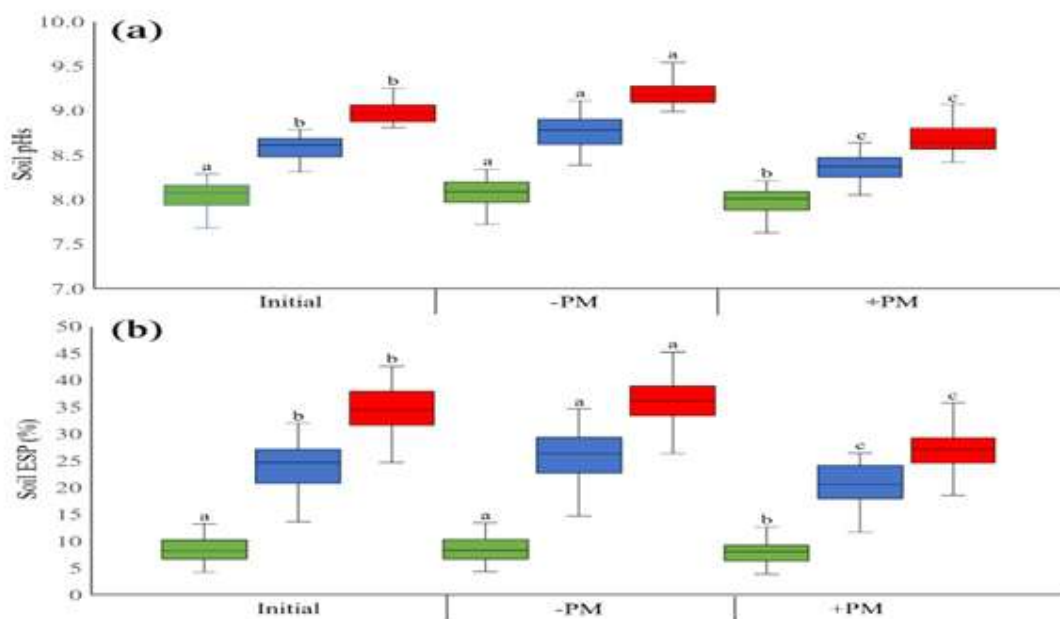
Pressmud as ameliorating agent : The press mud, an unused sugar industry by-product, contains significant amounts of macro and micronutrients, as well as high calcium sulphate and organic matter, which supply Ca directly to the soil and replace excess Na⁺ from the soil exchange complex, and sulphur convert into sulphuric acid that lower down the soil pH, and improve the physical, chemical and biological properties of sodic soils which can also be a substitute for reclamation of sodic soils (Negim 2016). Khattak and Khan (2004) reported that the pressmud containing high amount of sulphate (SO₄) and carbonates (CO₃) and usually contains about 70% lime, 15-20% organic matter and 2-3% sugar. Each year, India produces approximately 12 million tonnes of press mud. (Gupta *et al.*, 2011). Singh *et al.* (2019) conducted an experiment in village Santaraha of Uttar Pradesh (N 27° 36' 31" to 27° 36' 32" latitude, E 80° 11' 34" to 80° 11' 52" longitude) during 2011–14 on rice with various level of sodicity and reclamation procedures were tested in a three-replication factorial design. In the 0-15 cm soil layer, the experimental soil had an initial pH of 9.2–10.4, EC₂ of 0.67–2.21 dS/m, exchangeable sodium percentage (ESP) of 34–89, and organic carbon of 0.08–0.21%. Field experiment consisted of 4 sodicity levels [S1- slightly sodic (pH 9.2), S2- moderately sodic

(pH 9.6), S3- sodic (pH 10.0), and S4- severely sodic (pH 10.4)] and 2 reclamation practices, i.e. existing practice (EP) including the application of gypsum at 50% GR and the improved practice (IP) application of reduced dose of gypsum at 25% GR + 10 t/ha press mud. Under both EP and IP reclamation procedures, they found that applying amendments reduced soil pH, EC, and ESP while increasing SOC at all sodicity levels (Table-1). IP reduced the soil pH from 9.2 to 8.5, 9.6 to 8.5, 10.0 to 9.2 and 10.4 to 9.4 and correspondingly increased the organic carbon from 0.21 to 0.32%, 0.12 to 0.26%, 0.08 to 0.16% and 0.08 to 0.14% in S1, S2, S3 and S4 sodicity levels, respectively. Similarly, ESP also reduced from 34 to 16, 58 to 24, 78 to 29 and 89 to 39 with IP which showed 52.9, 58.6, 62.8, and 56.2% reduction over the initial and 24.6, 20.4, 32.4, and 24.9% over the EP (Table-1). The decrease in soil pH and ESP and increase in SOC and improved biological activities in IP may be due to combined use of gypsum and press mud which led to higher biomass production (Singh *et al.*, 2014). Similarly, higher reduction in Na⁺ and increase in Ca²⁺ and Mg²⁺ contents was recorded in IP as compared to EP (Table-1). Moreover, the addition of organic matter produced more organic acids which mobilized the soil calcium as reflected by the soil analysis before and after reclamation (Table-1). It was observed that sodicity indicators like pH, ESP and SOC were found

similar or even better in the IP treatment as compared to the EP treatment. It shows that the reclaiming effect of the press mud @ 10 t/ha was similar to gypsum @ 25% GR.

EC, Electrical conductivity; SOC, soil organic carbon; ESP, exchangeable sodium percentage; figures in parenthesis shows the values in saturation extract : Experimental work was conducted by O. Negim (2016) under laboratory conditions in polyvinyl chloride (PVC). The PVC was 30 cm height and 10 cm inner diameter. To assist leaching, a 5 cm layer of sand was added on the bottom of each soil column as a filter. Soil samples (0-30 cm) were collected from Sohag university experimental farm, Sohag, Egypt. They were air dried, crushed to pass through a 2-mm sieve and determined for their physico-chemical soil properties. The E_{Ce}, pH and CEC were 48.5 dS/m, 8.22 and 8.46 cmol/kg measured respectively. The soil treatments were consisted of control (CTRL untreated soil), pressmud (PM), gypsum by product (G) and the combinations of both PM and G to improvements of characteristics of highly calcareous saline sodic soil. PM was applied at application rates of 0, 2.5, 5 and 10% of soil weight. Gypsum was mixed with the upper 5cm of soil column with applied at 0, 2.5 and 5 g/kg addition rates. All soil treatments were replicated three times. A total of 36 columns were available and the treatments with PM, G and PM+G were incubated at field capacity moisture under laboratory conditions for one month before main leaching experiments. The results of

experiments were presented in the table 2. The effect of soil amendments on soil pH and EC revealed that all the treatments reduced significantly the pH and EC of the soil as compared to initial value (8.33 and 48.5 dS/m). It was noticed that, the combination of PM+G was more effective in reducing the pH and EC soil compared with application of PM or G alone. This reduction in pH soil could be due to acidifying effect of organic and inorganic acids produced during the decomposition of organic amendments (Prapagar *et al.*, 2012). While in case of EC Prapagar *et al.* (2012) suggested that the decrease in EC of soil was due to the addition of organic matter and leaching of excessive ions by improving soil physical properties. This decrease may be also due to the leaching of soluble salts and the effect of organic and inorganic acids which produced during the decomposition of amendments (Udayasoorian *et al.*, 2009). In case of soluble cations PM addition rates was less efficient in reducing soluble Na as compared with G and PM+G. It can be noted that, the best reduction of soluble Na was observed when the addition of the highest rates of PM+G (T12) with a value of 11.33 meq/l. This value was much lower than the initial value (289.88 meq/l) promoting the ability of PM combined with G in reduction soluble Na. Such these results are in harmony with those obtained by (Yazdanpanah and Mahmoodabadi, 2013). This reduction of Na⁺ may be due to the leaching process and the effect of acids which formed during the decomposition of amendments and also gypsum efficiency to decrease soluble Na and this



Non-Sodic (green colour), Slightly Sodic (blue colour) and Moderately Sodic (red colour)

Figure-1: Changes in (a) soil pHs and (b) ESP due to pressmud application compared to initial values across different soil with PM addition. By comparison, soil pH and ESP (Figure-1) in fields receiving PM amelioration were observed to decrease compared to initial values. The organic matter added through PM application (Figure-1) and the subsequent stimulation of microbial activity could have increased the pCO₂ in the soil solution, lowering pH and leading to the dissolution of native CaCO₃. Ca ions released during this process could have replaced Na in the soil exchange, lowering ESP.

Table-3 : Effect of PBSW on soil properties after harvest of sunflower.

Treatments	Exchangeable bases (C mol (p ⁺) Kg ⁻¹)								Exchangeable sodium percentage (ESP) (%)	
	Ca ⁺⁺		Mg ⁺⁺		K ⁺		Na ⁺			
	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
T ₁ Control	20.34	19.06	8.40	7.26	1.60	1.38	9.79	11.61	23.23	28.96
T ₂ PBSW @ 30 m ³ ha ⁻¹	25.80	22.46	10.80	8.46	2.03	1.89	8.45	10.90	17.25	24.27
T ₃ PBSW @ 60 m ³ ha ⁻¹	28.33	23.80	11.87	9.26	2.57	2.17	7.57	10.50	14.77	22.34
T ₄ PBSW @ 90 m ³ ha ⁻¹	30.00	25.33	12.47	10.27	3.19	2.46	7.02	10.10	13.09	20.61
T ₅ PBSW @ 120 m ³ ha ⁻¹	30.17	27.40	13.47	11.50	3.77	2.73	6.33	9.50	11.56	18.31
T ₆ PBSW @ 150 m ³ ha ⁻¹	33.03	28.03	13.93	12.40	4.30	3.14	5.69	9.16	9.79	17.00
T ₇ PBSW @ 180 m ³ ha ⁻¹	34.60	29.93	14.66	13.36	5.80	3.66	4.95	8.30	8.22	14.79
T ₈ FYM 5 Mg ha ⁻¹ + RDF	20.70	19.00	9.20	7.80	1.80	1.33	8.83	11.21	19.31	25.46
T ₉ FYM 5 Mg ha ⁻¹ + Gypsum + RDF	28.73	24.93	12.00	9.90	2.40	1.78	8.28	10.41	15.89	21.69
CD (0.05%)	1.914	1.896	1.473	0.882	0.089	0.681	1.040	0.944	2.087	1.929

Table-4 : Effect of raw spentwash and gypsum application on sodic soil.

Treatments	pH (1:2)				Exch. Ca ⁺ Mg (c mol (p ⁺) kg ⁻¹)				EC (dS m ⁻¹)			
	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days
	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days
T ₁ : Gypsum @ 50% GR	10.22	9.93	9.84	9.83	7.24	6.53	6.40	6.39	2.32	2.18	1.88	1.82
T ₂ : Gypsum @ 75% GR	10.05	9.84	9.77	9.75	7.33	6.88	6.73	6.54	2.37	2.15	1.95	1.76
T ₃ : Gypsum @ 100% GR	10.06	9.64	9.55	9.52	7.82	7.30	7.29	7.24	2.43	2.06	1.86	1.75
T ₄ : Spentwash @ 2.5 lakh liters ha ⁻¹	9.90	9.68	9.54	9.50	8.66	8.08	8.03	7.85	3.86	2.59	2.23	1.83
T ₅ : Spentwash @ 5.0 lakh liters ha ⁻¹	9.79	9.21	9.18	9.19	9.65	8.59	8.46	8.22	4.10	3.94	2.72	2.12
T ₆ : Spentwash @ 7.5 lakh liters ha ⁻¹	9.64	9.39	9.35	9.32	9.72	8.70	8.53	8.33	5.77	4.17	3.96	2.45
T ₇ : Spentwash @ 10.0 lakh liters ha ⁻¹	9.68	9.51	9.53	9.51	9.83	8.93	8.65	8.37	6.41	5.23	4.18	3.96
SEm±	0.056	0.18	0.11	0.07	0.077	0.81	0.48	0.69	0.49	0.228	0.12	0.09
CD p=0.05)	0.232	0.55	0.33	0.23	0.23	2.46	1.47	2.08	1.47	0.67	0.37	0.28

result is in accordance with that reported by (Udayasoorian *et al.* 2009; Abdel-Fatah, 2012).

The effect of soil amendments on soil exchangeable sodium percentage is showed in Table-2. The incorporation of PM with G was more effective in reducing of the ESP soil as compared with PM or G alone. The ESP at the end of leaching ranged from 6.55% to 13.43% as compared with the initial value of 22.14%, thus exhibiting a decrease in the value between 70 to 40%. The highest reduction of ESP was recorded for the treatment receiving the highest application rates of PM + G (T12). The decrease in soil ESP with increasing rates of amendments may be attributed to increase Ca in soil solution as a result of addition gypsum and organic amendments which promoted Na displacement and removed by leaching process. Nagim recommended from the current work that the PM+G in combinations is the best influence treatments than single ones to reduce soil salinity and sodicity.

Sheoran *et al.* (2021) conducted a field experiment in 5 villages in Kaithal District of Haryana. Each trial had two paired plots: (a) farmers' practice/without pressmud application (–PM) and (b) pressmud application at 10 Mg

ha⁻¹ on a dry weight basis (+PM). The result indicated that, when PM was applied (+PM), soil pH_s reduced also. There were significant ($p = .05$) reductions in soil ESP.

Effect of spent wash on saline and sodic soils : In India molasses based distilleries are considered to be one of the most polluting agro-based industries due to generation of large amount of foul smelling, brown coloured waste water with very high BOD and COD which called as spent wash. Approximately 40 million m³ of distillery spent wash are discharged annually from 285 alcohol distilleries in India (Sindhu *et al.*, 2007). The raw spent wash is highly acidic in nature and possess high salt content and higher amounts of dissolved and suspended solids and also has appreciable quantities of calcium along with plant nutrients and easily oxidisable organic matter. As a result, it can be utilised as a source of plant nutrients as well as a soil amendment. Spent-wash from sugar mills is readily available in the area and can be used as a low-cost alternative solution for sodic soil restoration when combined with gypsum. Shinde *et al.* (2019) conducted an experiment on "Use of post biomethanated spent wash as a soil amendment for sodic soils" in sodic calcareous soil belonging to Sawargaon series of isohyperthermic family

Table-5 : Effect of raw spentwash and gypsum application on calcareous sodic soil.

Treatments	Exch. Ca ²⁺ Mg (c mol (p ⁺) kg ⁻¹)				pH (1:2)				EC (dS m ⁻¹)			
	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days	30 days	60 days	90 days	120 days
T ₁ : Gypsum @ 50% GR	16.22	15.83	15.62	15.41	8.92	8.87	8.84	8.83	1.12	1.01	0.91	0.85
T ₂ : Gypsum @ 75% GR	17.19	16.70	16.30	16.12	8.62	8.58	8.53	8.52	1.14	1.09	1.06	1.08
T ₃ : Gypsum @ 100% GR	18.13	17.85	16.58	16.30	8.46	8.48	8.45	8.44	1.15	1.12	1.04	1.05
T ₄ : Spentwash @ 2.5 lakh liters ha ⁻¹	18.22	17.10	16.95	16.41	8.57	8.45	8.43	8.41	1.98	1.86	1.48	1.35
T ₅ : Spentwash @ 5.0 lakh liters ha ⁻¹	19.83	18.05	17.52	17.18	8.33	8.28	8.25	8.24	3.15	2.84	2.52	1.90
T ₆ : Spentwash @ 7.5 lakh liters ha ⁻¹	22.0	19.95	19.88	19.62	8.38	8.36	8.34	8.33	4.20	3.77	3.41	2.72
T ₇ : Spentwash @ 10.0 lakh liters ha ⁻¹	25.0	22.05	23.93	23.10	8.53	8.44	8.42	8.42	4.57	4.28	3.93	3.58
SEm±	0.85	0.45	0.44	0.44	0.15	0.07	0.22	0.22	0.31	0.21	0.22	0.22
CD p=0.05)	2.57	1.35	1.31	1.33	0.64	0.21	0.67	0.66	0.93	0.65	0.65	0.65

Table-6 : Chemical properties and heavy metal contents of the tested soil and FG DG.

Material	Chemical properties			
	pH	EC (mS cm ⁻¹)	ESP (%)	EX Na
Tested soil	8.34	1.31	30.1	6.5
FG DG	7.02	/	0.17	/

Table-7 : Changes in physical soil structure characteristics.

Treatment	Volume weight / (g·cm ⁻³)			Porosity / %			Infiltration rate mm·min ⁻¹
	0-10 cm	10-20 cm	20-30 cm	0-10 cm	10-20 cm	20-30 cm	0-30 cm
0	1.18a	1.14a	1.20a	55.47a	56.98a	54.72b	8.30a
1.5%	1.12b	1.09b	1.15a	57.74b	58.87b	56.60a	15.6b
3.0%	1.10b	1.12c	1.12c	58.49b	57.08a	57.74b	19.8c
6.0%	1.08b	1.10d	1.07b	59.25c	58.49b	59.62c	28.4d

of Vertic haplustepts at Post Graduate Research Farm of the Mahatma Phule Krishi Vidyapeeth, Rahuri which lies between 19047'–19057'N latitude and 74018'–74019' E longitude. The experiment was laid out in randomized block design with nine treatments viz., control, varying doses of Post biomethanated spentwash (30, 60, 90, 120, 150 and 180 m³ ha⁻¹), FYM + recommended dose of fertilizers (RDF) and FYM + Gypsum @ 50 % gypsum requirement (GR) + RDF with three replications. The onetime application of post biomethanated spent wash (PBSW), FYM and gypsum were done 3 months before sowing sunflower. The RDF for sunflower 60: 30: 30 and gypsum requirement (GR) was 16.21 t/ha as per soil test. The results of the study are described in the table 3. By applying spent wash there was increase in exchangeable Ca²⁺, K⁺ and Mg²⁺ were observed in surface soil layer. Similar trend with respect to Ca²⁺, K⁺ and Mg²⁺ were found in sub surface soil layer (30-60 cm). In surface and sub-surface soil layer the highest exchangeable Ca²⁺, K⁺ and Mg²⁺ was found in T₇. With an increase in PBSW dose, exchangeable Ca²⁺, K⁺, and Mg²⁺ increased in both soil layers; however, the magnitude was greater in the surface layer. T₈ (FYM + RDF) had no statistically significant increase in exchangeable Ca²⁺, K⁺, or Mg²⁺ in both soil layers, but T₉ (FYM + Gypsum + RDF) had a statistically significant increase in exchangeable Ca²⁺, K⁺, and Mg²⁺ that was comparable to lower PBSW

doses (60, 90 and 120 m³ ha⁻¹ in surface and 60, 90 m³ ha⁻¹ in sub surface soil layer). The increase in value of exchangeable Ca²⁺ of soil might be due to solubilization of native CaCO₃ by the production of acid during the decomposition of organic matter as well as high Ca²⁺ content in PBSW, resulting in increase in calcium on the exchangeable complex of soil. These results were close conformity with reports of Malathi (2002).

The increase in exchangeable Mg²⁺ in soil was possibly due to dissolution of Ca²⁺ and Mg²⁺ containing minerals in the soil by organic acid produced during decomposition of organic matter as well as high Mg²⁺ content in PBSW contributed to increase in exchangeable Mg²⁺ in soil. While the increase in exchangeable K⁺ in soil was due to application of PBSW which contain high potassium. On the other hand the exchangeable Na⁺ decreased with increase in level of application of PBSW over control in both the soil layers, however more decrease was observed in surface layer than sub surface layer of soil. The exchangeable Na⁺ decreased from 9.79 C mol (p⁺) kg⁻¹ to 4.95 C mol (p⁺) in surface soil layer. The reduction in exchangeable Na⁺ was highest in T₇ in both the soil layers. The reduction in exchangeable Na⁺ was due to release of calcium from PBSW and gypsum, which replaced Na⁺ from clay complex resulting into decrease in exchangeable sodium from soil, (Kaushik *et al.* 2005).

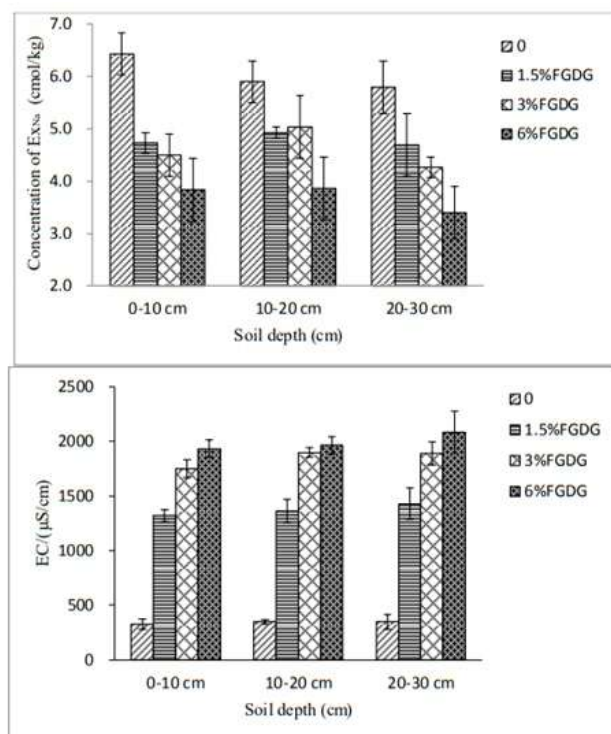


Figure-2 : Changes in the EX-Na and EC of the soil.

This decrease was more prominent as the dose of PBSW was increased upto $180 \text{ m}^3 \text{ ha}^{-1}$. Similar trend was also observed in exchangeable sodium percentage. There was significant decrease in the ESP of soil with increase in the amount of PBSW application over control in both the layers of sodic soil; however, ESP of surface layer was less than sub surface soil layer. The decreased ESP of soil was due to the decrease in exchangeable Na^+ , due to the replacement of exchangeable Na^+ from the clay complex by exchangeable Ca^{2+} present in the PBSW as well as dissolved CaCO_3 by high organic load of PBSW. The decreased ESP of soil due to application of PBSW was observed by Malathi (2002). Shinde *et al.* (2019) concluded that the use of PBSW @ $180 \text{ m}^3 \text{ ha}^{-1}$ was beneficial in amelioration of sodic soil and was found far more effective than the use of FYM + gypsum +RDF or only FYM + RDF. A similar experiment was also conducted by Lakshmi *et al.* (2019) in green house with sodic and calcareous sodic soil having pH >8.5 and ESP >15. Different quantities of raw spentwash (RSW) were applied in pots on the basis of gypsum requirement of the soils. The sodic soil was sandy clay loam in texture with pH - 10.4 and ESP - 37.94 (per cent), electrical conductivity of 1.2 dS m^{-1} and the organic carbon content of 0.44 (per cent). The calcareous sodic soil was light black in colour with an alkaline reaction (pH-9.5). The lime content was 8.5 percent and the ESP was 28.65 per cent. The electrical conductivity and organic carbon contents were 0.8 dS m^{-1} and 0.36 per cent respectively. The

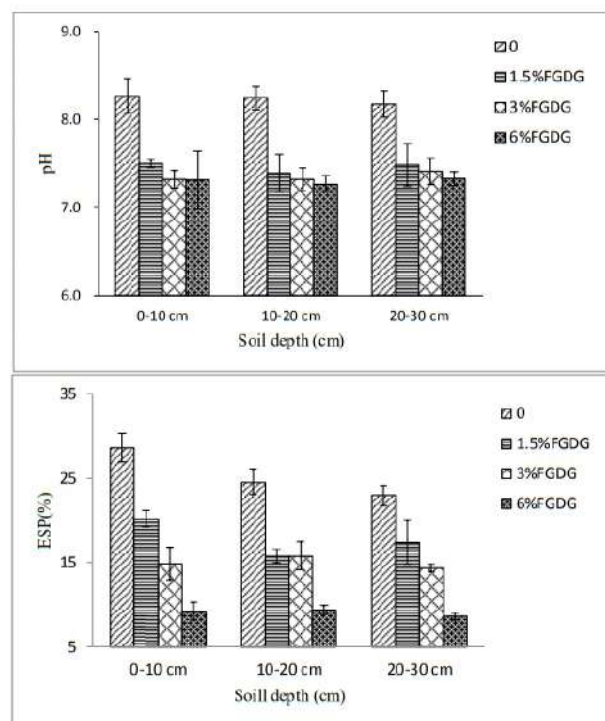


Figure-3 : Changes in the pH and ESP of the soil.

results of study were presented in table 4 and 5. In both sodic and calcareous sodic soil, applying varying amounts of raw spentwash and gypsum based on the gypsum requirement of the soil resulted in considerable differences in soil pH T6 (RSW@ 7.5 lakh litres ha^{-1}) showed the greatest drop in soil pH of sodic soil, followed by T7 (RSW@10.0 lakh litres ha^{-1}) which was considerably superior to gypsum treatment. In calcareous sodic soil, T5 (RSW@ 5.0 lakh litres ha^{-1}) showed a considerable drop in pH, followed by T6 (RSW@7.5 lakh litres ha^{-1}) and was significantly superior than gypsum treatment. Decrease in soil pH in both the soils was attributed to acidic nature of raw spent wash (pH 4.1) which might have solubilized the native calcium carbonate and released free calcium ions and other calcium bearing minerals to the soil. In addition the spent wash has calcium to an extent of 2600 mg L^{-1} . There was marginal and minimum reduction in soil pH at 90 and 120 days after application compared to 60 days. The decrease in soil pH was more pronounced in Calcareous sodic soil compared to sodic soil. This was due to acidic nature of raw spent wash which might have solubilized the native free lime thus facilitating the release of Ca+Mg in free ionic forms and these ions have replaced the Na^+ on the exchange complex. Also, the substantial quantity of sulfur present in raw spentwash, might have solubilised the CaCO_3 thus decreasing the pH of soil. Results obtained in this study are in conformity with the findings of Mahendra (2007).

Table-8 : Effect of coal combustion fly ash on soil physical properties.

Treatment	Bulk density (g cm ⁻³)	pH of soil	ESP
50 GR	1.52 _{abc} (± 0.03)	9.47 _a (± 0.10)	24.6 _a (± 2.90)
25 GR	1.55 _{bc} (± 0.04)	9.61 _{bc} (± 0.09)	30.4 _b (± 1.63)
FA 2.5% (w/w)	1.52 _{abc} (± 0.02)	9.68 _c (± 0.12)	32.5 _b (± 1.59)
FA 5% (w/w)	1.49 _{ab} (± 0.01)	9.80 _c (± 0.16)	38.4 _c (± 2.33)
25GR + FA 2.5% (w/w)	1.48 _a (± 0.02)	9.52 _{ab} (± 0.10)	31.2 _b (± 2.42)
25GR + FA 2.5% (w/w) + GM	1.50 _{ab} (± 0.02)	9.60 _{bc} (± 0.08)	28.2 _{ab} (± 2.52)
FA 5% (w/w) + GM	1.48 _a (± 0.03)	9.54 _{ab} (± 0.11)	37.2 _c (± 2.90)
Control	1.57 _c (± 0.06)	10.05 _d (± 0.18)	67.5 _d (± 2.02)

Table-9 : Effect of phosphogypsum and mined gypsum in reclamation on soil physico-chemical properties.

Treatments	pH	Dispersible clay	Bulk density (Mg m ⁻³)	ECe (ds m ⁻¹)	ESP
50 GR _M	8.6	20.89	1.40	0.9	20.4
50 GR _{PG} (10.5 Mg ha ⁻¹)	8.5	18.35	1.35	0.8	18.3
50 GR _{PG} – KFC (Followed by karnal grass)	8.4	17.53	1.35	0.7	17.8
25 GR _M + 25 GR _{PG}	8.5	19.86	1.39	0.8	19.4
25 GR _{PG}	8.7	27.24	1.43	0.6	25.2
12.5 GR _M + 12.5 GR _{PG}	8.9	28.92	1.44	0.6	26.5
CD @ 5%	0.1	1.82	0.05	0.1	1.5

Table-10 : Effect of basic slag and lime on chemical properties of acid soil.

Treatments	pH	Avail. P ₂ O ₅ (kg ha ⁻¹)	Fe (mg kg ⁻¹)	Mn (mg kg ⁻¹)	Cu (mg kg ⁻¹)	Zn (mg kg ⁻¹)
T ₁ : Farmer's practice (Only DAP)	4.85	27.4	127.3	11.2	3.32	0.87
T ₂ : T ₁ + basic slag at 2 t ha ⁻¹	5.03	29.9	115.6	10.9	3.52	0.94
T ₃ : T ₁ + lime at 2 t ha ⁻¹	5.11	26.7	110.1	8.9	3.28	0.90
T ₄ : Recommended dose of NPK (RDF)	4.81	30.0	137.3	15.7	3.45	0.92
T ₅ : 50% RDF + basic slag at 2 t ha ⁻¹	5.05	27.6	118.3	10.5	3.52	0.95
T ₆ : 50% RDF + lime at 2t ha ⁻¹	5.17	29.7	117.4	9.2	3.26	1.00
T ₇ : 75% RDF + basic slag at 2 t ha ⁻¹	5.32	31.0	119.8	10.4	3.53	0.97
T ₈ : 75% RDF + lime at 2 t ha ⁻¹	5.35	29.9	114.1	9.0	3.36	0.93
T ₉ : 100% RDF + basic slag at 2 t ha ⁻¹	5.36	33.8	109.5	10.4	3.31	1.02
T ₁₀ : 100% RDF + lime at 2t ha ⁻¹	5.42	30.5	104.3	9.4	3.28	0.97
SE.m±	0.2	1.1	4.6	0.7	0.2	0.04
CD (0.05)	NS	3.2	13.6	2.0	NS	NS

At different quantities of spent wash there was significantly increased in the electrical conductivity of soil compared to gypsum treatments. Significantly highest soil electrical conductivity was recorded in T₇ which received raw spentwash @ 10.0 lakh liters ha⁻¹ (6.41 dS m⁻¹) in sodic soil and similar trend was observed in Calcareous sodic soil at 30 days. A similar pattern was observed 60 days after application. In comparison to 30 and 60 days after application, there was a small decrease in soil EC at 90 and 120 days. The electrical conductivity of both soils was greatly boosted by increasing the amount of raw spentwash applied, with the maximum electrical conductivity value seen in the treatment getting 10.0 lakh litres ha⁻¹. Applied gypsum slightly increased the soil EC but was not significant compared to raw spent wash application. The increase in the soluble salt content in the gypsum amended pots might be attributed to the chemical reactions of gypsum in the soil rendering them to more soluble sulphate of sodium. The presence of more soluble

salt resulted in higher conductivity values in gypsum treated pots. There was no much variation between the two soils with respect to EC values. However, there was a gradual reduction in soluble salt concentration with increase in the number of days after application of raw spentwash and gypsum which may be due to the leaching of soluble salts through drainage holes provided. The decrease in conductivity values in each treatment over a period of time may be attributed to leaching of salts through drainage during reclamation.

Application of raw spentwash at different quantities significantly increased the exchangeable Ca+Mg of sodic soil compared to gypsum treatments. Significantly highest soil exchangeable Ca+Mg was recorded in T₇ in sodic and calcareous sodic soil receiving RSW@ 10.0 lakh liters ha⁻¹ at 30 and 60 days. At 90 and 120 days after application, there was a slight reduction in soil exchangeable Ca+Mg compared to 30 and 60 days after application. The increase in exchangeable Ca+Mg might

Table-11 : Effect of basic slag and lime on different forms of soil acidity.

Treatments	Exch. Al ³⁺	Exch. acidity	pH dependent acidity	Total potential acidity	Total acidity
			(cmol (p ⁺) kg ⁻¹)		
T ₁ : Farmer's practice (Only DAP)	0.43	0.7	5.4	6.1	1.9
T ₂ : T ₁ + basic slag At 2 t ha ⁻¹	0.25	0.5	4.5	5.0	1.4
T ₃ : T ₁ + lime at 2 t ha ⁻¹	0.33	0.6	4.7	5.3	1.5
T ₄ : Reccomended dose of NPK (RDF)	0.47	1.2	5.3	6.5	2.3
T ₅ : 50% RDF + basic slag at 2 t ha ⁻¹	0.25	0.5	4.1	4.7	1.5
T ₆ : 50% RDF + lime at 2t ha ⁻¹	0.33	0.5	4.5	5.0	1.4
T ₇ : 75% RDF + basic slag at 2 t ha ⁻¹	0.25	0.5	4.2	4.7	1.4
T ₈ : 75% RDF + lime at 2 t ha ⁻¹	0.33	0.5	4.8	5.3	1.4
T ₉ : 100% RDF + basic slag at 2 t ha ⁻¹	0.25	0.4	4.2	4.7	1.4
T ₁₀ : 100% RDF + lime at 2t ha ⁻¹	0.25	0.4	4.6	5.0	1.4
SE.m±	0.03	0.03	0.23	0.4	0.12
CD (0.05)	0.08	0.09	0.70	1.1	0.35

Table-12 : Impacts of PMS on soil pH, organic carbon and available water capacity.

Dosage	pH	OC (g kg ⁻¹)	Nutrient uptake by groundnut (kg ha ⁻¹)		
			N	P	K
0% LR	4.9 ^e	5.4 ^d	62.7 ^e	11.5 ^e	32.7 ^e
20% LR	5.3 ^d	5.6 ^c	68.6 ^d	12.4 ^d	36.4 ^d
30% LR	5.6 ^c	5.9 ^b	77.3 ^c	14.1 ^c	40.2 ^c
40% LR	5.8 ^b	6.0 ^a	82.7 ^b	15.1 ^b	42.3 ^b
50% LR	6.0 ^a	6.0 ^a	95.8 ^a	17.1 ^a	47.5 ^a
60% LR	6.2 ^a	6.1 ^a	96.9 ^a	17.4 ^a	47.7 ^a

Table-13 : Effect of PMS on chemical properties of soil.

Treatment	pH	EC	P	Fe	Mn	Zn
				(mg kg ⁻¹)		
Control	6.04f	.037d	13.1bc	202.3a	1.8c	17.3a
PMS _{0.1%}	6.19f	0.58c	11.5a	191.0ab	2.1bc	15.1ab
PMS _{0.2%}	6.92e	1.08c	16.0a	182.1b	2.6ab	14.2bc
PMS _{0.5%}	7.29d	1.31c	16.7a	164.7c	3.0a	12.6cd
PMS _{1%}	7.24d	1.63b	15.3ab	142.5d	2.6ab	10.8de
PMS _{2%}	7.63c	1.82b	16.5a	120.0e	2.8ab	9.5e
PMS _{4%}	8.25b	1.96b	16.0a	86.9f	2.5ab	9.4e
PMS _{8%}	8.74a	2.76a	14.3ab	87.8f	2.4abc	8.4e

Table-14 : The effect of incubation time on chemical properties of soil.

Time Incubation (Days)	pH	EC (dS m ⁻¹)	P	Fe	Zn	Mn
				(mg kg ⁻¹)		
1	7.57a	1.54a	14.6a	136.7b	2.5a	12.3a
30	7.24b	1.46a	15.3a	148.9a	2.6a	12.4a
90	7.06c	1.31b	14.9a	156.2a	2.4a	11.7a

be due to enhanced dissolution of free CaCO₃ upon application of higher quantity of raw spentwash. During distillation of molasses, lime is added in distilleries to maintain the pH, which ultimately accumulates in spentwash and becomes available in soils upon its application. Increased Ca+Mg content in both the soil was due to the presence of 2600 mg L⁻¹ of Ca and 1700 mg L⁻¹ of Mg in raw spentwash that was added to the soils in different quantities which helped in better replacement of exchangeable sodium by Ca ions. Further, the acidic nature of raw spentwash (pH 4.11) might have solubilized

native free lime which released Ca+Mg in free ionic forms which might have also contributed for increased Ca+Mg on exchange sites with the replacement of exchangeable sodium. Lakshmi *et al.* (2019) concluded that in the pot experiment raw spent wash application @5.0 lakh liters ha⁻¹ significantly reduced the pH, exchangeable sodium and ESP of soil at 30 and 60 days after application and the reduction was marginal there after upto 120 days.

Effect of Flue Gas Desulfurization (FGD) Gypsum on saline and sodic soils : In coal-fired power plants, a wet limestone-gypsum process is used to remove mid-sulfur

coal, producing a large quantity of industrial waste in the form of desulfurization gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Flue gas desulfurization gypsum (FGDG) has become increasingly popular in recent years for soil improvement, mine reclamation, and desalination and remediation of saline-alkali land. While enhancing the physical structure and chemical properties of soil, this substance can reduce soil pH and alkalinity (exchangeable sodium percentage, ESP), as well as the movement of nutrients, sediments, pesticides, and other pollutants from soil to water. To study all these effect of FGD gypsum Fu *et al.* (2021) conducted an experiment in lab in plastic cylinders filled with soil taken from the Shanghai Institute of Technology, located in the inland Shanghai Fengxian District on the northern shore of Hangzhou Bay, having bulk density $0.92\text{--}1.22 \text{ g/cm}^3$, and the water content $16.7\text{--}18.0 \%$. The physicochemical properties of soil and FGD gypsum are listed in Table-6.

Four mass ratios of FGDG were used according to the commonly used optimum ratios of FGDG for improving soil (0%, 1.5%, 3.0% and 6.0% of the total mass). Table 8 shows that two years after the application of FGDG, changes occurred in the soil density, porosity and permeability to different degrees. The results indicate that FGDG decreases soil density, increases total porosity and improves the structure of soil, thus benefiting water infiltration and the transport of nutrients and heavy metals in soil. FGDG can enhance the adsorption capacities of soil ions: Ca^{2+} can replace Na^+ in soil colloids, so the soil colloids mainly absorb Ca and form a soil aggregate structure, which ensures suitable soil porosity; therefore, the ventilation and water permeability of the soil are improved, which facilitates the entry and discharge of water (Chen & Dick 2012; Chen *et al.*, 2017).

Fu *et al.* (2021) observed the effect of FGD on soil chemical properties and presented their results in Figure 2 and Figure 3. The results showed that the FGDG had been thoroughly mixed with the soil and gradually dissolved in the two years after application. Ca^{2+} in the FGDG replaced Na^+ in the soil over time, and the replaced Na^+ was removed with the leachate as a certain amount of exchangeable Na^+ can be removed with leachate. Soil EC is a very important soil property that significantly affects plant growth. EC significantly increased in all layers with increasing FGDG application rate, and compared with the control treatment, the EC of all soil layers. The original soil sample had a high pH (>8.3) and ESP ($>30.2\%$), indicating that the soil was moderately alkaline. By applying FGDG there was significantly decreased the pH of all soil layers. As the amount of FGDG increased, the magnitude of the decrease gradually increased. Similarly, FGDG treatment significantly reduced the soil alkalinity, and the average

alkalinity of all soil layers was significantly lower than that of the control.

Studies have shown that FGDG can reduce the pH of agricultural soils and maintain a stable soil pH over time, mainly due to the reaction of FGDG and EX-Na^+ in soil colloids acting to simultaneously replace Na^+ in the soil. The soluble salt Na_2SO_4 generated can permeate deep into the soil layers, reducing the pH of the soil as the Na concentration on the surface declines. Mao *et al.* (2016) found that the exchanged Na ions travel to the deep soil or are lost to the surrounding water through natural rains. The quantity of exchangeable Ca^{2+} in the soil grows dramatically as EX-Na^+ in the soil decreases, which reduces the alkalinity of the soil to some extent but also increases the salt ion concentration in the soil significantly in a short time.

Effect of Fly Ash on saline and sodic soils : Fly-ash is defined as the resulting residue in furnaces of thermal power plants from the combustion of coal, and contains minerals which are not fully burnt (Basu *et al.*, 2009). Indian power generation is mainly dependent on coal-based thermal power station. The coal combustion products produced every year is around 112MT (million tons) in India and it exceeds 225 MT by 2017. Fly ash is used in a feasible way as an amendment to sodic soil, whereby the soluble concentration of Ca^{+2} in the soil, will increase (Kumar and Singh, 2003). Its successful use as a soil amendment as a means of improving plant growth has been proven on numerous occasions (Jala and Goyal, 2006). To demonstrate the use of fly ash (FA) as a standard sodic soil remediation Mishra *et al.* (2019) demonstrated an experiment at the experimental farm of ICAR-Central Soil Salinity Research Institute, Regional Research Station located at Shivri, Lucknow. Field experiments with eight treatments were laid out and replicated three times in plots of 30 m^2 using a randomized block design having three replications during 2013–2014. The treatment were as follows : T_1 , 50% gypsum requirement (50GR; conventional); T_2 , 25% gypsum requirement (25GR); T_3 , FA 2.5% of soil mass (w/w); T_4 , FA 5% (w/w); T_5 , 25GR + FA 2.5% (w/w); T_6 , 25GR + FA 2.5% (w/w) + sesbania as GM; T_7 , FA 5% (w/w) + GM; and T_8 , control (barren sodic soil). The outcomes of the experiment were presented in the table 8. They observed that the GM (green manure) and FA 2.5% significantly influenced a reduction in pH in these sodic soils. The lowest or minimum soil pH was recorded in the 50GR followed by 25GR + FA 2.5% (w/w). At the higher rate of FA 5% (w/w), this incorporation did not show significant changes in soil pH in comparison with the lower rate of FA 2.5% (w/w), except in the treatment where GM was incorporated. A combined application of FA, gypsum, and GM significantly reduced the dispersion ratio to 81%.

Compared with control, the BD of soil was also significantly lower (1.48 g cm^{-3}) in the treatments with FA 2.5% (w/w) + 25GR and FA 5% (w/w) + GM. Mishra *et al.* (2019) concluded that the addition of 25GR + FA 2.5% (w/w) was found to be more effective in the reclamation and crop yield enhancement, but in case of non-availability of gypsum, FA 2.5% (w/w) alone could be an alternative ameliorant to gypsum.

Effect of Phosphogypsum on saline and sodic soils :

Phosphogypsum (PG) is a by-product of the wet acid synthesis of phosphoric acid from rock phosphate, and it contains more than 92 percent calcium sulphate, making it an excellent calcium source that can also be utilised as a soil conditioner for sodic soils. Phosphogypsum is a byproduct of the synthesis of phosphoric acid from rock phosphate in a wet process by the phosphate fertiliser industry. The manufacturing of 1 tonne of phosphoric acid results in the formation of 4.5 to 5.5 tonnes of PG in the wet process. Phosphogypsum is predominantly composed of calcium sulphate dihydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) with minor amounts of silica, typically in the form of quartz and unreacted phosphate rock. In India, over 11 million tonnes of PG are produced each year, resulting in massive stockpiles at plant locations.

Nayak *et al.* (2013) conducted an experiment for comparing the efficiency of PG and mined gypsum, when applied at chemically equivalent rates. The experimental site was located at $26^\circ 47' 58'' \text{ N}$ latitude and $80^\circ 46' 24'' \text{ E}$ longitude in the salt-affected soils of the central Indo-Gangetic plain. The soil had a sandy clay loam texture with the following parameters: sand 490 g kg^{-1} , silt 185 g kg^{-1} , clay 325 g kg^{-1} , pH 9.8, electrical conductivity (EC_e) 1.9 dSm^{-1} , exchangeable sodium percentage (ESP) 38.5, calcium carbonate (CaCO_3) 20.8 g kg^{-1} , organic carbon 0.30 g kg^{-1} , and cation exchangeable capacity (CEC) $16.7 \text{ cmol (p}^+) \text{ kg}^{-1}$. Six treatments were laid out in plots of 40 m^2 in a randomized block design with four replications. Treatments were T_1 , 50 GR_M (mined gypsum applied at 50% GR, i.e., 10.5 Mg ha^{-1}); T_2 , 50 GR_{PG} [PG applied at 10 Mg ha^{-1} (equivalent to 50 GR_M)]; T_3 , 50 GR_{PG}-KFC [PG applied at 10 Mg ha^{-1} , followed by karnal grass (*Dicanthium fusca* L. Kunth) as first crop]; T_4 , 25 GR_M 25 GR_{PG} (mined gypsum applied at 5.25 Mg ha^{-1} and PG applied at 5 Mg ha^{-1}); T_5 , 25 GR_{PG} (PG applied at 5 Mg ha^{-1}); and T_6 , 12.5 GR_M 12.5 GR_{PG} (mined gypsum applied at 2.62 Mg ha^{-1} and PG applied at 2.5 Mg ha^{-1}). The results of the study were presented in table 11. From the table it can be concluded that application of PG at 10 Mg ha^{-1} , followed by karnal grass (*Leptochloa fusca* L. Kunth) as the first crop, resulted the greatest reduction of soil pH followed by PG applied at 10 Mg ha^{-1} (Table 9). The PG treatment decreased soil pH by increasing the amount of Ca^{2+} present in the soil solution and increasing

H^+ ion due to residual sulfuric acids. The ESP of soil showed a similar trend as pH (Table 9). The PG treatment resulted in greater reduction of pH and ESP because of its greater solubility over mined gypsum; Ca^{2+} permeates to lower depths because of the increased rate of water entry and causes reduction in ESP even at a greater depth. The effectiveness of karnal grass in greater reduction is because it has an extensive root system that increases the partial pressure of CO_2 (P_{CO_2}), enhancing the dissolution of calcite (Qadir *et al.*, 2006), which reduces the sodicity of calcareous sodic soil. Dispersible clay content expressed as percentage of total clays was significantly reduced in the PG-treated soil. The dispersible clays were not significantly different between the 25 GRPG and 12.5 GRM 12.5 GRPG treatments. The results clearly suggest that higher doses of PG can result in significant reductions of ESP and dispersible clays (i.e., 50 GRPG). Nayak *et al.* (2013) concluded that Phosphogypsum was found to be superior than mined gypsum at reclaiming resources, The use of PG causes a higher drop in surface soil pH and ESP.

Effect of Basic Slag on acid soils :

Basic slag containing CaO , MgO , SiO_2 and micronutrients, such as copper, zinc, manganese and iron is a byproduct obtained from steel industry. Calcium and magnesium compounds, because of their basicity, improve soil pH and also serve as plant nutrients. Application of basic slag of steel industry is cost effective in reducing soil acidity. The study about the ameliorating effects of basic slag given below. Mamatha *et al.* (2019) conducted a field experiment during kharif 2014 at Alasulige village using paddy as test crop in hilly zone of Karnataka. Basic slag was alkaline in nature (pH 9.2) and contained about 24.8 per cent Ca, 10.08 per cent Mg, 0.62 per cent phosphorus and 8.2 percent silicon. The soil of the field was acidic (pH 4.92) in nature. The result of the experiment was presented in table 10 and 11. Due to liming, the pH of the soil increased somewhat (Table-10). The release of alkaline elements such as calcium ions, which neutralise soil acidity by displacing the aluminium, hydrogen, and iron ions that are prominent in acidic soils, can be attributed to the increase in pH of soil with the addition of basic slag and lime. These findings matched those of Bhat *et al.* (2010). Due to the application of basic slag and lime, the available P content of the soil changed dramatically. P content was highest in the treatment that received 100 percent RDF+ basic slag at a rate of 2 t ha^{-1} (36.1 kg ha^{-1}) followed by the treatment that received 100 percent RDF+ lime at a rate of 2 t ha^{-1} (36.1 kg ha^{-1}) (33.8 kg ha^{-1}) (Table 10). Increase in the available P content of the soil might be due to the increased soil pH upon liming. This culminated in an increased microbial activity which has accelerated the

decomposition of organic matter and could have enhanced the labile P in the soil.

Significant decrease in the DTPA extractable Fe and Mn content was noticed with the basic slag and lime application (Table 12). This result was supported by Takac *et al.*, (2009) who reported that liming result in a strong decrease in the content of DTPA extractable forms of iron and manganese, because the level of bioavailable forms of many metals are negatively correlated with pH value. Table 13 shows that soil acidity parameters such as exchangeable acidity, exchangeable aluminum, total potential acidity, total acidity, and pH dependent acidity varied significantly due to the application of basic slag and lime. The decrease in exchangeable acidity could be due to the neutralization effect of lime on Al^{3+} , H^+ and other hydrolysable acid producing ions in soil. The added Si reacts with Al^{3+} to form insoluble hydroxo-aluminosilicate, which reduces the availability of aluminium in soil. Ma and Takahashi found that as the quantity of silicic acid in the soil solution grew, the concentration of Al^{3+} decreased, which they attributed to the creation of non-toxic Al-Si complexes. Mamatha *et al.* (2019) concluded that application of basic slag and lime at the rate 2 t ha^{-1} were efficient in amending acidic soil. Thus, basic slag can be used as an alternative to lime for the amelioration of acidic soil and it also can be utilized as a nutrient source in acidic.

Effect of Paper mill Sludge on acidic soils : Mamatha *et al.* (2019) found that supplementing acidic soil with basic slag and lime at a rate of 2 t ha^{-1} was effective. The most popular liming material used to remediate acid soil is limestone, however small and marginal farmers in eastern India couldn't afford to buy lime in the form of pure CaCO_3 or MgCO_3 due to their high cost. Alternative low-cost liming materials, such as paper mill sludge (PMS), which is made from by-products of the paper mill and includes CaCO_3 , can be used to treat acid soil (Torkashvand *et al.*, 2010; Kar *et al.*, 2010). The amount of PMS required, on the other hand, is determined by the papermaking methods, soil type, crop species, and cultivars (Noble and Hurney 2000; Caires *et al.*, 2005). Lime sludge is the solid waste generated during the process of turning wood chips into paper pulp. Calcium carbonate (CaCO_3) is the main component of lime mud, and it is estimated that 0.47 m^3 of lime mud is produced for every tonne of pulp produced (Wirojanagud *et al.*, 2004). Kar *et al.* (2014) conducted on farm trial during 2007 to 2009 rainy seasons in a representative acid soil area of eastern India (Bhimda, Badasahi block, Mayurbhanj district, Orissa). During this season, farmers of the region mostly grow groundnut in rainfed uplands which are acidic in nature (pH ranged from 4.9 to 5.1), but receive very low levels of productivity from the crop. Six treatments viz., No PMS (0% LR); PMS @

20% LR (20% LR); PMS @ 30% LR (30% LR); PMS @ 40% LR (40% LR); PMS @ 50% LR (50% LR); PMS @ 60% LR (60% LR) were imposed in randomized block design (RBD) with 3 replications. The PMS was applied every year in ploughed layer, 4-5 weeks before sowing of the groundnut crop. The results of experiment are given in Table-12.

An upward shift in pH was noticed from 4.9 (control) to 6.2 (0.6 LR treatments) in the 0-0.15 m depth. Increase in pH was 0.40 units for L_2 , 0.70 units for L_3 , 0.9 units for L_4 and 1.1 units for L_5 and 1.3 for L_6 compared to the control (L_0). It was also found that PMS significantly increased the pH, which was proportional to the application rate of PMS up to 50% LR (Table12). Organic carbon contents of different rates of PMS amended soil were 5.4 to 6.1 g kg^{-1} . Averaged over study years, the organic carbon content was significantly higher under 50 and 60% LR than that of other treatments. But averaged over the PMS treated plots, the impacts of PMS on soil organic carbon was not found significant in different study years. Kar *et al.* (2014) concluded that the increased soil pH after amendment with PMS may be attributed to the presence of Ca, Mg and Na in PMS. A similar study was carried out by Torkashvand (2010). The acidic soil is treated with 0.1, 0.2, 0.5, 1, 2 and 8% W/W dry paper mill sludge ($L_{0.1}$, $L_{0.2}$, $L_{0.5}$, L_1 , L_2 , L_4 and L_8). The result of the studied was described in table 13 and 14. Table 13 shows the effect of added paper mill sludge on soil pH and EC. Paper mill sludge remarkably increased pH as well as EC, which was proportional to the application rate of paper mill sludge. On the base of Table 16, there is a significant difference in pH (PS 0.01) between three incubation times. Increase in soil pH indicates the usefulness of paper mill sludge as a liming agent for amelioration of acid soils, but further amount of this by-product is not suitable as a soil amendment particularly in primary stages. Similar results was obtained by He *et al.* (2009) for the use of paper mill lime mud as a liming agent and its effect on soil pH and ryegrass growth. Paper mill lime sludge is a calcareous compound with a high pH that initially increased soil pH, but soil buffering capacity reduced soil pH during the incubation time, although, in an equilibrium system including CaCO_3 - CaO - H_2O , pH did not increase to more than 8.5.

Conclusions

On the basis of above discussion, it can be concluded that the industrial by product in alone or in combination with other organic like FYM and inorganic like gypsum, lime can be used for amelioration of problematic soils. It could be recommended from the current work that the PM+G in combinations is the best influence treatments than single

ones to reduce soil salinity and sodicity. Soil properties like pH, EC, organic carbon, exchangeable sodium percentage (ESP), contents of cations and anions were improved significantly under the PM+G in combinations. Application of gypsum @ 100% GR had similar effect in reducing the soil pH and ESP as that with raw spent wash application @ 2.5 lakh liters ha⁻¹. Adding an appropriate amount of FGDG can effectively improve saline-alkaline (coastal saline) soil. After the application of FGDG, the physicochemical properties of the soil can be significantly improved, the bulk density can be reduced, the porosity can be increased, the EX-Na⁺ content can be reduced, and the pH and ESP can be significantly reduced. Where gypsum is not in the quantities for the usual 50GR applications to achieve an adequate yield response and reduction of pH, zeta potential, BD, and dispersion ratio of degraded sodic soil with an ESP of 69.7 and dispersion ratio 96%, the treatment 25GR + FA (Fly ash) 2.5% or 25GR + FA 2.5% + GM (Green manure) presents an alternative. Whereas the lower dose of FA 2.5% (w/w) will also be effective in improving the productivity of degraded sodic soils in absence of gypsum. Phosphogypsum was found to be better at reclaiming materials than mined gypsum. The use of PG causes a larger reduction in surface soil pH and ESP. In case of acid soil, promising potential of paper mill sludge can be used as an inexpensive source of available lime for correction of soil acidity. The PMS was found to be useful to enhance the soil pH, nutrient uptake, biomass, leaf area and yield and reduced water footprints of groundnut production significantly when it was applied up to 50% LR. However, no significant differences on these parameters were observed when PMS was applied above 50% LR. Basic slag or lime @ 2 t ha⁻¹ can be used as a nutrient source in acidic soils and can be used as an alternative to lime for acidic soil amelioration. Therefore, industrial by product have huge potential to ameliorate problematic soil.

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Mean Performance and Genetic Variability for Grain Yield and other Yield Component Traits in Barnyard Millet (*Echinochloa frumentacea* L.)

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Abstract

A set of twenty-three barnyard millet genotypes were evaluated at Agricultural Research Station, Vizianagaram, Acharya NG Ranga Agricultural University with an aim to estimate the extent of variability among tested entries for ten characters including yield and its attributes. The trial was conducted in randomized block design with three replications. Mean sum of squares from analysis of variance of all the studied characters showed significant variation for the genotypes. The genotype VMBC 335 (28.70 q/ha) showed highest grain yield followed by VMBC 336 (26.57 q/ha) and VMBC 350 (26.39 q/ha) with an overall mean of 23.8 q/ha. High phenotypic and genotypic coefficient of variation were recorded for days to 50% flowering, days to maturity, number of productive tillers per plant, lobe length, grain yield per hectare and fodder yield. Most of the characters studied had high heritability except number of productive tillers and panicle length.

Key words : Genetic variability, heritability, GCV and PCV, *Echinochloa frumentacea*.

Introduction

Barnyard millet (*Echinochloa frumentacea* L.) is largely grown in tropical regions including India and Middle and Central Africa. It emerged as a fastest growing multipurpose crop that yields food and forage in a shorter duration (more commonly around 6-8 weeks) [1]. The crop requires low inputs even under unfavorable weather conditions such as drought and excessive soil moisture [2]. In India, the mid hills of Himalayan region of Uttarakhand in the North and the Deccan plateau region of Andhra Pradesh and Tamil Nadu in the south are the two major barnyard millet growing agro-ecologies [3]. The crop is mostly cultivated in harsh and fragile environments, with minimal use of agricultural inputs due to its remarkable ability to withstand erratic rainfall and fluctuating weather conditions [4]. As it can be cultivated and harvested in between major crop growing seasons, it could be considered as supplementary crop for farmers. Farmers also used as a substitute crop in emergencies when the main crop fails.

In recent times, barnyard millet has gained attention because of its high nutritive value and abiotic and biotic stress tolerance. It contains of 65 % carbohydrate, 11% protein, 3.9% fat and 13.6% crude fiber. Apart from these, the crop is also an excellent source of minerals such as Iron (Fe) and Zinc (Zn) along with few antioxidative compounds [5–7]. These make the barnyard millet a nature's gift for the modern mankind who is engaged in sedentary activities.

Besides being an important crop, a very little improvement work has been carried out in barnyard millet. Information on diversity among available germplasm and genetic relationships among accessions are fundamental importance for breeding and the maintenance of germplasm. It could be a provision for breeding activities by the plant breeders [8]. The literature availability on the collection, evaluation, preservation, and utilization of barnyard millet genotypes is very limited till date. Keeping in view to enhance the yield potential and identify the superior sources for various yield contributing traits the present investigation has been carried out with an objective of assessment of existed genetic variability for the different morphological traits.

Materials and Methods

The present investigation was carried out in the Randomized Block Design (RBD) during kharif 2020 under rainfed condition at agricultural Research Station, Vizianagaram, Acharya NG Ranga Agricultural University, at an altitude of about 74 m above mean sea level, lying between 18.1159°N latitude and 83.406°E longitude with tropical savanna climate characterized by high humidity. The average annual rainfall of the experimental site is about 1097 mm and the soil type is sandy loam with pH 7.2. The plant material procured from the All India Coordinated Research Project (AICRP) on Small Millets, ICAR-Indian Institute of Millet Research (IIMR), Hyderabad consists of 23 barnyard millet genotypes including two check varieties viz., VL 207 and DHBM-93-3

Table-1 : Mean performances of yield and yield component traits for 23 barnyard millet genotypes evaluated during Kharif 2020.

Sl. No	Name of the genotype	DFF (#)	DM (#)	PH (cm)	NPT (#)	PL (cm)	LL (cm)	LW (cm)	LOBL	GY (q)	FY (q)
1.	VMBC 344	45.3	75.3	145.4	3.3	24.9	36.6	3.1	2.2	25.00	59.4
2.	VMBC 333	46.0	76.7	131.0	2.3	24.2	36.0	3.2	2.9	24.16	58.4
3.	VMBC 334	30.7	60.7	117.9	3.1	27.4	23.3	2.4	4.7	15.37	48.3
4.	VMBC 335	32.3	62.0	126.7	3.1	27.4	27.3	2.5	4.7	28.70	56.9
5.	VMBC 336	36.3	67.7	129.8	3.0	23.0	33.9	2.9	2.4	26.57	55.5
6.	VMBC 337	32.3	61.3	126.0	3.9	24.0	33.1	2.3	3.0	17.69	42.8
7.	VMBC 338	30.3	60.0	104.8	4.0	21.9	29.1	2.2	2.0	15.00	38.0
8.	VMBC 339	45.3	75.7	126.2	2.7	25.3	29.1	2.3	2.6	18.05	45.1
9.	VMBC 340	47.3	78.3	129.9	3.7	23.4	42.4	2.5	5.5	25.09	53.5
10.	VMBC 341	31.3	61.3	127.1	3.6	25.7	25.9	2.3	4.3	25.00	50.0
11.	VMBC 332	34.0	64.3	129.7	3.3	25.7	35.3	2.7	3.1	25.18	46.1
12.	VMBC 343	30.3	60.3	122.2	3.3	24.0	28.8	2.4	2.3	16.39	40.6
13.	VMBC 344	43.0	73.7	128.9	3.4	25.6	31.2	2.3	2.8	24.17	58.8
14.	VMBC 345	26.0	56.7	121.8	3.1	27.7	27.7	2.5	3.9	10.93	24.8
15.	VMBC 346	38.7	69.3	125.0	5.0	23.0	33.2	2.4	3.7	17.87	44.8
16.	VMBC 347	25.7	55.7	134.4	3.3	20.6	26.8	2.2	3.6	13.61	33.7
17.	VMBC 348	26.0	56.3	115.0	2.8	25.6	30.7	2.7	2.7	15.00	37.8
18.	VMBC 349	46.0	76.3	110.7	3.6	24.2	25.8	2.3	3.0	21.39	54.0
19.	VMBC 350	46.3	77.3	122.4	3.0	22.8	28.0	2.5	3.3	26.39	58.3
20.	VMBC 351	25.7	55.3	122.6	2.8	27.2	26.4	2.7	3.3	11.39	29.9
21.	VMBC 352	26.3	55.0	136.9	4.0	27.0	28.8	6.5	2.1	13.61	33.1
22.	VL 207*	38.7	70.0	126.2	3.4	23.8	33.2	3.0	2.4	21.57	58.6
23.	DHBM-93-3*	35.7	66.7	136.1	4.0	26.7	34.8	3.1	2.5	22.68	61.3
	Mean	35.6	65.9	125.9	3.4	24.8	30.8	2.7	3.2	20.0	47.4
	CD (5%)	1.7	1.9	18.9	1.1	4.1	6.6	2.5	2.4	5.45	11.60
	CD (1%)	2.2	2.5	25.3	1.5	5.4	8.8	3.1	3.2	7.29	15.49
	CV (%)	2.9	1.7	9.1	19.9	9.9	13.0	6.9	8.7	12.56	14.88

*, indicates check varieties included

Table-2 : Mean sum of squares from analysis of variance for yield and its component characters among 23 barnyard millet genotypes tested during Kharif 2020.

Source of variation	df	DFF	DM	PH	NPT	PL	LL	LW	LOBL	GY	FY
Treatments	22	180.3**	197.9**	228.8**	1.0**	11.1**	60.4**	3.2**	2.6**	87.95**	348.06**
Replications	2	0.6	0.6	1.2	0.0	0.8	20.7**	2.6**	2.2**	7.96**	65.98**
Error	44	1.0	1.3	132.4	0.5	6.1	15.9	2.4	2.1	11.01	49.70

**, significant at 1% (p=0.01)

(Table 1). Genotypes were sown in three replications with a spacing of 25 cm between rows and 10 cm between plants within a row. All the recommended agronomic practices were followed strictly to rise healthy plant stand.

The morphological data of various traits such as days to 50% flowering (DFF, in number), days to maturity (DM, in number), plant height (PH, in cm), number of productive tillers (NPT, in number), leaf length (LL, in cm), leaf width (LW, in cm), lobe length (LOBL, in cm), grain yield per hectare (GY, in q) and fodder yield (FY, in q). Data recorded for DFF, DM, GY and FY on plot basis and rest of all recorded on plant basis *i.e.* randomly selected five individual plants. The data recorded was subjected to

statistical analysis such as analysis of variance (ANOVA) [9] and the genetic parameters such as genotypic and phenotypic coefficient of variations (PCV and GCV)[10], heritability broad sense (H) [11] and genetic advance in percent of mean(GAM) [12] were worked out. The above genetic parameters were estimated using 'agricole' package in RStudio [12].

Results and Discussion

Among 23 studied test genotypes, VMBC 347 and VMBC 351 showed earliness in 50% flowering and maturity (26 and 56 days, respectively) followed by VMBC 345 and VMBC 348 with 30.3 days overall mean whereas VMBC 340 (47 and 78 days) showed late flowering and maturity

Table-3 : Estimated genetic parameters such as GCV, PCV, Heritability and Genetic advance as percent mean (GAM) of studied traits for 23 barnyard millet entries.

Genetic parameters	DFF	DM	PH	NPT	PL	LL	LW	LOBL	GY	FY
GCV	21.7	12.3	4.5	22.1	5.2	12.5	14.5	22.3	25.27	21.04
PCV	21.9	12.4	10.2	23.3	11.2	18.0	14.9	47.3	30.21	25.77
ECV	2.9	1.7	9.1	19.9	9.9	13.0	46.5	45.7	16.55	14.88
H	98.3	98.0	69.5	27.1	21.4	68.3	61.5	62.7	69.97	66.67
GA	15.8	16.5	5.2	6.4	1.2	5.5	8.8	4.2	8.72	16.77
GAM	44.3	25.1	24.1	13.0	5.0	17.9	7.2	6.6	43.55	35.40

GCV, genotypic coefficient of variation; PCV, phenotypic coefficient of variation; ECV, environmental coefficient of variation; H, heritability broad sense; GA, genetic advance; GAM, genetic advance as percent mean

followed by VMBC 350 and VMBC 333 (46 and 77 days) (Table 1). VMBC 344 showed highest plant height (145.4 cm) followed by VMBC 352 (136.9 cm) and DHBM-93-3 (136.1 cm) with 127.3 cm overall mean. The genotype VMBC 346 recorded maximum number of productive tillers (five) followed by VMBC 352, DHBM-93-3 and VMBC 338 with four productive tillers. Panicle length was highest for VMBC 345 (27.7 cm) followed by VMBC 335 and VMBC 334 with 27.4 cm. The genotype VMBC 340 showed highest leaf length (42.4 cm) and lobe length (5.5cm). For grain yield, genotype VMBC 335 (28.70 q/ha) showed highest followed by VMBC 336 (26.57 q/ha) and VMBC 350 (26.39 q/ha) with an overall mean of 23.8 q/ha. Similarly, genotypes DHBM-93-3 recorded 61.3 q/ha fodder yield followed by VMBC 344 (59.4 q/ha) and VMBC 344-1 (58.8 q/ha).

Mean sum of squares of all the recorded traits showed significant variation among the evaluated test entries (Table-2). This suggested the presence of ample amount of variation among the genotypes which could be useful for the effective selection for further improvement programmes. The results were supported by earlier works [13,14]. In the present study, the variation among test genotypes was estimated as coefficient of variation and the phenotypic coefficient of variance (PCV) was slightly higher in magnitude than genotypic coefficient of variance (GCV) for all the characters studied indicating the interaction of genotypes with environment (Table 3). High PCV and GCV were recorded for days to 50% flowering, days to maturity, number of productive tillers per plant, lobe length, grain yield per hectare and fodder yield indicating sufficient variation among the genotypes studied. Heritability is a measure of genetic relationship between parents and progeny. In the present study, estimated heritability is high for most of the characters studied except number of productive tillers and panicle length (Table-3). High heritability alone is not sufficient enough to exercise selection unless the information is accompanied with substantial amount of genetic advance. Thus, genetic advance is another important selection parameter which is exploited along

with heritability to predict the genetic advance of the trait. High genetic advance as per cent mean coupled with high heritability was observed for days to 50% flowering, days to maturity, plant height, leaf length, fodder yield and grain yield per hectare indicating the importance of additive gene action in governing the inheritance of these characters. These results were in accordance with earlier findings in barnyard millet crop [15-19] whereas similar findings reported in finger millet [20-22].

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Inter-Trait Associations among Proso Millet Genotypes

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Abstract

The present investigation aimed to study variability, heritability and associations for ten traits among twenty pre released cultures of proso millet at Agricultural Research station, Vizianagaram during kharif, 2020. For all of the traits studied, there was a wide range of variation. VP 002 (20.1 q/ha), VP 008 (19.6 q/ha), and VP 016 (19.0q/ha) all had higher on-par grain yields. VP 020 (50.0 q/ha) had the highest fodder output, followed by VP 022 (47.8 q/ha). The heritability and GAM of flag leaf width (cm) and grain yield were high indicating additive gene action. The existence of additive gene action was also indicated by moderate heritability and high GAM in the number of productive tillers per plant and fodder yield, but the rest of the traits are expected to have both additive and non-additive gene action. Plant height, leaf length, and leaf width were all associated with grain yield, while plant height, leaf length, and leaf width were all significantly associated with fodder yield. Hence, associated traits can be simultaneously improved.

Introduction

Small millet crops have been cultivated for over 5000 years because of their particular adaption capabilities for poor degraded lands and ability to endure abiotic stress. They are members of the Poaceae (Graminae) family and are commonly grown as rainfed crops on marginal soils. Millets are native to many parts of India, not only as a food but also as a cultural aspect of the country. The most important small millet crops in India include finger millet, barnyard millet, foxtail millet, proso millet, kodo millet and little millet. (Gowda et al., 2006) Despite the fact that small millets are grown in practically every state and region, individual millet distribution is not regular. Barnyard millet and proso millet are primarily grown in Uttar Pradesh's hills and north-eastern region, as well as North Bihar's plains and Western Uttar Pradesh and Maharashtra's plains.

Proso Millet, commonly known as broom corn or common millet, is one of the most nutritious and delicious temperate millets. It grows well in a variety of soil types and climates. It is a short-season crop, reaching maturity 60 to 75 days after sowing, compared to all millets. It's most commonly grown as a summer crop that's seeded late. Proso millet can reach a height of three to four feet. Broom corn gets its name from the fact that its compact panicle droops at the top like an old broom. Its round seeds have a smooth, shiny shell and are about 1/8 inch across. Because the seeds are encased in the hulls and difficult to remove by ordinary milling procedures, the grain has a relatively high percentage of indigestible fibre.

Knowledge of genetic variability in the population is

required for any crop improvement initiative. Traditional breeding methods rely on the availability of different germplasm and the presence of diversity to improve genetics. For any systematic breeding programme to begin, understanding the kind and magnitude of genetic variability existing in the gene pool is crucial (Anuradha et al., 2017). The presence of significant genetic variety in the starting material increases the likelihood of developing desirable plant types. As a result, an attempt was made to quantify the level of variation for yield-contributing traits in proso millet by looking at PCV, GCV, Heritability, and Genetic Advance, which could give useful selection indicators for crop development.

Materials and Methods

During the kharif of 2020, twenty proso millet lines, including one check variety (TNAU 202), were evaluated at the Agricultural Research Station in Vizianagaram, Andhra Pradesh. Each entry was planted in a randomised complete block design (RCBD) with three replications and a 30x10 cm spacing. Each genotype was grown in five 3 m long rows. To keep the crop healthy, standard management procedures were followed. Plant height (cm), number of productive tillers per plant, panicle length (cm), flag leaf length (cm), and flag leaf width (cm) were all measured on five plant basis. By viewing the entire plot, days to 50% flowering and days to maturity were observed. Per plot yield of fodder and grain yields were recorded and then converted into per hectare.

Although the coefficients of variability can be calculated by normalising the phenotypic and genotypic variances, analysis of variance may not indicate absolute

Table-1 : Mean sum of squares from analysis of variance (ANOVA) for grain yield and yield component traits in proso millet.

Source of variation	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers	Panicle length (cm)	Leaf length (cm)	Leaf width (cm)	No. of leaves/plant	Grain yield (q/ha)	Fodder yield (q/ha)
Treatments (df=19)	19.6**	32.4**	346.6*	1.9**	25.3**	21.3*	0.2*	1.0*	36.81**	123.8**
Replications (df=2)	3.0	1.2	2789.1**	0.0	0.3	13.1	0.2*	2.7*	0.32	141.0
Error (df=38)	1.7	1.0	108.5	0.7	10.3	7.1	0.0	0.4	4.39	44.4

**, significant at 1% probability (p=0.01)

Table-2 : Mean performance of ten traits including grain yield and yield component traits for twenty proso millet genotypes evaluated.

Sl. No.	Entry	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers	Panicle length (cm)	Leaf length (cm)	Leaf width (cm)	No. of leaves/plant	Grain yield (q/ha)	Fodder yield (q/ha)
1.	VP 002	40.5	71.0	115.5	5.2	37.5	33.3	2.0	8.7	20.1	37.5
2.	VP 003	35.5	63.5	92.2	4.2	27.0	22.9	1.0	6.7	9.7	30.1
3.	VP 006	41.0	71.5	108.4	5.7	35.5	35.6	2.0	7.5	11.0	39.0
4.	VP 008	36.5	65.0	105.7	7.7	32.0	29.1	1.5	5.8	19.6	23.6
5.	VP 010	39.5	69.0	97.7	5.7	31.1	30.1	1.4	6.2	18.3	30.2
6.	VP 011	40.5	70.0	128.3	4.7	37.6	31.5	1.5	6.3	9.7	27.7
7.	VP 012	39.5	69.5	99.1	5.5	36.5	30.8	1.8	7.5	11.0	21.0
8.	VP 014	42.5	75.0	138.1	4.3	38.9	35.7	1.9	6.5	9.4	43.3
9.	VP 016	40.0	69.5	104.2	4.8	35.6	30.8	1.6	6.0	19.0	40.8
10.	VP 017	40.0	67.5	121.1	5.8	33.8	36.5	1.8	6.5	10.4	40.9
11.	VP 018	41.5	70.5	129.8	3.7	36.2	31.3	1.6	7.5	9.4	40.2
12.	VP 019	47.0	79.0	107.1	4.2	32.9	35.4	1.7	6.3	13.3	38.5
13.	VP 020	38.0	66.5	114.6	4.5	30.6	33.2	1.8	7.0	9.3	50.0
14.	VP 021	44.5	74.5	106.8	6.3	32.5	30.5	1.6	6.8	21.8	39.2
15.	VP 022	41.0	71.5	124.1	4.2	31.6	33.2	1.9	6.7	11.8	47.8
16.	VP 023	38.5	68.0	108.8	5.7	35.8	32.8	1.8	6.0	8.9	43.9
17.	VP 024	38.0	66.5	102.8	4.8	32.3	27.2	1.0	6.7	10.1	31.8
18.	VP 025	40.5	71.0	123.7	4.7	39.3	32.3	1.7	6.2	12.5	43.9
19.	VP 026	41.0	71.0	126.7	4.3	40.8	30.1	1.9	6.0	17.4	35.6
20.	TNAU 202	39.0	69.5	135.1	6.2	39.2	35.2	1.9	7.7	15.4	44.9
	Mean	40.2	69.9	114.4	5.1	34.7	31.8	1.6	6.6	13.1	37.5
	Minimum	35.5	63.5	92.2	3.7	27.0	22.9	1.0	5.8	8.9	21.0
	Maximum	47.0	79.0	138.1	7.7	40.8	36.5	2.0	8.7	21.8	50.0
	CD (5%)	2.7	2.1	21.8	1.8	6.7	5.6	0.3	1.3	4.4	13.9
	CD (1%)	3.7	2.8	29.8	2.4	9.2	7.6	0.4	1.8	6.0	19.1
	CV (%)	3.2	1.4	9.1	16.7	9.2	8.3	8.8	9.1	15.7	17.8

CD: Critical difference, CV: Coefficient of variation

variability. As a result, Burton and Devane's components of variation, such as genotypic and phenotypic coefficients of variation (GCV and PCV), were calculated (1953). Separating the influence of the environment from overall variability is also important for selection. This refers to the accuracy with which a genotype may be identified based on its phenotypic performance, and heritability was computed in the broad sense according to Allard (1960). The heritability estimates alone aren't enough to predict how people will react to selection. As a result, when heritability estimates were paired with genetic advance estimates, the heritability estimates seemed more important. As a result, the genetic advancements as a percentage mean (GAM) were calculated. According to Johnson et al., heritability and genetic advance were divided into three categories: low, medium, and high (1955). Falconer's technique was used

to identify phenotypic correlations since selection is based on a complex web of relationships (1981).

Results and Discussion

The Analysis of variance (Table-1) indicated significant variations among different proso millet entries for all traits studied while significant variations among replications were observed for plant height and No. of leaves per plant. These results are in consonance with that of Anuradha *et al.*, (2020) in foxtail millet, Anuradha *et al.*, (2014) in barnyard millet and Anuradha *et al.*, (2013) in finger millet. There was a considerable range of variation for all the traits studied (Table 2). Among all the entries evaluated, VP 003 (64 days to maturity) was the earliest (Table 2) while the late maturity was recorded in VP 019 (79 days). Plant height ranged from 92.2 cm (VP 003) to 138.1 cm (VP 014) with a mean of 114.4 cm whereas number of

Table-3 : Genetic variability parameters for studied traits in twenty proso millet genotypes.

Variability parameter	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of productive tillers	Panicle length (cm)	Leaf length (cm)	Leaf width (cm)	No. of leaves/plant	Grain yield (q/ha)	Fodder yield (q/ha)
GCV	7.3	5.6	9.5	14.7	7.9	8.4	15.8	8.6	30.1	16.8
PCV	8.0	5.8	13.2	22.3	12.1	11.8	18.1	12.6	34.0	24.5
ECV	3.2	1.4	9.1	16.7	9.2	8.3	8.8	9.1	15.7	17.8
h^2 (bs)	83.9	94.2	52.3	43.6	42.1	50.1	76.4	47.1	78.7	47.2
GA	5.6	7.9	16.3	1.0	3.7	3.9	0.5	0.8	7.4	8.9
GAM	13.8	11.2	14.2	20.0	10.5	12.2	28.5	12.2	55.1	23.8

Table-4 : Pearson's correlation values (r) for studied characters including yield and yield components in twenty proso millet genotypes.

S.No.	Traits	Days to 50% flowering	Days to maturity	Plant height	Number of productive tillers	Panicle length	Leaf length	Leaf width	No. of leaves/plant	Grain yield
1.	Days to maturity	0.968**								
2.	Plant height	0.283	0.334							
3.	No. of productive tillers	-0.261	-0.264	-0.26						
4.	Panicle length	0.291	0.385	0.678**	-0.069					
5.	Leaf length	0.535*	0.566**	0.571**	0.055	0.466*				
6.	Leaf width	0.403	0.477*	0.538*	0.061	0.590**	0.823**			
7.	No. of leaves/plant	0.037	0.072	0.124	-0.047	0.142	0.214	0.325		
8.	Grain yield	0.167	0.159	-0.196	0.487*	0.056	-0.112	0.081	-0.004	
9.	Fodder yield	0.274	0.287	0.500*	-0.317	0.142	.561*	0.486*	0.098	-0.169

**, Correlation is significant at 1% probability ($p=0.01$), *, Correlation is significant at 1% probability ($p=0.05$)

productive tillers per plant varied from 3.7 (VP 018) to 7.7 (VP 7.7) with a mean of 5.1. Broad range was observed for panicle length which varied from 27 cm (VP 003) to 40.8 cm (VP 026) and similarly leaf length varied from 22.9 cm (VP 003) to 36.5 cm (VP 017). The range for width of the flag leaf was almost doubled, 1.0 cm (VP 003) to 2.0 cm (VP 002). The variation in grain yield was from 8.9 q/ha (VP 023) to 21.8 q/ha (VP 021). Higher on par grain yields were also recorded in VP 002 (20.1 q/ha), VP 008 (19.6 q/ha) and VP 016 (19.0 q/ha). High fodder yield was recorded in VP 020 (50.0 q/ha) followed by VP 022 (47.8 q/ha).

For all variables investigated, PCV values were higher than GCV, which is consistent with previous findings Anuradha *et al.*, (2020) in foxtail millet, browntop millet; Anuradha *et al.*, (2014) in barnyard millet and Anuradha *et al.*, (2013) in finger millet (Table 3).

GCV and PCV ranged from 5.6 & 5.8 respectively for days to maturity to 30.1, 34.0 respectively for grain yield while ECV ranged from 1.4 (days to maturity) to 17.8 (fodder yield). ECV was more than GCV for number of productive tillers/plant, panicle length, leaf width and fodder yield and the variation of GCV and PCV was very high for number of productive tillers/plant and fodder yield. The heritability ranged from 42.1 (number of productive tillers/plant) to 94.2 (Days to maturity) while that of GAM was from 10.5 (number of productive

tillers/plant) to 55.1 (Grain yield). These results are in accordance with previous studies of Manoharan (1978) and Hawlader (1991).

GCV and PCV were low to medium for days to 50% flowering, days to maturity, plant height, panicle length, leaf length and number of leaves per plant while medium to high GCV and PCV were recorded in number of productive tillers/plant, leaf width and fodder yield. Grain yield was observed to have high GCV and PCV indicating lot of variation in the evaluated proso millet genotypes. High heritability was recorded for days to 50% flowering, days to maturity, leaf width and grain yield while rest of the traits recorded moderate heritability. GAM was high for number of productive tillers per plant, flag leaf width (cm), fodder yield and grain yield. High heritability along with high GAM was noticed for flag leaf width (cm) and grain yield indicating additive gene action. Number of productive tillers per plant and fodder yield recorded moderate heritability and high GAM which signified the presence of additive gene action while in the rest of the traits are supposed to have both additive and non-additive gene action based on the combination of heritability and GAM. Similar outcomes were informed earlier by Panwar and Kapila (1992), Anuradha *et al.*, (2020).

Correlations aid in the selection of superior genotypes based on phenotypic selection of heritable traits. Days to 50% flowering was positively and

significantly correlated with days to maturity and leaf length while days to maturity was also significantly correlated in positive direction with leaf width. Plant height was associated positively and significantly with panicle length, leaf length, leaf width and fodder yield. Leaf length had positive significant association with more number of traits, viz., days to 50% flowering, days to maturity, plant height, panicle length, leaf width and fodder yield. As like leaf length, leaf width was associated with many traits except days to 50% flowering. Number of leaves were associated with none of the traits. Grain yield was significantly and positively associated with number of productive tillers per plant while fodder yield was associated with plant height, leaf length and leaf width. Number of productive tillers per plant and grain yield can be improved simultaneously with selection.

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Genetic Variability Studies in Foxtail Millet (*Setaria italica* L.) for Yield and its Related Traits

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Abstract

Foxtail millet (*Setaria italica* (L.) P.Beauv.] is one of the most economically important millet crop after finger millet. Crop improvement is possible through exploitation of variability present in the population and understanding heritability of various traits. Hence, the present investigation was undertaken to study the genetic variability, heritability of grain yield and its yield related traits. Analysis of Variance of 20 foxtail millet genotypes revealed significant variation for all the traits studied except for plant height. Phenotypic Coefficient of Variation is moderate for number of productive tillers per plant (19.01), grain yield (18.01) and fodder yield (13.52). Moderate heritability coupled with moderate GAM was observed by fodder yield indicating both of additive and non additive gene action.

Key words : Foxtail millet, variability, heritability.

Introduction

Foxtail millet (*Setaria italica* (L.) P. Beauv) also known as Italian millet is important crop next to finger millet among seven small millets. It is also known by different names such as giant setaria, German millet, Chinese millet, Hungarian millet. In India it is cultivated in an area of 5 lakh hectares and the production of 2.9 million tons with productivity of 600 kg per hectare (Anonymous, 2016). It is one of the most economically important millet crop grown for grain and fodder purpose. These grains are rich in protein, fibre, α carotene, minerals viz., calcium, iron, potassium, magnesium, zinc, antioxidants and vitamins (Rai *et al.*, 2002). Millet based dietary fiber, improves glycemic control, decreases hyper insulinemia and lowers plasma lipid concentrations in patients with type 2 diabetes (Jali *et al.*, 2012).

In spite of the health benefits provided by foxtail millet, it has remained as a neglected crop from the mainstream of crop improvement research compared to other cereals such as maize, rice, wheat etc. The reason being millets were neglected in Green Revolution, is that, millet processing, i.e. dehusking is difficult than paddy and no machines are available in millet growing areas and distribution of fine grains through public distribution system made the consumers to shift entirely to fine grains, thus low demand and low production and availability complementarily reduced the area under millet cultivation, production and consumption.

Yield being a complex character is influenced by many of its dependent traits and is controlled by many genes as well as environmental influence. Knowledge on

inheritance of yield and its related traits, heritability, expected genetic advance and association between various economic traits is necessary for planning successful selection procedure for evolving high yielding genotypes. The present investigation was carried out to know the gene action governing the yield and its attributing traits which aids in improvement of the yields.

Materials and Methods

The experiment was conducted with 20 foxtail millet lines including one check variety (SiA 3085) and they were evaluated at Agricultural Research Station, Vizianagaram, Andhra Pradesh during *kharif*, 2019. Genotypes were planted in a randomized complete block design (RCBD) with three replications and a spacing of 30 × 10 cm. per each entry. Every genotype was grown in 10 lines each of 3 m length. Fertilizers, DAP (87 kg/ha), MOP (42 kg/ha) and urea (22 kg/ha) were applied basally at the time of land preparation and remaining 22 kg/ha Urea was applied three weeks after sowing. Standard management practices were followed to maintain a healthy crop. Observations were recorded on five plants for plant height (cm), number of productive tillers per plant and panicle length (cm). Days to 50% flowering, days was recorded by visualizing the entire plot. Fodder yield and grain yield were recorded on per plot basis and then converted into per hectare.

The mean of all the plants for each trait under each replication was subjected to ANOVA as per the method suggested by (Panse and Sukhathme, 1967). The estimates of GCV and PCV were worked out according to

Table-1 : ANOVA of twenty foxtailmillet genotypes.

Source of Variations	Df	Mean Sum of Squares						
		DFF	DM	PH	NPT	PL	GY	FY
Treatments	19	18.61	23.35	181.79	0.48	10.93	44.16	89.13
Replications	2	9.45	16.27	12.60	0.80	10.04	16.64	16.34
Error	38	1.98	4.44	115.65	0.24	5.39	20.26	32.45

Note : DFF: Days to 50% flowering; DM: Days to maturity; PH: Plant height (cm); NPT: No. of productive tillers per plant; PL: Panicle length (cm GY: Grain yield (q/ha); FY: Fodder yield (q/ha).

Table-2 : Performance of twenty foxtail millet genotypes.

S. No.	Entry	DFF	DM	PH	NPT	PL	GY	FY
1.	DHFt 109-3	46.33	76.67	141.47	3.47	23.38	30.94	51.98
2.	SiA 3220	45.67	76.33	143.33	2.67	23.26	26.06	51.98
3.	TNSi 337	45.33	75.33	143.40	2.53	23.60	24.64	48.21
4.	SiA 3159	48.67	79.67	148.47	2.47	25.23	34.52	58.73
5.	IIMR FXM-2	46.33	76.33	145.47	2.73	21.16	27.91	52.12
6.	GPUF-2	45.00	75.00	155.53	3.07	22.70	33.82	50.79
7.	TNSi 354	46.00	76.67	141.73	2.80	21.61	24.88	49.34
8.	PKS 22	45.67	76.00	136.93	3.33	21.67	22.51	50.53
9.	SiA 3303	42.00	73.33	139.67	2.73	21.10	31.79	44.11
10.	SiA 4200	50.00	82.00	166.20	3.07	25.78	33.36	64.68
11.	GPUF-3	48.00	78.67	141.47	4.00	23.57	30.97	57.21
12.	GPUF-4	48.67	80.33	142.93	3.13	23.55	29.72	58.13
13.	TNSi 364	45.00	77.00	154.00	3.27	21.29	25.93	52.98
14.	IIMR Fxm-4	50.00	80.33	156.87	2.80	25.96	32.22	59.33
15.	IIMR Fxm-5	39.67	69.00	135.80	2.40	26.22	27.61	43.85
16.	IIMR FT-1	45.33	75.33	141.13	2.73	18.99	23.27	46.49
17.	DHFt 109-3-1	46.67	77.33	154.40	3.20	23.89	31.25	58.93
18.	DHFt 109-3-2	47.33	77.67	149.07	2.93	21.83	33.18	54.50
19.	Local Check	44.33	76.33	153.60	3.47	21.75	31.35	49.87
20.	SiA 3156	48.00	78.00	143.73	2.73	21.30	34.05	55.95
	Mean	46.20	146.76	76.87	2.98	22.89	29.50	52.99
	CD (1%)	3.11	23.81	4.67	1.09	5.14	9.96	12.61
	CD (5%)	2.32	17.77	3.48	0.81	3.84	7.44	9.41
	CV (%)	3.04	7.33	2.74	16.53	10.14	15.26	10.75

the method suggested by (Burton, 1952). Heritability in broad sense was calculated as per the formula given by (Lush, 1940). Range of heritability was categorized as suggested by (Robinson *et al.* 1949). Genetic advance was estimated according to the method suggested by (Johnson *et al.* 1955). Correlations were calculated as suggested by (Johnson *et al.* 1955).

Results and Discussion

Genetic variability studies is the basis for any crop improvement programme. It also helps us to know the main root cause of variation whether it is sensitive to environment or not, whether it can be transformed to the next generation or not, based on this breeding programme can be planned. Analysis of variance showed significant differences among the genotypes for all the characters included under study except for plant height (Table-1). Similar results were reported earlier (Anuradha *et al.*, 2013, 2017a; 2017b; 2019a and 2019b). The extent of

variability in respect of range, mean, phenotypic coefficient of variability, genotypic coefficient of variability, heritability, genetic advance and genetic advance as percent of mean were presented in (Table-3).

The values of PCV obtained for yield and its attributing characters ranged from 4.26 for days to maturity to 19.01 for number of productive tillers per plant. The values of GCV ranged from 3.20 for plant height to 9.57 for grain yield. Phenotypic coefficient of variability is higher than genotypic coefficient of variability for all the characters indicating that the interaction of genotypes with environment. Moderate PCV were recorded for number of productive tillers per plant (19.01), grain yield (18.01) and fodder yield (13.52). Similar results were reported by Anuradha *et al.*, 2020. Narrow range of variations were recorded for days to 50% flowering (5.94, 5.10), days to maturity (4.26, 3.27) and plant height (8.00, 3.20) indicating less variation for these traits.

Table-3 : Genetic parameters of twenty foxtail millet genotypes.

S. No.	Parameter	DFF	DM	PH	NPT	PL	GY	FY
1.	Mean	46.20	146.76	76.87	2.98	22.89	29.50	52.99
2.	Minimum	39.67	135.80	69.00	2.40	18.99	22.51	43.85
3.	Maximum	50.00	166.20	82.00	4.00	26.22	34.52	64.68
4.	GCV	5.10	3.20	3.27	9.39	5.94	9.57	8.20
5.	PCV	5.94	8.00	4.26	19.01	11.75	18.01	13.52
6.	ECV	3.04	7.33	2.74	16.53	10.14	15.26	10.75
7.	H ² (B)	73.72	16.01	58.65	24.39	25.50	28.22	36.80
8.	Genetic Advance	4.16	3.87	3.96	0.28	1.41	3.09	5.43
9.	GAM	9.02	2.64	5.15	9.55	6.17	10.47	10.25

Note : DFF: Days to 50% flowering; DM: Days to maturity; PH: Plant height (cm); NPT: No. of productive tillers per plant; PL: Panicle length(cm); GY: Grain yield (q/ha); FY: Fodder yield (q/ha)

In the present study, SiA 3159 (34.52q/ha) had significantly out yielded the check variety for grain yield (31.35 q/ha) (Table 2). IIMR Fxm-5 was the earliest with 69 days of maturity whereas the check variety is having 76 days of maturity. The genotypes with early duration can be used for breeding earliness in crop improvement programmes. Among all the genotypes studies IIMR Fxm-5 (135.cm) observed to be the shortest followed by PKS 22 (136.93 cm) and these genotypes can be used for breeding non lodging genotypes. More number of productive tillers per plant which is an indicative for getting more grain yield were shown by GPUF-3 (4.0) whereas the local check found to be (3.47) in number. More panicle length was shown by IIMR-Fxm-5 (26.22 cm). The genotype IIMR-Fxm-5 having lower plant height, more panicle length and early duration.

Variability studies indicates only the possibility of selections. For reliable selection one has to depend on heritability studies. Highly heritable traits are governed by genotypic variances rather than with environmental variance. Hence, there is more chance for success in selection of genotypes based on heritability. However, heritability informs whether the variation is genetic or non genetic while Genetic Advance as Percent Mean (GAM) enlightens the aspect of gene action. High heritability was shown by days to 50 % flowering (73.72) indicating the presence of additive gene effect. Moderate heritability coupled with moderate GAM was observed by fodder yield indicating both of additive and non additive gene action. The results were similar with the earlier reports of Brunda *et al.*, (2017), Anuradha *et al.*, (2017). Low heritability coupled with low GAM was observed by plant height, number of productive tillers per plant and panicle length indicating preponderance of non additive gene action and environment is the main role in governing this character and selection for this character may be not effective.

Conclusions

Significant variation for all the traits studied was observed in the present study among 20 foxtail millet genotypes. GCV and PCV were low to high for the traits studied indicating low to high variability in the present population. Moderate PCV were recorded for number of productive tillers per plant, grain yield and fodder yield. Whereas the GCV for all the traits were low.

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Effect of Organic Manures on Yield, Quality and Soil Health in Finger Millet

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Abstract

The experiment is conducted to study the effect of use of organic source of nutrients in comparison with conventional (Inorganic) method of cultivation on soil health, yield and quality of finger millet. The soil is sandy loam in texture, neutral in reaction with low soluble salts, low in organic carbon (0.42) and available nitrogen (227 kg/ha) and medium in available phosphorus (59 kg/ha) and potassium (265kg/ha). The long- term experiment is laid out with two treatments i.e. organic treated plot and inorganic treated plot (conventional plot) for six years from 2014 to 2019 during *Kharif* season. The organic inputs were supplied in the form of *insitu* incorporation of green manures (sunhemp), application of farmyard manure, neem cake and biofertilizers (*Azospirillum* and Phosphorus Solubilising Bacteria) whereas the inorganic plot was treated with Recommended dose of fertilizer (60-40-30 kg/ha of NPK). The results of the mean pooled data over a period of six years have been statistically analysed using T-test and revealed that even after 6 years of the experiment grain and straw yields of conventional plot (2750 kg/ha and 7257 kg/ha) are higher than organic plot (2392 kg/ha and 6711 kg/ha, respectively). But the soil available nitrogen, phosphorus and zinc were found high in organic plot (251 kg/ha, 78 kg/ha and 1.35 ppm) compared to conventional plot (237 kg/ha, 72 kg/ha and 1.19 ppm, respectively). Whereas the plant nitrogen uptake was not significantly influenced between the plots but the plant phosphorus and potassium uptake was high in conventional plot (14.6 kg/ha and 33.8 kg/ha) compared to organic plot (11.7 kg/ha and 28.3 kg/ha respectively).

Key words : Conventional, finger millet, organic, nutrient uptake, soil fertility and yield.

Introduction

Finger millet (locally called as *Ragi* or *chodi*), is the third most important millet in India next to sorghum and pearl millet, covering an area of 2 million hectares with annual production of 2.15 million tones. The most striking feature, which made finger millet an important dry land crop, is its resilience and ability to withstand adverse weather conditions when grown in soils having poor water holding capacity. However, with the changing climatic patterns declining the soil productivity indications are ripe that use of only chemical fertilizers cannot ensure sustained production of these crops (Mollah *et al.*, 2011). In recent years, much emphasis has been given for use of organics to produce adequate amount of high-quality food.

The high input agriculture has led to self- sufficiency in food grains but it has posed several new challenges. The conversion of inefficient plant protection measures in modern chemical intensive agriculture has resulted into degradation of lands owing to low crop yields with poor quality of produce (Pradhan and Mondal, 1997). Continuous use of chemical fertilizers is leading to reduction in the crop yields and resulted in imbalance of nutrients in the soil, which has adverse effects on soil health. However, it is now realized that in fields under intensive monoculture which receive heavy applications of chemical fertilizers alone, there is a slow decline in

productivity. All these factors result in decline in the productivity of most of the crops. Hence, conversion of modern chemically intensive agriculture to a more suitable form of agriculture like organic farming appears to be an option for maintaining the desirable agricultural production in future (Modgal *et al.*, 1995). Use of organic manures alone or in combination with chemical fertilizers will help to improve physico-chemical properties of the soils, efficient utilization of applied fertilizers for improving seed yield and seed quality. The organic production system aims at supporting and sustaining healthy ecosystems, soil, farmers, food production, community and the economy. Reduction and elimination of the adverse effects of synthetic fertilizers and pesticides on human health and the environment is a strong indicator that organic agriculture is gaining worldwide attention (Aksoy, 2001).

Organic soil management is necessary for restoring soil health, which is pre-requisite for sustenance of yield. But it will take time until the desired developments are obtained, considering that resource scarcity forms the major bottle neck towards its adoption in wider scale. Therefore use of locally available agro-inputs in agriculture by avoiding or minimizing the use of synthetically compounded agrochemicals appear to be one of the probable options to sustain the agricultural productivity.

Table-1 : Effect of organic and inorganic manures on growth, yield of finger millet.

S. No.	Particulars	Organic plot	Conventional plot	T Value	P Value
1.	Plant height (cm)	110.4	117.38	8.39	0.014*
2.	No. of Productive tillers/plant	2.85	3.20	7.49	0.017*
3.	Leaf length (cm)	30.91	35.13	20.67	0.002**
4.	Leaf width (cm)	1.19	1.13	0.905	0.460
5.	Ear head length (cm)	8.66	8.71	0.854	0.483
6.	No. of Fingers/ear	7.48	7.76	2.592	0.122
7.	Straw yield (q ha ⁻¹)	6711	7257	13.34	0.006**
8.	Grain yield (q ha ⁻¹)	2392	2750	5.65	0.029*

*Significant at P=0.05 level

** Significant at P= 0.01 level

Table-2 : Effect of organic and inorganic manures on soil health at harvest.

S. No.	Particulars	Initial Values	Organic plot	Conventional plot	T value	P value
1.	Organic carbon (%)	0.42	0.45	0.43	2.18	0.16
2.	pH	7.02	7.02	6.68	5.11	0.04*
3.	EC	0.25	0.23	0.23	0.23	0.84
4.	Available N (kg ha ⁻¹)	227	251	237	4.86	0.039*
5.	Available P ₂ O ₅ (kg ha ⁻¹)	59	78	72	9.46	0.01*
6.	Available K ₂ O(kg ha ⁻¹)	265	305	292	2.38	0.14
7.	Available Zn (ppm)	1.75	1.35	1.19	4.90	0.04*
8.	Available Fe (ppm)	10.1	9.84	8.96	0.87	0.48
9.	Available Mn (ppm)	5.95	5.82	5.23	1.82	0.21
10.	Available Cu (ppm)	1.35	1.56	1.52	0.37	0.74

*Significant at P=0.05 level

** Significant at P= 0.01 level

Table-3 : Effect of organic and inorganic manures on Plant nutrient uptake of finger millet.

S. No.	Particulars	Organic plot	Conventional plot	T value	P value
1.	N Uptake (kg ha ⁻¹)	61.6	62.5	1.21	0.35
2.	P Uptake (kg ha ⁻¹)	11.7	14.6	4.91*	0.04*
3.	K Uptake (kg ha ⁻¹)	28.3	33.8	5.55*	0.03*
4.	Zn Uptake (gm ha ⁻¹)	92.2	96.7	0.91	0.46
5.	Fe Uptake (gm ha ⁻¹)	119.3	124.1	1.73	0.23

*Significant at P=0.05 level

Materials and Methods

The long-term field experiment was being conducted for the past 6 years since *kharif*, 2014 at Agricultural Research Station, Vizianagaram, ANGRAU, to study the effect of organic method of farming using organic inputs in comparison with conventional method of farming using inorganic fertilizers on growth parameters, yield, soil fertility status grain quality and nutrient uptake at harvest in finger millet. The soil was sandy loam in texture, neutral in reaction with low soluble salts, low in organic carbon (0.42) and available nitrogen (227 kg/ha) and medium in available phosphorus (59 kg/ha) and potassium (265kg/ha). The experiment was laid out with two treatments *i.e.* organic treated plot and inorganic treated plot (conventional plot). The Recommended Dose of Fertilizer (60:40:30 kg NPK ha⁻¹) was applied to the inorganic treated plot. Recommended dose of nitrogen was applied through urea in two equal splits as basal and

30 days after transplanting to the conventional plot. Entire dose of phosphorus and potassium were applied through single super phosphate in the conventional plot whereas FYM@ 5t ha⁻¹ along with neem cake @ 1t ha⁻¹ as top dressing were applied to organic treated plot. Moreover, green manure (sunhemp) was grown *insitu*, incorporated and biofertilizers in the form of *Azospirillum* and Phosphorus Solubilizing Bacteria @ 5 kg ha⁻¹ were applied in organic plot. The initial soil samples were collected before sowing of the crop at 0-15 cm depth in 2014 and the final soil samples were collected after harvest of the crop during all the six years and analyzed using the standard procedures.

Results and Discussion

The pooled mean data (Table-1) of all the six years recorded significantly higher grain and straw yields in the conventional plot compared to organic plot. Even after a period of six years the conventional (Inorganic) method of

cultivation of finger millet showed 14.40 % higher grain yields when compared to organic method of cultivation. While observing the pooled mean data, among the two treatments, significantly highest grain and straw yields were recorded in conventional plot (2749.6 kg ha⁻¹ and 7257.4 kg ha⁻¹) compared to the organic plot (2391.1 q ha⁻¹ and 6711.3 q ha⁻¹). Similar results were also recorded by Pawar *et al.*, (2013). The increase in the yields can be owed to the fact that conventional plot recorded higher growth and yield attributing characters when compared to the organic plot. Among the plant growth characters, plant height and leaf length were found significantly high in conventional plot (117.4cm and 35.1cm) compared to the organic plot (110.4cm and 30.9cm). Among the yield contributing characters the number of productive tillers/plant, ear head length and numbers of fingers/ear were also found highest in conventional plot (3.2, 8.7 cm and 7.8) compared to the organic plot (2.9, 8.6cm and 7.5cm), but no significant difference was found between the two treatments.

After completion of the sixth year of the experiment it is noted that pH and EC of soil were unchanged over their initial status under both the treatments (Table-2) which was in accordance with Rajiv, D. *et al.*, (2014). The Organic Carbon % has shown an increased trend in the organic plot (0.44%) by 0.2% compared to the initial value (0.42%). The buildup of Organic Carbon could be attributed to the manures and subsequently addition of leaf residue and debris of plants (Bhandari *et al.*, 2002). The soil available macronutrients N, P₂O₅ and K₂O showed an increasing trend over their parental status in both the organic and inorganic treatments. The mean pooled data of the soil available Nitrogen and Phosphorus were found significantly high in organic plot (251.3 kg ha⁻¹ and 78.2 kg ha⁻¹) compared to the conventional method (237.3 kg ha⁻¹ and 71.5 kg ha⁻¹), whereas the soil available Potassium was found high in organic plot (305.2 kg ha⁻¹) compared to the conventional plot (292.3 kg ha⁻¹), but there is no significant difference between the two treatments. The soil available Zn was found significantly high in the treatment of organic plot (1.35 ppm) compared to the conventional plot (1.19 ppm) and no significant difference was found in soil available Fe, Mn and Cu among both the treatments.

The plant P and K uptake (Table-4) were found significantly high in conventional plot (14.6 kg ha⁻¹ and 33.8 kg ha⁻¹) when compared to the organic plot (11.7 kg ha⁻¹ and 28.3 kg ha⁻¹) whereas the plant N uptake even though found higher in the inorganic plot but did not show any significant difference between the two treatments. These results are in consonance with the findings of Singh *et al.*, 2009. The uptake of micronutrients was not significantly influenced by both the treatments.

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Resistant Source Identification in Barnyard Millet under Natural Field Conditions against Sheath Blight Disease Incited by *Rhizoctonia solani* Kuhn

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Abstract

Barnyard millet is the second important small millet after finger millet in India. In the present study a total of 22 barnyard millet varieties including checks were evaluated for identification of resistance source against banded blight disease at Agricultural Research Station, Vizianagaram during *kharif*, 2021 under natural field conditions. The screening revealed that none of the test lines or varieties were immune or highly resistant. However, VMBC 333 (23.13%), VL 254 (25.40%), ACM 15-353 (25.87%) TNEf 319 (25.40%) and DHBM 93-3 (26.20%) were recorded as resistant to banded blight. The disease intensity was ranged from 23.13% (VMBC 333) to 59.27% (ACM 15-343), whereas it was 8.67% in resistant check (PRB 903) and 66.50% in susceptible check (LDR-1).

Key words : Barnyard millet, banded blight, resistant, screening, susceptible.

Introduction

Small millets are warm-season cereals largely grown in the semi arid tropical regions of Asia and Africa, under rainfed farming systems (Rai *et al.*, 2008). Small millets includes finger millet (*Eleusine coracana*), kodo millet (*Paspalum scrobiculatum*), proso millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), little millet (*Panicum sumatranse*), barnyard millet (*Echinochloa frumentacea*) and Browntop millet (*Brachiaria ramosa*). Small millet grains are rich in dietary energy, vitamins, several minerals (especially micronutrients such as iron, calcium and zinc), insoluble dietary fiber and phytochemicals with antioxidant properties (Bouis, 2000) and are considered as “Nutri-cereals”. They are rich in compounds that help against several chronic diseases like ischemic strokes, cardiovascular diseases, cancers, obesity and Type II diabetes (Jones *et al.*, 2000, Jones, 2006).

Barnyard millet (*Echinochloa frumentacea*) is one of the hardiest millets, which is called by several names viz., Japanese barnyard millet, ooda, oadalu, sawan, sanwa, and sanwank. Nutritionally, Barnyard millet is an important crop. It is a fair source of protein, which is highly digestible and is an excellent source of dietary fiber with good amounts of soluble and insoluble fractions (Veena *et al.* 2005). The carbohydrate content is low and slowly digestible (Veena *et al.* 2005), which makes the Barnyard millet a natural designer food. In the present days of increased diabetes mellitus, barnyard millet could become an ideal food. Although barnyard millet like any other minor millet is nutritionally superior to cereals, yet its utilization is limited. Besides, barnyard is a fastest

multipurpose crop, which yields food and forage in a short duration and at low inputs even under adverse climatic conditions. The crop Barnyard millet prone to many diseases and can be effectively controlled by application of fungicides and practicing suitable management practices. However, the poor farmers required only varieties with resistance to the disease. Hence, the study was undertaken to identify the barnyard millet genotypes resistant to banded blight disease.

Materials and Methods

A field experiment was conducted against sheath blight caused by *Rhizoctonia solani* during *kharif*, 2021 at Agricultural Research Station, Vizianagaram. The experiment was laid on a plot in Randomized Block Design (RBD), with 22 varieties replicated three times which was sown in two rows of 3 m length with a spacing of 22.5 x 10 m. The recommended agronomic practices and other standard packages of practices were adopted at the time of crop growth period. Five randomly selected plants were selected from each genotype/replication for recording the observations. The genotypes of barnyard millet were screened under natural epiphytotic conditions and no artificial inoculation was made. Infected plants were examined for lesion development and disease severity was assessed on the basis of lesion length by using 0 to 5 scale (Anon, 1996).

Percent Disease Index (PDI) was calculated by using the formula

PDI for severity

$$= \frac{\text{Sum of all disease ratings}}{\text{Total no. of ratings} \times \text{Maximum disease grade}} \times 100$$

Table-1 : Standard Evaluation System (SES) scale for leaf blast disease.

Score	Description	Reaction
0	No incidence	Immune
1	Vertical spread of the lesions upto 20% of the plant height	HR
2	Vertical spread of the lesions upto 21-30% of the plant height	R
3	Vertical spread of the lesions upto 31-45% of the plant height	MR/MS
4	Vertical spread of the lesions upto 46-65% of the plant height	S
5	Vertical spread of the lesions upto 66-100% of the plant height	HS

Table-2 : Reaction of Barnyard millet entries against banded blight.

S. No.	Entry	Banded blight (%)	Yield/ plot (g)
1.	IIMR BM-8-1920	28.93	MR
2.	TNEf 317	30.93	MS
3.	IIMR BM-3-1920	35.60	MS
4.	VMBC 336	27.13	MR
5.	VL 272	28.67	MR
6.	IIMR BM-2-17	33.20	MS
7.	VMBC 333	23.13	R
8.	TNEf 307	40.47	MS
9.	BYMNDL-5	32.87	MS
10.	TNEf 315	35.13	MS
11.	BYMNDL-4	25.53	R
12.	DHBM 4-73	34.27	MS
13.	VL 271	39.87	MS
14.	VL 254	25.40	R
15.	ACM 15-343	59.27	S
16.	ACM 15-353	25.87	R
17.	TNEf 319	25.40	R
18.	VMBC 335	35.60	MS
19.	DHBM 93-3	26.20	R
20.	VL 207	41.13	MS
21.	PRB903 (R)	8.67	HR
22.	LDR1 (s)	66.50	HS
	MEAN	33.17	
	C.D. (5%)	3.8	
	C.D. (1%)	5.0	
	C.V. (%)	6.8	

Results and Discussion

22 barnyard millet varieties were screened for banded blight reaction. Among the screened entries, no variety was found to be immune to *R. solani* also none found to be highly resistant. However, VMBC 333 (23.13%), VL 254 (25.40%), ACM 15-353 (25.87%) TNEf 319 (25.40%) and DHBM 93-3 (26.20%) were recorded as resistant to banded blight. The disease intensity was ranged from 23.13% (VMBC 333) to 59.27% (ACM 15-343), whereas it was 8.67% in resistant check (PRB 903) and 66.50% in susceptible check (LDR-1) (Table-2).

Patro *et al.*, (2017) evaluated ten varieties where the disease intensity ranges from 85.33% (VL 207) to 97.33% (DHBM 18-6, VL 249 and DHBM 99-6) while it was 98.67% in the local check. Divya *et al.*, (2016) evaluated thirteen varieties and the per cent disease intensity was

ranged from 27.9% (ACM 10-082) to 92.5% (RBM 7-2) whereas it was 93.7% in susceptible check. Patro *et al* (2014) and Nagaraja *et al* (2016) reported that all the small millet crops were found infected with *R. solani*. Similar research was also done in other small millet crops by Neeraja *et al.*, 2016, Patro *et al.*, 2013 and Patro *et al.*, 2016. Patro *et al.*, 2018a evaluated twenty three barnyard millet varieties and reported that no variety was found to be immune to *R. solani* also none found to be resistant. However, varieties VB- 16-7 (40.00), VB-16-8 (46.67), VB16-20 (49.33), LRB-9 (44.00) and LRB-19 (49.30) were found to be resistant. Varieties VB-15-3 (56.00), VB-15-6 (57.33), VB-16-31 (52.00), PRB 903 (54.67), LRB-1 (52.00) and LRB-26 (56.00) as moderately resistant to moderately susceptible. Whereas, VB-15-1 (80.00) and LRB-21 (81.33) were found to be as susceptible. Patro *et al.*, 2018b evaluated 9 genotypes and reported that TNEf 204 (49.33) and VL 172 (45.33) entries as moderately

susceptible and DHBM 99-6, DHBM 19-7 and RBM 36 (73.33) as susceptible entries. Patro *et al.*, 2019 evaluated 14 genotypes and reported that disease intensity was ranged from 53.8 (DHBM 33) to 97.5 (TNEf 204) which were recorded as susceptible entries. Patro *et al.*, 2020 screened 19 barnyard millet entries and revealed that none of the test lines or varieties were immune or highly resistant. However, LBT 1 (22.3%) and LRB 2 (25.3%) were recorded as moderately resistant. The disease intensity was ranged from 22.3% (LBT 1) to 85.0% (LRB 15), whereas it was 21.7% in resistant check (PRB 903) and 97.1% in susceptible check (LDR-1). These genotypes would be of immense value to the breeders involved in developing high yielding resistant genotypes of barnyard millet.

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Screening for identification of Kodo millet varieties against banded blight (BB) disease incited by *Rhizoctonia solani* Kuhn

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Abstract

A total of 20 kodo millet varieties including resistant and susceptible checks were evaluated for identification of resistance source against banded blight disease at Agricultural Research Station, Vizianagaram during *kharif*, 2021 under natural field conditions. The screening revealed that none of the test lines or varieties were immune or highly resistant. However, KMNDL-1 (24.23%), RPS 1009 (23.07%), DK 151 (25.10%), DK 159 (27.60%) and TNPsc 313 (27.63%) shown resistant reaction. Percent disease severity ranged from 23.07% (RPS 1009) to 54.6% (IIMR-KM-1) whereas it was 68.7% in susceptible check 8.27% in resistant check.

Key words : Banded blight, kodo millet, resistance, screening, susceptible.

Introduction

Kodo millet (*Paspalum scrobiculatum*) is one of the hardiest crops grown in Madhya Pradesh, Maharashtra, and Uttar Pradesh and various other parts of India. Minor millets like kodo is also described as nutritious millet and has received far less research and development attention than other crops with regard to crop improvement and utilization. It is the main source of protein and minerals in the daily diets of tribal and weaker section living in remote rural areas. Millets are nutritionally superior than other cereals. The millet contains a high proportion of complex carbohydrate and dietary fiber which helps in prevention of constipation and slow release of glucose to the blood stream. Glycemic index is an important tool used in treating people with diabetes, cardiovascular disease management and weight regulation programs. Millets including Kodo contain water soluble fiber and this property may be utilized for maintaining or lowering blood glucose response among diabetic and CVD patients. Glycemic load (GL) representing both quality and quantity of carbohydrate in a food and allows comparison of the likely glycemic effect of realistic portion of the different foods (Neelam, *et al.* 2013).

As it is a low value crop doesn't offer much scope for additional cash inputs like fungicides and chemical methods of control are generally not advisable, hence growing resistant varieties is the best option. Very little efforts have been made to identify the resistant sources of foxtail millet against banded leaf blight disease. So an attempt was made to identify the sheath blight resistant lines.

Material and Methods

20 entries of kodo millet varieties were evaluated at Agricultural Research Station, Vizianagaram. These entries were evaluated in two rows of 3 m length sown at 22.5×10cm spacing in infector row method using JK-76 as a susceptible check so as to ensure the availability of sufficient inoculum during *kharif* 2021. Infected plants were examined for lesion development and disease severity was assessed on the basis of lesion length by using 0 to 5 scale (Anon, 1996).

Percent Disease Index (PDI) was calculated by using the formula

$$\text{PDI for severity} = \frac{\text{Sum of all disease ratings}}{\text{Total no. of ratings} \times \text{Maximum disease grade}} \times 100$$

Results and Discussion

20 kodo millet varieties including checks were evaluated for identification of resistance source against banded blight disease. The screening revealed that none of the test lines or varieties were immune or highly resistant. However, KMNDL-1 (24.23%), RPS 1009 (23.07%), DK 151 (25.10%), DK 159 (27.60%) and TNPsc 313 (27.63%) shown resistant reaction. Percent disease severity ranged from 23.07% (RPS 1009) to 54.6% (IIMR-KM-1) whereas it was 68.7% in susceptible check and 8.27% in resistant check (Table-2).

Patro *et al.* (2017) screened 10 kodo millet entries and the disease intensity ranged from 78.00% (DPS-118) to 98.67% (RK-64) in which it was 97.33% in the check.

Table-1 : Standard Evaluation System (SES) scale for leaf blast disease.

Score	Description	Reaction
0	No incidence	Immune
1	Vertical spread of the lesions upto 20% of the plant height	HR
2	Vertical spread of the lesions upto 21-30% of the plant height	R
3	Vertical spread of the lesions upto 31-45% of the plant height	MR/MS
4	Vertical spread of the lesions upto 46-65% of the plant height	S
5	Vertical spread of the lesions upto 66-100% of the plant height	HS

Table-2 : Reaction of Kodo millet varieties to banded blight.

S. No.	Entry	Banded blight (%)	Reaction
1.	TNPsc 312	35.13	MS
2.	KMNDL-1	24.23	R
3.	TNPsc 310	32.40	MS
4.	DK 151	25.10	R
5.	GAK 3	34.47	MS
6.	KMNDL-4	48.77	S
7.	TNPsc 308	45.30	S
8.	BK-64	34.50	MS
9.	RPS 716	37.40	MS
10.	DK 159	27.60	R
11.	IIMR-KM-1	54.60	S
12.	IIMR-KM-2	31.43	MS
13.	RPS 1005	34.20	MS
14.	RPS 1009	23.07	R
15.	KMNDL-5	46.60	S
16.	TNPsc 313	27.63	R
17.	TNAU 86	34.23	MS
18.	RK 390-25	41.47	MS
19.	RK 390-25(R)	8.27	HR
20.	JK-76(S)	68.7	HS
	MEAN	35.73	
	C.D. (5%)	8.4	
	C.D. (1%)	11.2	
	C.V. (%)	14.1	

However, kodo millet varieties KAVT 5, KAVT 20 and KAVT 22 were found as resistant genotype. Patro *et al.* (2016) screened six varieties in which RK 390-25 (20.5) was found to be highly resistant. However, DPS 118 (21.7) was recorded as resistant, TNAU 86 (63.6) and RK 153 (64.4) as susceptible, GPUK 3 (70.2) and TNAU 26 (87.4) was found to be highly susceptible. The mean performance of six centers as revealed that RK 390-25 (8.8), DPS 118 (17.1) as highly resistant, GPUK 3 (21.0), RK 156 (23.0) and TNAU 86 (30.0) as resistant varieties. Patro *et al.* (2016) evaluated 27 genotypes and revealed that DHKM 3 (24.0) and BK 20 (25.5) showed less severity of banded blight as compared to control TNAU 26, whereas hundred percent disease severity was recorded in DHKM 3-3, BK 10 and DHKM 3 genotypes. Patro *et al.* (2014) and Nagaraja *et al.* (2016) reported that all the small millet crops were found infected with *R. solani*. Similar research was also done in other small millet crops by Neeraja *et al.* 2016, Patro *et al.* 2013 and Patro *et al.* 2016. Eleven entries were evaluated against

banded blight and reported that TNAU 86 (53.33) and BK 48 (53.33) were recorded as moderately susceptible varieties by Patro *et al.* 2018. A total of 15 kodo millet varieties including check were evaluated for resistance to banded blight and revealed that none of the test lines or varieties were immune or highly resistant. Whereas, RPS 1005 (57.7) and RPS 1007 (59.7) were recorded as susceptible. These genotypes would be of immense value to the breeders involved in developing high yielding resistant genotypes of kodo millet.

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Identification of Resistant Source of Little Millet (*Panicum sumatrense*) Varieties Against Banded Blight Disease Incited by *Rhizoctonia solani* Kuhn

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Abstract

A field experiment was conducted during *kharif*, 2021 at Agricultural Research Station, Vizianagaram, Acharya N.G. Ranga Agricultural University, to identify the resistant sources against *Rhizoctonia solani* which causes banded blight disease in little millet. Among them none of the variety could exhibit the immune reaction, whereas RLM 223 (check) recorded as highly susceptible to banded blight. The percent disease incidence of Banded blight ranged from 22.47% (TNPSu 177) to 60.33% (GPUL 8) where it was 57.53% in susceptible check RLM 223.

Key words : Little millet, banded blight, *Rhizoctonia solani*, resistant, susceptible.

Introduction

Little millet (*Panicum sumatrense* Roth ex Roemer and Schultes), locally known as kutki, mejhari, medois one of the hardest minor cereal crops belonging to the family Poaceae (Gramineae) and is indigenous to Indian sub-continent. The crop is cultivated by tribal and poor farmers in low fertile soils with low or no cash input for food and feed. It has an excellent rejuvenating capacity compared to other cereal crops. In India, the crop is cultivated in an area of 291 thousand hectares with annual production of 102 thousand tones and productivity of 349 kg per hectare which is very less as compared to other cereal crops. Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Odisha, Tamil Nadu, Karnataka, Jharkhand and Gujarat are major little millet growing states in the country.

Studies on management of sheath blight in little millet is meager in the literature, however few studies on identification of resistant sources and management through seed treatment with carbendazim has been reported. Although, disease can be controlled by application of different chemicals but this is not the right way to control diseases in the present context because chemical application has its many disadvantages like soil pollution, water pollution and environment hazardous. Now a days people are very conscious to health and they are moving to organic production and consumption. The growing of resistant genotypes of crops is one of the best ways to manage many biotic and abiotic stresses in organic crop production system. The present study was focused on status of the disease in the farmers' field and identification of resistant sources.

Materials and Methods

A field experiment was conducted against sheath blight caused by *Rhizoctonia solani* during *kharif*, 2021 at Agricultural Research Station, Vizianagaram. The experiment was laid on a plot in Randomized Block Design (RBD), with 23 varieties, replicated three times which was sown in two rows of 3 m length with a spacing of 22.5 x 10 m. The recommended agronomic practices and other standard packages of practices were adopted at the time of crop growth period. Five randomly selected plants were selected from each genotype/replication for recording the observations. The genotypes of little millet were screened under natural epiphytotic conditions and no artificial inoculation was made. Infected plants were examined for lesion development and disease severity was assessed on the basis of lesion length by using 0 to 5 scale (Anon, 1996).

Percent Disease Index (PDI) was calculated by using the formula

PDI for severity

$$= \frac{\text{Sum of all disease ratings}}{\text{Total no. of ratings} \times \text{Maximum disease grade}} \times 100$$

Results and Discussion

23 little millet varieties were screened for banded blight reaction. Among the entries, no entry was found to be immune to *R. solani* whereas, six entries were found to be resistant. RLM 223 (check) recorded as highly susceptible to banded blight. The percent disease incidence of Banded blight (Sheath blight) ranged from 22.47% (TNPSu 177) to 60.33% (GPUL 8) where it was 57.53.1% in susceptible check RLM 223 (Table-2).

Table-1 : Standard Evaluation System (SES) scale for leaf blast disease.

Score	Description	Reaction
0	No incidence	Immune
1	Vertical spread of the lesions upto 20% of the plant height	HR
2	Vertical spread of the lesions upto 21-30% of the plant height	R
3	Vertical spread of the lesions upto 31-45% of the plant height	MR/MS
4	Vertical spread of the lesions upto 46-65% of the plant height	S
5	Vertical spread of the lesions upto 66-100% of the plant height	HS

Table-2 : Evaluation of little millet genotypes against sheath blight.

S. No.	Entry	Banded blight (%)	Reaction
1.	TNPsu 231	27.93	R
2.	VS 6	43.73	MS
3.	IIMR-LM-8400-17	39.07	MS
4.	TNPsu 177	22.47	R
5.	OLM 18	43.87	MS
6.	LMNDL-5	28.37	R
7.	IIMR-LM-4004	37.80	MS
8.	IIMR-R18-5004	35.33	MS
9.	GPUL 11	45.67	S
10.	VS 19	30.53	MS
11.	LMNDL-4	36.53	MS
12.	IIMR-LM-4001	29.07	R
13.	IIMR-LM-4006	28.40	R
14.	VS 25	30.53	MS
15.	TNPsu 227	39.53	MS
16.	VS 13	29.07	R
17.	GPUL 8	60.33	S
18.	DHLM 36-3	27.53	R
19.	BL 6	32.40	MS
20.	JK 8	34.33	MS
21.	OLM 203	37.33	MS
22.	RLM208 (R)	9.43	HR
23.	RLM 223 (S)	57.5	S
	Mean	57.53	
	C.D. (5%)	4.4	
	C.D. (1%)	5.8	
	C.V. (%)	7.5	

Patro and Madhuri (2014) screened 19 little millet genotypes of different maturity groups and reported that RLM 43 as resistant genotype and JK 8 as susceptible genotype. Patro *et al.* (2014) and Nagaraja *et al.* (2016) reported that all the small millet crops were found infected with *R. solani*. Similar research was also done in other small millet crops by Neeraja *et al.*, 2016, Patro *et al.*, 2013 and Patro *et al.*, 2016. Patro *et al.*, 2019 reported that IIMRLM-8437-7 (4.4) is found to be resistant when screened 24 varieties. Patro *et al.*, 2020 screened 17 entries and reported that all the entries were found to be infected with banded blight disease. These genotypes would be of immense value to the breeders involved in developing high yielding resistant genotypes of little millet.

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Identification of Potent Resistant Varieties of Proso Millet against Banded Blight Disease Incited by *Rhizoctonia solani* Kuhn.

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Abstract

A total of 23 proso millet varieties including checks were evaluated for identification of resistance source against banded blight disease at Agricultural Research Station, Vizianagaram during *kharif*, 2021 under natural field conditions. Among the screened entries, none of the test lines or varieties were immune or highly resistant. However, IIMR 163 (28.07%), DHPM 81-3 (28.17%), GPUP 30 (26.93%), GPUP 32 (22.93%) and PMNDL-2 (28.20%) found to be resistant. The disease severity was ranged from 22.93% (GPUP 32) to 50.47% (TNPm 267). Whereas, it was 72.93% in susceptible check and 7.80% in resistant check.

Key words : Banded blight, proso millet, resistance, susceptible.

Introduction

Small millet crops belonging to Poaceae have a long history of cultivation of more than 5000 years and grown in many states (Gowda et al. 2006) due to their unique adaptation properties for poor degraded lands and ability to tolerate abiotic stress besides being high quality fodder crops and high nutritive value. In India, the antiquity of proso millet (*Panicum milliaceum* L.) is not clear. The crop is cultivated in sporadic patches from the Himalayas in the north and to Tamil Nadu in the south (Nagaraja et al. 2007). It is grown in Madhya Pradesh, Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Bihar, Uttar Pradesh and Uttarakhand (Sinha and Upadhyay 1997). Incidentally, proso millet is known to be affected by several diseases.

As it is a low value crop doesn't offer much scope for additional cash inputs like fungicides and chemical methods of control are generally not advisable, hence growing resistant varieties is the best option. Very little efforts have been made to identify the resistant sources of foxtail millet against banded leaf blight disease. So an attempt was made to identify the sheath blight resistant lines.

Materials and Methods

Twenty entries of proso millet initial advanced varieties were evaluated at Vizianagaram falling under different agro climatic situations. These entries were evaluated in two rows of 3 m length sown at 22.5×10 cm spacing in infector row method using Nilavoor Local as a susceptible check so as to ensure the availability of sufficient inoculum during *kharif* 2019. Banded blight (BB) was recorded by using 0 to 5 scale (Anon, 1996).

Percent Disease Index (PDI) was calculated by using the formula

PDI for severity

$$= \frac{\text{Sum of all disease ratings}}{\text{Total no. of ratings} \times \text{Maximum disease grade}} \times 100$$

Results and Discussion

A total of twenty three proso millet entries were evaluated during *kharif* 2021 against banded blight disease incited by *Rhizoctonia solani* Kuhn. The screening revealed that none of the test lines or varieties were immune or highly resistant to banded blight. However, IIMR 163 (28.07%), DHPM 81-3 (28.17%), GPUP 30 (26.93%), GPUP 32 (22.93%) and PMNDL-2 (28.20%) found to be resistant. The disease severity was ranged from 22.93% (GPUP 32) to 50.47% (TNPm 267). Whereas, it was 72.93% in susceptible check and 7.80% in resistant check.

Patro et al., (2015) screened 18 proso millet genotypes and reported DhPrMv 2164 (29.23%) and DhPrMv 2769 (28.90%) as resistant to moderately resistant genotypes. Patro et al., (2017) screened eleven varieties and reported that minimum disease severity (64.00%) was recorded in TNAU 145 whereas it was 90.67 % in check. Patro et al (2014) and Nagaraja et al (2016) reported that all the small millet crops were found infected with *R. solani*. Similar research was also done in other small millet crops by Neeraja et al., 2016, Patro et al., 2013 and Patro et al., 2016. Patro et al., 2020 evaluated 20 proso millet varieties including checks for identification of resistance source to banded blight and revealed that none of the test lines or varieties was

Table-1 : Standard Evaluation System (SES) scale for leaf blast disease.

Score	Description	Reaction
0	No incidence	Immune
1	Vertical spread of the lesions upto 20% of the plant height	HR
2	Vertical spread of the lesions upto 21-30% of the plant height	R
3	Vertical spread of the lesions upto 31-45% of the plant height	MR/MS
4	Vertical spread of the lesions upto 46-65% of the plant height	S
5	Vertical spread of the lesions upto 66-100% of the plant height	HS

Table-2 : Evaluation of proso millet genotypes against banded blight.

S. No.	Entry	Banded blight (%)	Reaction
1.	IIMR 163	28.07	R
2.	TNPm 252	30.27	MS
3.	VP 002	30.67	MS
4.	PMNDL-1	30.67	MS
5.	PMNDL-4	33.40	MS
6.	TNPm 267	50.47	S
7.	TNPm 280	33.33	MS
8.	VP 008	36.27	MS
9.	DHPM 81-3	28.17	R
10.	GPUP 27	30.27	MS
11.	TNPm 275	38.87	MS
12.	GPUP 30	26.93	R
13.	GPUP 32	22.93	R
14.	GPUP 33	34.27	MS
15.	GPUP 28	40.33	MS
16.	DHPM 60-4	37.20	MS
17.	PMNDL-2	28.20	R
18.	HB-1	34.33	MS
19.	TNAU 164	30.40	MS
20.	TNPm 230	37.67	MS
21.	TNAU 202	37.67	MS
22.	TNPm230 (R)	7.80	HR
23.	Nilavoor local (S)	72.93	HS
	MEAN	33.44	
	C.D. (5%)	4.2	
	C.D. (1%)	5.6	
	C.V. (%)	7.7	

immune, highly resistant or resistant to the disease. These genotypes would be of immense value to the breeders involved in developing high yielding resistant genotypes of little millet. Patro *et al.*, (2019) reported that the disease intensity was less in TNPm 247 (64.00) followed by GPUP 21 (68.00) and was highest in TNAU 151 (81.33) followed by GPUP (76.00) when screened 8 proso millet entries against *R. solani*.

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Assessment of Genetic Diversity among Finger Millet (*Eleusine coracana* L.) Pre-Released Varieties

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Introduction

Finger millet (*Eleusine coracana* L.) [family Poaceae (Gramineae)] ranks fourth in importance among millets in the world after sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*) and foxtail millet (*Setaria italica*). Finger millet is an annual robust grass, mainly grown as a grain cereal in the semi-arid tropics and subtropics of the world under rainfed conditions. Early maturity, low input requirements, freedom from major pests and diseases, rejuvenation capacity after all abiotic of stress conditions have made this crop an ideal for dryland farming. Finger millet crop requires a day temperature of 30 °C to 34 °C whereas 22 °C to 25 °C night temperatures for optimal growth along with good sunshine. It thrives best in the regions where the average annual rainfall is about 100 cm. It can be grown on a wide range of soils from rich loam to poor shallow upland soils with good organic matter. This crop survives best in soils with a pH of 5.0 to 8.2 (Rani *et al.*, 2021).

Genetic improvement through conventional breeding approaches depends mainly on the availability of the diverse germplasm and the amount of genetic variability present in the population (Prabhu *et al.*, 2008). The availability of diverse genetic resources or germplasm is a prerequisite for genetic improvement of any crop. Besides the availability of germplasm, the characterization of respective germplasm is essential for effective exploitation in crop improvement programs.

Information on the nature and degree of genetic divergence would help the plant breeder to choose right parents for breeding programmes (Vivekanandan and Subramanian, 1990). Among the multivariate procedures, Mahalanobis (1936) generalized distance (D^2) has been used extensively. Attempt has been made in this study to assess the nature and magnitude of genetic divergence for yield and its component in finger millet and also to identify divergent parents from distantly related clusters for suitable hybridization. The choice of suitable parent material of diverse origin with the possibility of obtaining large frequency of transgressive segregants is the reason

behind success of any hybridization programme. The D^2 statistics is one of the powerful and widely accepted tools to assess the relative contribution of different component traits to the total diversity. Knowledge of genetic diversity among genotypes on the basis of divergence analysis usually helps a breeder in choosing diverse parents for breeding program. Therefore, the present investigation was undertaken to estimate the extent of genetic diversity in finger millet pre-released genotypes.

Materials and Methods

The experimental material consisted of 25 finger millet genotypes which were procured from ICAR-Indian Institute of Millets Research (IIMR), Hyderabad. The material was grown in simple randomized block design (RBD) with two replications at the Agricultural Research Station, Vizianagaram, Acharya N.G. Ranga Agricultural University, Andhra Pradesh. The material were sown with standard spacing 22.5 cm × 10 cm and all the recommended agronomic and cultural practices were followed for raising a healthy crop. Morphological data were recorded on five randomly taken plants per replication of each genotype for eight characters including yield and yield components viz., days of 50% flowering (DFF), days to maturity (DM), plant height (PH), number of productive tillers per plant (NPT), number of fingers per ear (NFE), ear length (cm) (EL), grain yield (q/ha) (GY) and fodder yield (q/ha) (FY). Genetic diversity was studied following Mahalanobis's (1936) D^2 statistics. On the basis of D^2 values genotypes were grouped into different clusters according to Tocher's method given by Rao (1952).

Results and Discussion

Analysis of variance revealed significant differences among the genotypes for all the characters under study, indicating considerable amount of variability in experimental material. The recordings of the means, range, coefficient of variation and standard error are presented in Table 1. The genotypes viz., WN 562 (30.99 q/ha) followed by PR 202 (27.44 q/ha), PR 1639 (27.34

Table-1 : List of 25 finger millet genotypes and their mean performance for yield and yield component characters during Kharif 2018.

Entry Code	Entry Name	Days to 50% flowering	Plant height (cm)	Number of productive tillers	Number of fingers	Ear length (cm)	Days to maturity	Grain yield (q/ha)	Fodder yield (q/ha)
1.	WN 562	81.79	99.26	2.86	7.56	8.02	117.57	30.99	89.59
2.	GPU 99	93.14	100.35	2.80	7.00	9.08	128.62	25.47	86.17
3.	GPU 67 (C)	91.74	94.16	3.05	6.61	9.77	126.14	23.41	75.65
4.	KMR 652	88.14	92.82	3.10	6.98	7.17	121.86	23.49	74.18
5.	VR 1117	86.05	97.72	3.02	7.43	6.82	119.33	22.91	67.79
6.	VL 394	79.10	103.84	2.94	7.71	8.41	113.81	23.24	67.69
7.	GPU 45 (C)	75.38	105.45	2.79	7.53	7.38	111.02	24.17	70.93
8.	HR-13	82.19	100.18	3.02	6.67	7.71	116.55	25.79	78.19
9.	KMR 650	81.14	100.19	2.85	7.04	8.12	115.57	26.02	76.66
10.	RAUF 17	81.69	98.09	2.85	7.77	8.62	116.55	26.42	71.21
11.	TNEc 1299	83.93	110.11	2.88	6.77	8.77	119.48	26.90	78.87
12.	WN 591	84.21	100.93	2.85	6.84	8.19	119.12	25.36	71.13
13.	VL 376 (C)	85.07	106.73	2.85	7.29	8.97	120.05	26.94	76.36
14.	VR 1110	75.98	100.95	2.92	7.83	8.19	112.17	27.06	75.66
15.	VL 382	83.64	102.92	3.06	6.74	8.08	118.40	27.25	84.14
16.	BR-14-27	72.74	106.13	2.90	7.18	8.79	107.62	23.43	72.84
17.	PR 202 (C)	81.60	102.96	2.95	7.09	7.53	114.43	27.44	82.66
18.	TNEc 1297	82.19	103.83	2.91	7.17	7.52	117.14	26.35	79.68
19.	GPU 98	82.74	102.67	2.75	7.69	8.81	117.31	25.73	72.17
20.	OEB 604	81.17	99.88	2.83	7.34	8.40	115.98	24.34	65.25
21.	PR 1639	91.17	103.15	2.81	6.78	9.61	125.74	27.34	80.12
22.	IIMRFM-8023-17	85.83	102.63	2.90	7.20	8.53	119.83	23.09	69.65
23.	IIMRFM-8011-17	73.24	100.47	2.90	7.07	8.49	109.43	21.49	65.78
24.	GSMC-1	76.02	98.04	2.87	6.83	8.32	111.02	23.32	68.47
25.	Local check	92.95	97.88	2.95	7.21	7.51	124.93	22.75	82.11
	Mean	82.91	101.25	2.90	7.17	8.27	117.59	25.23	75.32
	C.V.	10.11	9.89	20.13	11.37	15.10	7.60	28.90	26.66
	F ratio	19.44	6.14	0.99	8.25	14.06	14.68	3.58	4.44
	F Prob.	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00
	S.E.	1.29	1.54	0.09	0.13	0.19	1.38	1.13	3.10
	C.D. 5%	3.59	4.29	-	0.35	0.54	3.82	3.12	8.60
	C.D. 1%	4.72	5.64	-	0.46	0.70	5.03	4.11	11.31
	Range Lowest	72.74	92.82	2.75	6.61	6.82	107.62	21.49	65.25
	Range Highest	93.14	110.11	3.10	7.83	9.77	128.62	30.99	89.59

Table-2 : Clustering pattern of 35 finger millet genotypes by Tocher's method.

Name of the cluster	Number of genotypes	Name of genotypes
Cluster I	10	HR-13, KMR 650, TNEc 1299, WN 591, VL 376 (C) VL 382, PR 202 (C), TNEc 1297, OEB 604, IIMRFM-8023-17
Cluster II	5	WN 562, VL 394, RAUF 17, VR 1110, GPU 98
Cluster III	3	BR-14-27, IIMRFM-8011-17, GSMC-1
Cluster IV	3	GPU 99, GPU 67 (C), PR 1639
Cluster V	3	KMR 652, VR 1117, Local check
Cluster VI	1	GPU 45 (C)

Table-3 : Average intra (diagonal) and inter-cluster D2 values among six clusters.

Cluster Name	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
Cluster I	0.03	0.04	0.06	0.1	0.06	0.06
Cluster II		0.03	0.06	0.13	0.08	0.06
Cluster III			0.02	0.17	0.14	0.06
Cluster IV				0.03	0.14	0.25
Cluster V					0.03	0.11
Cluster VI						0

Table-4 : Mean values of six clusters estimated by Tocher's method.

Cluster and characters	Days to 50% flowering	Plant height (cm)	Number of productive tillers	Number of fingers	Ear length (cm)	Days to maturity	Grain yield (q/ha)	Fodder yield (q/ha)
Cluster I	83.1	103.04	2.91	7.02	8.18	117.65	25.95	76.26
Cluster II	80.26	100.96	2.86	7.71	8.41	115.48	26.69	75.26
Cluster III	74.00	101.55	2.89	7.03	8.53	109.36	22.75	69.03
Cluster IV	92.02	99.22	2.88	6.79	9.49	126.83	25.41	80.65
Cluster V	89.05	96.14	3.02	7.21	7.17	122.04	23.05	74.69
Cluster VI	75.38	105.45	2.79	7.53	7.38	111.02	24.17	70.93

Note : Bold figures are minimum and maximum values

Table-5 : Contribution of different characters towards genetic divergence.

Variables	Times ranked 1st	Contribution %
Days to 50% flowering	102	35.0
Plant height (cm)	35	11.67
Number of productive tillers		0.0
Number of fingers	55	18.33
Ear length (cm)	85	28.33
Days to maturity	2	0.67
Grain yield (q/ha)	16	5.33
Fodder yield (q/ha)	5	1.67

Table-6 : Eigene values and percent variation contribution by principal components of eight characters for 25 finger millet varieties.

Principal components	PC1	PC 2	PC 3	PC 4	PC 5
Eigene Value (Root)	2.31	1.934	1.455	1.02	0.466
% Var. Exp.	28.875	24.172	18.187	12.748	5.831
Cum. Var. Exp.	28.875	53.047	71.234	83.982	89.813
Days to 50% flowering	0.531	0.087	0.108	0.204	0.708
Plant height (cm)	-0.449	0.252	-0.193	-0.446	0.408
Number of productive tillers	0.464	-0.406	0.125	-0.109	-0.26
Number of fingers	-0.224	-0.048	-0.369	0.783	-0.057
Ear length (cm)	0.129	0.493	0.5	0.075	-0.063
Days to maturity	0.01	0.623	0.142	0.197	-0.298
Grain yield (q/ha)	0.342	0.255	-0.557	0.021	0.161
Fodder yield (q/ha)	0.341	0.257	-0.468	-0.3	-0.378

q/ha), VL 382 (27.25 q/ha) and VR 1110 (27.06 q/ha) recorded with high grain yield with overall mean value of 25.23 q/ha.

Based on relative magnitude of D^2 values 25 finger millet genotypes were grouped into six clusters (Table-2) (Figure-1). Cluster I had the maximum of ten genotypes

followed by cluster II with four genotypes. Cluster III, IV and V had three genotypes each while the remaining cluster VI was solitary. The check included namely GPU-45 formed single stocked cluster indicating wide diversity from set. The average intra and inter cluster D^2 values (Table 3 and Figure 2) showed that the intra cluster distance ranged from 0.02 (cluster III) to 0.03 (cluster I, II,

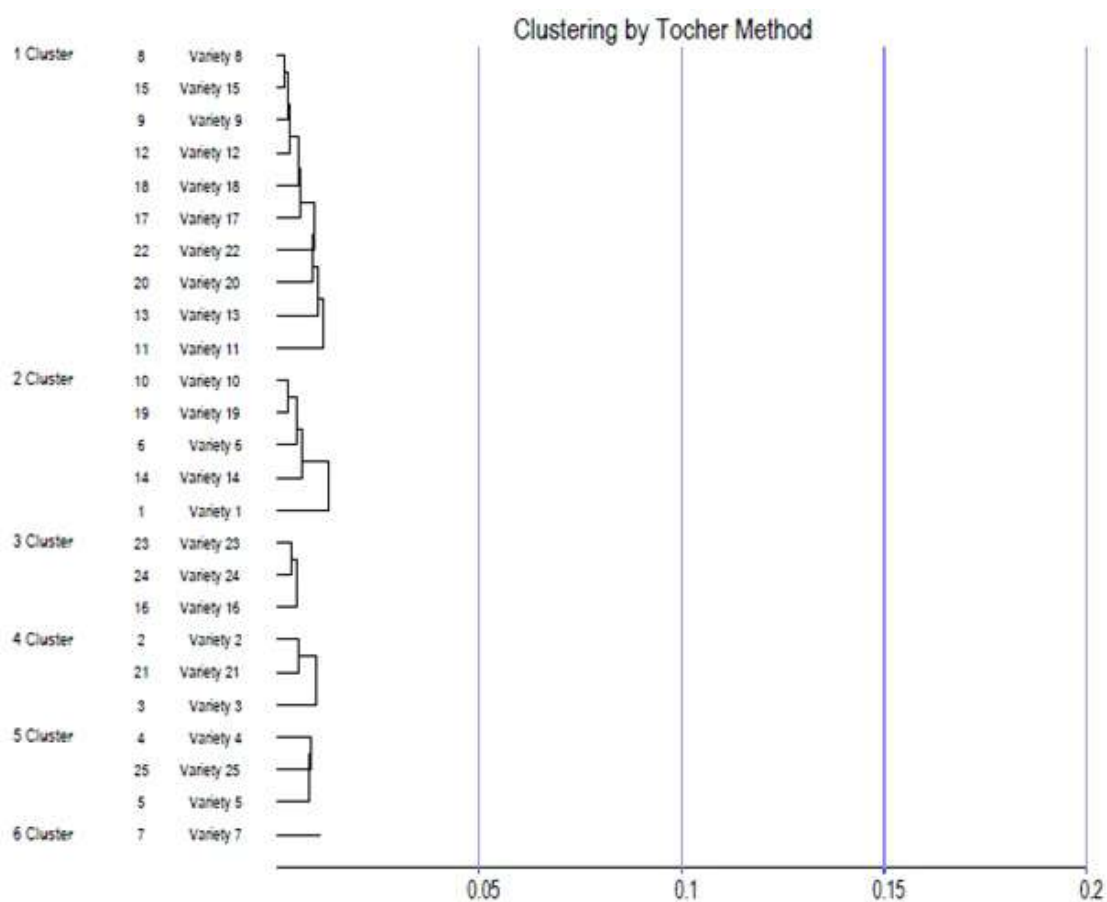
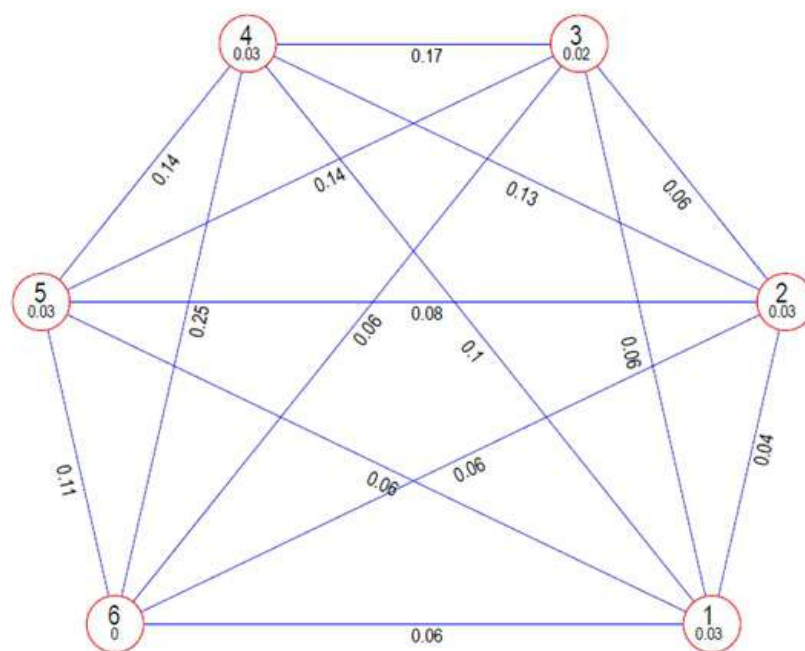


Figure-1 : Dendrogram showing relationship of 25 finger millet genotypes in six clusters based on Mahalanobis D^2 values.



Mahalanobis Euclidean Disatnce (Not to the Scale)

Figure-2 : Inter and intra-cluster distances between six clusters based on Mahalanobis's D^2 statistics.

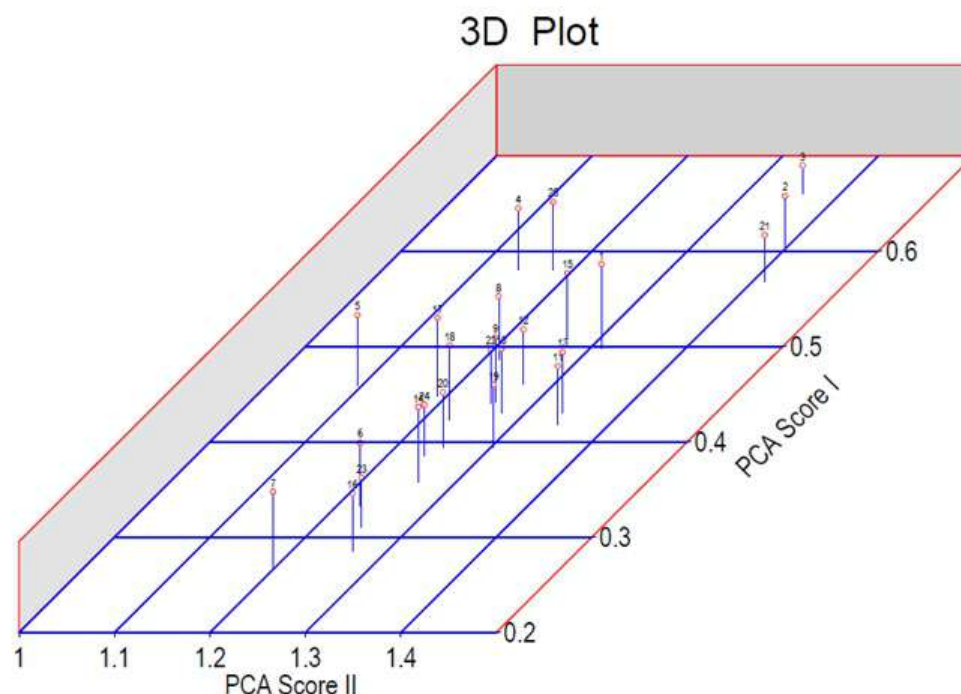


Figure-3 : Three-dimensional plot showing diversity among 25 finger millet genotypes based on principal component analysis.

IV and V). There was a three solitary cluster possessing single entry with no intra cluster distance. The inter cluster D^2 values ranged from 0.04 (between cluster I and II) to 0.25 (between cluster V and VI).

The cluster means estimated over 25 genotypes for the eight characters revealed nearly considerable inter cluster variation (Table-4). Cluster II recorded high number of fingers per ear (7.71) and grain yield (26.69 q/ha). Cluster III exhibited minimum number of days to 50% flowering (74 days) and days to maturity (109 days). Cluster V had maximum number of tillers (3.02) whereas cluster IV had maximum ear length (9.49 cm) and fodder yield (80.65 q/ha). Similarly, cluster VI showed highest mean value for plant height (105.45 cm). Based on intra and inter-cluster distance among the groups, it is suggested to make crosses between the genotypes of the clusters V (KMR 652, VR 1117, Local check) and cluster VI (GPU 45) after confirming their general combining ability for evolving transgressive segregants for yield and yield components. Contribution of different characters towards genetic divergence is presented in Table-5. The trait days to 50% flowering (35.0%) contributed maximum towards total diversity followed by ear length (28.33%), number of fingers per ear (18.33%), plant height (11.67%), and grain yield (5.33%). Similar results were also reported by Anantharaju and Meenakshiganesan (2008), Prabhu *et al.* (2008), Kadam (2008) and Anuradha *et al.* (2020).

Principal component analysis (PCA) analysis

showed that first four principal components (PC) with more than one eigen value and those contributing almost 84% of the total variation (Table 6). Among four PCs, first PC (PC1) contributed 28.87% of total variation followed by PC2 (24.1%), PC3 (18.1%) and PC4 (12.7%). Diversity among the studied genotypes depicted on a three-dimensional plot with three principal components on x, y, z-axis was given in the figure 3. Similar reports published by Sinha and Mishra (2015), Patil *et al.* (2017), Patil *et al.* (2019), Salini *et al.* (2010), Shoba *et al.* (2017) and Jyothsna *et al.* (2016).

Present investigation revealed that genetic divergence has no relationship with the geographic origin as observed by the random pattern of distribution of genotypes into various clusters which are originally from different geographic regions. This could be due to there as on that genotypes in a particular geographic region could have been evolved with different objectives and varied local situations. Hence, genotypes with same geographical origin could have under gone change for different characters under selection during the process of evolution.

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Use and Importance of Different Information Sources among Veterinary Students of G.B.P. University of Agriculture and Technology : A Qualitative Study

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Introduction

Information is recognized as a vital source and the basic need, for the progress of humanity and the development of a nation, as a whole. It means that every piece of information should be extracted from wherever it is available and provided to the users at the right time, in the right proportion, without delay of time. Only then, can that piece of information be put to its maximum use. Information is everywhere. We have to categorize it and at the same time let the users know about which source contains what information. Only, when the research scholars know about the contents and whereabouts of information can they use it easily, without having someone to assist them. Now-a-days, subjects are multi-disciplinary in nature because of which, they have become complex. Simultaneously, with the growth in literature there are a number of sources that let us know of the earlier as well as latest developments in a subject. As a result of this growth, the problems of literature explosion have been felt. This tremendous expansion of literature is difficult to be handled or consulted. To make this process easier, attempts have been made to categorize documents, containing information.

Research Methodology

The Questionnaire and Interview methods have been used to collect different types of data from users, 150 Veterinary Scientists were selected. Out of these only 120 responses found usable. The investigator personally visited the Veterinary Students. Repeated visits were made to distribute and obtain the filled-up questionnaires. Some respondents were not willing to fill up the questionnaire of their own. In such case, the investigator himself noted down the oral responses given by the respondents.

Data Analysis and Findings : This study presents the empirical data collected by means of survey i.e. through the distribution of questionnaire among the sample population selected for the study. The data are presented in tabular form, along with brief description.

(a) Books : Table-1 reveals that 41 (34.16%) respondents

use the books very frequently. 52(43.33%) respondents use the books frequently and 22(18.33%) respondents use the books some time and only 5 (4.16%) respondents use the books rarely.

(b) Reference books : Table-1 shows that 18 (15%) respondents use the reference books very frequently. 48 (40%) respondents use the reference books frequently whereas 36 (30%) respondents use the reference books some time and only 13 (10.83%) respondents use the reference books rarely and there are 5(4.16%) respondents which are never go to the library for using the reference books.

(d) Theses/ dissertations : According to Table 1 there are only 3 (2.5%) respondents who use the theses/ dissertations very frequently. 33(27.5%) respondents use the theses/dissertation frequently and 52 (43.33%) respondents showed that they use the theses/dissertation some time. There are 24(20%) respondents who use the theses/dissertation rarely and 8 (6.66%) respondents never go to the library for theses/dissertations.

(f) Periodicals :

(a) Current journals : 45 (37.5%) and 52(43.33%) respondents use current journal very frequently and frequently respectively 12 (10%) and 6 (5%) respondents use current journal some time and rarely respectively and there are only 5 (4.16%) respondents which is never use the current journals.

(b) Back volumes of journal : 24 (20%) and 36 (30%) respondents use the back volumes of journals very frequently and frequently respectively and 26 (21.66%) and 18(15%) respondents use the back volumes of periodicals some time and rarely respectively. There are only 5 (4.16%) respondents which never use the back volume of journal.

(c) General magazines : According to Table 1 there are 9 (7.5%) and 28 (23.33%) respondents which use the general magazines very frequently and frequently respectively. 41 (34.16%) respondents are using the general magazines some time and 33 (27.5%) respondents

Table-1 : Use of information sources.

Documentary sources		Very frequently	Frequently	Some time	Rarely	Never
Books	F	41	52	22	5	-
	P	34.16	43.33	18.33	4.16	
Reference Books	F	18	48	36	13	5
	P	15.00	40.00	30.00	10.83	4.16
Thesis/Dissertations	F	3	33	52	24	8
	P	2.5	27.5	43.33	20.00	6.66
PERIODICALS	F	45	52	12	6	5
	P	37.5	43.33	10.00	5.00	4.16
a. Current Journals	F	24	36	26	18	16
	P	20.00	30.00	21.66	15	13.33
b. Back Vols. of Journals	F	9	28	41	33	8
	P	7.5	23.33	34.16	27.5	6.66
c. General Magazines	F	15	27	33	20	25
	P	12.5	22.5	27.5	16.66	20.83
Abstracting Journals	F	10	22	28	30	30
	P	8.33	18.33	23.33	25.00	25.00
Indexing Journals	F	33	36	38	25	6
	P	27.5	30.00	31.66	20.83	5.00
Library Catalogues	F					
	P					

Importance of Sources of Information :

Table-2 : Importance of Sources of Information.

Source of information		1 st Priority	2 nd Priority	3 rd Priority	4 th Priority	5 th Priority	6 th Priority	7 th Priority
Books	F	45	19	21	18	4	6	7
	P	37.5	15.83	17.5	15.00	3.33	5.00	5.83
Periodicals	F	36	40	18	7	8	6	5
	P	30.00	33.33	15.00	5.83	6.66	5.00	4.16
Dissertation/theses	F	10	21	22	36	17	10	4
	P	8.33	17.5	18.33	30.00	14.16	8.33	3.33

Note : F= Frequency and P= Percentage

use the general magazines rarely and 8 (6.66%) respondents are never use the general magazines.

(g) Abstracting journals : 15(12.5%) respondents use the abstracting journal very frequently. 27 (22.5%) respondents use the abstracting journal frequently. 33 (27.5%) and 20 (16.66%) respondents uses the abstracting journal some time and rarely respectively and only 25(20.83%) respondent which are never uses the abstracting journals.

(h) Indexing journals : 10(8.33%) respondents use indexing journal very frequently. 22(18.33%) respondents use indexing journal frequently. 28 (23.33%) and 30(25%) respondents use the indexing journal some time and rarely respectively. There are 30 (25%) respondent which never use the indexing journal.

(p) Library catalogue : 33 (27.5%) and 36 (30%) respondent use library catalogue very frequently and frequently. 38 (31.66%) and 25 (20.83%) respondents use the library catalogue some time and rarely and there are 6 (5%) respondents which never use the library catalogue.

Table-2 reveals the importance of sources of information to the Veterinary students.

(a) Books : 45 (37.5%) respondents gave first preference to books. 19 (15.83%) respondents gave second preference to books and 21 (17.5%) and 18 (15%) respondents gave third and fourth preference to books respectively. Superna (2009) reported that most of veterinary scientists gave the first priority to books, periodicals, dissertation/thesis, and least preference to government documents and newspapers.

(b) Periodicals : 36 (30%) and 40 (33.33%) respondents shows periodicals as their first preference and second preference respectively and 18 (15%) and 7 (5.83%) respondents mention periodicals as their third and fourth preference respectively. Pelzer and Leysen (1991) indicated that veterinarians continue to rely on personally owned books and journals for information needs.

(e) Dissertation/ theses : 10 (8.33%) and 21 (17.5%) respondents indicated their first and second preference to govt. document respectively. 22 (18.33%) and 36 (30%) respondents indicated their third and fourth preference to govt. documents respectively.

Conclusion

Books are the most important source of information followed by periodicals. Students of Veterinary science have made use of books more frequently as compared to Reference books. Thesis and Dissertation are not used by many students. Current journals are more frequently used rather than back volumes. General magazines have been used by Veterinary Students some time. 30% Veterinary Students used library catalogues services.

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Use of library Service and Computerised service by the Veterinary students of G.B. Pant University of Agriculture and Technology : A Survey

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Introduction

Information is regarded as vital resource and an invaluable commodity in modern times. The right information available to the right person at the right time in the aim of any modern library. Developments in computer, communication and information access technologies are bringing revolutionary changes in the modes and methods of information storage, retrieval and transmission. In olden days the function of the libraries were merely the collection and preservation of the documents, but in the 21st century the books are not our means of the preservation but also for the dissemination of the information continued of them. Now - a- days most of the functions carried out the libraries have been modernized with new technology. The national policy on education has also emphasized the need for a better library service in the time to come. In this connection libraries play an important role for the promotion of education and research with the advent. Internet and advancement of information technology it becomes possible to have the access to various information sources and databases available in different parts of the world.

Coincidentally, in the past decade, the computer revolution has introduced dramatic new developments, which have had a significant impact on the availability of information for veterinarians. Many reports have described the use of new computer-based technologies in veterinary practices. Pion and Ferguson (1996) place the actual number of veterinary practices online to date as being "only a small minority (perhaps 10%) of the veterinary profession." Even earlier, in 1990, Pion and Ferguson founded the Veterinary Information Network (VIN), available on America Online, as a forum for practice support services, continuing education, and a searchable information database. Both of these services purport to provide fast and easy access to a broad spectrum of information targeted specifically to the veterinary profession. "The Information Age is definitely here, and more and more veterinarians are finding that a computer system is as necessary to their practice as a stethoscope"

Research Methodology

The Questionnaire and Interview methods have been used to collect different types of data from users, 150 Veterinary Scientist were selected. Out of these only 120 responses found usable. The investigator personally visited to the Veterinary Students. Repeated visits were made to distributed and obtain the filled-up questionnaires. Some respondents were not willing to fill up the questionnaire of their own. In such case, the investigator himself noted down the oral responses given by the respondents.

Data Analysis and Findings : This study presents the empirical data collected by means of survey i.e. through the distribution of questionnaire among the sample population selected for the study. The data are presented in tabular form, along with brief description.

(a) Circulation service : 98 (81.66%) respondents use circulations services, whereas 22 (18.33%) respondents do not use circulation services provided by library.

(b) Reference service : Table 1 shows that 87 (72.5%) respondents have made use of reference service and 23 (19.16%) have not made use of reference service. Superna, (2011) reported that 87.17% veterinary scientist use computerized service and Circulation service had been found more utilized by Haryana Agricultural University.

(c) Indexing services : 18 (15%) respondent indicated that they use the indexing service, whereas 102 (85%) mentioned that they do not use the indexing service.

(d) Abstracting service : 22 (18.33%) respondents use abstracting service and 98 (81.66%) do not use this service.

(e) Photocopying service : 12 (10%) respondents use photocopying service and 108 (90%) do not use photocopying service.

(f) Current awareness services : It is indicated in table 1 that 62 (51.66%) respondents use current awareness service and 58 (48.33%) respondents do not use current awareness services.

Table-1 : Use of library services.

Services		User	Non-users
Circulation service	F	98	22
	P	81.66	18.33
Reference service	F	87	23
	P	72.5	19.16
Indexing service	F	18	102
	P	15.00	85.00
Abstracting service	F	22	98
	P	18.33	81.66
Photocopying service	F	12	108
	P	10.00	90.00
Current awareness service	F	62	58
	P	51.66	48.33

Note : F= Frequency and P= Percentage

Table-2 : Use of Computerized Services.

Services		User	Non-users
Online Service (C-era and others)	F	80	40
	P	66.66	33.33
Offline Service (Cab Abstract and others)	F	62	58
	P	51.66	48.33
RFID Book Drop	F	40	80
	P	33.33	66.66
RFID KISOK	F	79	41
	P	65.83	34.16

Note : F= Frequency and P= Percentage

Use of Computerised Services :

Table-2 shows the use of computerized service by the veterinary students. There are 80 (66.66%) veterinary students which use online service. 62 (51.66 %) Veterinary Students use offline service within the library. 40 (33.33%) students use the RFID book drop and 80(66.83 %) students uses RFID KISOK. According to Pelzer et al. (1998) the use of the computerized indexes and the library's online catalogue were the first choices of the RGPO students for seeking current information, but their second-year traditional curriculum classmates named textbooks first, followed by computerized indexes.

Conclusion

Circulation Service and Reference service is most availed service. Abstracting service is more used as compared by indexing service. Photocopy service is not much used by Veterinary Students. Online Service (C-era and other) is more used by Veterinary Students as compared to Offline service (Cab abstracts and others) 40.83% Veterinary

Students have been used RFID Book drop service and 65.83% used RFID KISOK.

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Legume Intercrops in Fruit Based Agroforestry System of Coastal Odisha

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Abstract

A field experiment was conducted during 2020 and 2021 at the Agroforestry Research Station under the All India Co-ordinated Research Project on Agroforestry, O.U.A.T., Bhubaneswar. The experiment was consisted in RBD with 16 treatment combinations including 12 fruit based intercropping systems are comprised of three fruit species i.e. mango (*Mangifera indica* L.), jackfruit (*Artocarpus heterophyllus* L.) & cashewnut (*Anacardium occidentale* L.) which were 5 year old and four legume crops i.e. arhar, cluster bean, blackgram & cowpea and its four sole crops. Soil moisture content is not significantly differ with each other, however among the intercrops higher soil moisture content was observed with cluster bean followed by blackgram, arhar and cowpea irrespective of fruit tree associated and among the fruit trees higher soil moisture was recorded with mango followed by jackfruit and cashew nut irrespective of the associated intercrops throughout the cropping season. The maximum available nitrogen was observed in mango + blackgram (250.2 kg ha⁻¹) followed by mango + cowpea (243 kg ha⁻¹). However the maximum available phosphorous content was observed in under mango + clusterbean system (64.3 kg ha⁻¹) followed by jackfruit + clusterbean system (57.6 kg ha⁻¹) and the maximum available potassium content was observed in under mango + cowpea system (167.1 kg ha⁻¹) followed by jackfruit + cowpea system (164.1 kg ha⁻¹). Out of jackfruit based intercrops the maximum tree height was recorded in jackfruit + cowpea (8.09 m), out of mango based intercrops mango+ cowpea (3.92 m) and out of Cashewnut based intercrops cashewnut + cowpea (4.27 m) at 66 months. The maximum collar girth was recorded with cashewnut (73 cm) in cashewnut + blackgram followed by jackfruit + cowpea (69.35 cm). However maximum crown spread observed with cashewnut (7.69 m) in Cashewnut + blackgram system followed by cashewnut + cowpea (6.49 m). Sole crops were performing better in all legume but when we considered economics of combination cashewnut + arhar contributed significantly maximum gross return (Rs.73060 ha⁻¹) over others, as well as the maximum net return was obtained from cashewnut + arhar (Rs. 51060 ha⁻¹). Similarly the cashewnut + arhar system the B: C ratio was found to be highest (3.32) as compared to its controlled condition.

Key words : Legume intercrops, fruit crops, soil moisture, available NPK, growth performance of legume and fruit trees, yield and economics.

Introduction

Agricultural production in red acidic uplands soil of Odisha under rainfed condition is unstable and unproductive. The different intensities of cyclones, droughts and floods occur almost every year in most of the coastal districts. The irregularities of monsoon behaviour and cyclone greatly affect the overall production potential. Some alternate land-use systems for these uplands for the enrichment of soil fertility and enhance productivity are suggested. Fruit trees inter-cropped with legume being an alternative land-use system that integrates the cultivation of arable crops, fruit trees and silvi component. Legume crops are playing important role in the initial growth years of trees and fruit plants that provide nitrogen to the fruit tree. Because there is less competition for natural resources such as sunlight, moisture, air, and nutrients, so different cropping sequences have been verified for yielding a

higher level of production by growing different crops that can be grown successfully underneath fruit plants and trees in their early stages of growth. (7)

Keeping these all facts in view, an experiment was conducted to analyze the performance of legume intercrops, their nutrient enrichment status under a fruit-based agroforestry system for rainfed uplands agro-ecological situations of coastal Odisha.

Materials and Methods

The research site is situation in the Agroforestry Research Station of O.U.A.T., Bhubaneswar that is located at 20 ° 15 ' North longitude and 85 ° 52 ' East latitude with an altitude of 25.9 meter MSL. The area comes under tropical hot and humid climate, with rainfall of 1472 mm, average maximum temperature of 32.7 ° C and minimum temperature of 25.2 ° C. Tillage operation was done by a

power tiller drawn Cultivator to prepare the field, followed by two cross-harrowing to pulverise the soil. After harrowing, well-rotten FYM was applied, well-mixed with the soil by planking, and levelled the soil. The texture of the soil is sandy loam. Before starting the experiment, soil samples were taken from a depth of 0-15 cm, on using all of the recommended soil sampling protocols. This experiment was started in 2015 *kharif* season under AICRP project and this is the sixth year of Agri-horticultural system. Also in previous years legume intercrop was grown in this site. In this study the intercrops were sown in respective plots where it was grown during 2019 with the existing fruit crops. The experiment was laid out in a Randomized Block Design (RBD) with three replications. The experiment was consisted of 16 treatment combinations involving three fruit crops along with four legume intercrops. Three fruit tree species such as *Magnifera indica* L. (Mango), *Anacardium occidentale* L. (Cashewnut), *Artocarpous heterophyllus* L. (Jackfruit) and four intercrops are *Cajanus cajan* L. (Arhar), *Cyamopsis tetragonoloba* (Cluster bean), *Vigna mungo* L. (Blackgram), *Vigna unguiculata* L. (Cowpea) were grown in *kharif* season of 2020 and 2021. Four intercrops i.e. Arhar (Variety- *Asha*), Cowpea (Variety- *Utkal manik*), Cluster bean (Variety- HG-563), Black gram (Variety- OBGG-17), raise during the *kharif* season with a recommended spacing and package of practices. The fruit trees such as jack fruit (Variety- *Daspalla local*), mango (Variety- *Arka Neelachal Keshari*), and cashewnut (Variety- *Jagannath*), were raised in 2015 by transplanting of fruit seedlings at spacing of 8 m × 7.5 m with recommended package of practices. The proper plant protection technique was followed for managing the ill effects of weeds, pests, and diseases on the growth of fruit trees and legume intercrops. The mango, jackfruit, and Cashewnut plant heights were measured by the Nickon hypsometer from convenient distance vertically from ground level to the tip of the leading crown. By using a measuring tape and calliper, the collar girth of individual trees was measured. The collar girth was measured at 15 cm above the soil surface. The crown spread was recorded at 12 pm noon by using shadow of crown. Crown width taken in east - west direction as well as north – south direction for taking mean of both direction. The soil samples from each treatment were collected from 0 to 15 cm depth before sowing and after harvest of each season crop. The collected samples were shade dried followed by grinding and sieving (2 mm mesh sieve) of the samples, which were kept in polythene bags for analysis of soil fertility status. The soil available N, P and K were estimated by following standard methods. On gravimetric technique, soil samples were taken in moisture boxes, one at 0-15 cm and the other at 15- 30 cm for estimating the

soil moisture content. The percentage of soil moisture content was calculated by using the formula :

$$\text{Soil moisture content (\%)} = \frac{\text{Fresh water – dry weight}}{\text{Dry weight}} \times 100$$

The yield of fruit tree and legumes intercrop were recorded time to time from each plot, and at the end of each season, the total yield was calculated and converted to yield per hectare. An economic analysis was conducted in order to compare the profitability of various treatments. The benefit cost ratio was computed by dividing the gross return by the cost of cultivation. The experimental data obtained were subjected to statistical analysis adopting Fisher's method of analysis of variance as out lined by (6).

Results and Discussion

Soil moisture content : Out of all intercrops, it observed maximum soil moisture content with cluster bean subsequently in blackgram, arhar, and cowpea without considering the fruit tree associated. As because the cluster bean is a drought resistance, deep rooted legume crop and it required less water for its growth and development as compared to other legume crops that contribute on its higher water use efficiency by which there was more moisture content in the soil. (5) found that cluster bean is a drought resistant crop and it required less water for its growth and development.

The soil moisture content subsequently increases from July to August and reduce slowly after September, and the lowest soil moisture content was observed in December in all treatments. (Table-1) It might be because of crop water requirement was increase with crop growth and also, we, observed less rainfall in December and subsequent months. We also observe higher soil moisture contain in lower depth as compared to upper surface of soil in all the treatment during entire duration. The high soil moisture content was found with sole intercrops grown in open control from September to October but after that, the higher available soil moisture content was found in all fruit based agroforestry system as compared to the open field conditions. If we not considered the fruit trees associated, when the soil moisture was low towards the end of the *kharif* season, there was lower evaporation loss under the tree canopy. (2) observed that mango intercrop plantation had highest soil moisture content as compared to sole mango plantation.

Available nitrogen, phosphorous and potassium : The available nitrogen, phosphorous and potassium was observed higher in all fruit based agroforestry system as compared to its initial values. (Table-2) The value of available nitrogen ranged from 214.7 kg ha⁻¹ to 201.2 kg ha⁻¹. The maximum available nitrogen was observed in Mango + Blackgram (T4) (250.2 kg ha⁻¹) then after Mango

Table-1 : Soil moisture content (%) of sole legume crop, different fruit crop and intercrop in fruit-based agroforestry system (Pool data of 2020 and 2021).

Treatment	September		October		November		December		Mean	Mean	Mean
	15-30 (cm)	30-60 (cm)	15-30 (cm)	30-60 (cm)	15-30 (cm)	30-60 (cm)	15-30 (cm)	30-60 (cm)	15-30 (cm)	30-60 (cm)	Overall (cm)
Mango + Arhar : T ₁	12.4	13.5	11.4	12.7	11.51	13.43	7.14	9.7	10.61	12.33	11.47
Mango + cluster bean : T ₂	11.44	13.82	10.87	13.98	11.67	13.42	10.31	12.84	11.07	13.51	12.29
Mango + Cowpea : T ₃	13.07	14.2	12.15	13.28	9.68	11.19	7.28	9.56	10.54	12.05	11.30
Mango + Blackgram : T ₄	11.57	13.65	11.35	13.46	10.88	12.66	8.17	8.64	10.49	12.10	11.29
Mean	12.12	13.79	11.44	13.35	10.93	12.67	8.22	10.18			
Jackfruit + Arhar : T ₅	11.24	14.49	10.41	11.47	9.37	11.34	9.11	10.63	10.03	11.98	11.00
Jackfruit + cluster bean : T ₆	12.4	13.61	11.45	12.33	10.96	11.46	8.19	10.77	10.75	12.04	11.39
Jackfruit + Cowpea : T ₇	12.45	13.63	11.26	12.26	10.62	11.89	8.56	10.44	10.72	12.055	11.38
Jackfruit + Blackgram : T ₈	12.68	13.53	11.42	13.43	10.45	12.62	9.82	10.84	11.09	12.60	11.84
Mean	12.19	13.81	11.13	12.37	10.35	11.82	8.92	10.67			
Cashewnut + Arhar : T ₉	12.78	13.42	11.78	12.62	10.62	12.57	8.87	10.61	11.0125	12.305	11.65
Cashewnut + cluster bean : T ₁₀	12.37	13.78	11.69	12.56	11.27	12.22	8.53	10.44	10.965	12.25	11.60
Cashewnut + Cowpea : T ₁₁	11.84	13.85	10.71	12.81	9.36	11.46	7.28	7.82	9.79	11.48	10.64
Cashewnut + Blackgram : T ₁₂	11.58	12.78	11.74	12.15	10.84	12.03	7.73	10.07	10.47	11.75	11.11
Mean	12.14	13.45	11.48	12.53	10.52	12.07	8.10	9.73			
Sole Arhar : T ₁₃	12.49	13.27	11.22	12.31	10.69	12.93	8.65	10.42	10.76	12.23	11.49
Sole cluster bean : T ₁₄	12.71	13.75	11.67	12.79	10.81	12.37	8.41	10.87	10.9	12.44	11.67
Sole Cowpea : T ₁₅	12.83	11.46	11.71	12.56	10.58	12.32	7.43	9.53	10.63	11.46	11.05
Sole Blackgram : T ₁₆	12.94	13.92	11.49	12.75	10.53	12.64	8.32	10.59	10.82	12.47	11.64
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table-2 : Available N, P, K in soil under fruit based Agroforestry system (Pool data of 2020 and 2021).

Treatment	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
Mango + Arhar : T ₁	231.8	55.6	149.4
Mango + clusterbean : T ₂	238.9	64.3	155.6
Mango + cowpea : T ₃	243.0	54.4	167.1
Mango + blackgram : T ₄	250.2	50.7	158.5
Jackfruit + Arhar : T ₅	216.6	53	147.2
Jackfruit + clusterbean : T ₆	218.3	57.6	153.5
Jackfruit + cowpea : T ₇	216.8	50.1	164.1
Jackfruit + blackgram : T ₈	234	48	157
Cashewnut + Arhar : T ₉	214.7	49.1	146
Cashewnut + clusterbean : T ₁₀	216	53.2	150.2
Cashewnut + cowpea : T ₁₁	220.2	48.4	157.4
Cashewnut + blackgram : T ₁₂	229.1	47.4	153.1
Initial soil status (2015)	213.8	44.8	144.1

+ Cowpea (T₃) (243 kg per hectare) and the lowest available nitrogen content was found in Cashewnut + Arhar system (T₉) (214.7 kg per hectare). The increase in available nitrogen owing to the addition of manures and fertiliser to leguminous as well as nitrogen fixation by legume intercrops such as blackgram, cowpea, and arhar over the years. (8) observed that blackgram have higher nitrogen content (0.85 %) as compared to other legumes which contribute in increasing the nitrogen content in soil. Maximum nitrogen concentration in intercropping treatment of cowpea was observed by. (3)

The available phosphorus the value ranged from 47.4 kg ha⁻¹ to 64.3 kg ha⁻¹. The highest content of

available phosphorous was observed in mango + Clusterbean intercropping (T₂) (64.3 kg ha⁻¹) subsequently in jackfruit + Clusterbean intercropping (T₆) (57.6 kg ha⁻¹) and the minimum content of available phosphorous was observed in Cashewnut + Blackgram intercropping (T₁₂) (47.4 kg ha⁻¹). The improvement in available phosphorous content was because of legume intercrop root exudates solubilised the exchangeable phosphorus as well as increase the total microorganisms in rhizosphere particularly PSB (phosphorous solubilising bacteria).

The content of available potassium values under fruit based agroforestry systems ranged from 146 kg ha⁻¹ to

Table-3 : Growth performance of legume intercrops and fruit trees under fruit based Agroforestry system (Pool data of 2020 and 2021).

Fruit Tree Species	Intercrops	Number of branches per legume plants	Legume plant height (cm)	Number of pods per legume plants	Tree height (m)	Collar girth (cm)	Crown spread (m)
Mango	ARHAR (T ₁)	21.23	142.92	420.34	3.37	44.09	3.6
	CLUSTERBEAN (T ₂)	23.76	60.02	64.85	3.63	46.59	3.76
	COWPEA (T ₃)	5.67	62.72	13.42	3.92	54.23	4.45
	BLACKGRAM (T ₄)	5.85	60.02	17.67	3.71	49.37	4.2
Jackfruit	ARHAR (T ₅)	17.35	141.22	336.76	6.35	56.67	4.27
	CLUSTERBEAN (T ₆)	21.61	57.51	58.89	6.92	57.06	5.73
	COWPEA (T ₇)	3.67	54.31	11.53	8.09	69.35	6.41
	BLACKGRAM (T ₈)	5.01	57.51	16.11	7.32	61.47	6.07
Cashewnut	ARHAR (T ₉)	17.42	141.13	330.34	3.71	58.5	6.11
	CLUSTERBEAN (T ₁₀)	21.83	58.52	59.65	3.64	60.71	6.41
	COWPEA (T ₁₁)	4.27	55.34	11.37	4.27	61.81	6.49
	BLACKGRAM (T ₁₂)	5.21	58.52	16.25	3.58	73.00	7.69
Control (Sole intercrops)	ARHAR (T ₁₃)	20.31	142.42	422.84	0	0	0
	CLUSTERBEAN (T ₁₄)	24.72	60.39	66.81	0	0	0
	COWPEA (T ₁₅)	5.97	63.53	13.13	0	0	0
	BLACKGRAM (T ₁₆)	5.91	60.39	17.72	0	0	0
C.D. (0.05)		0.47	5.33	1.21	1.24	14.14	1.96

Table-4 : Yield and Economics of fruit trees and legume intercrops under fruit based Agroforestry system (Pool data of 2020 and 2021).

Fruit Tree Species	Intercrops	Intercrop Grain/Green Yield (Kg/ha.)	Fruit Yield (Kg/ha)	Gross Return (Rs/ha)	Net Return (Rs/ha)	B:C Ratio
Mango	Arhar (T ₁)	740	430	59520	37520	2.70
	Clusterbean (T ₂)	8350	290	42100	20100	1.91
	Cowpea (T ₃)	1763	368	46300	24300	2.10
	Blackgram (T ₄)	392	315	40810	18810	1.85
Jackfruit	Arhar (T ₅)	595	0	37485	15485	1.70
	Clusterbean (T ₆)	7800	0	31200	9200	1.41
	Cowpea (T ₇)	1274	0	25480	3480	1.15
	Blackgram (T ₈)	312	0	24960	2960	1.13
Cashewnut	Arhar (T ₉)	620	340	73060	51060	3.32
	Clusterbean (T ₁₀)	8200	270	32800	10800	1.49
	Cowpea (T ₁₁)	1445	333	62200	40200	2.82
	Blackgram (T ₁₂)	326	300	26080	4080	1.18
Control (Sole Intercrops)	Arhar (T ₁₃)	734	0	46242	24242	2.10
	Clusterbean (T ₁₄)	8500	0	34000	12000	1.54
	Cowpea (T ₁₅)	1775	0	35500	13500	1.61
	Blackgram (T ₁₆)	390	0	31200	9200	1.41
C.D. (0.05)		117	0	4989	1463	

Crops	Sale rate (Rs/kg)	Crops	Sale rate (Rs/kg)
Arhar (grain)	63	Blackgram (grain)	80
Clusterbean (green)	4	Mango (ripe)	30
Cowpea (green)	20	Cashewnut (kernal)	100

165.2 kg ha⁻¹. (Table- 2) The highest content of available potassium was found in mango + cowpea intercropping (T₃) (167.1 kg ha⁻¹) subsequently in jackfruit + cowpea system (T₇) (164.1 kg ha⁻¹) and the minimum content of available potassium was observed in under cashewnut + Arhar intercropping (T₉) (146 kg ha⁻¹). This might be

because of more uptake of potassium by arhar and less uptake by cowpea.

Growth performance of legume crops : It was observed that number of branches per plant significantly higher in cowpea sole crop as compare the other combination. In

order to number of branches per plant; cowpea sole > T3 > T11 > T7 was observed in different stage of crop development. It might be due to shading effect of fruit trees. (Table-3)

It was observed that plant height significantly higher in cowpea sole crop as compared to the other combination. In order to plant height cowpea sole > T3 > T11 > T7 was observed in different stage of crop development. It was observed that number of pod per plant significantly higher in cowpea sole crop as compared to the other combination. In order to number of pod per plant cowpea sole T3 > T11 > T7 was observed in different stage of crop development, which might be due to shading effect of fruit trees.

It was observed that plant height significantly higher in Mango + Arhar (T1) as compared to the other combination. In order to plant height T1 > T13 > T5 > T9 was observed in different stage of crop development. It was observed that number of branch per plant significantly higher in arhar sole crop as compared to the other combination. In order to number of branch per plant T1 > T13 > T9 > T5 was observed in different stage of crop development. It was observed that number of pod per plant significantly higher in Arhar sole crop as compared to the other combination. In order to number of branch per plant T1 > T13 > T5 > T9 was observed in different stage of crop development. (4) Observed intercrop yield was less than sole and intercrop yields increased with increase in tree row spacing.

Growth performance of fruit trees : Irrespective of the intercrops, jackfruit has highest tree height subsequently in cashew nut and mango. This might be because jackfruit has more growth in sapling stage as compared to mango and cashew nut. Irrespective of woody species, the total height in trees in association with cowpea and blackgram was observed higher over cashew nut and arhar. It shows that less competition gives by cowpea and blackgram for moisture, nutrient etc. to fruit trees. The height of fruit trees with arhar was observed less, (Table-3) that might be because arhar gives more competition to fruit trees for different resources as we know arhar is an exhaustive crop with regards to water utilization, nutrient uptake, etc. and it also has long growing duration as compared to other intercrops grown and also it might be due to jackfruit having hereditary high growth rate as compared to cashew nut and mango as well as positive effect of cowpea and blackgram as intercrop, similar finding also reported by (9).

The fruit trees collar girth was significantly different from other trees in fruit based agroforestry system. It was observed that high collar girth was found in cashew nut + blackgram and lowest collar girth was found in mango + arhar agroforestry systems. (Table-3) That might be because of less competition of these intercrops with trees as

well as we know that blackgram and cashew nut have different soil moisture and nutrient extraction pattern/depth. The positive effect of blackgram and cowpea as intercrop has also been reported by (10).

Similarly, out of all fruit trees, cashew nut gives out the maximum crown spread (7.69 m) subsequently in jackfruit and mango. In respect of interaction of fruit trees with intercrops no significant variation was observed. The values of crown spread give out a clear cut difference at the end of fifth year's age. That might be because of difference in genetic makeup among fruit trees with respect to crown spread. Cashew nut plants have more crown spread ability as compared to mango and jackfruit (11) also reported similar effect of the fruit trees.

Yield and economics of fruit based intercropping system : Out of all intercrops the maximum legume yield was observed in mango + cluster bean system (8350 kg ha⁻¹) and the sole cluster bean was observed 8500 kg ha⁻¹. The performance of cluster bean was relatively better compared to other legume intercrops.

Economics of all the fruit based agroforestry systems and open field grown crops were different due to their difference in production. The gross return from intercrops significantly differs in fifth year of the fruit based agroforestry system. Arhar + cashew nut (T₉) gives out significantly highest gross return (Rs. 73,060 ha⁻¹) as compared to others. Blackgram + Jackfruit (T₇) gives out significantly less gross return (Rs. 24,960 ha⁻¹). The difference in gross return in intercrops is because of difference in yield and sale price.

Out of all intercrops the highest net return was observed in cashew nut + arhar (T₉) (Rs 51060 ha⁻¹) and the net return from its control was observed Rs 24242 ha⁻¹. The minimum net return was found in blackgram under jackfruit + blackgram system (T₇) (Rs 2960 ha⁻¹), the net return of control was observed Rs 9200 ha⁻¹. The difference due to different yield cost of cultivation and sale price. (Table-4)

The B: C ratio of the fruit based agroforestry system was observed low as compared to its controlled condition. In the fruit based agroforestry system, the range of B: C ratio differs from 1.13 to 3.32 and in control condition it differs from 1.41 to 2.21. The B: C ratio was observed highest (3.32) in the cashew nut + arhar system (T₉) as compared to its controlled condition (2.10). The lowest B: C ratio (1.13) was found in jackfruit + blackgram (T₇). Intercrops not only give some seasonal return throughout the development phase of fruit tree, but they also aid in the enhancement of soil physico-chemical characteristics. (Table-4) Because the tree canopy was so low throughout the period, shade had no influence on

the growth and economic production of these intercrops. (1) found that multi cropping outperformed sole cropping in terms of yield and economics.

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Effect of Sucrose and Aluminium Sulphate on Vase Life of Cut Chrysanthemum (*Dendranthema grandiflora*) cv. Yellow Star

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Abstract

The present investigation on "Effect of sucrose and aluminium sulphate on vase life of Cut Chrysanthemum (*Dendranthema grandiflora*) cv. Yellow star" concluded that among the different treatments of sucrose and aluminum sulphate the best results were shown by treatment (T₇) Sucrose 2% + Al₂(SO₄)₃ 200 ppm resulting helped to maintain favourable water relation maximum water uptake, flower diameter, total solution consumption, weight of spikes and minimum water loss, shows lowest water loss/water uptake ratio as compared to those in other treatments. Longest vase life (21 days) was recorded with Sucrose 2% + Al₂(SO₄)₃ 200 ppm whereas, vase life in control alone was (10 days only).

Key words : Chrysanthemum, sucrose, aluminium sulphate and vase life.

Introduction

Chrysanthemum is botanically called *Dendranthema grandiflora* commonly known as Gul-e-Daudi and it belongs to the family Asteraceae. Chrysanthemum is a herbaceous perennial plant growing to 50-150 cm tall with deeply lobed leaves and have fibrous root system. The chromosome number of chrysanthemum is (2n =18) known as Queen of -flowers (Sajid *et al* 2018). It is a national flower of Japan and its name is derived from two Greek words "chrysos" and "anthos" meaning gold and flower respectively (Rahman *et al* 2016). Fresh cut flowers are used for decorative purposes such as vase arrangement and bouquets at formal events (Allah *et al* 2019). Chrysanthemum is one of the most common cut flowers and of the highest economic importance in the floriculture industry for decoration and adornment and also traded both as potted plants and cut flowers in world markets (Amin 2017). In India, flower cultivation covers 3,39,000 ha area and 19,91,000 MT production of loose flower and 867000 MT production of cut flowers (NHB 2020). In Punjab flower cultivation covers 2.092000 ha total area and 13.073000 MT production of loose flowers (NHB 2019). The Post harvest handling maintains flower freshness and original color of flower for a longer period which is chiefly governed by internal mechanism that includes balance between water uptake and water loss, stem plugging, respiration rate and production of toxic substances like ethylene and external factors that include environmental conditions and microbial attack on the cut ends of the stem (Gunjan and Srivastva 2014). The sugar provides a Respiratory substrate, while the germicides

control harmful bacteria and prevents plugging of the conducting tissues (Ahmad and Dole 2014). Sucrose has further effect on maintaining higher fresh weight in cut flowering stems by inducing stomata closing and thus reducing water loss. Sucrose has been found to be the most commonly used sugar in prolonging vase life of cutflower. The exogenous application of the sucrose supplies of the sucrose supplies the cut flower with much needed substrates for respiration, and enables cut flowers harvested at the bud stage to open, which otherwise could not occur naturally and it acts as osmotically active molecule, thereby leading to the promotion of subsequent water relations (Khalid, 2012). Aluminium Sulphate has been recommended for maintaining the longevity of several cut flowers moreover it acts as antimicrobial agent in vase solutions. In chrysanthemum aluminum sulphate treatment enhanced the vase life and improved the postharvest visual quality of cut stems by retaining freshness in leaves. The higher concentrations of Aluminium Sulphate decreased chlorophyll content, fresh weight of stem and vase life in rose cultivar cherry brandy (Jowkar *et al* 2012).

Materials and Methods

The present investigation was conducted at Horticulture Laboratory of School of Agricultural Science and Technology RIMT University, Mandi Gobindgarh, Punjab during 2021 to study the "Effect of sucrose and aluminium sulphate on vase life of Chrysanthemum (*Dendranthema grandiflora*) cv. Yellow star". The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Two flowers spike were kept in each

replication according to the treatments. The observations were recorded on days taken to open the water uptake (g/stem), water loss (g/stem), water loss/ water uptake ratio (g /stem) , Total solution consumption, flower diameter (cm), weight of spike (g/ stem) and vase life (days) were observed by manually counting Flower diameter (cm) on 3rd , 6th ,9th , 12th ,15th,18th , and 21st were measured by using slide calipers Water uptake calculated with measurement of the flask + solutions (without the stem) Water loss calculated with measurement of flask+ solution + stem represented the water loss . Transpirational loss of water divided by uptake represented the water loss / water uptake ratio. Weight of spike (g) was measure by the weighing balance/scale. Total solution consumption (ml) was measure by using measuring cylinder. Flower diameter (cm) was measure with vernier calliper.

Table-A : Technical programme of research.

Number of treatments	:	10
Number of replications	:	3
Total number of Spikes	:	60
Time of Experiment	:	12 th Feb. 2021
Cultivar	:	Yellow star
Experiment design	:	Complete Randomized Design

Table-B : Detail Treatments of research.

Sr. No.	Symbol used	Treatment Combination
1.	T ₁	Tap Water (Control)
2.	T ₂	Sucrose 1%
3.	T ₃	Sucrose 1% + Aluminium Sulphate 100 ppm
4.	T ₄	Sucrose 1% + Aluminium Sulphate 200 ppm
5.	T ₅	Sucrose 2%
6.	T ₆	Sucrose 2% + Aluminium Sulphate 100 ppm
7.	T ₇	Sucrose 2% + Aluminium Sulphate 200 ppm
8.	T ₈	Sucrose 3%
9.	T ₉	Sucrose 3% + Aluminium Sulphate 100 ppm
10.	T ₁₀	Sucrose 3% + Aluminium Sulphate 200 ppm

Results and Discussion

The data regarding on water uptake (g/stem) is presented in table-1 and Fig.-1 On day 3rd, 6th, 9th, 12th, 15th, 18th and 21st day of vase life maximum water uptake (10.95, 11.12, 11.31, 10.35, 6.03, 3.16, and 2.59 g/ stem) were observed in Treatment T₇ (Sucrose 2%+ Aluminium Sulphate 200 ppm) which was found statistically significant as compared to all treatments followed by treatment T₉, T₁₀ and T₆ whereas, treatment T₁ (control) resulted minimum water uptake, On the 9th day of investigation water uptake showed peak as compared to other days of vase life however, minimum water uptake were observed on 21st day of vase life. Sucrose improves water absorption from the vase solution which maintain turgidity and freshness,

aluminum sulphate which act as a germicide there by encouraging water transport through cut stem by inhibiting the vascular blockage and delaying the increase in membrane permeability. This result in with the findings of Shobha and Gowda (1994) in calendula, Reddy *et al* (1994) in gladiolus and Singh *et al* (1994) in tuberose.

The data regarding on water loss g/stem is presented in table-2 and Fig.-2 On 3rd, 6th, 9th, 12th, 15th, 18th and 21st day of vase life the water loss was less found in T₇ (Sucrose 2% + aluminium sulphate 200 ppm) (5.17, 4.76, 5.13, 4.05, 1.95, 0.58 and 0.39 g/ stem) followed by treatment T₉, T₁₀ and T₆ whereas ,T₁ (control) resulted highest water loss, on 9th day of vase life water loss were maximum and It is cleared from above results that different concentrations of sucrose and aluminium sulphate is effective in water uptake and enhancing vase life and decreasing water loss when these solutions were used singly .But in combination their solutions were found more effective in maintaining an increased pattern of water uptake and decreasing water loss by transpiration . The present study were supported by Shobha and Gowda (1994) in cut calendula flower and Mukhopadhyay (1982) in cut tuberose.

The data regarding water loss/water uptake ratio is presented in table .3 & Fig.3 From 3rd day to 21st day of experiment treatment T₁ (1.11, 1.15, 0.76, 1.55, 2.36 and 2.05) (control) had the highest ratio followed by T₂ where as T₇ (sucrose 2%+aluminum sulphate 200 ppm has the lowest water loss/water uptake ratio This result is in agreement with the findings of Jamil *et al* 2016 in cut hippeastrum flower .Solutions of sucrose and aluminium sulphate alone and in combination were found effective in maintaining a decrease in the ratio of transpiration loss and water uptake in the present study were also supported by Shobha and Gowda (1994) in cut calendula flowers.

The data regarding on diameter of the flower is presented in table-4 and Fig.-4. Data showed at three day intervals upto 21st day of vase life it was found that maximum flower diameter (6.78, 5.95, 5.77, 5.85, 5.66, 5.55 and 5.57 ml) in T₇ (sucrose 2%+aluminium sulphate 200 ppm) were significant as compared to all treatments followed T₉ which at par with T₁₀ and minimum flower diameter were recorded in treatment T₁ (control) Results of the present experiment were in accordance with the findings of (Qadri *et al* 2001) in which flower diameter was maximum with Aluminium sulphate in combination with sucrose .Among all the chemical treatments tried ,the maximum final diameter and maximum vase life was observed with flowers kept in vase solutions containing Al₂SO₄ (Amin 2017) in chrysanthemum flowers.

The data regarding on total solution consumption,

Table-1 : Effect of Sucrose and Aluminum sulphate on Water uptake per stem (gm) of cut chrysanthemum cv. Yellow star.

Treatments	3 rd Day	6 th Day	9 th Day	12 th Day	15 th Day	18 th Day	21 st Day
T ₁	7.46	7.47	7.66	6.67	3.70	1.17	0.57
T ₂	7.49	7.63	7.66	7.12	3.72	1.54	0.58
T ₃	10.42	10.61	7.94	7.83	5.50	1.62	0.75
T ₄	10.44	10.76	8.15	7.89	5.68	1.66	0.89
T ₅	7.55	7.78	7.75	7.71	4.76	1.54	0.71
T ₆	10.61	10.81	10.60	8.27	5.72	2.01	1.08
T ₇	10.95	11.12	11.31	10.35	6.03	3.16	2.59
T ₈	7.89	7.84	7.88	7.72	5.08	1.58	0.74
T ₉	10.65	10.92	11.28	10.27	6.00	2.69	1.82
T ₁₀	10.63	10.88	11.01	9.52	5.91	2.68	1.45
CD at 1%	0.15	0.35	0.17	0.13	0.39	0.13	0.08

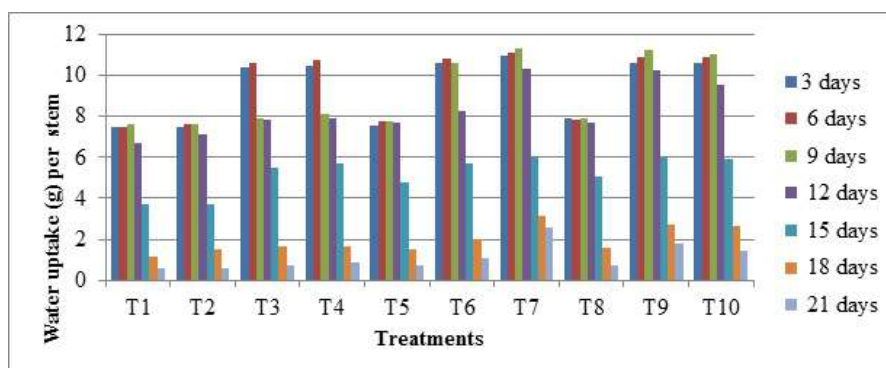


Figure-1

Table-2 : Effect of Sucrose and Aluminum sulphate on Water loss per stem (gm) of cut chrysanthemum cv. Yellow star.

Treatments	Water loss g/stem						
	3 days	6 days	9 days	12 days	15 days	18 days	21 Days
T ₁	8.31	8.58	8.74	5.11	5.74	2.76	1.16
T ₂	8.24	8.39	8.71	4.85	5.56	2.63	1.13
T ₃	5.57	5.45	5.54	4.60	3.45	1.04	0.62
T ₄	5.46	5.39	5.44	4.47	3.44	1.03	0.57
T ₅	8.18	8.35	8.51	4.63	3.55	1.09	0.66
T ₆	5.25	5.36	5.43	4.36	2.65	1.02	0.56
T ₇	5.18	4.76	5.13	4.05	1.95	0.58	0.39
T ₈	8.14	8.25	6.95	4.63	3.53	1.04	0.65
T ₉	5.18	5.21	5.23	4.11	2.61	0.83	0.45
T ₁₀	5.19	5.33	5.33	4.34	2.62	0.86	0.55
CD at 1%	0.10	0.07	0.27	0.11	0.13	0.05	0.05

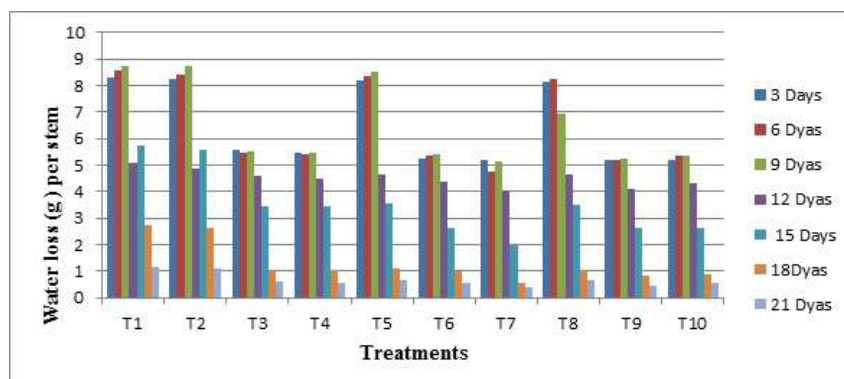
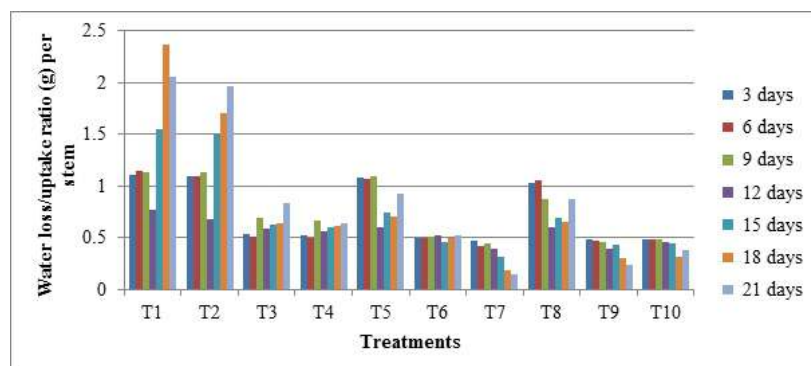


Figure-2

Table-3 : Effect of Sucrose and Aluminum sulphate on Water loss per stem (gm)/ water uptake ratio of cut chrysanthemum cv. Yellow star.

Treatments	Water loss g/stem/water uptake ratio						
	3 days	6 days	9 days	12 days	15 days	18 days	21 Days
T ₁	1.113	1.150	1.141	0.766	1.550	2.366	2.050
T ₂	1.100	1.099	1.137	0.681	1.500	1.711	1.964
T ₃	0.534	0.514	0.698	0.587	0.627	0.642	0.838
T ₄	0.523	0.501	0.667	0.566	0.607	0.620	0.639
T ₅	1.083	1.073	1.098	0.601	0.746	0.710	0.931
T ₆	0.495	0.496	0.512	0.527	0.464	0.505	0.521
T ₇	0.473	0.428	0.453	0.392	0.324	0.182	0.149
T ₈	1.031	1.052	0.882	0.600	0.696	0.658	0.870
T ₉	0.486	0.477	0.464	0.400	0.435	0.309	0.245
T ₁₀	0.488	0.490	0.484	0.456	0.443	0.322	0.379
CD at 1%	0.0109	0.0357	0.0257	0.0116	0.0546	0.0497	0.1326

**Figure-3****Table-4 : Effect of Sucrose and Aluminum sulphate on flower diameter (cm) of cut chrysanthemum cv. Yellow star.**

Treatments	Flower diameter (cm)						
	3 days	6 days	9 days	12 days	15 days	18 days	21 days
T ₁	5.44	5.55	5.47	4.93	4.66	4.44	4.34
T ₂	5.65	5.74	5.55	5.46	5.34	5.26	5.25
T ₃	5.95	5.84	5.65	5.65	5.49	5.46	5.45
T ₄	5.96	5.84	5.66	5.66	5.55	5.46	5.45
T ₅	5.89	5.75	5.63	5.55	5.46	5.43	5.37
T ₆	6.02	5.87	5.66	5.70	5.55	5.53	5.45
T ₇	6.78	5.95	5.77	5.85	5.66	5.55	5.57
T ₈	5.94	5.77	5.65	5.64	5.49	5.46	5.44
T ₉	6.27	5.92	5.76	5.75	5.63	5.55	5.54
T ₁₀	6.23	5.88	5.68	5.73	5.57	5.54	5.53
CD at 1%	0.06	0.08	0.06	0.06	0.08	0.06	0.05

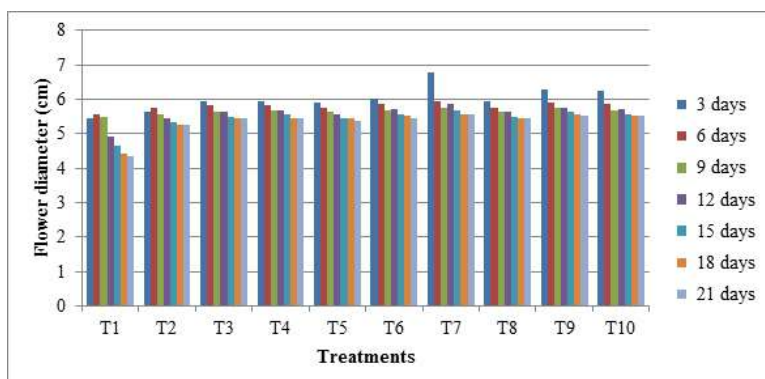
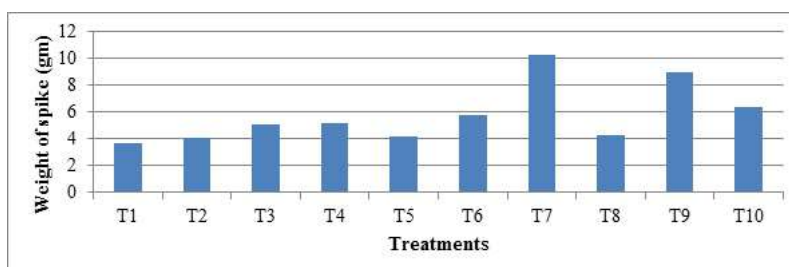
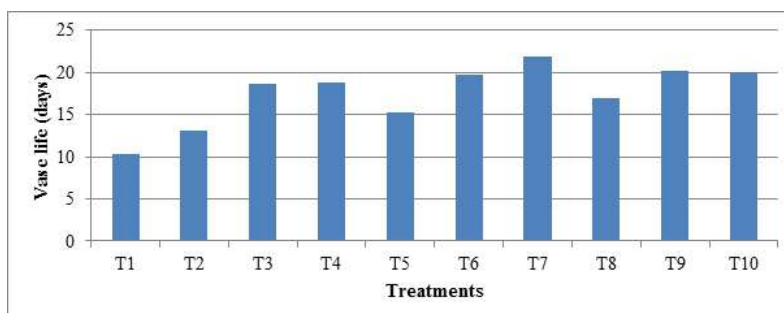
**Figure-4**

Table-5 : Effect of Sucrose and Aluminum sulphate on Total solution consumptions (ml), Weight of spike/stem (gm) and Vase life (days) of cut chrysanthemum cv. Yellow star.

Treatments	Total solution consumptions (ml)	Weight of spike/stem (gm)	Vase life (days)
T ₁	31.48	3.69	10.33
T ₂	31.67	4.05	13.17
T ₃	33.00	5.03	18.64
T ₄	34.00	5.18	18.83
T ₅	32.67	4.19	15.27
T ₆	34.00	5.82	19.67
T ₇	35.67	10.25	21.89
T ₈	33.00	4.23	17.00
T ₉	34.33	9.01	20.17
T ₁₀	34.15	6.33	20.10
CD at 1%	2.62	0.35	1.55

**Figure-6****Figure-7**

weight of the spike and vase life is presented in table-5 and Fig.-5, 6, 7. The maximum total solution consumption (35.66 ml) was recorded when spike was treated with T₇ (sucrose 2 % + aluminium sulphate 200 ppm) was found statistically significant as compared to all treatments where as T₉ (34.33), T₁₀ (34.15), T₄ (34.00), T₆ (34.00) was found non significant. While the minimum total solution consumption (31 ml) was recorded with treatment T₁ (31.48) and followed T₂ (31.66 ml). This might be due to antimicrobial property of aluminium sulphate which acidified the vase solution and reduced microbial growth (Hassanpour *et al* 2004). Previous studies have also reported that antimicrobial compound like aluminium control microbial and ensure water uptake and delay senescence of cut flower (Liao *et al* 2001).

The maximum weight of the spike (10.25 g) was recorded in treatment T₇ (Sucrose 2% + Al₂SO₄ 200ppm) which is followed by T₉ (Sucrose 3% + Al₂SO₄ 100ppm) (9.01 g) The minimum weight of the spike (3.69 g) was

observed in treatment T₁ (Control) which followed by T₂ (4.05), T₅(4.19) and T₈ (4.23 g) Aluminium sulphate act as an antimicrobial agent in vase solution (Halvey and Mayank ,1981) by inhibiting of bacterial vessel blockage. It is the agreement with result of eustoma flowers that aluminium sulphate had increased water uptake and fresh weight of spikes (Liao *et al*, 2001).

Maximum vase life (21 days) was observed in treatment T₇ (Sucrose 2% + Al₂SO₄ 200 ppm) which was followed by T₉ (3% Sucrose + Al₂SO₄ 100 ppm) 20.17 days and was at par with T₆ (19.67) and T₁₀ (3% Sucrose + Al₂SO₄ 200 ppm) (20.10) days. While, the minimum vase life (10.33 days) was obtained in treatment T₁ (Control). This is an accordance with the findings of study are further supported by Gowda (1990) in gladiolus. Mukhopadhyay (1982) in tuberose and Gowda (1990) in Tuberose. Ichimura (2006) in cut roses .Singh and Sharma (2008) in gladiolus spike Jowkar *et al* (2012) reported that aluminum sulfate treatment significantly

increased vase life and improved postharvest visual quality by retaining freshness even at the end of vase life. Singh *et al* (2016) in Lilum flowers treated with sucrose 2% in combination with Al_2SO_4 (100 or 200 ppm) delayed petal senescence and extended the vase life (12.8 days). Previous studies also reported that antimicrobial proliferation and ensure water uptake and delay senescence of cut flowers (Liao *et al* 2001, Sarkka 2005).

Conclusions

Prolong vase life of cut flowers is an important aspect regarding cut flowers and is an interesting field for research therefore in the present study it was concluded that the highest vase life (21.89 days) was observed in treatment, combination of Sucrose 2% + Al_2SO_4 200 ppm shows maximum water uptake, flower diameter, weight of spike and total solution consumption and reduced water loss maintain water balance, better water relations thereby increased vase life by delaying senescence of Chrysanthemum stems proved the best combination compared to other treatments.

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Effect of Holding Solution on Vase Life of Gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty

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Abstract

The present investigation was conducted at horticulture laboratory of school of agricultural science and technology RIMT University, Mandi Gobindgarh, Punjab during 2021 to study the "Effect of holding solution on vase life of gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty". Among the different treatments the best results was showed by treatment (T₉) Sucrose 6% + Al₂(SO₄)₃ 300 ppm resulting in maximum number of days taken to open the basal floret (4.17 days), highest longevity of floret (4.67 days), maximum floret diameter of 1st (9.38cm), 3rd (9.78cm) and 5th (9.15cm), highest open florets percentage (83.87%), minimum fresh weight loss of spike (9.46 g) and lowest non-open florets percentage (16.13%). Highest vase life (10.33 days) was obtained in treatment T₉ combination with Sucrose 6% + Al₂(SO₄)₃ 300 ppm in cut gladiolus flower.

Key words : *Gladiolus*, holding solution, sucrose and vase life.

Introduction

Gladiolus (*Gladiolus grandiflorus* L.) belongs to the family "Iridaceae" and sub-family "Exioideae". Chromosome number 2n=30. Gladiolus was introduced in India in 16th-19th century by the Britishers. The origin place of this plant is said to be South Africa. Gladiolus being is a potential cut flower grown globally for its attractive spikes Sinha and Roy (2002). Gladiolus is a flower of glamour and perfection which is known as the queen of bulbous flowers due to its flower spikes with florets of massive form, brilliant colours, attractive shapes, varying size and excellent shelf life. It is grown as flower bed in gardens and used in floral arrangements for interior decoration as well as making high quality bouquets Lepcha *et al* (2007). The area under floriculture production in India was 305 thousand hectare with a production of 2301 thousand tonnes of loose flowers and 762 thousand tonnes of cut flowers NHB (2020).

It is well documented that one of the main causes for inferior cut flowers quality is the blockage of xylem vessels by microorganisms that accumulate in the vase solution or in the vessels themselves. When the vessels of stems blocked, continuing the water uptake and transpiration by the leaves of cut flowers results in net loss of water of flower and stem tissue Hassan (2005). More solution uptake of cut flowers held in citric acid suggesting a decrease in xylem blockage due to reduced microbial growth, low water uptake by cut flowers is often due to occlusions located mainly in the basal stem end He *et al*

(2006) and microorganisms and their decay products are a common cause of stem end blockage (van Doorn, 1997, Williamson *et al* 2002). Citric acid lowers the pH of cell sap and prevents the blockage of xylem vessels, thereby improving water uptake and extending longevity. It promotes floral opening and maintains postharvest quality of cut tuberose spikes Jowkar and Salehi (2006). Sucrose may be consumed by cut flowers as a source of energy and as an osmotic regulator (Bieleski 1993, Moalem Beno *et al* 1997). Sucrose dosage needs to be made appropriately in order to provide an effective balance between sugar-water concentration in the cellular tissue of cut flowers for each treatment, species or even for a specific cultivar within a species Lu *et al* (2010). Furthermore, sucrose in the vase solution may promote microbial growth and that would inhibit water uptake by presence of dissolved sugars that cause blockage in xylem vessels (Van Doorn 1997, Ranwala and Miller 2009). Aluminium sulphate (Al₂(SO₄)₃), an antimicrobial compound has been recommended in commercial preservative solutions for maintaining vase life of several cut flowers (Liao *et al* 2001, Ichimura *et al* 2006). Aluminium sulphate acidifies vase solution, diminishes bacterial proliferation and enhances water uptake. Besides antimicrobial compound, carbohydrates are also necessary for maintenance of turgor pressure and providing energy source for flower opening Sarkka (2005).

Materials and Methods

The present investigation was conducted at Horticulture Laboratory of School of Agricultural Science and Technology RIMT University, Mandi Gobindgarh, Punjab during 2021 to study the “Effect of holding solution on vase life of gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty”. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. Two flowers spike were kept in each replication according to the treatments. The observations were recorded on days taken to open the basal floret (days), longevity of floret (days) and vase life (days) were observed by manually counting days. Floret diameter (cm) of 1st, 3rd and 5th were measured by using slide calipers. Open florets percentage (%) and non-open florets percentage (%) were recorded by counting total number of opened florets in each spike and percentage was calculated by using formula. Fresh weight loss of spike (g) was measure by the weighing balance/scale. Increase in spike length (cm) was measured with the help of measuring scale. Total solution consumption (ml) was measure by using measuring cylinder.

Results and Discussion

A lab experiment was conducted to determine the effect of holding solution on vase life of gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty. The results obtained with respect to vase life of cut flowers have been discussed with a view to find out the effect of different holding solutions.

In Table-1 maximum days taken to open basal floret was observed in treatment T₉ (Sucrose 6% + Al₂SO₄ 300 ppm) 4.17 days which is followed by T₁₀ (Sucrose 6% + Citric Acid 300 ppm) 3.83 days and is at par with T₉. While, the minimum days to open basal floret (2.33 days) was observed in T₁ (Control) than the other remaining treatments. The highest number of days to floret longevity was found in treatment T₉ (Sucrose 6% + Al₂SO₄ 300 ppm) 4.67 days which is followed by T₆ (Sucrose 4% + Al₂SO₄ 300 ppm) 4.50 days and is at par with T₆ and T₁₀. Whereas, the shortest longevity days of floret (2.83) was observed in T₁ (Control). It is desirable to delay opening of buds in the cut flower inflorescence to increase its vase life. The combination treatment of Al₂(SO₄)₃ and sucrose was found highly effective in delaying opening of flowers as reported by Singh *et al* (2016). Sucrose 5% + Al₂SO₄ 300 ppm found maximum (4.63) days taken in basal floret to open which was reported by Kumar (2015). Sucrose in combination with either citric acid or aluminium sulphate maintains endogenous levels of soluble sugars and soluble proteins which in turn provide energy for floret development and increased the longevity of flower

Hussain *et al* (2001). The increase in floret longevity by mineral salts might be due to the fact that mineral salt increased the osmotic concentration and pressure potential of the petal cells thus improving their water uptake. The increase in floret diameter and floret longevity might be due to continuous absorption of water, regular supply of carbohydrates, antimicrobial activity of aluminium sulphate and low pH of the solution thus maximum (4.18 days) floret longevity was recorded in treatment combination with 3% sucrose + 200 ppm aluminium sulphate where reported by Pal *et al* (2015).

The maximum 1st floret diameter (9.38cm) was observed in treatment T₉ (Sucrose 6% + Al₂SO₄ 300ppm) which is followed by treatment T₁₀ (Sucrose 6% + Citric Acid 300 ppm) 9.05cm and was at par with T₁₀ and T₆. While the minimum floret diameter (6.48cm) was found in treatment T₁ (Control). Maximum 3rd floret diameter (9.78cm) was observed in treatment T₉ which is followed by T₁₀ (9.21cm) and was at par with T₁₀ and T₆ (Sucrose 6% + Al₂SO₄ 200ppm). Whereas, minimum floret diameter (7.55cm) was observed in treatment T₁ (Control). On the 5th floret maximum floret diameter (9.15cm) is found in T₉ which is followed by T₁₀ (8.82cm) and is at par with T₁₀. While, the minimum diameter (5.89cm) of the floret was found in T₁ (Control). The maximum open floret percentage (83.87%) has observed in treatment T₉ (Sucrose 6% + Al₂SO₄ 300 ppm) which is followed by T₆ (Sucrose 6% + Al₂SO₄ 200ppm) 81.06%. Minimum floret opening percentage (61.94%) is found in treatment T₁ (Control). The increase in floret diameter and floret longevity might be due to continuous absorption of water, regular supply of carbohydrates, antimicrobial activity of aluminium sulphate and low pH of the solution as reported by Pal *et al* (2015). Application of Al₂SO₄ (300 ppm or in combination with sucrose 2%, 4%) in cut gladiolus “Pink friendship” flowers had shown an increase in flower diameter Pal and Kumar (2004). Al₂SO₄ has been found to acidify the holding solution to reduce bacterial and fungal growth hence increases the water absorption by spikes and increased the opening of florets percentage (Halevy and Mayak 1981, Bhattacharjee 1999). Similar result was found in treatment combination with Sucrose 5% + Al₂SO₄ 300 ppm has maximum floret opening percentage Kumar (2015).

Table-2 the maximum (91.33ml) solution consumption was found in treatment T₁₀ (Sucrose 6% + Citric Acid 300 ppm) which is followed by T₉ (Sucrose 6% + Al₂SO₄ 300 ppm) 89.67ml and is at par with T₉. Minimum (62.00ml) solution consumption was found in treatment T₁ (Control). Maximum increase in spike length (2.50cm) was found in T₆ (Sucrose 4% + Al₂SO₄ 200 ppm) which was followed by T₉ (Sucrose 6% + Al₂SO₄ 300 ppm) 2.20cm. While, the minimum increase in spike length

Table-1 : Effect of holding solution on days taken to open basal floret, longevity of floret (days), open florets (%) and floret diameter (cm) in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

Treatments	Days taken to open the basal floret	Longevity of floret (days)	Open florets (%)	Floret diameter (cm)		
				1 st floret	3 rd floret	5 th floret
T ₁	2.33	2.83	61.94	6.48	7.55	5.89
T ₂	2.67	3.00	72.94	7.33	7.70	7.10
T ₃	3.17	3.33	75.22	8.35	8.58	8.13
T ₄	3.33	3.50	74.09	8.12	8.32	7.89
T ₅	2.83	3.17	73.96	7.74	7.96	7.54
T ₆	3.50	4.50	81.06	8.78	8.93	8.44
T ₇	3.67	3.83	77.15	8.41	8.68	8.17
T ₈	3.00	3.67	75.45	8.04	8.13	7.74
T ₉	4.17	4.67	83.87	9.38	9.78	9.15
T ₁₀	3.83	4.33	79.61	9.05	9.21	8.82
CD at 1%	0.599	0.764	0.988	0.751	0.958	0.633

Table-2 : Effect of holding solution on total solution consumption (ml), increase in spike length (cm), fresh weight loss of spike (g), non-open florets (%) and vase life (days) in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

Treatments	Total solution consumption (ml)	Increase in spike length (cm)	Fresh weight loss of spike (g)	Non-open florets (%)	vase life (days)
T ₁	62.00	0.51	31.65	38.06	06.50
T ₂	71.00	0.85	16.76	27.06	07.67
T ₃	75.33	1.11	11.96	24.78	08.67
T ₄	76.67	1.05	12.40	25.91	08.17
T ₅	73.00	0.92	14.67	26.04	08.50
T ₆	81.00	2.50	10.35	18.94	10.17
T ₇	83.00	1.81	11.68	22.85	09.17
T ₈	78.33	1.50	12.13	24.85	08.83
T ₉	87.67	2.20	09.46	16.13	10.33
T ₁₀	91.33	1.93	11.46	20.39	09.50
CD at 1%	1.896	0.231	1.896	0.988	0.924

(0.51cm) was found in treatment T₁ (Control). Sucrose improves water balance in cut flowers because it effects on the closure of stomata and reduction of water loss Marousky (1971). Citric acid is considered to maintain the water balance and to reduce bacterial proliferation in the vase solution thus avoiding the obstruction of the xylem vessels de Capdeville *et al* (2003). Previous workers have also reported the positive effect of citric acid 3% combination with sucrose 6% increase in absorption of vase solution Dwivedi *et al* (2018). Similarly, maximum water uptake was recorded in Citric Acid 125 ppm + 8% Sucrose Mureleedharan and Joshi (2017). Increase in spike length might be happen due plant cell division. Similar result has been found in treatment combination with 4% sucrose + 300 ppm Al₂SO₄ has the highest (8.25 cm) increase in spike length Kumar *et al* (2010).

The minimum fresh weight loss of the spike (9.45g) was recorded in treatment T₉ (Sucrose 6% + Al₂SO₄ 300ppm) which is followed by T₆ (Sucrose 4% + Al₂SO₄ 200ppm) 10.35g and is at par with T₆. The maximum fresh weight loss of the spike (31.65g) was observed in treatment T₁ (Control). The minimum percentage of

non-open floret (16.13%) was recorded in treatment T₉ (Sucrose 6% + Al₂SO₄ 300 ppm) which is followed by T₆ (18.94%). While, the maximum non-open floret percentage (38.06%) was recorded in treatment T₁ (Control). Aluminium sulphate increases the fresh weight of flower confirmed by Maryam *et al* (2012). Sucrose facilitated the higher intake of water and total soluble sugars in the petal cells probably by enhancing the osmotic driving force for the solution uptake by making the cells water potential more negative. The increase in solution uptake in the cut spikes further caused increase in spike weight Kashyap *et al* (2016). The flower treated with 200 ppm Al₂SO₄ + 5% Sucrose recorded the highest relative fresh weight among all the treatments Farahat *et al* (2014) in cut rose flower. Similarly, the flower treated with Al₂SO₄ 400 ppm + 8% Sucrose recorded the highest relative fresh weight among all the treatment Muralleedharan *et al* (2020). Al₂SO₄ has been found to acidify the holding solution to reduce bacterial and fungal growth hence increases the water absorption by spikes and increased the opening of florets percentage (Halevy and Mayak 1981, Bhattacharjee 1999). The enhanced number of open florets per spike might be due to sucrose

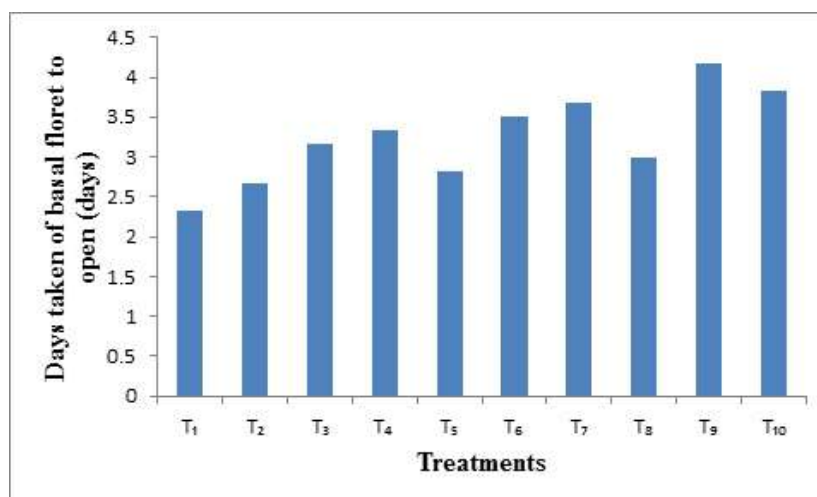


Figure-1 : Effect of holding solution on days taken of basal floret to open in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

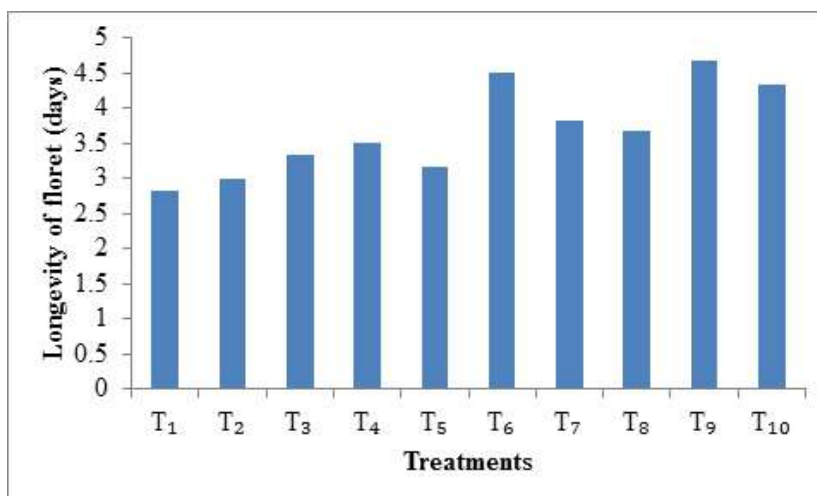


Figure-2 : Effect of holding solution on longevity of floret (days) in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

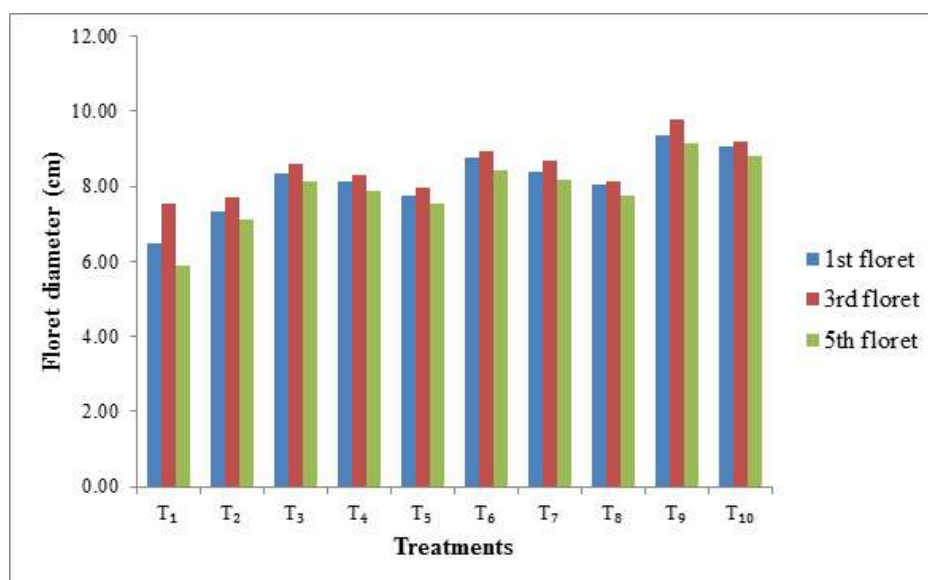


Figure-3 : Effect of holding solution on floret diameter (cm) in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

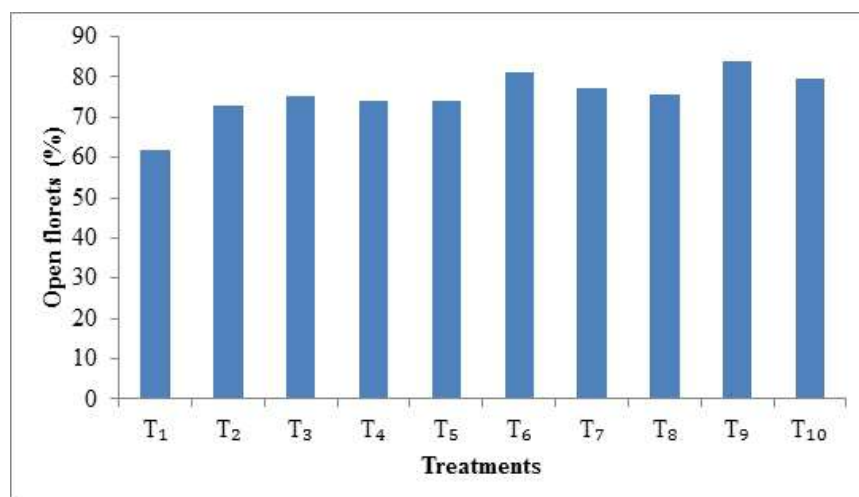


Figure-4 : Effect of holding solution on open florets percentage in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

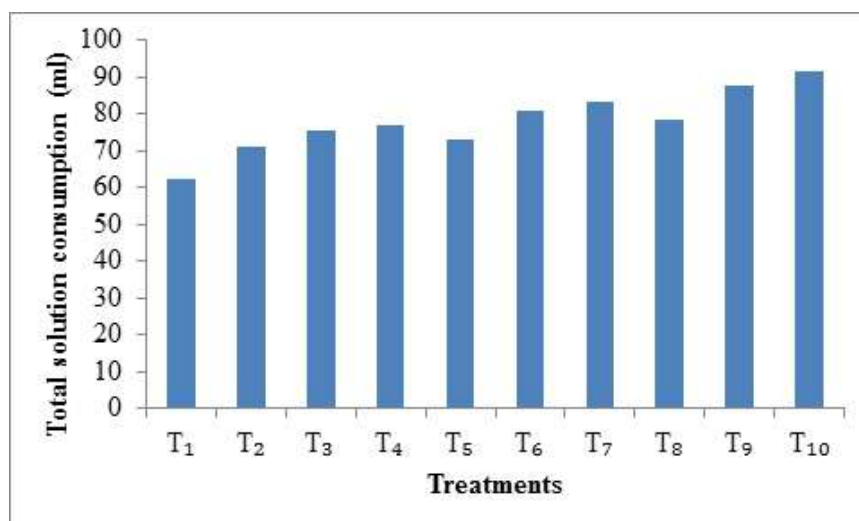


Figure-5 : Effect of holding solution on total solution consumption in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

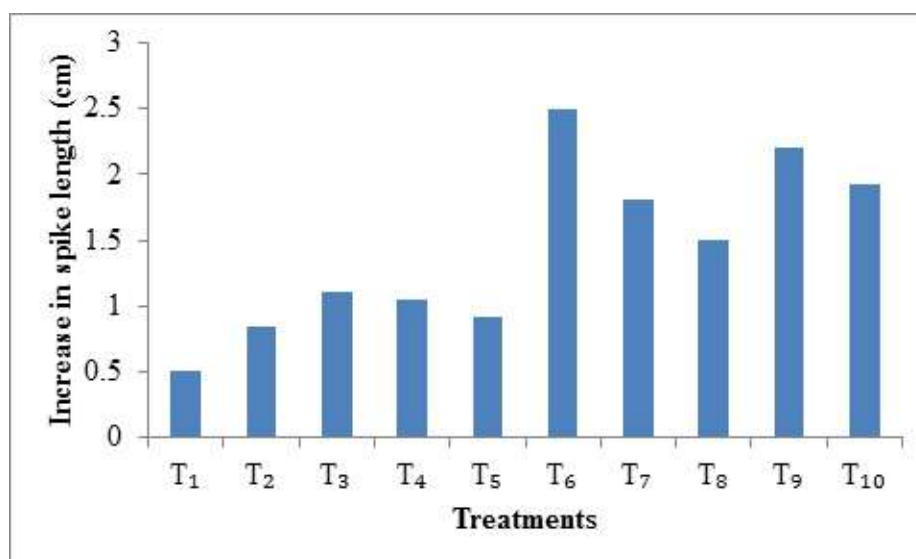


Figure-6 : Effect of holding solution on increase in spike length of gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty

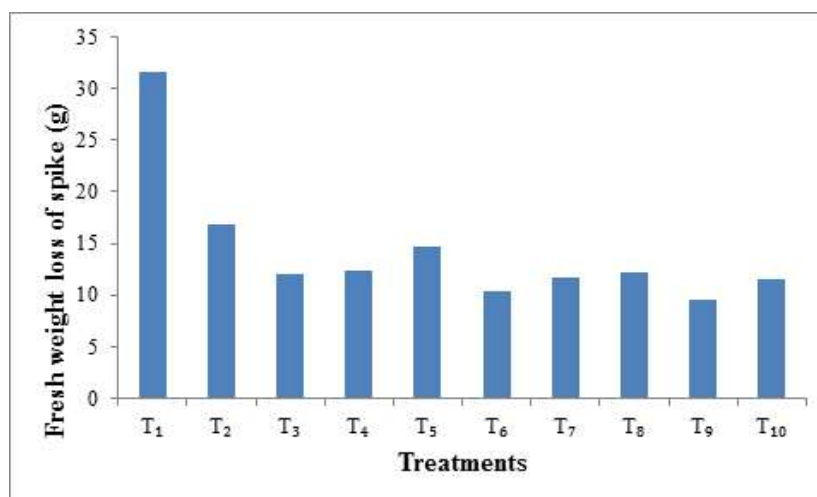


Figure-7 : Effect of holding solution on fresh weight loss of spike (g) in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

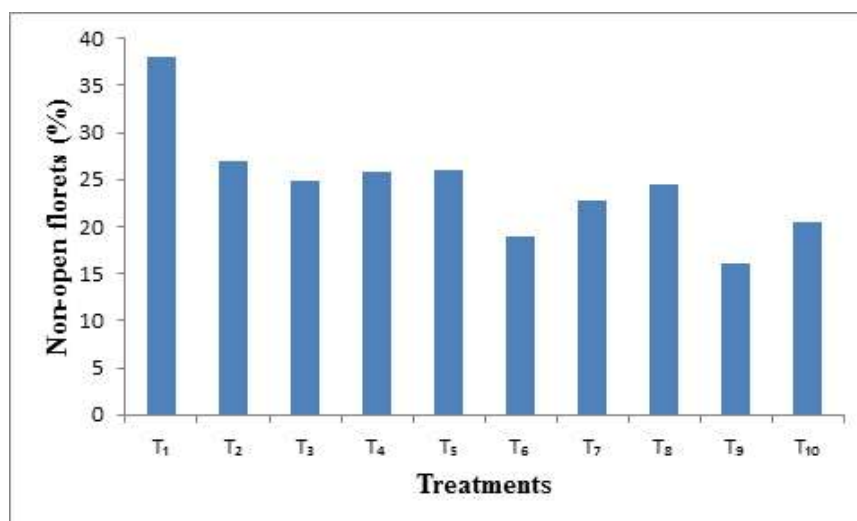


Figure-8 : Effect of holding solution on non-open floret percentage in gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

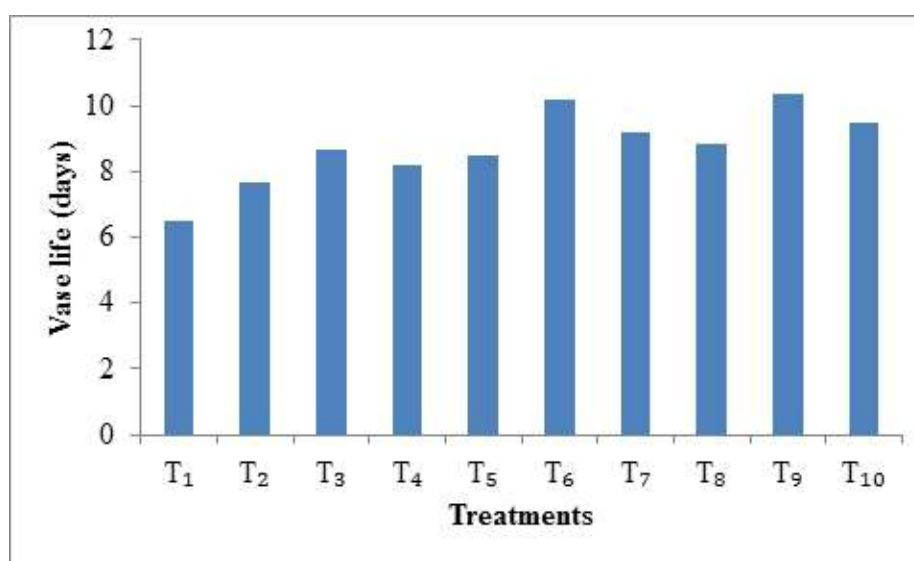


Figure-9 : Effect of holding solution on vase life in spike of gladiolus (*Gladiolus grandiflorus* L.) cv. American Beauty.

and higher solution uptake. Similar result was found in treatment combination with Sucrose 5% + Al_2SO_4 300 ppm has minimum non-open floret percentage Kumar (2015).

Maximum vase life (10.33 days) was observed in treatment T_9 (Sucrose 6% + Al_2SO_4 300 ppm) which was followed by T_6 (4% Sucrose + Al_2SO_4 200 ppm) 10.17 days and was at par with T_6 and T_{10} (6% Sucrose + Citric Acid 300 ppm). While, the minimum vase life (6.50 days) was obtained in treatment T_1 (Control). Jowkar *et al* (2012) reported that aluminum sulfate treatment significantly increased vase life and improved postharvest visual quality by retaining freshness even at the end of vase life. Sucrose supply increases the longevity of many cut flowers, since sucrose can act as a source of nutrition for tissues approaching carbohydrate starvation, flower opening and subsequent water relations Kuiper *et al* (1995). Chemical preservative solution Al_2SO_4 400 ppm + 8% Sucrose have maximum vase life (30.78 days) in cut *Athurium* flowers Muraleedharan (2020). Similar result was found in vase solutions containing 200 ppm aluminium sulphate + 5% sucrose significantly increased their vase life (14.50 days) in rose cut flower Farahat *et al* (2014). *Gladiolus* cut flower cv. White prosperity has also found vase life of 10.07 days in treatment combination 4% sucrose + 400 ppm aluminium sulphate Kumar *et al* (2010).

Conclusions

Prolong vase life of cut flowers is an important aspect regarding cut flowers and is an interesting field for research therefore in the present study it was concluded that the highest vase life (10.33 days) was observed in treatment, combination of Sucrose 6% + Al_2SO_4 300 ppm. Maximum days taken to open the basal floret (4.17 days), highest longevity of floret (4.67 days), maximum floret diameter of 1st (9.38cm), 3rd (9.78cm) and 5th (9.15cm), highest open florets percentage (83.87%), minimum fresh weight loss of spike (9.46 g) and lowest non-open florets percentage (16.13%) were found in treatment combination with Sucrose 6% + Al_2SO_4 300 ppm. Whereas, maximum increase in spike length (2.50cm) was found in treatment Sucrose 4% + Al_2SO_4 200 ppm while, in treatment with Sucrose 6% + Citric Acid 300 ppm has maximum total solution consumption (91.33 ml) was observed. So it was concluded that by the application of sucrose with aluminum sulphate at the concentration of 6% and 300 ppm the vase life of cut particularly in case of *gladiolus* flowers can be increased from 6 days to 11 days.

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Incidence of Competitor Moulds in Blue Oyster [*Hypsizygus ulmarius* (Bull. : Fr.) Redhead] Mushroom Cultivation

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Abstract

Mushrooms, the fruiting bodies of macrofungi comprise a large heterogeneous group and vary in shape, size, colour, appearance and edibility and also known for numerous nutritional and medicinal values. *Hypsizygus ulmarius* is a high yielding mushroom and is gaining popularity in Asia and Europe owing to its simple and low cost production technology and higher biological efficiency. Mushrooms cultivation affected adversely by a large number of Competitor Moulds from substrate preparation to fruiting. Occurrence of competitor moulds were minimum during the month October, 2015 (15.9 per cent) and it increased considerably with the fluctuating environmental conditions (Meteorological Factors) and reached its peak during the month of April, 2016(18.5 per cent). The untreated substrate showed the highest mould incidence (84 %), whereas, hot water and chemical treatment methods significantly reduced the mould incidence. In case of hot water treatment, the mould incidence was 4 per cent, whereas, the incidence was similar when Bavistin; 50 ppm alone or Bavistin; 50 ppm + Formalin; 500 ppm were used and when Formalin; 500 ppm alone was used, it had higher mould incidence (38.7 %).

Key words : Mushrooms, *Hypsizygus ulmarius*, competitor moulds, meteorological factors, hot water treatment, chemical treatment.

Introduction

Mushrooms, the fruiting bodies of macrofungi comprise a large heterogeneous group and vary in shape, size, colour, appearance and edibility. Among 110,000 species of fungi about 16,000 species comprise mushrooms (Wasser, 2010). Mushrooms are considered for good quality amino acids, vitamin B complexes, sodium, potassium, iron, dietary fibers and also as the prime source of ergosterol or provitamins, (Jr, 2005). Mushrooms are known for several nutritional and medicinal benefits and are cultivated worldwide (A. Ghimire et al., 2021). From numerous studies, edible mushrooms are also found to have many pharmacological effects like antiviral, antioxidant, anti-tumoral, hypo-cholesterolemic and hypoglycemic (Cheung, 2010). Edible mushrooms are also useful in reducing stress, cholesterol, asthma, diabetes, cancer, insomnia etc. (Wani et al., 2010). The history of consumption of mushrooms is believed to have started during the hunting and gathering period (Wani et al., 2010). However, the first mushroom cultivation is believed to have started from China around 600BC and now China is the world's largest producer and consumer of mushrooms (Zhang, 2014). Wild mushrooms, edible mushrooms and medicinal mushrooms are considered as the major categories of Global Mushroom Industries (Royse et al., 2017). Most

popular edible mushrooms of the world are Cremini mushroom, Morel mushroom, Shiitake mushroom, Oyster mushroom, White button mushroom, and Straw mushroom (Joseph, 2021). Out of the total mushroom species, more than 3000 species of mushrooms are found edible. Out of these 3,000 species of edible mushrooms, about 100 species are under economic cultivation, among them only about 60 species are commercially cultivated worldwide (Chang and Wasser, 2017). Economically mushroom farming is being done in more than 100 countries (Gupta et al., 2018). The trend in production (in tonnes) of mushrooms and truffles in the world from 2010 to 2019 is depicted in Fig.-1 (FOASTAT (4/26/2021)). Among different genera of mushroom, Lentinula is the most widely grown mushroom worldwide followed by *Pleurotus* spp. and *Auricularia* spp. However, among the cultivated mushrooms in Nepal, Oyster mushroom occupies 86% of the total production, followed by button mushroom (10%), shiitake mushroom (2%) and other mushrooms (2%) (Raut, 2019). *Hypsizygus ulmarius* is a high yielding mushroom and is gaining popularity in Asia and Europe owing to its simple and low cost production technology and higher biological efficiency (Mane et al., 2007).

Like all other crops, mushrooms are also affected adversely by a large number of biotic and abiotic factors

from substrate preparation to fruiting. So cultivation of disease-free mushrooms is a frightening task. Among the biotic agents, fungi, bacteria, viruses, nematodes, insects and mites cause damage to mushrooms directly or indirectly. Many of these act as competitor moulds thereby adversely affecting spawn run whereas others attack the fruit bodies at various stages of crop growth producing distinct disease symptoms. At times there is complete crop failure depending upon the stage of infection, quality of compost and environmental conditions. General distribution of various competitor moulds and pathogenic fungi is as follows and Table-1 (Sharma et al., 2007):

(1) Those occurring mainly in compost include: Olive green mould (*Chaetomium olivaceum* and other spp.), Ink caps (*Coprinus* spp.) Green moulds (*Aspergillus* spp. *Penicillium* spp. And *Trichoderma* spp.), Black moulds (*Mucor* spp., *Rhizopus* spp.) and other (*Myriococcum praecox*, *Sporotrichum* sp., *Sepedonium* sp., *Fusarium* spp., *Cephalosporium* spp., *Gliocaldium* spp., and *Papulospora* spp.).

(2) Fungi occurring on the growing mushrooms: Cinnamon mould (*Peziza ostracoderma*), wet bubble (*Mycogone perniciosus*), Dry bubble (*Verticillium fungicola*), Cobweb (*Cladobotryum dendroides*), Pink mould (*Trichothecium roseum*) and green moulds.

(3) Fungi attacking the fruit bodies only: Fusarial rot (*Fusarium* spp.).

At any phase of growth an undesirable growth or development of certain moulds can occur and can adversely affect the final mushroom yield.

Materials and Methods

(1) Screening of Incidence of Competitor Moulds : Screening of Competitor Moulds Incidence in mushroom bags was carried out in two seasons during October-December, 2015 and February-April, 2016 under natural conditions.

The incidences of different competitor moulds were recorded. Infected mushroom bags were tagged and the contaminated micro floras were identified. Total numbers of infected beds were counted from each replication.

A month wise average data on mean temperature, relative humidity were recorded. Spawn of *Hypsizygus ulmarius* (blue oyster mushroom) was supplied from the Sri Amman Biocare to the progressive farmers for cultivation. Paddy straw was taken as substrate and chemical sterilization technique was followed in cultivation. Container system of cultivation (polypropylene bags) was followed in all experiments. Samples of various diseases and the competitor fungi were collected on a

regular basis from the cropping room and subsequently, in vitro studies have been carried out in laboratory.

(2) Bag filling : The best substrate (wheat straw) with most effective supplement (gram flour @ 5%) and sorghum grains based spawn were selected for cultivation of *H. ulmarius*.

For disinfecting the substrate before spawning, different substrate sterilization methods viz., hot water and chemicals (substrate was soaked in water containing Bavistin (50 ppm), Formalin (500 ppm) and Bavistin (50 ppm) + Formalin (500 ppm) for 16 hrs) were employed for substrate treatment.

A unit of 2.5 kg dry straw substrate was used for each treatment, which was equally divided in five bags (polypropylene bags with size of 40x20cm) representing each as replication.

(3) Cropping : During spawn run, the mushroom house had nearly dark conditions with a temperature range of 20-25°C and relative humidity (80-90 %), which was maintained by regularly spraying water in the mushroom house and the windows. Doors of mushroom house were opened for minimum time to have high CO₂ concentration. After spawn run, fresh air was introduced by opening the windows/doors at regular intervals to reduce the CO₂ concentration in mushroom house and lights were switched on to provide about 500 lux brightness, coupled with regular spraying of water to have high humidity. These conditions were maintained throughout the growing period except during cap thickening and maturity, when humidity was lowered (approximate 70%) by reducing the number of water sprays in the mushroom house.

Results and Discussion

(1) Role of Meteorological Factors : The observations regarding influence of different temperature and relative humidity on the incidence of competitor moulds and yield of *Hypsizygus ulmarius* (blue oyster mushroom) was studied and the data obtained are presented in Table 2; Fig.2. The observations shown that the occurrence of competitor moulds were minimum during the month October, 2015 (15.9 per cent) and it increased considerably with the fluctuating environmental conditions and reached its peak during the month of April, 2016(18.5 per cent).

Minimum range of contamination was observed during the month of October–December, 2015, when maximum biological efficiency (yield) obtained.

(2) Role of different substrate treatment methods : The untreated substrate showed the highest mould incidence (84%), whereas, hot water and chemical treatment methods significantly reduced the mould incidence. In

Table-1 : Fungal diseases of oyster mushrooms in India.

Sr. No.	Casual organism	Symptoms	Control	References
1.	<i>Cladobotrym apiculatum</i> , <i>C.verticillatum</i>	White cottony growth on the substrate; small brown irregular sunken spots or fluffy growth on fruit bodies; soft rot and decay of sporophores emitting foul smell	Spray bavistin 50ppm	Upadhyay et al; 1987; Sohi and Upadhyay 1980; Goltapeh et al. 1989
2.	<i>Gliocladium virens</i>	Fruit bodies covered by mycelium and green spots; young pin-heads become soft, brown, pale, yellow and decay. Mature fruit bodies show brown spots enclosed by yellow halo.	Spray 100ppm bavistin or benomyl	Bhardwaj et al. 1987; Sharma and Jandaik, 1983
3.	<i>Arthrobotrys pleuroti</i>	Fluffy growth on substrate and fruit bodies; infected tissues turn yellow, water logged and rot.	Spray 50 ppm bavistin	Ganeshan,1987
4.	<i>Sibirina fungicola</i>	Powdery white growth on stipe, gills and the primordia; primordia show brownish discolouration and soft rot and mature fruit bodies turn fragile.	Proper aeration and RH essential; spray benomyl twice	Sharma and Jandaik, 1983, Jandaik and Sharma, 1983.

Table-2 : Weather parameters during cropping period of *Hypsizygus ulmarius*.

Sr. No.	Month	Standard meteorological week number	*Room temperature (°C)	*Bag temperature (°C)	Relative humidity (%)
1.	October, 2015	42	26	28	80
		43	24.5	26.6	83
2.	November, 2015	44	21.1	23.4	85
		45	15.5	18	90
		46	20.9	22.8	90
		47	18.4	21.5	89
3.	December, 2015	48	17.4	19.6	87
		49	17.4	20	90
		50	14.3	17.3	87
4.	February, 2016	8	18.1	21.3	80
5.	March, 2016	9	20.3	22.6	80
		10	20.8	23.1	85
		11	21.1	23.7	85
		12	22.4	24.4	90
6.	April, 2016	13	23.8	25.8	87
		14	24.1	26.6	90
		15	25.2	28.3	90

Table-3 : Effect of different substrate treatment methods on yield and Mould incidence during October–December, 2015.

Sr. No.	Treatment	Yield (g/kg)	Mould incidence (%)
1.	HWT*	676.2	0.01(4.0)
2.	Bavistin (50 ppm)	554.8	20(23.8)
3.	Formalin (500 ppm)	418.0	40(38.7)
4.	Bavistin (50 ppm) + Formalin (500 ppm)	501.6	20(23.8)
5.	Control	364.8	95.9(84.1)
6.	CD (0.05)	30.3	(15.9)

*Hot water treatment

Figures in parentheses are angular transformed values.

case of hot water treatment, the mould incidence was 4 per cent, whereas, the incidence was similar when Bavistin; 50 ppm alone or Bavistin; 50 ppm + Formalin; 500 ppm were used (Fig. 3) and when Formalin; 500 ppm alone was used, it had higher mould incidence (38.7 %).

(3) Cultivation of *Hypsizygus ulmarius*: The mushroom was cultivated using wheat straw and the substrate was supplemented with 5 per cent gram flour. *H. ulmarius* was

cultivated during October-December, 2015 and February-April, 2016. The results revealed that substrate treatment methods influenced the yield parameters and mould incidence. The yield of this mushroom increased from 364.8 (control) to 676.2 g (hot water treatment), 554.8 g (Bavistin;50 ppm), 418 g (formalin;500 ppm) and 501.6 g/kg substrate (bavistin;50 ppm + formalin;500 ppm) during 2015 (Table 3) and a similar trend was also

Table-4 : Effect of different substrate treatment methods on yield and Mould incidence during February–April, 2016.

Sr. No.	Treatment	Yield (g/kg)	Mould incidence (%)
1.	HWT*	645.8	10 (14.5)
2.	Bavistin (50 ppm)	521.4	24 (26.4)
3.	Formalin (500 ppm)	402.9	44 (41.2)
4.	Bavistin (50 ppm) + Formalin (500 ppm)	470.4	30 (32.3)
5.	Control	354.2	99.9 (89.3)
6.	CD (0.05)	50.5	(18.5)

*Hot water treatment

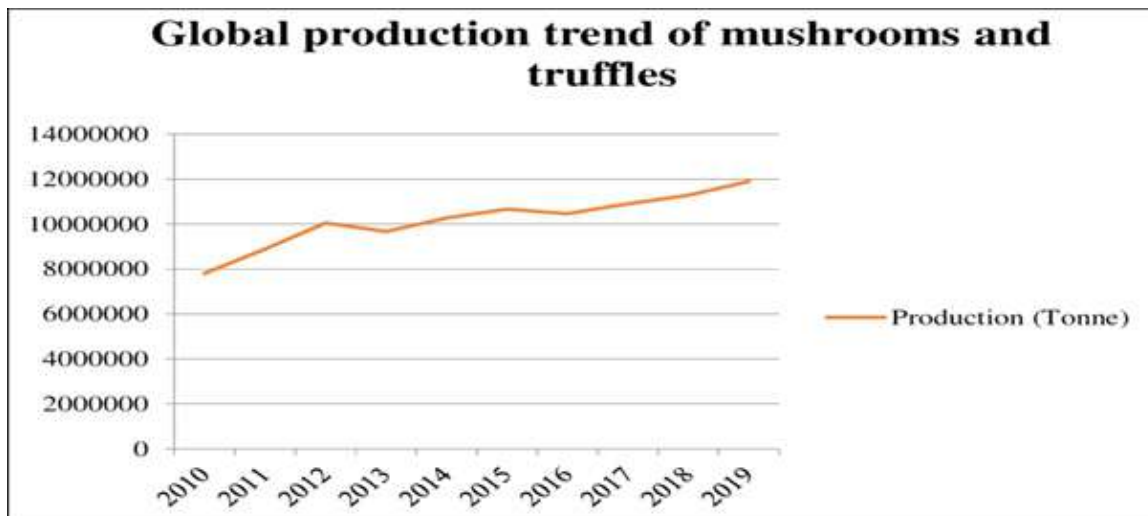
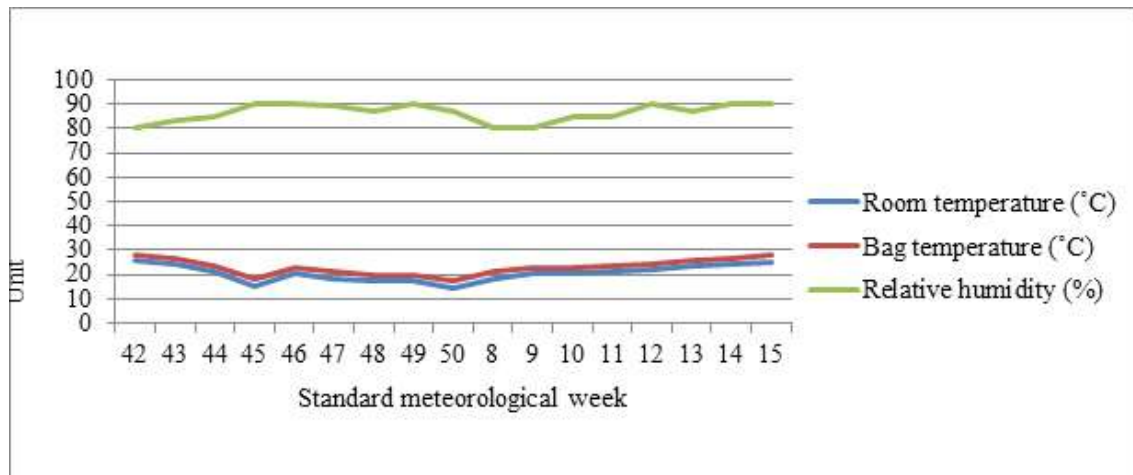
Figures in parentheses are angular transformed values.

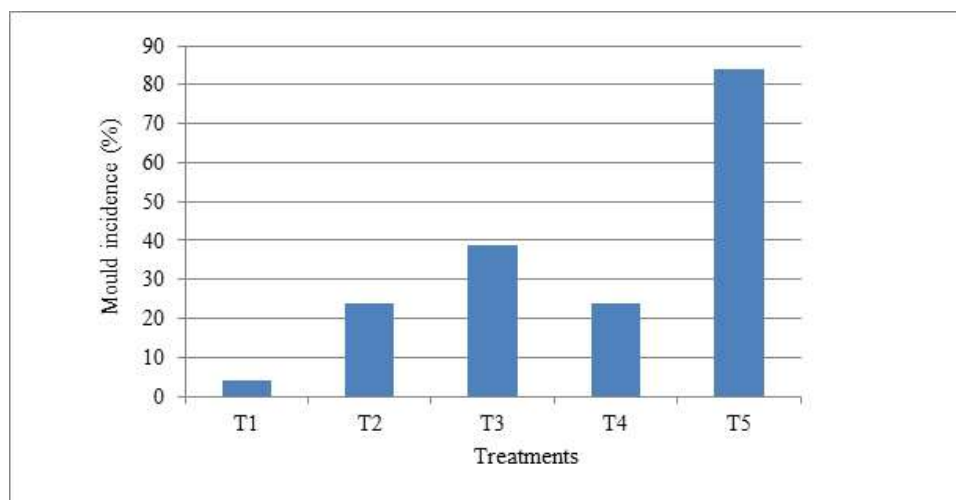
Table-5 :Effect of different substrate treatment methods on yield and Mould incidence (pooled values of year, 2015 and 2016).

Sr. No.	Treatment	Yield (g/kg)	Mould incidence (%)
1.	HWT*	661	5.1 (18.3)
2.	Bavistin (50 ppm)	538.1	22 (25.2)
3.	Formalin (500 ppm)	410.5	42 (39.9)
4.	Bavistin (50 ppm) + Formalin (500 ppm)	486.0	25 (28.8)
5.	Control	359.4	97.9 (85.8)
6.	CD (0.05)	33.0	(16.2)

*Hot water treatment

Figures in parentheses are angular transformed values.

**Fig.-1 : Production/Yield of Mushrooms and truffles in the world (2010—2019). FOASTAT (4/26/2021)****Fig.-2 : Weather parameters during cropping period of *Hypsizygus ulmarius*.**



T₁-Hot water treatment, T₂-Bavistin (50 ppm), T₃-Formalin (500 ppm), T₄-Bavistin (50 ppm) + Formalin (500 ppm), T₅-Control

Fig.-3 : Mould incidence during crop season-2015.

observed during 2016 cropping period (Table-4). The variation in the yield during 2015 and 2016 may be attributed to the higher incidence of competitor mould and environmental conditions prevalent at that time (Table-5). This work is in agreement with that of Sethi *et al.* (2012) who reported that spawn run period was minimum in hot water treated substrate in comparison to the chemical treatments and hot water treated substrate gave better yield and biological efficiency in comparison to the chemical treatments.

Conclusions

Several natural competitor mould are present to reduce mushroom yield and quality either through competition for food and space or due to the release of toxic metabolites. competitor mould could lead to mouldy growth like the green mould, yellow mould, and pink mould. These competitor mould can be eliminated from the substrates through several control methods *viz.*, hot water and chemicals (substrate was soaked in water containing Bavistin (50 ppm), Formalin (500 ppm) and Bavistin (50 ppm) + Formalin (500 ppm) for 16 hrs.

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Current Outlook on Understanding of Parawilt of Cotton and its Management

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Abstract

Cotton (*Gossypium* spp.) is the world's prominent natural textile fibre crop and a significant contributor of oilseed. It occupies an area of about 8.5 million hectares and is grown in both irrigated and rainfed area. Since the introduction of BT cotton technology it has been widely accepted by Farmers across the cotton growing states of India. Due to ready availability of Bt cotton seeds since 2002 and apparent advantages over non-Bt seeds, it spread rapidly in India within short span of time. However, Productivity decreased afterwards in the recent years due to emergence of new pests like mealy bug on Bt cotton hybrids. Parawilt is also an important constraint identified in Bt cotton hybrids. The detailed research work carried out at Central Institute for Cotton Research (CICR), Nagpur, have adequately established that it is a physiological disorder. Parawilt occurs in ill drained soils where the soil remains saturated at least for a few hours after rainfall. High air temperature and bright sun shine accelerates sudden wilting and leaves become chlorotic and turn bronze or red followed by drying. Irrigation management, Proper drainage, Planting of wilt tolerant cultivars and use of cobalt chloride (10 ppm) can manage this disease.

Key words : Bt cotton, non-Bt cotton, parawilt, CICR, cobalt chloride.

Introduction

Cotton (*Gossypium* spp.) is the world's prominent natural textile fibre crop and a significant contributor of oilseed. It occupies an area of about 8.5 million hectares and is grown in both irrigated and rainfed area. More than 70 per cent of the total cropped area is under rainfed condition and the lint yield per hectare is low as compared to the world average. Under rainfed condition, cotton production mainly depends on the timing and amount of rain, which is unique in every year. The duration of cotton crop is quite long due to its indeterminate growth habit. Therefore, both genotype and environment have conspicuous effects on growth and development. Physiological disorders appear in cotton as a reaction of plant response to environmental stresses, nutritional imbalances and chemical factors. Their effect on productivity depends upon the crop growth stage, intensity of incidence and loss of reproductive parts during ontogeny. However, there is a distinct difference between plant adaptation to harsh growing environment and physiological disorders. The various adaptive traits in plants as a response to the stress environment such as production of small leaves during drought and lenticel formation under waterlogged condition are not considered as physiological disorders.

Since the introduction of BT cotton technology it has been widely accepted by Farmers across the cotton growing states of India. Due to ready availability of Bt cotton seeds since 2002 and apparent advantages over non-Bt seeds, it spread rapidly in India within short span of time (Siddhapara *et al.*, 2013). Bt cotton hybrids having

genes against bollworms, farmers got rid of potential losses caused by them. Today more than 90% of cotton growing area is under Bt and now India is second largest cotton producing country of the world. With the introduction of transgenic Bt cotton hybrids in Punjab in 2005-06, the area under cotton in Punjab had increased and there was drastic increase in the seed cotton yield in 2006 and 2007. However, Productivity decreased afterwards in the recent years due to emergence of new pests like mealy bug on Bt cotton hybrids. Parawilt is also an important constraint identified in Bt cotton hybrids. Parawilt of cotton involves sudden drooping of leaves, When irrigation or rainfall are applied after long dry Spell (Sarlach *et al.* 2008). Now a days parawilt is being observed in Bt cotton fields of Andhra Pradesh, Telangana, Maharashtra, Karnataka, Madhya Pradesh, Gujarat and Uttar Pradesh.

A huge amount of work has been done to study the cause of the disease. Isolation, pathogen distribution and transmission studies proved that the fungi, bacteria and nematodes were not associated in the occurrence of disease. As observed previously that the Fusarium wilt occurs in groups of plants in the entire field but the parawilt occurs in random distribution (Mayee *et al.*, 1990). Moisture stress and water logging Favour parawilt incidence accompanied by ethylene Production in cotton hybrids (Mayee *et al.* 1990). Excessive water stagnation in the fields causes wilting of plants, which is physiological disorder due to anaerobic conditions of the soil and has no association of plant pathogens (Sahey *et al.* 1988; Mayee *et al.* 1990)

Exposure of the crop to repeated cycles of low and excess moisture stress during the growth period has adverse effect on growth and development (Ramamurthy *et al.*, 2009). The potential growth and developmental rates for a particular genotype may be decreased by stress factors (Shukla *et al.*, 2013). Hebbar and Mayee (2011) reported that parawilt occurs when the soil is suddenly saturated by a heavy downpour of rain for a continuous period of time and the sun shines bright and hot for later days which they consider may be due to the imbalance of uptake and loss of water under flooding in cotton field. A probe conducted by the Genetic Engineering Approval Committee on wilting in Madhya Pradesh, and Gene Campaign in Andhra Pradesh and Maharashtra reported that wilting was more in Bt fields compared to non-Bt fields. The greater occurrence of wilting in Bt fields over non-Bt fields prompted this team to conclude that the insertion of foreign Bt gene into host genome made the plants vulnerable to adversities.

A close watch on the sequence of events leading to the occurrence of parawilt in farmers' fields in different cotton-growing areas and the subsequent successful simulation of this disorder in experimental fields and the detailed research work carried out at Central Institute for Cotton Research (CICR), Nagpur, have adequately established that it is a physiological disorder.

Cause :

The exact cause of parawilt is still unknown. There is a correlation with the environment for the occurrence of parawilt. Also it occurs usually in a period in which soil environment is unfavourable to root growth. Many Plant Physiologist and Plant Pathologist after years of study established that parawilt is caused by several factors, which leads to poor root development and its function. There are three main factors which are implicated with the cause of this disorder complex i.e. agronomic, weather condition and plant factors. All these factors interact to cause seasonal occurrence of Parawilt. Parawilt occurs in ill drained soils where the soil remains saturated at least for a few hours after rainfall. High air temperature and bright sun shine accelerates sudden wilting. Its occurrence may also depend on the vigour of the plants, apparently being much more severe, if the hybrid cotton is being grown as it grows rapidly. Parawilt is more common and severe on clayey soils because they drain more slowly than sandy soils, but injury sometimes may occurs even on sandy soils, if poorly drained. This suggests that the main pre-requisites are essential for occurrence of parawilt are: Soil saturation or water-logging, Grand growth stage of crop and bright sunshine and hot air temperature (Hebbar and Mayee, 2011).

In waterlogged soils, the diffusion of gases through

soil pores is so strongly inhibited by their water content that it fails to match the needs of growing roots. A slowing of oxygen influx is the principal cause of injury to roots and the shoots they support. It was further demonstrated that the rate of water intake fell by 60 per cent within 1 h of flooding and continued to decrease steadily until the rate levelled off after 3 h of flooding at about 25 per cent of the rate after 15 min of flooding. This experiment showed that flooding of the soil results in a rapid decrease in permeability to water, which causes the sudden wilting often observed in the field. Cotton is one of the most susceptible of crop plants to injury from flooding or saturation of the soil with water. Cotton roots survive less than 30 min of oxygen deprivation. Waterlogging for longer duration could lead to the formation of adventitious root system in waterlogging-tolerant varieties. The newly formed adventitious roots usually contain aerenchyma and these roots can replace the stress-damaged roots that are formed before waterlogging.

At initial stages, plants have relatively slower growth rate and this gradually increases and peaks at flowering and early fruiting stage. At this stage plants have high metabolic rate. With optimum light, temperature and soil moisture, plants exhibit high transpiration, stomatal conductance and photosynthesis. There are several studies which have emphasized that leaf photosynthesis can be influenced by the presence of developing fruits. A positive effect of crop load on photosynthesis has been reported in many plant species, including *Citrus unshiu*, *Prunus cerasus*, *Vitis vinifera*, soybean and cotton. The intensity of light has a direct effect on photosynthesis. Generally speaking, the higher the intensity faster is the rate of photosynthesis until a maximum rate is reached. On a cloudy day, the rate would be slower. Plants growing under cloudy weather or shade, if waterlogged, do not wilt because of low stomatal conductance, transpiration and photosynthesis. On the other hand, sudden wilt occurs in plants that are waterlogged under bright sunlight.

High soil temperature would be expected to increase the rate and severity of flooding injury, because it can act in several ways. Root respiration increases with increasing temperature, causing an increase in oxygen requirement which probably results in more rapid injury than would occur with a low oxygen requirement. It was further observed that a higher oxygen concentration is required for root growth at high temperatures than at low temperatures.

Symptom :

The wilt may develop either slow or quick, the sudden wilt in cotton is characterized by a premature death of top leaves followed by collapse of the plant. The drooping of leaves appears soon after a continuous and heavy rain

Processes in Causing Parawilt:

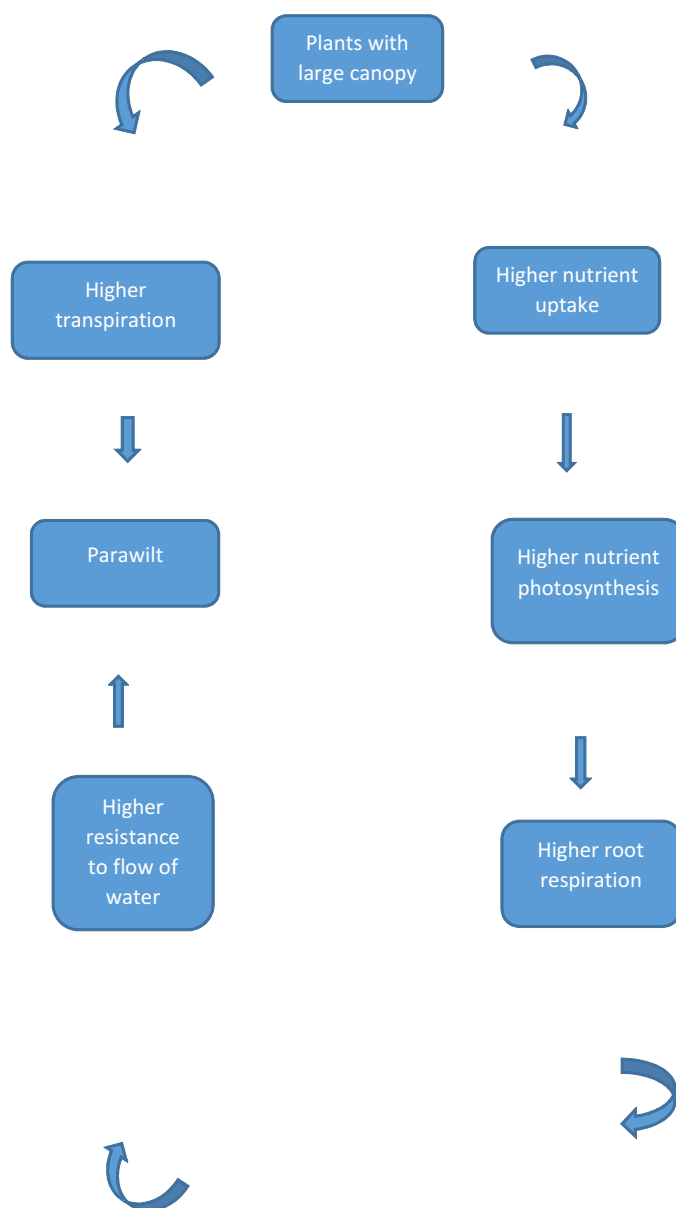


Figure : Flowchart of different processes involved in causing parawilt.

recedes and bright sun shine appears. If sun shines bright and hot, persists for a few hours, leaves become chlorotic and turn bronze or red followed by drying. Young plants are generally not affected and the symptoms typically occur from flowering stage. Premature abscission of leaves and fruiting parts may occur. After few days entire plant sheds its leaves.

The incidence is particularly high in plants with large canopy and heavy boll load. Squares and young bolls are shed and immature bolls are forcefully opened. If parawilt occurs just prior to harvest, bolls may forcefully open but

will not ripen fully, leading to poor quantity and unmarketable quality. Wilted plants show development of anthocyanin pigment. These plants exhibit high photosynthesis and transpiration rates. Consequently, for the production of proteins and other food, these plants require a high uptake of nutrients. Nutrient uptake, which is an active process and inhibited under anaerobic (water-logged) conditions. As a result of the feedback inhibition of root respiration, the root system degenerates in wilted plants. Damage to the roots affects their ability to take up and move water to the rest of the plant. This,

coupled with higher transpiration in wilted plants due to their insensitive stomata, causes parawilt in cotton.

Most of the wilted plants gradually recover and produce new flushes, however their contribution to yield is negligible. Under cloudy weather, leaves often turn yellow and die with little or no wilting. Epinasty appears more on top leaves compared to lower leaves. All the plants in a row may not wilt. Similarly, in a hill if there are two plants, one plant may wilt whereas the other plant may remain normal. Flowering and squaring are the most vulnerable stages of cotton crop for parawilt incidence. Recovery of the parawilt affected plant depends on at what stage parawilt occurs. If the parawilt occurs at early squaring or flowering stage, recovery may occur to certain extent (Hebbbar and Mayee 2011). At times wilt spreads like a wild fire and can cover the whole field within a few hours of its initiation. Hardly any time is left to think of control measures.

Incidence of Parawilt :

The incidence of parawilt is more frequently observed in Bt cotton crop and almost all the Bt cotton hybrids studied were found to be susceptible to Parawilt. In North India, where more than 95% of the crop is irrigated, plants wilt both due to excessive irrigation and late-season rains. In Central India, where more than 70% of the crop is rainfed, quite often it suffers from wilting due to heavy rains during August–October. In South India, where part of the crop is cultivated under irrigated condition and the rest under rainfed condition, wilting at some stage of its life cycle is common. The incidence of parawilt varied from 0.5-7.5% on the different Bt. cotton hybrids during 2009 and it was from 1.5-8.5% during 2010 in the month of July-August. The maximum parawilt was observed in MRC6301 and MRC 6304 in both the years. (Sarlach *et al.*, 2013). Jambhulkar *et al.* (2014) reported 3.4-9.5% incidence of parawilt in southern Rajasthan. The incidence is very less and scattered. Thus there is no report of huge economic loss.

Management :

Management of parawilt is possible only when there will be better regulation at above-ground level so as to keep the soil–plant–atmosphere continuum intact under higher incidence of extreme rainfall events as projected by the scenarios of climate change. The major issues need to be taken care of while managing incidence of parawilt are :

1. Irrigation management. Excess irrigation at any stage of crop must be avoided because over irrigating in the early life of a crop forces the roots to grow on the surface and can support the plants till flowering. At flowering, the demand of more moisture and the tendency to apply more irrigation water results in soil anaerobiosis which in plants

with shallow roots, leads to sudden wilt. Over irrigating, under hot and bright sun, particularly at flowering and early boll set, should be avoided. Irrigation may be provided during grand growth phase to avoid prolonged exposure of plants to dry condition.

2. Proper drainage : Cotton crop mostly grown in black cotton soil which has high amount of clay. Such soils have a tendency to absorb and retain more water. Cotton crops grown in well drained soils are less at risk of developing parawilt than those grown in poorly drained soils

3. Planting of wilt tolerant cultivars : Wilting was not seen in *G.arboreum* and *G.herbaceum* genotypes. Hybrids like JKHY 1, DCH 32, NHH 44 are wilt sensitive. Varieties such as LRA 5166, LRK 516 (Anjali), SRT1, MCU 5 VT, AKH 4, G 27 and Jayadhar are relatively tolerant to wilt.

4. Excessive use of farm yard manure and fertilizers may be avoided in heavy soils.

5. Curtail excessive vegetative growth.

A recommendation was made to farmers to use spray of cobalt chloride (10 ppm) on parawilt affected plants. Cobalt (Co), a transition element, is an essential component of several enzymes and co-enzymes. It has been shown to affect growth and metabolism of plants, in different degrees, depending on the concentration and status of cobalt in rhizosphere and soil. It also promotes the growth of seedlings and alleviates the senescence of aged tissues as it inhibits the activities of ACC oxidase and reduced ethylene (ETH) production. Toxic effect of cobalt on morphology include leaf fall, inhibition of greening, discolored veins, premature leaf closure, and reduced shoot weight. Being a component of vitamin B12 and cobamide coenzyme, Co²⁺ helps in the fixation of molecular nitrogen in root nodules of leguminous plants. The beneficial effects of cobalt include retardation of senescence of leaf, increase in drought resistance in seeds, regulation of alkaloid accumulation in medicinal plants and inhibition of ethylene biosynthesis. Co is an inhibitor of 1-aminocyclopropane 1- carboxylic acid (ACC) oxidase and does inhibit ETH production (Locke *et al.*, 2000). At low concentration Co significantly increased shoot and root length and did not influence shoot and root dry weight, whereas higher Co concentrations resulted in a considerable decrease of shoot and root length as well as shoot and root dry weight (Abdul Jaleel *et al.*, 2009). Co at high levels may inhibit root and shoot growth directly by inhibition of cell division or cell elongation or a combination of both, resulting in the limited exploration of the culture medium volume for uptake and translocation of nutrients and water and induced mineral deficiency (Hemantaranjan *et al.*, 2000).

As the stress continued, lipid peroxidation and chlorophyll damage in the leaves of potato seedlings became aggravated. Furthermore, treatment with cobalt alleviated the lipid peroxidation, the reduction in chlorophyll content, and cell membrane damage. These results showed that cobalt alleviated leaf damage as the osmotic stress was aggravated.

Conclusions

There is a correlation with the environmental conditions for the occurrence of parawilt. It also occurs usually in a period in which soil environment is unfavourable to root growth. Many Plant Physiologist and Plant Pathologist after years of study established that parawilt is caused by several factors, which leads to poor root development and its function. There are three main factors which are implicated with the cause of this disorder complex i.e. agronomic, weather condition and plant factors. All these factors interact to cause seasonal occurrence of Parawilt the sudden wilt in cotton is characterized by a premature death of top leaves followed by collapse of the plant. The drooping of leaves appears soon after a continuous and heavy rain recedes and bright sun shine appears.

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Soil Salinity : A Serious Environmental Concern and Plant Growth Promoting Microorganisms as One of the Solutions for its Alleviation

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Abstract

Most crop plants are sensitive to salinity caused by high concentrations of salts in the soil, and the area of land impacted by it is expanding day by day, salinity is one of the harshest environmental variables restricting crop plant productivity. Average yields for all significant crops are only a fraction of record yields, ranging from 20% to 50%; these losses are primarily due to drought and high soil salinity, climatic circumstances that may increase in many locations as a result of global climate change. To deal with such effects, a variety of adaptations and mitigation methods are required. Salinity stress can be alleviated through efficient resource management and crop/livestock improvement to evolve healthier breeds. However, because such solutions are time-consuming and costly, there is a need to create simple and low-cost biological methods for salinity stress control that can be implemented quickly. Microorganisms with unique qualities such as salinity tolerance, genetic diversity, synthesis of suitable solutes, generation of plant growth stimulating hormones, bio-control capability, and contact with crop plants could play a significant role in this regard.

Introduction

The beginning of the twenty-first century is defined by worldwide water scarcity, pollution, and rising salinization of land and water. Two risks to agricultural sustainability are the growing human population and the shrinking amount of land accessible for production (Shahbaz and Ashraf, 2013). Various environmental stresses, such as high winds, extreme temperatures, soil salinity, drought, and flood, have had an impact on the production and cultivation of agricultural crops. Soil salinity is one of the most damaging environmental stresses, causing significant reductions in cultivated land area, crop productivity, and quality (Yamaguchi and Blumwald, 2005; Shahbaz and Ashraf, 2013). A saline soil is one with an exchangeable sodium of 15% and an electrical conductivity (EC) of the saturation extract (EC_e) in the root zone that surpasses 4 dS m⁻¹ (about 40 mM NaCl) at 25 °C. Most crop plants' yields are reduced at this EC_e, however many crops' yields are reduced at lower EC_e (Munns, 2005; Jamil *et al.*, 2011). High salinity affects 20 percent of total cultivated and 33 percent of irrigated agricultural lands worldwide, according to estimates. Furthermore, for a variety of causes, including limited precipitation, high surface evaporation, weathering of native rocks, irrigation with saline water, and poor cultural practises, salinized areas are expanding at a rate of 10% per year. High salinity affects 20 percent of total cultivated and 33 percent of irrigated agricultural lands worldwide, according to estimates. Furthermore, for a variety of

causes, including limited precipitation, high surface evaporation, weathering of native rocks, irrigation with saline water, and poor cultural practises, salinized areas are growing at a pace of 10% each year. By the year 2050, it is expected that more than half of all arable land will have been salinized (Jamil *et al.*, 2011). Water and soil management measures have aided agricultural production on salinity-affected soils, but an extra benefit from these methods appears to be problematic (Zahir *et al.*, 2008). Soils that have been impacted are a major limiting issue in the production of every major crop around the world (Bacilio *et al.*, 2004; Shannon and Grieve, 1999). To meet the predicted population needs by 2050, a significant rise (an estimated 50%) in grain yields of important crop plants such as rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), and maize (*Zea mays* L.) is necessary (Godfray *et al.*, 2010). Plant and soil productivity research is critical because of the pressing need to feed the world's rising population while also combatting soil degradation, salinization, and desertification. In such circumstances, appropriate biotechnology is required to improve not just crop productivity but also soil health through interactions between plant roots and soil microorganisms (Lugtenberg *et al.*, 2002). Plant growth is known to be slowed in salt-stressed soils (Paul, 2012). Endocellular and intracellular microorganisms invade plants in their natural environment (Gray and Smith, 2005). Microorganisms in the rhizosphere, particularly beneficial bacteria and fungi, can boost plant performance in stressful situations and, as

a result, increase yield both directly and indirectly (Dimkpa *et al.*, 2009). Some plant growth-promoting rhizobacteria (PGPR) may stimulate plant growth and development directly by delivering fixed nitrogen, phytohormones, iron sequestered by bacterial siderophores, and soluble phosphate to plants (Hayat *et al.*, 2010). Others do so by shielding the plant from soil-borne diseases, the majority of which are caused by harmful fungus (Lutgtenberg and Kamilova, 2009). Soil salinization is a global phenomenon that has harmed agricultural productivity. High osmotic stress, nutritional abnormalities and toxicities, poor soil physical conditions, and reduced crop productivity all affect crops produced on saline soils. The current review focuses on the use of plant growth promoting microorganisms to improve production under stressful conditions and boost plant tolerance to salinity stress.

Problem of soil salinization

Soil salinity is a significant issue in irrigated agriculture. Soils in hot and arid areas of the world are typically saline and have little agricultural potential. Many crops are cultivated under irrigation in these places, and to make matters worse, poor irrigation management causes secondary salinization, which affects 20% of irrigated land worldwide (Glick *et al.*, 2007). In arid and semi-arid areas, irrigated agriculture is a major human activity that frequently results in secondary salinization of land and water supplies. In the soil, salts are found as ions (electrically charged forms of atoms or compounds). Ions are released when minerals in the soil weather. They can also be applied as fertilisers or by irrigation water, and they can move upward in the soil from shallow groundwater. Salts accumulate in the soil when precipitation is insufficient to drain ions from the soil profile, resulting in soil salinity (Blaylock *et al.*, 1994). Water-soluble salts are found in all soils. Essential nutrients are absorbed by plants in the form of soluble salts, but excessive accumulation inhibits plant growth. Physical, chemical, and/or biological soil degradation processes had major effects for global natural resources over the previous century (for example, compaction, inorganic/organic contamination, and decreased microbial activity/diversity). Due to the introduction of irrigation in new locations, the area beneath the afflicted soils continues to grow each year (Patel *et al.*, 2011). In many nations, salinization is acknowledged as one of the most serious dangers to environmental resources and human health, affecting around 1 billion hectares worldwide/globally, or about 7% of the earth's continental extent, or roughly 10 times the size of Venezuela or 20 times the size of France (Metternicht and Zinck, 2003; Yensen, 2008). In India, it is estimated that saline soil covers over 7 million hectares of land (Patel *et al.*, 2011). The majority of this occurs in the Indo-Gangetic Plain,

which spans Punjab, Haryana, Uttar Pradesh, Bihar, and parts of Rajasthan. Gujarat and Rajasthan's dry regions, as well as Gujarat, Madhya Pradesh, Maharashtra, Karnataka, and Andhra Pradesh's semi-arid regions, are heavily influenced by saline plains.

Impact of salinity on plants

Under salt stress, agricultural crops respond in a variety of ways. Salinity affects not just the agricultural yield of most crops, but also the physicochemical qualities of the soil and the area's ecological balance. Low agricultural production, low economic returns, and soil degradation are all effects of salt (Hu and Schmidhalter, 2002). Seed germination, plant growth, and water and nutrient uptake are all affected by salinity, which is the result of complex interactions between morphological, physiological, and biochemical processes (Akbarimoghaddam *et al.*, 2011; Singh and Chatrath, 2001). Plant development is influenced by salinity in practically every way, including germination, vegetative growth, and reproductive development. Plants are subjected to ion toxicity, osmotic stress, nutritional (N, Ca, K, P, Fe, Zn) deficiency, and oxidative stress as a result of soil salinity, which inhibits water uptake. Because phosphate ions precipitate with Ca ions, soil salinity significantly inhibits plant phosphorus (P) absorption (Bano and Fatima, 2009). Sodium, chlorine, and boron, for example, have specific harmful effects on plants. Excessive sodium accumulation in cell walls can quickly cause osmotic stress and cell death (Munns, 2002). If the soil contains enough of the poisonous element, plants sensitive to these elements may be damaged even at low salt concentrations. Because many salts are also plant nutrients, high salt levels in the soil can disrupt the plant's nutrient balance or prevent some nutrients from being absorbed (Blaylock *et al.*, 1994). Salinity also influence photosynthesis, mostly by reducing leaf area, chlorophyll content, and stomatal conductance, and to a lesser extent by lowering photosystem II efficiency (Netondo *et al.*, 2004). Salinity has a negative impact on reproductive development by promoting microsporogenesis and stamen filament elongation, as well as increasing programmed cell death in specific tissue types, ovule abortion, and fertilised embryo senescence. Because of the low osmotic potential of the soil solution (osmotic stress), specific ion effects (salt stress), nutritional imbalances, or a combination of these variables, the saline growth medium has various negative impacts on plant growth (Ashraf, 2004). All these factors have negative physiological and biochemical impacts on plant growth and development, as well as molecular consequences (Munns and James, 2003). (Tester and Davenport, 2003). Growth or survival of the plant is monitored to determine plant tolerance to salinity stress because it integrates the up- or down-regulation of several

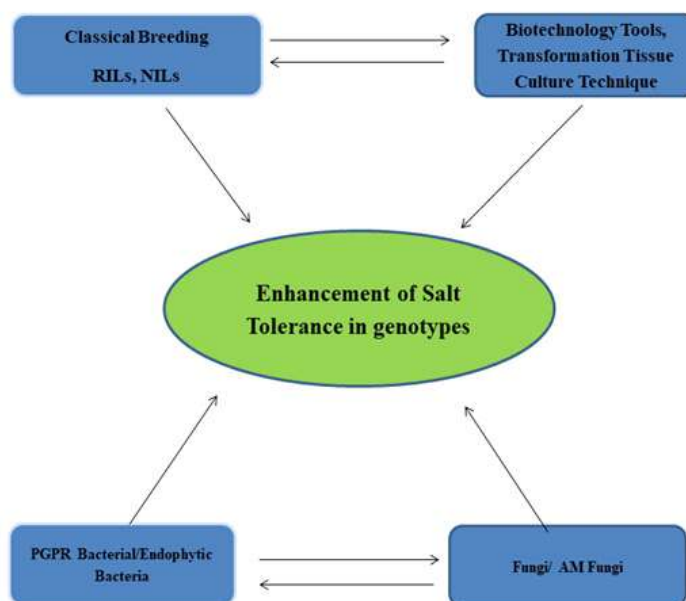


Plate 1 : Different approaches for improvement of salt tolerance in agricultural crops.

physiological mechanisms occurring inside the plant. For plants developing in a saline media, osmotic equilibrium is critical. When this balance is disrupted, cells lose their turgidity, become dehydrated, and eventually die. On the other hand, salinity's negative effects on plant growth could be due to a reduction in the delivery of photosynthetic assimilates or hormones to growing plants (Ashraf, 2004). Ion toxicity is caused by the substitution of Na^+ for K^+ in metabolic activities, as well as conformational changes in proteins caused by Na^+ and Cl^- . K^+ is a cofactor for numerous enzymes and cannot be replaced by Na^+ . High K^+ levels are also essential for tRNA binding to ribosomes and, as a result, protein synthesis (Zhu, 2002). Metabolic imbalance is caused by ion toxicity and osmotic stress, which leads to oxidative stress (Chinnusamy *et al.*, 2006). During the reproductive period, salt has a greater negative impact on plant development. Wheat plants exposed to 100–175 mM NaCl had a significant reduction in spikelets per spike, delayed spike emergence, and lower fertility, resulting in poor grain yields. The concentrations of Na^+ and Cl^- in the shoot apex of these wheat plants, however, were less than 50 and 30 mM, respectively, which is too low to limit metabolic responses (Munns and Rawson, 1999). As a result, the negative consequences of salinity are likely due to the salt-stress effect on cell cycle and differentiation. Salinity causes a brief pause of the cell cycle by lowering the expression and activity of cyclins and cyclin-dependent kinases, resulting in fewer cells in the meristem and so limiting growth. During salt stress, post-translational inhibition of cyclin-dependent kinase also reduces its activity. Salinity inhibits seed germination, seedling growth, enzyme

activity (Seckin *et al.*, 2009), DNA, RNA, protein synthesis, and mitosis, according to recent research (Tabur and Demir, 2010; Javid *et al.*, 2011).

Amelioration of salinity

Leaching of salt from the root zone, changes in farm management practises, and the adoption of salt-tolerant plants can all help to limit salinization. Better irrigation practises, such as the use of partial root zone drying methodology and drip or micro-jet irrigation to maximise water use, can help to sustain irrigated agriculture. Reduce the amount of water passing beyond the roots to prevent the spread of dry land salinity. This can be accomplished by reintroducing deep-rooted perennial plants that continue to grow and consume water during seasons when annual crop plants are not viable. This could help to restore the equilibrium between rainfall and water consumption, limiting increasing water tables and salt migration to the surface (Manchanda and Garg, 2008). Perennials can be planted in rotation with annual crops (phase farming), in mixed plantings (alley farming, intercropping), or in site-specific plantings (precision farming) in agricultural systems (Munns *et al.*, 2002). Although these approaches to sustainable management can reduce yield decline during salinity stress, application is generally limited due to cost and the availability of high water quality or water resources. A fundamental difficulty in abiotic stress management is developing efficient, low-cost, and easily adaptable approaches. As indicated in Plate 1, substantial research is being conducted worldwide to create solutions to cope with abiotic pressures, such as developing salt and drought tolerant cultivars, adjusting crop calendars, and resource

management approaches, among other things (Venkateswarlu and Shanker, 2009).

Use of salt tolerant crops and transgenics

One of the most essential ways for dealing with salinity is to use salt-tolerant crops. Because salt will be left in the soil after the water table is dropped, tolerance will be required not just for the “de-watering” species, but also for the annual crops that will follow. Crops with higher salt tolerance will be able to make better use of low-quality irrigation water. Understanding the mechanisms of salt limitation on plant growth and the mechanisms of salt tolerance at the entire plant, organelle, and molecular levels is required to improve plant salt tolerance. There is a change in gene expression pattern in saline circumstances, as well as qualitative and quantitative changes in protein synthesis. Although it is generally agreed that salt stress causes quantitative alterations in protein synthesis, whether salinity activates specialised genes implicated in salt stress is a point of contention. Unique gene(s) do not appear to be involved in salt tolerance (Manchanda and Garg, 2008). When a plant is exposed to abiotic stress, a number of genes are activated, resulting in higher levels of a variety of metabolites and proteins, some of which may be responsible for providing some degree of resistance to these stresses (Bhatnagar-Mathur *et al.*, 2008). Efforts to improve crop performance under environmental challenges using a transgenic method have been unsuccessful since the fundamental processes of stress tolerance in plants are still unknown.

For decades, plant breeding projects have focused on the development of salt-tolerant crops in order to maintain crop output in semiarid and saline environments. The researcher are using the Recombinant inbred lines (RILs) and Near isogenic lines (NILs) for alleviating the bad effect of salinity. Despite the release of multiple salt-tolerant cultivars, traditional breeding progress has been slow and unsuccessful, as only a few important determining genetic features of salt tolerance have been identified (Schubert *et al.*, 2009; Dodd and Perez-Alfocea, 2012). Epstein *et al.* (1980), published 25 years ago, described the technical and ecological restrictions to fixing the salinity problem. There is a genetic foundation for salt sensitivity, as evidenced by the existence of salt-tolerant plants (halophytes) and variability in salt tolerance between genotypes within salt-sensitive plant species (glycophytes) (Yamaguchi and Blumwald, 2005). Although many ways have been used to generate salt-tolerant plants using transgenics, complete success has yet to be realised. In laboratory investigations, the assessment of salt tolerance in transgenic plants has usually been done with a small number of seedlings or

mature plants. The tests were conducted in most cases in greenhouses, where the plants were not subjected to the conditions found in high-salinity soils (e.g., alkaline soil pH, high diurnal temperatures, low humidity, presence of other sodic salts, and elevated selenium and/or boron concentrations). The salt tolerance of field plants must be assessed, and more significantly, salt tolerance must be assessed in relation to yield. Because of the fluctuation of salt levels in field circumstances (Richards, 1983) and the potential for interactions with other environmental factors such as soil fertility, temperature, light intensity, and water loss owing to transpiration, evaluating field performance under salt stress is difficult. The fluctuation in sensitivity to salt during the life cycle complicates determining tolerance. Salinity, for example, has a significantly greater impact on grain output in rice than it does on vegetative growth (Khatun and Flowers, 1995). Because both are controlled by different mechanisms, the ability of tomato plants to germinate and grow under high salinity is not always correlated with their ability to grow under salt stress (Foolad and Lin, 1997), though some genotypes may show similar tolerance during germination and vegetative growth (Foolad and Chen, 1999). As a result, stress tolerance in the lab often has no resemblance with stress tolerance in the field. Despite several accomplishments in creating stress-tolerant transgenics in model plants such as tobacco, Arabidopsis, and rice (Grover *et al.*, 2003), there is a pressing need to verify these successes in additional crops. Many crop plants, particularly monocots, face a number of technical and financial problems when they are transformed. To begin with, transformation of any monocot other than rice is still uncommon and developing a series of independent homozygous lines is time and money intensive. Second, because many stress tolerance experiments employed by basic researchers entail employing nutrient-rich conditions, the stress tolerance screens will need to incorporate a field component (which in some cases include sucrose). This type of screen is unlikely to be related to performance on the field. Third, because saline soils are typically complex, containing elements such as NaCl, CaCl₂, CaSO₄, Na₂SO₄, high boron concentrations, and alkaline pH, plants that show promise will need to be evaluated in all these conditions (Joseph and Jini, 2010).

Microbes : abiotic stress alleviation tool in crops

Plant genetic engineering (Wang *et al.*, 2003) and, more recently, the use of plant growth-promoting bacteria (PGPB) have been explored as techniques to reduce the deleterious effects of high salt on plant growth (Dimkpa *et al.*, 2009). Microorganisms play a well-known and well-established role in plant growth promotion, nutrition management, and disease control. Beneficial microbes invade the rhizosphere and endorhizosphere of plants,

Table-1 : Role of plant growth promoting bacteria in salinity stress alleviation in plants.

Plant growth promoting bacterial	Crop plant	Role and activity of PGPR	References
<i>Achromobacter piechaudii</i>	Tomato (<i>Lycopersion esculentum</i>)	Reduced level of ethylene and improved plant growth	Mayak et al. (2004)
<i>Azospirillum</i>	Maize (<i>Zea mays</i>)	Restricted Na ⁺ Uptake and increased K ⁺ and Ca ₂ ⁺ uptake along with increased nitrate reductase and nitrogenase activity	Hamdia et al. (2004)
<i>Aeromonas hydrophila/caviae</i> <i>Bacillus insolitus</i> , <i>Bacillus sp.</i>	Wheat (<i>Triticum aestivum</i>)	Exopolysaccharide production	Ashraf (2004)
<i>Pseudomonas syringae</i> , <i>Pseudomonas fluorescens</i> , <i>Enterobacter aerogenes</i>	Maize (<i>Zea mays</i>)	ACC deaminase activity	Nadeem et al. (2007)
<i>Pseudomonas fluorescens</i>	Groundnut (<i>Arachis hypogaea</i>)	Enhanced ACC deaminase activity	Saravanakumar and Samiyappan (2007)
<i>Bacillus subtilis</i>	<i>Arabidopsis thaliana</i>	Tissue specific regulation of sodium transporter HKT1	Zhang et al. (2008)
<i>Pseudomonas mendocina</i>	Lettuce (<i>L. sativa</i> L. cv. <i>Tafalla</i>)	ACC deaminase activity and enhanced uptake of essential nutrients	Kohler et al. (2009)
<i>Rhizobium</i> , <i>Pseudomonas</i>	Maize	Decreased electrolyte leakage and, increase in proline production, maintenance of relative water content of leaves, and selective uptake of K ⁺ ion	Bano and Fatima (2009)
<i>Pseudomonas pseudoalcaligenes</i> , <i>Bacillus pumilus</i>	Rice (<i>Oryza sativa</i>)	Increased concentration of glycine betaine (compatible solute)	Jha et al. (2011)
<i>Pseudomonas putida</i> Rs-198	Cotton	Increase the absorption of the Mg ²⁺ , K ⁺ and Ca ²⁺ and decrease the uptake of the Na ⁺ from the soil	Yao et al. (2010)
PGPR (Mk1, <i>Pseudomonas syringae</i> Mk20, <i>Pseudomonas ?uorescens</i> ; and Mk25, <i>Pseudomonas ?uorescens</i> biotype G) and <i>Rhizobium phaseoli</i> strains M1, M6, and M9	Mung bean	ACC deaminase activity and improvement in growth and nodulation in mung bean	Ahmad et al. (2011)
<i>Raoultella planticola</i> Rs-2	Cotton	ACC deaminase activity	Wu et al. (2012)
<i>Brachy bacterium saurashtrense</i> (JG-06), <i>Brevibacterium casei</i> (JG-08), and <i>Haerero halobacter</i> (JG-11)	Groundnut (<i>Arachis hypogaea</i> L.)	High K ⁺ /Na ⁺ ratio and higher Ca ²⁺ , phosphorus, and nitrogen content	Shukla et al. (2012)
<i>Rhizobium phaseoli</i> and PGPR (<i>Pseudomonas syringae</i> , Mk1; <i>Pseudomonas fluorescens</i> , Mk20 and <i>Pseudomonas fluorescens</i> Biotype G, Mk25)	Mung bean (<i>Vigna radiata</i> L.)	ACC deaminase activity and increased water use efficiency	Ahmad et al. (2012)
<i>Rhizobium</i> and <i>Pseudomonas</i>	Mung bean (<i>Vigna radiata</i> L.)	IAA production and ACC deaminase	Ahmad et al. (2013)
<i>Pseudomonas putida</i> , <i>Enterobacter cloacae</i> , <i>Serratia flicaria</i> , and <i>Pseudomonas fluorescens</i>	Wheat	Enhanced germination percentage, germination rate, and index and improved the nutrient status of the wheat plants	Nadeem et al. (2013)
<i>Pseudomonas pseudoalcaligenes</i> and <i>Bacillus pumilus</i>	Salt sensitive rice GJ-17	Reduce lipid peroxidation and superoxide dismutase activity	Jha and Subramanian, 2014
<i>Acinetobacter</i> spp. and <i>Pseudomonas sp.</i>	Barley and oats	Production of ACC deaminase and IAA	Chang et al. (2014)
<i>Streptomyces sp.</i> strain PGPA39	'Micro tom' tomato	ACC deaminase activity and IAA production and phosphate solubilization	Palaniyandi et al. (2014)

promoting plant growth through a variety of direct and indirect processes (Nia *et al.*, 2012; Ramadoss *et al.*, 2013). Previous research suggests that using PGPR to relieve salinity-induced plant stress (Yao *et al.*, 2010), and the role of microorganisms in the control of biotic and abiotic stresses is becoming increasingly important. Recently, the question of PGPR-elicited abiotic stress tolerance has been revisited (Dodd and Perez-Alfocea, 2012; Yang *et al.*, 2009). For PGPR-induced physical and chemical changes that result in increased tolerance to abiotic stress, the name Induced Systemic Tolerance (IST) has been proposed. Plant growth is aided by PGPR

in two ways: indirectly by reducing plant pathogens, and directly by improving nutrient uptake through phytohormone production (e.g. auxin, cytokinin, and gibberellins), enzymatic decrease of plant ethylene levels, and/or siderophores production (Kohler *et al.*, 2006). It has been proven that inoculating plants with AM (arbuscular mycorrhizal) fungi promotes plant growth when they are exposed to salt (Cho *et al.*, 2006). Kohler *et al.* (2006) revealed that PGPR *Pseudomonas mendocina* strains have a beneficial influence on soil aggregate stabilisation. *P. alcaligenes* PsA15, *Bacillus polymyxa* BcP26, and *Mycobacterium phlei* MbP18 were found to be

able to endure high temperatures and salt concentrations, giving them a competitive advantage in arid and saline soils such as calcisol (Egamberdiyeva, 2007). Kohler *et al.* (2009) looked examined the effects of inoculating *Lactuca sativa* with a PGPR, *P. mendocina*, alone or in combination with an AM fungus, *Glomus intraradices* or *G. mosseae*, on growth, nutrient absorption, and other physiologic activities in the presence of salt stress. The plants infected with *P. mendocina* produced significantly more shoot biomass than the controls, suggesting that inoculation with specific PGPR could be a useful technique for alleviating salinity stress in salt-sensitive plants. Bacteria isolated from various challenged habitats have stress endurance capacity as well as plant growth-promoting properties, making them suitable seed bacterization candidates. Plants inoculated with these isolates had longer roots and shoots, more biomass, and higher amounts of biochemicals such chlorophyll, carotenoids, and protein (Tiwari *et al.*, 2011). The effects of PGPR interaction with other microorganisms on the physiological response of agricultural plants under various soil salinity regimes are still being investigated. Inoculations with selected PGPR and other microorganisms could be used to help salt-sensitive crops cope with salinity stress. As a result, more research is needed in this field, and the employment of PGPR and other symbiotic microorganisms can aid in the development of solutions to enable sustainable agriculture in saline soils.

Alleviation of abiotic stress in plants by rhizospheric bacteria

Apart from generating stress tolerance mechanisms, microorganisms can also confer resistance to plants to abiotic stresses such as drought, chilling injury, salt, metal toxicity, and high temperatures. Bacteria from various genera, such as *Rhizobium*, *Bacillus*, *Pseudomonas*, *Pantoea*, *Paenibacillus*, *Burkholderia*, *Achromobacter*, *Azospirillum*, *Microbacterium*, *Methylobacterium*, *Variovorax*, and *Enterobacter*, have been reported to provide tolerance to host plants under various abiotic stress environments in the last decade (Grover *et al.*, 2011). The use of these microbes in agriculture can decrease stress, bringing up a new and emerging application for microorganisms. Plant stress tolerance generated by microbes could be owing to a variety of mechanisms reported from time to time depending on research. Increased root length, root surface area, and number of root tips arise from PGPR's production of indole acetic acid, gibberellins, and some unknown factors, resulting in improved nutrient uptake and plant health under stress situations (Egamberdiyeva and Kucharova, 2009). Under saline conditions, plant growth promoting bacteria have been found to improve tomato, pepper,

canola, bean, and lettuce growth (Barassi *et al.*, 2006; Yildirim and Taylor, 2005).

Some PGPR strains produce cytokinin and antioxidants, resulting in the buildup of abscisic acid (ABA) and the degradation of reactive oxygen species. Antioxidant enzyme activity has been linked to oxidative stress tolerance (Stajner *et al.*, 1997). In pepper and tomato, another PGPR strain, *Achromobacter piechaudii* ARV8, which produces 1-aminocyclopropane-1-carboxylate (ACC) deaminase, provided IST against drought and salt (Mayak *et al.*, 2004). Many elements of plant life are influenced by ethylene levels, and ethylene production is tightly controlled, involving transcriptional and post-transcriptional mechanisms that are influenced by environmental factors such as biotic and abiotic stressors (Hardoim *et al.*, 2008). Ethylene, a plant hormone, governs plant homeostasis and results in reduced root and shoot growth when plants are stressed. Plant ACC is sequestered and destroyed by bacterial cells in the presence of ACC deaminase producing bacteria to provide nitrogen and energy. Furthermore, by eliminating ACC, the bacteria diminish ethylene's harmful effects, reducing stress and encouraging plant growth (Glick, 2007). In the rhizosphere, complex and dynamic interactions between microorganisms, roots, soil, and water cause changes in the soil's physicochemical and structural qualities (Haynes and Swift, 1990). Micro- and macroaggregates can be formed by microbial polysaccharides binding soil particles together. Plant roots and fungal hyphae fit between microaggregates, stabilising macroaggregates. Plants treated with bacteria that produce exo-poly saccharides (EPS) have better soil structure, which makes them more resistant to water and salinity stress (Sandhya *et al.*, 2009). Under saline conditions, EPS can bind to cations such as Na⁺, rendering it unavailable to plants. Drought and salt tolerance in plants were linked by Chen *et al.* (2007). When proBA genes from *B. subtilis* were introduced into *A. thaliana*, the transgenic plants produced more free proline and were more resistant to osmotic stress. Reduced electrolyte leakage and increased proline synthesis. Salt tolerance was achieved in *Zea mays* coinoculated with *Rhizobium* and *Pseudomonas* due to increased proline synthesis, decreased electrolyte leakage, maintenance of relative water content in leaves, and selective uptake of K ions (Bano and Fatima, 2009). *Rhizobacteria* found in areas where stress is frequent are likely to be more adaptable or tolerant and may be better plant growth promoters in stressful situations. Furthermore, inoculation with *P. putida* Rs 198 increased cotton growth and germination under salt stress, according to Yao *et al.* (2010). Tank and Saraf (2010) found that PGPRs that can solubilize phosphate and

generate phytohormones and siderophores in salt increase tomato plant development when exposed to 2 percent NaCl. In a 2009 study, Naz *et al.* found that strains obtained from Pakistan's Khewra salt range demonstrated tolerance when tested on saline media generated using rhizosphere soil filtrate. It's worth noting that the isolates produced ABA at a significantly higher concentration than previously reported. Furthermore, under induced salt stress, soybean plants infected with these isolates produced more proline, had longer shoot/root lengths, and had a greater dry weight. Similarly, Upadhyay *et al.* (2011) investigated the effects of PGPR inoculation on wheat growth and antioxidant status under saline conditions and found that co-inoculation with *B. subtilis* and *Arthrobacter* sp. could mitigate the negative effects of soil salinity on wheat growth by increasing dry biomass, total soluble sugars, and proline content. According to Jha *et al.* (2011) an endophytic bacterium in combination with a rhizospheric *B. pumilus* in paddy was able to protect the plant from abiotic stress by inducing osmoprotectant and antioxidant proteins, which was more effective than the rhizospheric or endophytic bacteria alone at early stages of growth. At lower salinity levels, plants treated with the endophytic bacterium *P. pseudoalcaligenes* had a much larger concentration of glycine beta-ine-like quaternary compounds and a higher shoot biomass. A combination of *P. pseudoalcaligenes* and *B. pumilus* demonstrated improved resistance to the negative effects of salinity at higher salinity levels. Inoculation of Azospirillum strains isolated from saline or non-saline soil on wheat yield and yield components in salinity was studied by Nia *et al.* (2012). They found that inoculation with the two isolates increased salinity tolerance of wheat plants, with the saline-adapted isolate significantly increasing shoot dry weight and grain yield under severe water salinity. Grain yield per plant was the component of grain yield that was most affected by inoculation. At all salinity levels, plants inoculated with saline-adapted Azospirillum strains showed increased N concentrations. Sadeghi *et al.* (2012) investigated the plant growth stimulating ability of an auxin and siderophore generating isolate of *Streptomyces* under saline soil conditions and found that the wheat plant grew and developed more quickly. In comparison to the control, they saw significant increases in germination rate, percentage and uniformity, shoot length, and dry weight. The application of the bacterial inocula raised the concentrations of N, P, Fe, and Mn in wheat shoots grown in both normal and saline soils, implying that *Streptomyces* isolates might be used as biofertilizers in salty soils. Ramadoss *et al.* (2013) investigated the effect of five plant growth-promoting halotolerant bacteria on wheat growth and discovered that inoculating those

halotolerant bacterial strains to alleviate salt stress (80, 160, and 320 mM) in wheat seedlings resulted in a 71.7 percent increase in root length compared to uninoculated positive controls. When compared to uninoculated wheat seedlings under 320 mM NaCl stress, *Hallobacillus* sp. and *B. halodenitrificans* demonstrated a 90 percent increase in root elongation and a 17.4 percent rise in dry weight, demonstrating a significant reduction of NaCl's harmful effects. These findings suggest that halotolerant bacteria isolated from saline environments could improve plant growth under saline stress via direct or indirect processes, and that they would be best used as bioinoculants in such situations. Isolating indigenous microorganisms from stress-affected soils and screening them for stress tolerance and PGP properties could aid in the rapid selection of effective strains for use as bioinoculants for stressed crops. Table 1 summarises some of the accomplishments and studies done in examining the role of rhizobacteria as salt stress remediators.

Conclusions

An ideal sustainable agricultural system maintains and enhances human health, provides economic and spiritual benefits to producers and consumers, protects the environment, and produces adequate food for a growing global population. Abiotic stress conditions in the environment are one of the most significant restrictions to agricultural output around the planet. Plant-associated microorganisms may play a key role in conferring abiotic stress tolerance. Rhizoplane, rhizosphere, and endophytic bacteria, as well as symbiotic fungi, may work through a range of ways, including stimulating the osmotic response, giving growth hormones and nutrients, acting as biocontrol agents, and inducing novel genes in plants. The development of stress-tolerant crop varieties through genetic engineering and plant breeding is necessary, but it is a time-consuming and costly process, whereas microbial inoculation to relieve stress in plants could be a more cost-effective and environmentally friendly option that could be available in a shorter time frame. Considering the present leads, more research is needed in this area, especially in terms of field evaluation and deployment of promising organisms as bio-fertilizers in stressed soil.

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Morphological Characterization of Wheat Genotypes to Different Doses of Phosphorus Fertilizer at Seedling Stage

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Abstract

The effect of phosphorus (P) on ten wheat genotypes, WH-147, Raj-4083, WH-1021, WH-1022, WH-1025, LOK-1, NW-2030, C-306, PBW-343, and PBW-550, was evaluated with three levels of phosphorus, i.e. 20%, 50%, and 100% of the recommended dose of P, respectively, in order to identify genotypes efficient in phosphorus uptake and utilization. Pot studies in a screen house were part of the project. Root length, shoot length, number of secondary roots, and root/shoot dry weight ratio were all measured. Seven days after germination, phosphatase activity was measured. Root length, root/shoot dry weight, and the number of secondary lateral roots all grew by 20%, but shoot length fell by 20%. The presence of secondary lateral roots was discovered to be a crucial factor in P deficiency. Wheat genotypes NW 2030 and WH 1022 were shown to be superior because they were able to maintain high phosphate activity, root length, and grain production at various phosphorus levels. WH 1022 also maintained a large number of secondary roots and a high root/shoot dry weight ratio.

Key words : *Phosphorus uptake, wheat genotypes, secondary lateral roots.*

Introduction

Phosphorus (P) is the second most important nutrient for plants after nitrogen and deficiency of phosphorus is a common mineral nutritional problem in both calcareous soils and acidic soils due to formation of poorly soluble P complexes with calcium in alkaline and aluminum and iron in acidic soils (17). It is estimated that P availability to plant roots is limited in nearly 67% of the cultivated soils, causing an important constraint to crop production (18). In Haryana most of the soil is calcareous thus most of the P applied to soils to meet P demand of plants is converted into unavailable forms of P that cannot be easily used and taken up by plant roots. It is estimated that around 20% of total P fertilizer is used by the first crop, with the remaining 80% being fixed in the soil as an unavailable form (9,12). Several ways for increasing P fertilizer use in the soil-plant system have been investigated Development of plant genotypes (e.g., 'P-efficient' genotypes) with greater ability to grow and yield under P-deficient soil conditions. Plants have a variety of adaptation methods for dealing with P stress, which results in morphological, physiological, biochemical, and molecular alterations (11). Wheat crop growth and yield is significantly influenced by phosphorus (15). Early stages of wheat crop required phosphorus for proper growth and good yield of wheat crop. Adequate amount of phosphorus enhances the root growth and seedling establishment of wheat crop. Phosphorus as a basic nutrient plays a vital role from seedling to maturity stage of plant. Besides, all phonological, physiological and morphological processes

improvement it also helps to enhance quality and as well as number of seeds on a plant (16). The presence of root hairs significantly enhances the effective root surface area while having little influence on root biomass (3,8). Uptake is directly connected to root length, root surface area, root hair length, and root hair density when P levels are low (7). To increase P absorption efficiency, partitioning, and utilization, as well as other agronomic measures, a full understanding of these adaptive responses, is required, which would result in meeting the sustainability challenge of P delivery to crops (2,6). P uptake efficiency genotypes can be identified by evaluating genotypes in both low and high P circumstances. As a result, the goal of this study was to find genotypes that are good at phosphorus uptake and utilization.

Materials and Methods

WH-147, Raj-4083, WH-1021, WH-1022, WH-1025, LOK-1, NW-2030, C-306, PBW-343, and PBW-550 wheat genotypes were tested with three levels of phosphorus, i.e. 20%, 50%, and 100% of the recommended dose of P, to discover genotypes efficient in phosphorus uptake and utilization. Pot studies in a screen house were part of the project. Dry weight and length of root, shoot, number of secondary roots, and phosphatase activity were measured at 15 days after germination. Activity of Alkaline phosphatase and acid phosphatase was measured in shoot after 15 days of germination. Alkaline phosphatase activity was estimated by homogenizing wheat root in Tris-HCl buffer using chilled mortar and pestle. The homogenate was centrifuged at 16000rpm for 30minutes

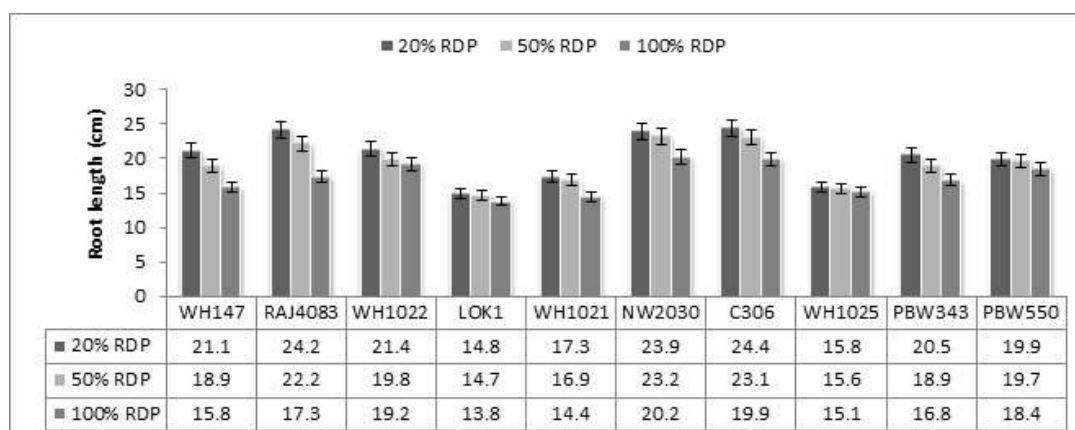


Figure-1 : Effect of different levels of phosphorus application on root length of wheat genotypes.

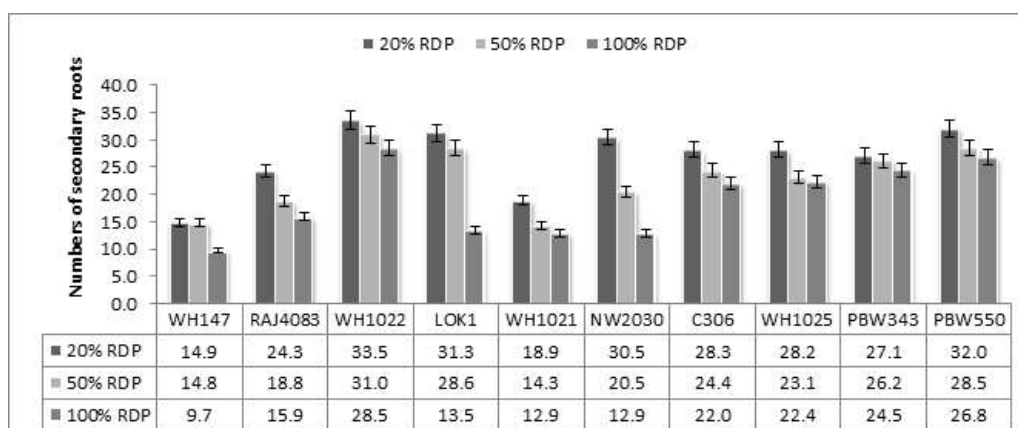


Figure-2 : Effect of different levels of phosphorus application on shoot length of wheat genotypes.

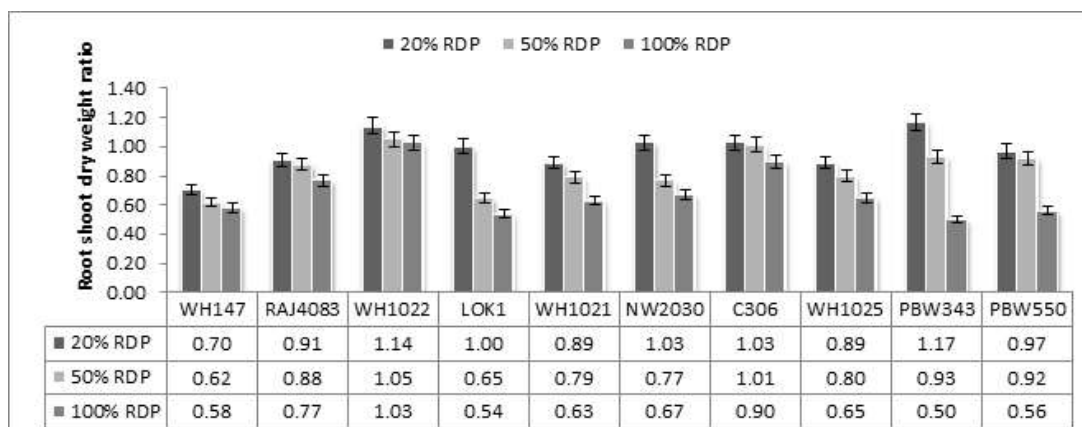


Figure-3 : Effect of different levels of phosphorus application on numbers of the secondary root of wheat genotypes.

at 0-4°C. 1ml of supernatant and 1ml of enzyme extract was incubated at 37°C for 20min. reaction was stopped with 5ml 0.1N NaOH and absorbance was recorded at 405nm and enzyme activity was estimated by using p-nitrophenol and for measuring acid phosphatase activity roots of wheat were homogenized in Tris-HCl buffer using chilled mortar and pestle. The homogenate was centrifuged at 16000 rpm for 30 minutes at 0-4°C. 1ml of supernatant and 50µl of enzyme extract was incubated at 37°C for 20 min. The solution was made alkaline with 5ml

of 0.1N NaOH to stop the reaction and absorbance was recorded at 410 nm and enzyme activity was estimated by using p-nitrophenol.

Results and Discussion

The root length of ten wheat seedlings decreased as the amount of phosphorus applied increased. The maximum root length was found at 20% P cm, followed by 50% P (19.3cm), and 100% P (19.3cm) (17.1cm). At various levels of phosphorus, Raj 4083, NW 2030, and C306 were

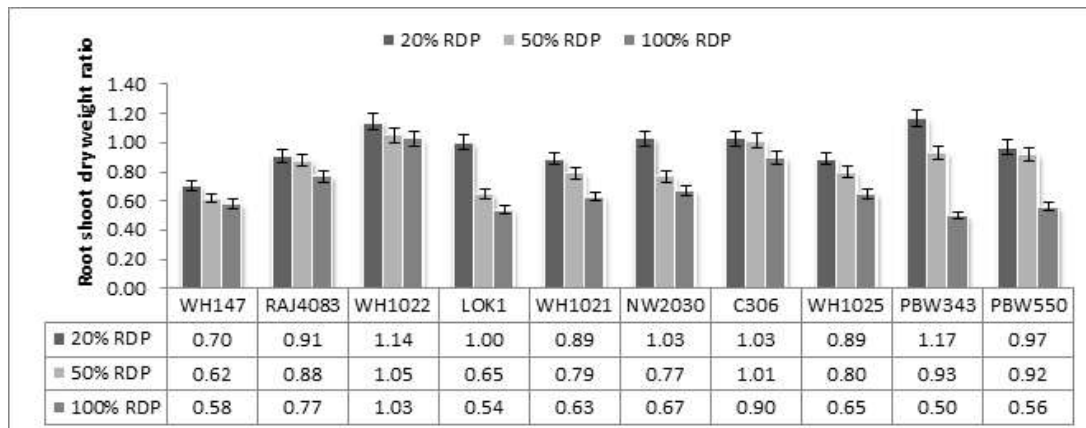


Figure-4 : Effect of different levels of phosphorus application on root shoot dry weight ratio of wheat genotypes.

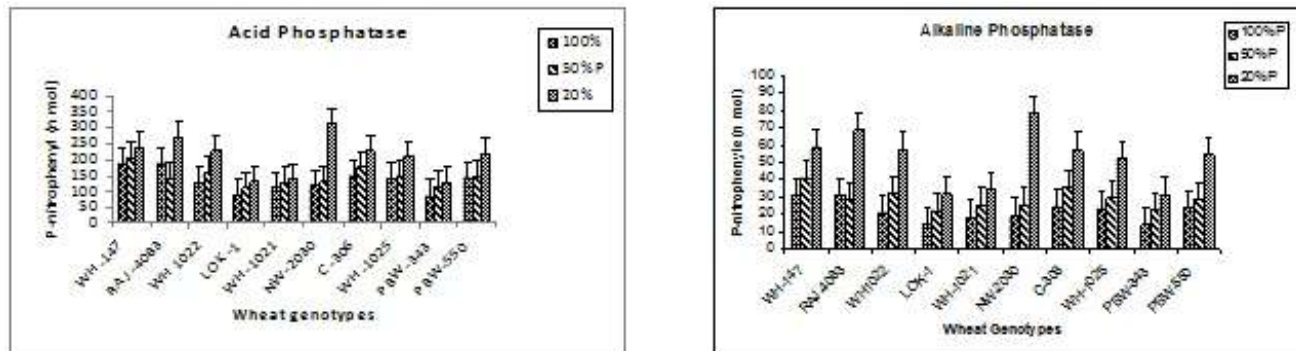


Figure-5 : Effect of different levels of phosphorus application on acid and alkaline phosphatase activity in wheat genotypes at 15 days after germination.

found to be superior in retaining root length (Figure-1). Increased phosphorus levels resulted in longer shoots. The maximum shoot length was obtained at 100% P (16.4 cm), followed by 50% P (15.2 cm), and 20% P (14.8 cm). Overall, WH 147, LOK 1, and C 306 were shown to have higher shoot length retention seven days after germination (Figure-2). The number of Secondary lateral roots decreased with increasing levels of phosphorus application. A maximum number of Secondary lateral roots was found at 20% P (20.6) application which decreased to (18.9) with 100% P application. Genotype WH1022 and PBW 550 were found superior in retaining secondary roots at different levels of phosphorus (Figure 3). Root/ Shoot dry weight ratio of ten wheat genotypes decreased with increasing level of phosphorus application. Maximum Root/ Shoot dry weight ratio was found at 20 % P application (0.97) followed by 50% P (0.84) and (0.68) at 100% P application. WH 1022 was found significant at a different level of P level (Figure 4). In diverse wheat genotypes, acid phosphatase activity increased as phosphorus levels decreased. Acid phosphatase activity was highest when 20 percent P was applied, followed by 50 percent P and 100 percent P. At a 20 percent P level, NW-2030 had the highest acid phosphatase activity, whereas at a 100 percent P level,

LOK-1, WH-1021, NW-2030, and PBW-343 had the lowest activity. The activity of alkaline phosphatase increased as the amount of phosphorus applied increased. In comparison to other genotypes, NW 2030 had the highest alkaline phosphatase activity at 20% P. At 100 percent P application, alkaline phosphatase activity was lowest in LOK 1 and PBW 343. (Figure-5).

Phosphorus absorption and utilization efficiency are influenced by root acidity (14). Secondary lateral roots would be a good criterion for choosing a phosphorus-efficient cultivar. When 10 and 20 kg P-1 were administered, the variation in phosphorus uptake and secondary root became reduced because increasing phosphorus had a detrimental influence on the secondary root (5), and similar results were reported in our investigation. Increased root/shoot ratio is thought to be significant for low-nutrient tolerance (4). Similar results were seen in our investigation, where the phosphorus efficient genotype maintained a greater root/shoot dry weight ratio during their growth under phosphorus-deficient conditions. Soil phosphatases are important in the mineralization of organic P substrates. Phosphatases are adaptive enzymes, and their activity rises as organic phosphorus compounds in plants are hydrolyzed. The

activity of phosphatases increases under phosphorus-deficient conditions, and the data reported in this study show that the activity of acid and alkaline pho increases as phosphorus decreases. Developing P-efficient plants by changing their adaptation mechanisms would be a long-term solution that would not jeopardize the environment or scarce P supplies (Elanchezhian *et al.*, 2015).

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Effect of Integrated Nutrient Management on Soil Health Parameters of Sweet Orange (*Citrus sinensis* Osbeck) cv. Mosambi

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Abstract

A trial was conducted to study the Effect of integrated nutrient management (INM) on growth, yield and quality parameters of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi was carried out during (June 2019–Nov. 2019) and (June 2020 - Nov. 2020). The experiment was conducted at Experimental area, Agrotechnology park of Krishi Vigyan Kendra, College of Agriculture, Gwalior, (M.P.). The nutrient status of the soil like pH, EC, nitrogen, phosphorus and potassium were significantly improved with application of combination of fertilizers. Minimum soil pH and EC (7.79, 7.67 and 0.296, 0.179 respectively) was obtained with application of the RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + Azotobacter (80 ml). Maximum Nitrogen (176.1, 195.2 kg ha⁻¹), Phosphorus (13.38, 14.45 kg ha⁻¹) and Potassium (208.3, 252.5 kg ha⁻¹) was obtained with application of the RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + Azotobacter (80 ml), whereas the minimum parameters were found associated with RDF (25%) + vermicompost (20 kg) (T₃).

Key words : INM, soil pH, soil EC, nitrogen, phosphorus, potassium, sweet orange.

Introduction

Citrus is one of the important fruit among all the fruit crops. It belongs to family Rutaceae and it is native to china. Citrus fruit is third largest fruit in cultivation which shares 12.5% production among all the fruit crops in India. In citrus group, major citrus species are mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*), lime (*Citrus aurantifolia*), lemon (*Citrus lemon*) and grapefruit (*Citrus paradise*). Improper and inadequate nutrition is one of the major causes of citrus decline in India (Chadha *et al.*, 1970). The response of fertilization in improving the growth, yield and fruit quality different citrus fruits is well recognized under different agro-climatic regions of the country (Ram *et al.*, 1997). Organic manure contains plant nutrients in small quantities as compared to fertilizers but they influence in building up of organic matter, good soil aggregation, permeability of soil and related physical properties to long lasting supply of several macro and micronutrients, vital plant promoting substances apart from increasing the density of microbes in the soil. This helps in the maintenance and possible improvement of soil fertility and health for sustaining crop productivity. FYM are source of primary nutrients of plants which contain 0.5% N₂O, 0.2% P₂O₅ and 0.5% K₂O. Nitrogen is essential component of amino acids, protein, nucleic acid, enzymes and alkaloids. Biofertilizers as a better

supplement can improve the quality and yield of fruit crops.

Vermicompost, which is the end product from organic matter decomposed through the vermicomposting process, is often used as soil organic fertilizer to increase crop yield because it has high humidified organic matter contents with good capacities for aeration, drainage and water holding (Tejada *et al.*, 2010), it can also be regarded a good amendment for heavy metal stabilization in soil due to its large specific surface area, high cation exchange capacity and richness in active functional groups (Ding *et al.*, 2021; Wang *et al.*, 2018).

The use of organic manures *viz.* farmyard manure, vermicompost forest litter and biofertilizers *viz.* Azotobacter, Phosphate solubilizing bacteria reduce the cost of cultivation and supplement the secondary and micronutrients to crops. Bio-fertilizers combined with organic manure influences the plant growth by enhancing root biomass; total root surface facilitates higher absorption of nutrients and increase in yield by reducing consumption of natural sources of energy. The organic fertilizers have proved that their application has the potential to increase the biomass and productivity of a wide range of crops.

Materials and Methods

The present study was conducted on 10 years old Sweet orange plants. cv. Mosambi, uniform 39 trees were selected for the experimental purpose. All the possible required cultural practices and basal application of manure and fertilizers were followed as per recommended schedules. Statistical analysis of the data was obtained by the analysis of variance method (Panse and Sukhatme, 1978).

Experimental details

The treatment combination consisting of different in organic and biofertilizers, were used to determine their nutrient status of soil of sweet orange orchards. The details of experimental plan of present investigation as per proposed technical programme are given below :

Treatments	Treatment combination
T ₀	Control (100% RDF)
T ₁	RDF (75%) + vermicompost (10 kg)
T ₂	RDF (50%) + vermicompost (15 kg)
T ₃	RDF (25%) + vermicompost (20 kg)
T ₄	RDF (75%) + vermicompost (10 kg) + PSB (80 ml)
T ₅	RDF (75%) + vermicompost (10 kg) + Azotobactor (80 ml)
T ₆	RDF (75%) + vermicompost (10 kg) + PSB (80 ml) + Azotobactor (80 ml)
T ₇	RDF (50%) + vermicompost (15 kg) + PSB (80 ml)
T ₈	RDF (50%) + vermicompost (15 kg) + Azotobactor (80 ml)
T ₉	RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + Azotobactor (80 ml)
T ₁₀	RDF (25%) + vermicompost (20 kg) + PSB (80 ml)
T ₁₁	RDF (25%) + vermicompost (20 kg) + Azotobactor (80 ml)
T ₁₂	RDF (25%) + vermicompost (20 kg) + PSB (80 ml) + Azotobactor (80 ml)

Experimental design – R.B.D. (Randomized Block Design)

Result and Discussion

The soil parameters such as soil pH, soil EC (dSm^{-1}), available nitrogen (kg ha^{-1}), available, phosphorus (kg ha^{-1}), and available potassium (kg ha^{-1}), were significantly influenced by different treatments of integrated nutrient management during both the year and pooled analysis.

The result clearly indicated that the Minimum soil pH 7.79 and 7.67 at the initial level the and final level of pooled year respectively) was recorded under the treatment T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) which was significantly superior to all the treatments under study. T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) was followed by T₆ (RDF 75% + vermicompost 10 kg) + PSB 80ml + Azotobactor 80 ml) that reported 7.80 and 7.69 respectively. the Maximum soil pH 7.86 and 7.82 at the initial level the and final level of pooled year

respectively) was recorded under T₃ (RDF 25% + vermicompost 20 kg). The observations related to soil pH in the present study have been supported by Tayeh (2003), and Marathe and bharambe (2007).

The minimum soil EC 0.296 and 0.179 at the initial level the and final level of pooled year respectively) was recorded under the treatment T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) which was significantly superior to all the treatments under study. T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) was followed by T₆ (RDF 75% + vermicompost 10 kg) + PSB 80ml + Azotobactor 80 ml) that reported 0.300 and 0.194 respectively. the Maximum soil EC 0.384 and 0.341 at the initial level the and final level of pooled year respectively) was recorded under T₃ (RDF 25% + vermicompost 20 kg).

The maximum available nitrogen in soil 176.1 and 195.2 at the initial level the and final level of pooled year respectively) was recorded under the treatment T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) which was significantly superior to all the treatments under study. T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) was followed by T₆ (RDF 75% + vermicompost 10 kg) + PSB 80ml + Azotobactor 80 ml) that reported 173.0 and 189.7 respectively. the minimum available nitrogen in soil 161.60 and 166.9 at the initial level the and final level of pooled year respectively) was recorded under T₃ (RDF 25% + vermicompost 20 kg).

The maximum available phosphorus in soil 13.38 and 14.45 at the initial level the and final level of pooled year respectively) was recorded under the treatment T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) which was significantly superior to all the treatments under study. T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) was followed by T₆ (RDF 75% + vermicompost 10 kg) + PSB 80ml + Azotobactor 80 ml) that reported 13.25 and 14.23 respectively. The Minimum available phosphorus in soil 12.47 and 12.64 at the initial level the and final level of pooled year respectively) was recorded under T₃ (RDF 25% + vermicompost 20 kg).

The maximum available potassium in soil 208.3 and 252.5 at the initial level the and final level of pooled year respectively) was recorded under the treatment T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) which was significantly superior to all the treatments under study. T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + Azotobactor 80 ml) was followed by T₆ (RDF 75% + vermicompost 10 kg) + PSB 80ml + Azotobactor 80 ml) that reported 206.4 and 245.7 respectively. the minimum available potassium in soil 181.1 and 194.2 at the initial

Table-1 : Effect of integrated nutrient management (INM) on Soil pH at initial level in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi.

Tr.	Treatments	Soil pH					
		Initial level			Final level		
		Year 1	Year 2	Pooled	Year 1	Year 2	Pooled
T ₀	Control (100% RDF)	7.89	7.78	7.84	7.83	7.71	7.77
T ₁	RDF (75%) + vermicompost (10 kg)	7.91	7.82	7.87	7.86	7.76	7.81
T ₂	RDF (50%) + vermicompost (15 kg)	7.88	7.80	7.84	7.85	7.73	7.79
T ₃	RDF (25%) + vermicompost (20 kg)	7.88	7.83	7.86	7.87	7.77	7.82
T ₄	RDF (75%) + vermicompost (10 kg) + PSB (80 ml)	7.90	7.78	7.84	7.82	7.72	7.77
T ₅	RDF (75%) + vermicompost (10 kg) + <i>Azotobacter</i> (80 ml)	7.90	7.74	7.82	7.79	7.67	7.73
T ₆	RDF (75%) + vermicompost (10 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	7.90	7.70	7.80	7.75	7.63	7.69
T ₇	RDF (50%) + vermicompost (15 kg) + PSB (80 ml)	7.89	7.77	7.83	7.81	7.71	7.76
T ₈	RDF (50%) + vermicompost (15 kg) + <i>Azotobacter</i> (80 ml)	7.86	7.77	7.82	7.81	7.71	7.76
T ₉	RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	7.89	7.68	7.79	7.72	7.62	7.67
T ₁₀	RDF (25%) + vermicompost (20 kg) + PSB (80 ml)	7.92	7.79	7.86	7.84	7.72	7.78
T ₁₁	RDF (25%) + vermicompost (20 kg) + <i>Azotobacter</i> (80 ml)	7.92	7.76	7.84	7.80	7.70	7.75
T ₁₂	RDF (25%) + vermicompost (20 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	7.90	7.72	7.81	7.77	7.65	7.71
	SEm ±	0.0797	0.0276	0.0422	0.0276	0.0276	0.0195
	CD 5%	0.2327	0.0807	0.1200	0.0807	0.0807	0.0556

Table-2 : Effect of integrated nutrient management (INM) on Electrical conductivity (dSm⁻¹) at initial level of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi.

Tr.	Treatments	Electrical conductivity (dSm ⁻¹)					
		Initial level			Final level		
		Year 1	Year 2	Pooled	Year 1	Year 2	Pooled
T ₀	Control (100% RDF)	0.396	0.296	0.346	0.293	0.291	0.292
T ₁	RDF (75%) + vermicompost (10 kg)	0.393	0.395	0.394	0.341	0.317	0.329
T ₂	RDF (50%) + vermicompost (15 kg)	0.394	0.338	0.366	0.328	0.302	0.315
T ₃	RDF (25%) + vermicompost (20 kg)	0.395	0.373	0.384	0.358	0.324	0.341
T ₄	RDF (75%) + vermicompost (10 kg) + PSB (80 ml)	0.397	0.287	0.342	0.275	0.265	0.270
T ₅	RDF (75%) + vermicompost (10 kg) + <i>Azotobacter</i> (80 ml)	0.394	0.250	0.322	0.238	0.222	0.230
T ₆	RDF (75%) + vermicompost (10 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	0.387	0.213	0.300	0.204	0.184	0.194
T ₇	RDF (50%) + vermicompost (15 kg) + PSB (80 ml)	0.398	0.276	0.337	0.265	0.255	0.260
T ₈	RDF (50%) + vermicompost (15 kg) + <i>Azotobacter</i> (80 ml)	0.394	0.234	0.314	0.223	0.209	0.216
T ₉	RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	0.395	0.197	0.296	0.187	0.171	0.179
T ₁₀	RDF (25%) + vermicompost (20 kg) + PSB (80 ml)	0.393	0.329	0.361	0.319	0.295	0.307
T ₁₁	RDF (25%) + vermicompost (20 kg) + <i>Azotobacter</i> (80 ml)	0.396	0.262	0.329	0.251	0.237	0.244
T ₁₂	RDF (25%) + vermicompost (20 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	0.390	0.228	0.309	0.218	0.224	0.221
	SEm ±	0.0021	0.0180	0.0091	0.0170	0.0212	0.0136
	CD 5%	0.0062	0.0526	0.0258	0.0496	0.0617	0.0386

level the and final level of pooled year respectively) was recorded under T₃ (RDF 25% + vermicompost 20 kg).

It has been well documented that the beneficial effects of farmyard manure and biofertilizer along with inorganic fertilizers help in improving the soil health in

terms of nutrient availability as well as by improving the soil physical and biological condition thereby, increasing the nutrient availability for the growth and developmental processes of the plant. The present findings are in accordance with the report of Sharma (2004).

Table-3 : Effect of integrated nutrient management (INM) on available nitrogen (kg ha⁻¹) at initial level in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi.

Tr.	Treatments	Available nitrogen (kg ha ⁻¹)					
		Initial level			Final level		
		Year 1	Year 2	Pooled	Year 1	Year 2	Pooled
T ₀	Control (100% RDF)	158.5	172.7	165.6	170.6	179.0	174.8
T ₁	RDF (75%) + vermicompost (10 kg)	158.2	169.0	163.6	165.6	173.0	169.3
T ₂	RDF (50%) + vermicompost (15 kg)	159.4	169.4	164.4	166.4	175.8	171.1
T ₃	RDF (25%) + vermicompost (20 kg)	158.4	165.0	161.7	162.5	171.3	166.9
T ₄	RDF (75%) + vermicompost (10 kg) + PSB (80 ml)	158.9	174.9	166.9	173.4	180.0	176.7
T ₅	RDF (75%) + vermicompost (10 kg) + <i>Azotobacter</i> (80 ml)	158.5	180.9	169.7	179.5	186.3	182.9
T ₆	RDF (75%) + vermicompost (10 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	158.8	187.2	173.0	186.3	193.1	189.7
T ₇	RDF (50%) + vermicompost (15 kg) + PSB (80 ml)	158.5	178.5	168.5	175.4	183.4	179.4
T ₈	RDF (50%) + vermicompost (15 kg) + <i>Azotobacter</i> (80 ml)	158.3	182.9	170.6	182.0	189.8	185.9
T ₉	RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	158.7	193.5	176.1	190.8	199.6	195.2
T ₁₀	RDF (25%) + vermicompost (20 kg) + PSB (80 ml)	158.1	168.7	163.4	168.5	174.7	171.6
T ₁₁	RDF (25%) + vermicompost (20 kg) + <i>Azotobacter</i> (80 ml)	158.3	179.1	168.7	178.0	184.6	181.3
T ₁₂	RDF (25%) + vermicompost (20 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	159.6	185.4	172.5	183.3	191.5	187.4
	SEm ±	1.8375	0.6937	0.9821	1.3367	0.9215	0.8118
	CD 5%	5.3634	2.0249	2.7925	3.9015	2.6898	2.3083

Table-4 : Effect of integrated nutrient management (INM) on available phosphorus (kg ha⁻¹) at initial level in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi.

Tr.	Treatments	Available Phosphorus (kg ha ⁻¹)					
		Initial level			Final level		
		Year 1	Year 2	Pooled	Year 1	Year 2	Pooled
T ₀	Control (100% RDF)	12.37	13.43	12.90	13.55	13.27	13.41
T ₁	RDF (75%) + vermicompost (10 kg)	12.40	12.92	12.66	12.99	13.07	13.03
T ₂	RDF (50%) + vermicompost (15 kg)	12.39	13.03	12.71	13.13	13.13	13.13
T ₃	RDF (25%) + vermicompost (20 kg)	12.41	12.53	12.47	12.63	12.65	12.64
T ₄	RDF (75%) + vermicompost (10 kg) + PSB (80 ml)	12.43	13.53	12.98	13.64	13.44	13.54
T ₅	RDF (75%) + vermicompost (10 kg) + <i>Azotobacter</i> (80 ml)	12.40	13.78	13.09	13.96	13.96	13.96
T ₆	RDF (75%) + vermicompost (10 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	12.42	14.08	13.25	14.21	14.25	14.23
T ₇	RDF (50%) + vermicompost (15 kg) + PSB (80 ml)	12.38	13.62	13.00	13.73	13.53	13.63
T ₈	RDF (50%) + vermicompost (15 kg) + <i>Azotobacter</i> (80 ml)	12.38	13.84	13.11	14.00	14.06	14.03
T ₉	RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	12.43	14.33	13.38	14.43	14.47	14.45
T ₁₀	RDF (25%) + vermicompost (20 kg) + PSB (80 ml)	12.42	13.52	12.97	13.61	13.41	13.51
T ₁₁	RDF (25%) + vermicompost (20 kg) + <i>Azotobacter</i> (80 ml)	12.42	13.72	13.07	13.83	13.81	13.82
T ₁₂	RDF (25%) + vermicompost (20 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	12.40	13.92	13.16	14.11	14.21	14.16
	SEm ±	0.0482	0.0320	0.0289	0.3209	0.1544	0.1781
	CD 5%	0.1406	0.0934	0.0822	0.9367	0.4506	0.5063

Table-5 : Effect of integrated nutrient management (INM) on Available Potassium (kg ha⁻¹) at initial level in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi.

Tr.	Treatments	Available Potassium (kg ha ⁻¹)					
		Initial level			Final level		
		Year 1	Year 2	Pooled	Year 1	Year 2	Pooled
T ₀	Control (100% RDF)	176.1	207.1	191.6	211.6	220.0	215.8
T ₁	RDF (75%) + vermicompost (10 kg)	178.9	191.5	185.2	196.3	202.9	199.6
T ₂	RDF (50%) + vermicompost (15 kg)	179.3	195.7	187.5	201.7	210.1	205.9
T ₃	RDF (25%) + vermicompost (20 kg)	176.8	185.4	181.1	190.8	197.6	194.2
T ₄	RDF (75%) + vermicompost (10 kg) + PSB (80 ml)	176.0	214.8	195.4	217.0	222.6	219.8
T ₅	RDF (75%) + vermicompost (10 kg) + <i>Azotobacter</i> (80 ml)	176.7	223.7	200.2	229.6	239.0	234.3
T ₆	RDF (75%) + vermicompost (10 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	175.8	237.0	206.4	241.3	250.1	245.7
T ₇	RDF (50%) + vermicompost (15 kg) + PSB (80 ml)	175.9	211.5	193.7	221.8	231.4	226.6
T ₈	RDF (50%) + vermicompost (15 kg) + <i>Azotobacter</i> (80 ml)	176.9	225.7	201.3	231.5	240.1	235.8
T ₉	RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	174.1	242.5	208.3	248.3	256.7	252.5
T ₁₀	RDF (25%) + vermicompost (20 kg) + PSB (80 ml)	175.7	202.9	189.3	207.5	214.5	211.0
T ₁₁	RDF (25%) + vermicompost (20 kg) + <i>Azotobacter</i> (80 ml)	173.8	217.8	195.8	224.7	234.5	229.6
T ₁₂	RDF (25%) + vermicompost (20 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	175.9	234.9	205.4	239.3	246.1	242.7
	SEm ±	1.9095	1.6822	1.2724	1.8932	0.9580	1.0609
	CD 5%	5.5733	4.9100	3.6180	5.5258	2.7963	3.0166

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Effect of Integrated Nutrient Management on Yield Parameters of Sweet Orange (*Citrus sinensis* Osbeck) cv. Mosambi

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Abstract

A trial was conducted to study the Effect of integrated nutrient management (INM) on growth, yield and quality parameters of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi was carried out during (June 2019–Nov. 2019) and (June 2020–Nov. 2020). The experiment was conducted at Experimental area, Agrotechnology park of Krishi Vigyan Kendra, College of Agriculture, Gwalior, (M.P.). Yield in term of total number of fruit per plant and yield of fruit per plant were significantly improved with application of combination of fertilizers. Highest number of fruits perplant (347.4) was obtained with application of the RDF 50% + vermicompost 15 kg + PSB 80ml + *Azotobacter* 80 ml as compared with RDF 25% + vermicompost 20 kg (274.3) and highest yield per plant (69.90kg) was obtained with application of the RDF 50% + vermicompost 15 kg + PSB 80ml + *Azotobacter* 80 ml as compared with RDF 25% + vermicompost 20 kg (50.81 kg).

Key words : INM, yield, sweet orange, mosambi.

Introduction

Sweet orange (*Citrus sinensis* Osbeck) is an important fruit crop which belongs to family Rutaceae and origin of Sweet orange is China. At present the citrus fruit production of India stands at 122.53 million tonnes, out of which 40.52 per cent share relates to mandarin, 26.29 per cent to sweet orange, 23.47 per cent to lime and lemon and 9.72 per cent to other citrus fruit crops (Anon., 2019). Among citrus, the sweet orange (*Citrus sinensis* Osbeck) commonly known as tight skin orange, is an important fruit crop in India. It occupies 2nd position in citrus fruits cultivated in India. Sweet orange is grown over 1.79 lakh hectare area with production of 2.88 million tonnes fruits per annum in India (Anon., 2019). While in Madhya Pradesh citrus is grown in area of 11.31 thousand ha with the production of 182.06 MT (NHB, 2017-2018). In India, it is grown in Andhra Pradesh, Maharashtra, Karnataka, Panjab, Hariyana and Rajasthan.

Nutrition in citrus plays an important role for maintaining vigour, productivity and quality fruit production for longer period. Improper and inadequate nutrition is one of the major causes of citrus decline in India (Chadha *et al.*, 1970). The response of fertilization in improving the growth, yield and fruit quality of different citrus fruits is well recognized under different agro climatic regions of the country (Ram *et al.*, 1997). Maximum fruit yield coupled with an adequate tree volume of sweet orange is attainable through combined use of organics

plus inorganic or bio-fertilizers (Marathe and Bharambe, 2007).

Vermicompost is a stable fine granular organic matter, which when added to the clay soil loosens the soil and provides passage for entry of air. The vermicompost, chiefly the faecal matter of earthworms is rich in plant nutrients, plant growth promoter and beneficial micro flora.

Azotobacter, a heterotrophic aerobic bacterium which fixes nitrogen as non-symbiotic is of wide occurrence in rhizosphere of many plants. There has been rise in the use of *Azotobacter* as biofertilizer as the ability of it to produce biologically active substances was ascertained; its effect on plants was associated with the process of nitrogen fixation and improving nitrogen of plants, as well as with the supply of biologically active compounds such as vitamins and gibberellins. Phosphorus solubilizing bacteria also increases the mobility of phosphorus nearer to the plants and make phosphorus available to plants. Use of biofertilizers for crop production is gaining momentum as they are environmentally safe when compared to chemical fertilizers in banana (Soorianathasundaram *et al.*, 2000).

Materials and Methods

The present study was conducted on 10 years old Sweet orange plants. cv. Mosambi, uniform 39 trees were selected for the experimental purpose. All the possible required cultural practices and basal application of

manure and fertilizers were followed as per recommended schedules. Statistical analysis of the data was obtained by the analysis of variance method (Panse and Sukhatme, 1978).

Experimental details

The treatment combination consisting of different in organic and biofertilizers, were used to determine their effects on yield of sweet orange fruits. The details of experimental plan of present investigation as per proposed technical programme are given below :

Treatments	Treatment combination
T ₀	Control (100% RDF)
T ₁	RDF (75%) + vermicompost (10 kg)
T ₂	RDF (50%) + vermicompost (15 kg)
T ₃	RDF (25%) + vermicompost (20 kg)
T ₄	RDF (75%) + vermicompost (10 kg) + PSB (80 ml)
T ₅	RDF (75%) + vermicompost (10 kg) + <i>Azotobacter</i> (80 ml)
T ₆	RDF (75%) + vermicompost (10 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)
T ₇	RDF (50%) + vermicompost (15 kg) + PSB (80 ml)
T ₈	RDF (50%) + vermicompost (15 kg) + <i>Azotobacter</i> (80 ml)
T ₉	RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)
T ₁₀	RDF (25%) + vermicompost (20 kg) + PSB (80 ml)
T ₁₁	RDF (25%) + vermicompost (20 kg) + <i>Azotobacter</i> (80 ml)
T ₁₂	RDF (25%) + vermicompost (20 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)

Experimental design : R.B.D. (Randomized Block Design).

Result and Discussion

The yield parameters such as number of fruit per plant and yield of fruits per plant were significantly influenced by different treatments of integrated nutrient management during both the year and pooled analysis.

The result clearly indicated that the maximum number of fruits per plant 338.8, 356.00 and 347.40 during first, second and pooled year respectively) was recorded under the treatment T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + *Azotobacter* 80 ml) which was significantly superior to all the treatments under study. T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + *Azotobacter* 80 ml) was followed by T₆ (RDF 75% + vermicompost 10 kg) + PSB 80ml + *Azotobacter* 80 ml) that reported 326.5, 338.1 and 332.3 fruits per plant during first, second and pooled year respectively. The minimum number of fruits per plant (268.2, 280.4 and 274.3 during first, second and pooled year respectively) was recorded under T₃ (RDF 25% + vermicompost 20 kg).

The maximum yield per plant (kg) (67.49, 71.74 and 69.60 kg during first, second and pooled year respectively) was recorded under the treatment T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + *Azotobacter* 80 ml) which was significantly superior to all the treatments under study. T₉ (RDF 50% + vermicompost 15 kg + PSB 80ml + *Azotobacter* 80 ml) was followed by T₆ (RDF 75% + vermicompost 10 kg) + PSB 80ml + *Azotobacter* 80 ml) that reported yield per plant (kg) of 64.30, 67.09 and 65.69 kg during first, second and pooled year respectively. The minimum yield per plant (kg) (49.53, 52.10 and 50.81 kg during first, second and pooled year respectively) was recorded under T₃ (RDF 25% + vermicompost 20 kg). The above results are in conformity with the findings of Dalal *et al.*, (2004).

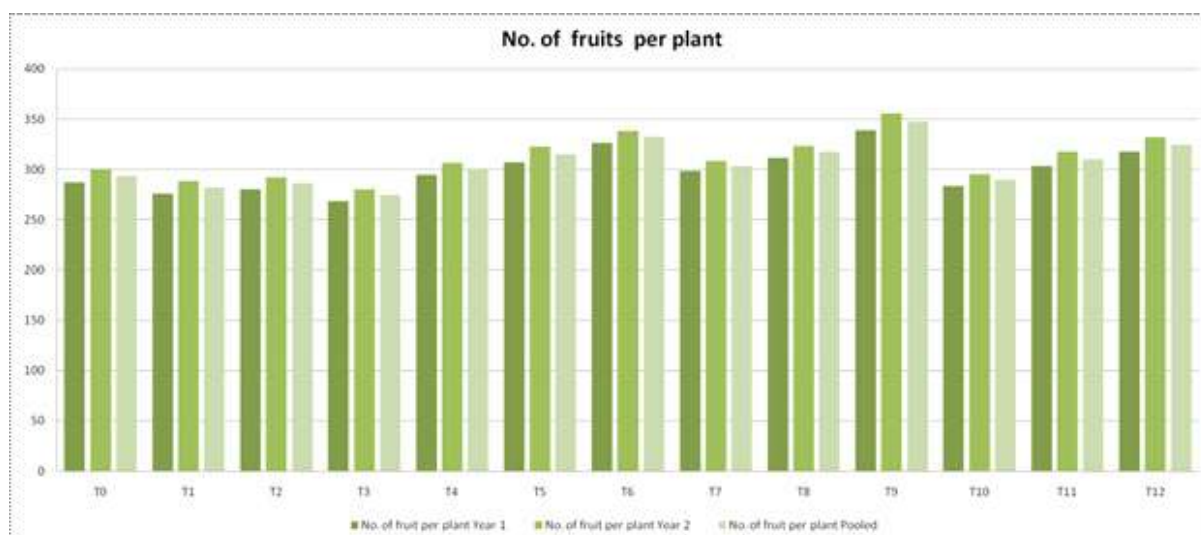
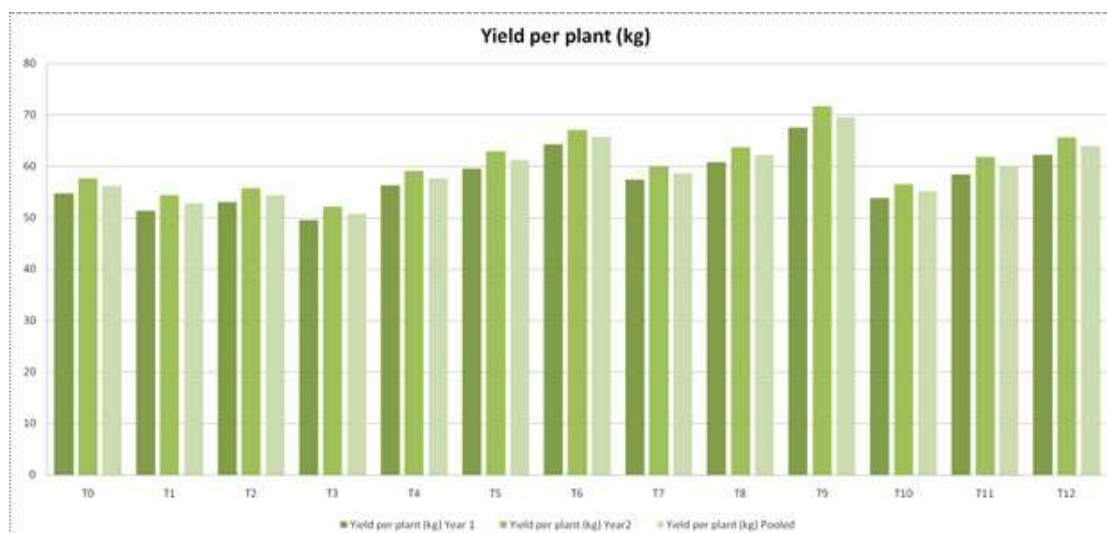
The improvement in the yield may be due to the combined application of organic and inorganic fertilizers is a result of the interaction between them which helped in increasing the soil nutrient availability and their uptake by

Table-1 : Effect of integrated nutrient management (INM) on No. of fruit per plant in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi.

Tr.	Treatments	No. of fruit per plant		
		Year 1	Year 2	Pooled
T ₀	Control (100% RDF)	287.3	299.5	293.4
T ₁	RDF (75%) + vermicompost (10 kg)	276.1	288.5	282.3
T ₂	RDF (50%) + vermicompost (15 kg)	280.4	292	286.2
T ₃	RDF (25%) + vermicompost (20 kg)	268.2	280.4	274.3
T ₄	RDF (75%) + vermicompost (10 kg) + PSB (80 ml)	294.7	306.5	300.6
T ₅	RDF (75%) + vermicompost (10 kg) + <i>Azotobacter</i> (80 ml)	307.3	322.5	314.9
T ₆	RDF (75%) + vermicompost (10 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	326.5	338.1	332.3
T ₇	RDF (50%) + vermicompost (15 kg) + PSB (80 ml)	298.4	308.4	303.4
T ₈	RDF (50%) + vermicompost (15 kg) + <i>Azotobacter</i> (80 ml)	311.6	323.4	317.5
T ₉	RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	338.8	356	347.4
T ₁₀	RDF (25%) + vermicompost (20 kg) + PSB (80 ml)	283.6	295.4	289.5
T ₁₁	RDF (25%) + vermicompost (20 kg) + <i>Azotobacter</i> (80 ml)	303	317.4	310.2
T ₁₂	RDF (25%) + vermicompost (20 kg) + PSB (80 ml) + <i>Azotobacter</i> (80 ml)	317.7	331.7	324.7
	SEm ±	1.360	1.898	2.158
	CD 5%	3.994	5.573	6.260

Table-2 : Effect of integrated nutrient management (INM) on yield per plant (kg) in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi.

Tr.	Treatments	Yield per plant (kg)		
		Year 1	Year 2	Pooled
T ₀	Control (100% RDF)	54.74	57.61	56.17
T ₁	RDF (75%) + vermicompost (10 kg)	51.36	54.35	52.85
T ₂	RDF (50%) + vermicompost (15 kg)	53.03	55.77	54.40
T ₃	RDF (25%) + vermicompost (20 kg)	49.53	52.10	50.81
T ₄	RDF (75%) + vermicompost (10 kg) + PSB (80 ml)	56.29	59.11	57.69
T ₅	RDF (75%) + vermicompost (10 kg) + Azotobacter (80 ml)	59.54	62.92	61.22
T ₆	RDF (75%) + vermicompost (10 kg) + PSB (80 ml) + Azotobacter (80 ml)	64.30	67.09	65.69
T ₇	RDF (50%) + vermicompost (15 kg) + PSB (80 ml)	57.36	59.85	58.60
T ₈	RDF (50%) + vermicompost (15 kg) + Azotobacter (80 ml)	60.84	63.71	62.27
T ₉	RDF (50%) + vermicompost (15 kg) + PSB (80 ml) + Azotobacter (80 ml)	67.49	71.74	69.60
T ₁₀	RDF (25%) + vermicompost (20 kg) + PSB (80 ml)	53.79	56.53	55.16
T ₁₁	RDF (25%) + vermicompost (20 kg) + Azotobacter (80 ml)	58.46	61.78	60.12
T ₁₂	RDF (25%) + vermicompost (20 kg) + PSB (80 ml) + Azotobacter (80 ml)	62.27	65.57	63.91
	SEm ±	0.258	0.348	0.387
	CD 5%	0.756	1.020	1.159

**Fig.-1 : Effect of integrated nutrient management (INM) on No. of fruit per plant in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi.****Table-2 : Effect of integrated nutrient management (INM) on yield per plant (kg) in sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi.**

the plants that resulted in better vegetative growth in terms of shoot length and number of leaves which have produced the higher quantum of carbohydrates needed for the development of the fruits thereby, increasing the number, size and weight of fruits which ultimately leads towards getting higher yield in these treatments. The lowest yield in treatment RDF 25% + vermicompost 20 kg (T_3) could be the result of poor vegetative growth on account of scarce nutrient availability in turn, reducing the number, size and weight of the fruits. Fruit yield and quality of citrus trees depends largely on nitrogen (N) and potassium (K) fertilization (Cantarella *et al.*, 2003 and Alva *et al.*, 2006). Fruit size increased with K supply, which was associated with increased leaf K concentration (Quaggio *et al.*, 2011).

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Synthesis and Characterization of Copper-Chitosan Nanoparticles and their Antibacterial Activity against *Pseudomonas syringae* pv. *Glycinea*

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ABSTRACT

Bacterial Blight of Soybean is caused by the bacterial agent *Pseudomonas syringae* pv. *glycinea*. It attacks all of the above-ground parts of soybean. Use of agrochemicals, pesticides and phytochemicals leads the deterioration of soil health, degradation of agro-ecosystems and environment pollution. Chitosan NPs have been investigated as a carrier for active ingredient delivery for various applications due to their biocompatibility, biodegradability, high permeability, cost-effectiveness, non-toxicity and excellent film forming ability, antimicrobial and insecticidal activities. Different metal chitosan complexes have been prepared to improve antimicrobial activity of chitosan. Copper (Cu) compounds are well known for their biocide activity and it is essential for plant growth and development. Cu-chitosan NPs have remarkable potential and act as a highly effective antibacterial agent against Bacterial Blight of Soybean at the concentration of 400ppm and 1000ppm.

Key words : Cu-chitosan, nanoparticles, ionic gelation technique, bacterial blight.

Introduction

Soybean [*Glycine max* (L.)] is one of the most important crop worldwide that provides two third of calories derived from agriculture (Ray *et al.*, 2013) and accounts for half of the global demand for oil and vegetable protein. Its continuous cultivation with simultaneous increase in area has led to increase in disease and pest occurrence. Currently, soybean is severely attacked by different major diseases, insect, pest and several weeds. Bacterial blight can be found in most soybean fields every year. Yield losses due to *Pseudomonas syringae* pv. *glycinea* have been reported as anywhere from 4%-40% depending on the severity of the conditions (Jagtap *et al.*, 2012). Bacterial blight of soybeans can enter leaves through wounds or natural openings such as stomata. After infection, small, water-soaked spots surrounded by a chlorotic halo appear on the leaves. The brown or black centers of these spots indicate that the tissue is dying. Typically these spots will enlarge and merge to form large, dead patches on the leaves. The leaves appear ragged if the dead tissue falls out. Lesions on pods are initially small and water-soaked but eventually enlarge, turn brown to black, and merge to encompass the whole pod. Infection can also occur on the stems, petioles and seeds (Zou *et al.*, 2005).

Agricultural production continues to be challenged by a large number of insect pests, diseases and weeds accounting for 40% losses per year (Pimentel *et al.*, 2009). The use of chemical substances for controlling

pathogen in soybean has been found to be effective (Allen *et al.*, 2004; Curto *et al.*, 2006; Brooker *et al.*, 2007) however long-term affect of pesticides might be vast and catastrophic on human beings, animals and soil micro-flora. Therefore, it should be regulated sincerely for protecting the ecosystem (Rai and Ingle, 2012).

Chitosan, a biopolymer of glucosamine and N-acetyl glucosamine residues, is a de-acetylated product of chitin. With the advancement of nanotechnology, chitosan based nanomaterials are being largely adapted for their exploration in plants (Shukla *et al.*, 2013). Chitosan is able to chelate various organic and inorganic compounds, making it well-suited for improving the stability, solubility and biocidal activity of chelated fungicides or other pesticides (Shukla *et al.*, 2013). Several studies showed that chitosan is not only an antimicrobial agent but also an effective elicitor of plant systemic acquired resistance to pathogens (Sharp *et al.*, 2013; Katiyar *et al.*, 2014; Xing *et al.*, 2014), enhancer and regulator of plant growth, development and yield (Gornik *et al.*, 2008; Cabrera *et al.*, 2013; Wang *et al.*, 2015).

Chitosan NPs reveal completely new or improved biological activities if compared with bulk chitosan due to altered physico-chemical characteristics like size, surface area, cationic nature, active functional groups, higher encapsulation efficiency etc (Saharan *et al.*, 2013). Chitosan NPs have been investigated as a carrier for active ingredient delivery for various applications due to their biocompatibility, biodegradability, high permeability, cost-effectiveness, non-toxicity and excellent film forming

ability (Shukla *et al.*, 2013) antimicrobial and insecticidal activities (Yin *et al.*, 2010; Zeng *et al.*, 2012; Ma *et al.*, 2013; Chen *et al.*, 2014). Chitosan NPs treatment of leaves and seeds produced significant improvement in the plant growth and innate immune response through induction of defence enzyme activity, upregulation of defence related genes including that of several antioxidant enzymes as well as elevation of the levels of total phenolics (Chen *et al.*, 2014; Chandra *et al.*, 2015).

Different metal chitosan complexes have been prepared to improve antimicrobial activity of chitosan. Various metal ions like Ag^+ , Cu^{2+} , Zn^{2+} , Mn^{2+} , or Fe^{2+} was individually loaded onto chitosan NPs for evaluation of antibacterial activity (Du *et al.*, 2009). Among these metals, Copper (Cu) compounds are well known for their biocide activity and it is essential for plant growth and development. Cu is also act as cofactor of numerous enzymes that take part in the electron transfer reactions of photosynthesis and respiration. In addition, Cu is involved in carbohydrate distribution, N_2 reduction and fixation, oxygen superoxide scavenging, ethylene sensing, cell wall metabolism, lignifications and protein synthesis. However, when Cu is present in high concentrations it is highly phytotoxic through interfering with photosynthesis, pigment synthesis and plasma membrane permeability. It causes metabolic disturbances that inhibit growth and development and initiate oxidative damage (Yruela *et al.*, 2009). Hence, Cu-chitosan complexes may serve as a reservoir for the slow release of Cu ions. The copper blending with chitosan have been developed to improve efficacy of their antibacterial (Qi *et al.*, 2004) and antifungal activities (Brunel *et al.*, 2013; Rubina *et al.*, 2017).

Materials and Methods

Synthesis of Cu-Chitosan NPs : For synthesis of Cu-chitosan NPs, a well established and reproducible method of cross linking coupled with ultra-sonication was used as described earlier (Qi *et al.*, 2004; Du *et al.*, 2009; Corradini *et al.*, 2010; Fan *et al.*, 2012; Saharan *et al.*, 2013; Saharan *et al.*, 2015; Manikandan and Sathiyabama, 2016; Choudhary *et al.*, 2017). 0.1 gm of chitosan (low molecular weight and 80% N-deacetylation, Sigma-Aldrich, St.Louis, USA) mixed in 100 ml of 1% acetic acid and stirrer at 500- 550 rpm(for 30 minutes). 0.25 gm of TPP (Sodium tripolyphosphate anhydrous, Loba Chemie) mixed in 100 ml of deionized water and stirrer (Remi Laboratory Instruments, Mumbai, India) at 500- 550 rpm (for 30 minutes). Filter the solution using whatman qualitative filter paper-1. Then chitosan solution was stirrer at 500-550 rpm. TPP solution mixed in chitosan solution with dropping rate of about 40 drops/ minute (Fig.1). Both solutions obtained as a colloidal solution.

Before finishing cross linking reaction as described above, CuSO_4 solution (0.02 gm in 10 ml) added into formulation and kept it for overnight stirring. The pellet resulting from centrifuge was suspended in deionized water by using ultra sonication with (Qsonica Missonix, USA) for 120 sec. at 4°C . It was repeated three times and the precipitated pellet was lyophilized (Freeze dryer with concentrator, LabTech) and stored at 4°C for further use.



Fig.-1: Scale up synthesis of Cu-chitosan Nanoparticles.

Characterization of Cu-chitosan NPs : Developed Cu-chitosan NPs were characterized for mean size, size distribution, functional group analysis and surface morphology by particle size analyzer (DLS: Dynamic Light Scattering), Fourier Transform Infra Red (FTIR), Transmission electron microscopy (TEM) and Scanning electron microscopy (SEM) through standardized methods (Saharan *et al.*, 2013; Saharan *et al.*, 2015). Elemental analysis of Cu-chitosan NPs was gauged by energy dispersive spectroscopy (SEM-EDS).

Dynamic light scattering (DLS) measurements : DLS was used for measurement of average particle size, polydispersity index (PDI) and zeta potential of nanoparticles on high performance particle zetasizer (ZS90, Malvern, UK). The sample was analyzed in triplicate at 25°C at a scattering angle of 90° . Deionized water was used as a reference for dispersing medium. The results are given as the average particle size obtained from the analysis of three different batches, each of them measured three times.

Fourier transforms infrared (FTIR) analysis : To confirm the synthesis of various nanoparticles, FTIR analysis was done. The results were recorded by ALPHA FT-IR spectrometer combined with Quick Snap™ (Bruker, Germany). FTIR spectroscopy is based on the chemical

bonds in a molecule that vibrate at characteristic frequencies depending on the elements and types of bonds. During FTIR measurements, a spot on the specimen is subjected to a modulated IR beam. The specimen's transmittance and reflectance of the infrared radiation at different frequencies is measured and translated into an IR absorption plot.

Transmission electron microscopy (TEM) : The nanocomposites were first diluted in ultrapure water (0.05 mg / ml, w/v), after which a negative staining technique was applied (Ottaviani *et al.*, 2000). In this technique, the diluted suspension was mixed with 2% uranyl acetate solution; a drop of the mixture was deposited onto a standard copper grid covered by a holey carbon film and dried at ambient temperature before observation. TEM micrographs were obtained using a FEI Spirit TEM (Hillsboro, USA) operated at 120 kV using 400-mesh Formvar[®]carbon-coated copper grid.

Scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS) observation : Scanning electron microscope was used to study the surface morphology of Cu-chitosan NPs. The samples were dried by critical point drying (CPD, *Emitech* K850) and mounted on aluminium stubs with double sided carbon and then coated with gold palladium using a sputter coater model SC7620 (*Emitech*). The images were then recorded in high vacuum mode using a Zeiss EVO MA10 scanning electron microscope (*Carl Zeiss Promenade*, Jena, Germany) between 400 X – 29.70 KX magnification at 20 kV EHT (Rejinolda *et al.*, 2011) . Elemental analysis of nanoparticles were carried out by Zeiss EVOMA10 scanning electron microscope equipped with energy dispersive X-ray spectroscopy elementary analyzer (EDS, *Oxford Instruments*) using analytical software QUANTAX 200.

Bacterial strain and inoculums preparation : Bacterial strain of *Pseudomonas syringae* pv. *glycinea* was obtained from Department of Pathology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology.

Growth medium : For the preparation of inoculums, a loopful of the stock culture were transfer in 50 ml of Luria Bertani broth and incubate at 37^o C on shaker (120 rpm) a loopful of the stock culture was transfer in 50 ml of Luria Bertani broth and incubate at 37^o C on shaker (120 rpm). OD was measured at 660 nm at various time duration (0, 12, 24, 36 and 48h). Then 100 μ l bacterial suspension were collected from appropriate growth inoculum and added to sterile test tubes containing LB Broth supplemented with different concentration of Cu-chitosan NPs viz. 100 ppm, 400 ppm, 600 ppm and 1000 ppm along

with control (without treatment) Bulk controls (Cu and chitosan). Bacterial growth was assessed by measuring OD at 660nm at various time duration (0, 12, 24, 36 and 48 h). At appropriate growth of test sample, test sample were collected and serial diluted to achieve countable colony number.

Inoculation procedure : Further, 50 μ l of diluted test sample was spread on 90 mm petri-plates containing King's medium B Base (King *et al.*, 1954). Colony numbers were counted after incubation of the plates for 24 hr in incubator at 29 $\pm$ 1 $^{\circ}$ C. CFU/ ml were calculated using the equation given below :

$$\text{CFU} = \frac{\text{Colony no.}}{\text{Plated sample (ml)}} \times \text{dilution factor}$$

Results and Discussion

Synthesis of Cu-Chitosan NPs : Cu-chitosan NPs was prepared by interaction of TPP anion with cationic chitosan and further chelating of copper ions using ionic gelation method (Jaiswal *et al.*, 2012; Saharan *et al.*, 2015). Chitosan has inter and intra-molecular hydrogen bonding. Chitosan molecules in aqueous adopt extensive flexible structures due to the electrostatic repulsion between the chains. In diluted acetic acid, chitosan and TPP spontaneously formed dense micro-nano complex. Under specific intensity of ultrasonic waves, cavitations generated by ultrasonication reorganize the complex and convert the micro complex into nano complex. Cu-chitosan NPs prepared in the present study exhibit a white crystal powder and appeared a semi transparent colloidal in aqueous. Cu-chitosan NPs were prepared by the interaction of oppositely charged macromolecules (chitosan and TPP) using ionic gelation method (Qi *et al.*, 2004; Du *et al.*, 2009; Corradini *et al.*, 2010; Fan *et al.*, 2012; Saharan *et al.*, 2013; Saharan *et al.*, 2015; Manikandan and Sathiyabama, 2016).

Characterization of Cu-chitosan NPs : DLS was used for the measurement of mean particles size, polydispersity index (PDI) and zeta potential of Cu-chitosan NP. The size distribution profile, shown in Fig.-2A, represents mean hydrodynamic diameter of Cu-chitosan NP, 295.4 $\pm$ 2.8nm. The PDI value 0.28 indicated monodisperse nature of Cu-chitosan NP. Zeta potential of Cu-chitosan NP (+ 19.6 mV, Fig. 2B) showed overall positive charge, which is important parameter for the stability and higher affinity towards biological membranes (Qi *et al.*, 2004; Du *et al.*, 2009; Saharan *et al.*, 2013; Saharan *et al.*, 2015). In present study, mean hydrodynamic diameter of Cu-chitosan NPs was 295.4 nm. The lower PDI value (0.28) specified the monodisperse nature of Cu-chitosan NP. In present study, + 19.6 mV zeta potential was recorded, which indicate overall positive charge on the

surface of NPs. The positive zeta potential significantly influences particle stability in suspension through the electrostatic repulsion between the positively charged nanoparticles. Thus the nanoparticles remain separated in the suspension and formulation become stable. In addition, positively charged nanoparticles have more affinity towards the negatively charged biological membranes. Therefore nanoparticles express more biological interaction in living system. It also signifies for more antimicrobial activities (Qi *et al.*, 2004; Du *et al.*, 2009; Saharan *et al.*, 2013; Saharan *et al.*, 2015). Charged nanoparticles have been reported to induce the foundation of new and longer pore by interacting with negatively charged macromolecules of biological membranes of fungi and bacteria, thus act as strong antimicrobial agents.

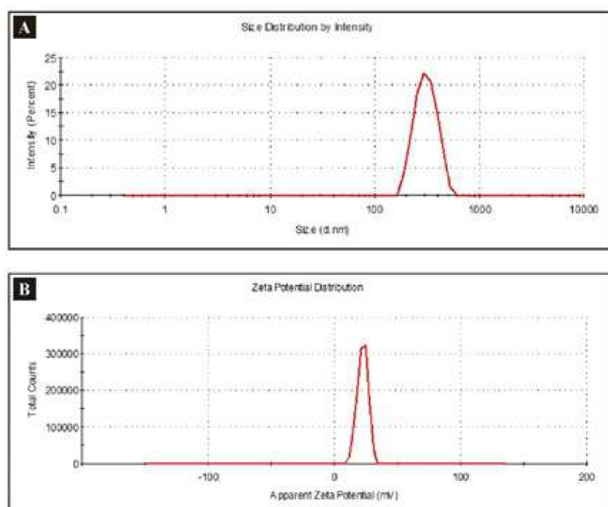


Fig-2 : DLS analysis of Cu-chitosan NPs (A) Size distribution by intensity and (B) Zeta potential distribution.

Fourier Transforms Infrared (FTIR) Analysis : FTIR analysis was performed to confirm the interaction of chitosan, TPP and Cu. In bulk chitosan a specific peak at 3424 cm^{-1} corresponds to the combined peaks of the -NH_2 and -OH group stretching vibration. The band at 1647 cm^{-1} is attributed to the CO-NH_2 group. The 1597 cm^{-1} peak of the -NH_2 bending vibration is sharper than the peak at 1647 cm^{-1} , which shows the high degree of deacetylation of the chitosan (Fig. 3A). The peaks at 1647 cm^{-1} (-CONH_2) and 1597 cm^{-1} (-NH_2) in the spectrum of Cu - chitosan NP was sharper and shifted to 1643 and 1539 cm^{-1} . Therefore, Cu interaction with chitosan induces redistribution of vibration frequencies (Fig. 3B). FTIR spectroscopy used infra-red waves which induce vibration in the chemical bonds and due to this vibration the presence and absence of functional group in sample could be examined. In present study, FTIR analysis was performed to confirm the interaction of chitosan, TPP and

Cu. In bulk chitosan specific peaks at 3424 cm^{-1} and 1647 cm^{-1} corresponds to the combined peaks of the -NH_2 , -OH group stretching vibration and CO-NH_2 group were observed. In Cu - chitosan NP spectrum, the peaks at 1647 cm^{-1} (-CONH_2) and 1597 cm^{-1} (-NH_2) were sharper and shifted to 1643 and 1539 cm^{-1} . Therefore, FTIR study showed redistribution of vibration frequencies in Cu-chitosan NP in compared to bulk chitosan and these results were in line with earlier findings (Saharan *et al.*, 2013; Saharan *et al.*, 2015; Choudhary *et al.*, 2017).

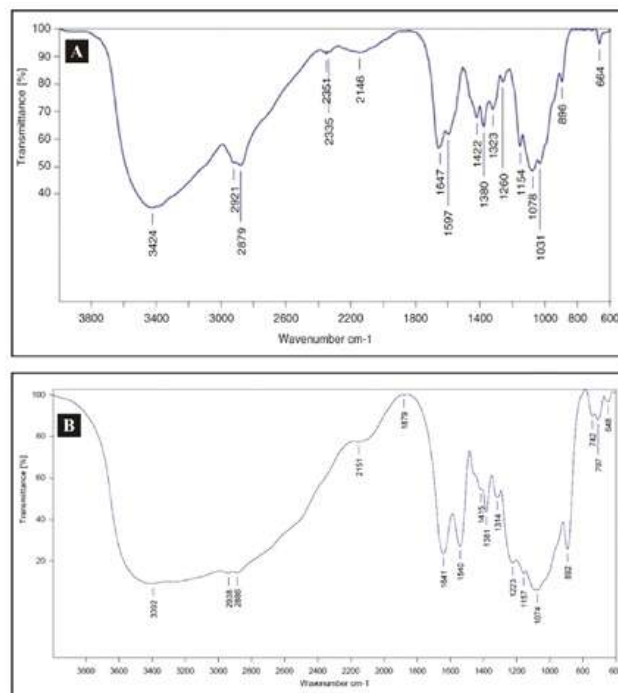


Fig-3 : FTIR spectra (A) Bulk chitosan and (B) Cu-chitosan NPs.

TEM and SEM Analyses : Actual behaviour of nanoparticles in aqueous suspension comes only through TEM study. Sphere-shaped (Fig.-4A) NP along with network of pores (Fig.-4B) verified by TEM. Further nano-organization of Cu-chitosan NP was confirmed by SEM micrograph. Cu-chitosan NP possess homogenous crystalline morphology at lower magnification (Fig. 5A). Whereas, highly porous structure (like barred enclosure) was displayed at higher magnification. Micro and nanoscale size pores were observed as per SEM micrograph (Fig.-5B). TEM micrograph confirmed the nano-organization of synthesized materials. Spherical shaped Cu-chitosan NP in range of $100\text{-}500\text{ nm}$ was observed under TEM study. TEM results obtained in present study, was found similar to earlier report, where Cu-chitosan NP showed highly porous network of chitosan nanomaterials (Saharan *et al.*, 2015).

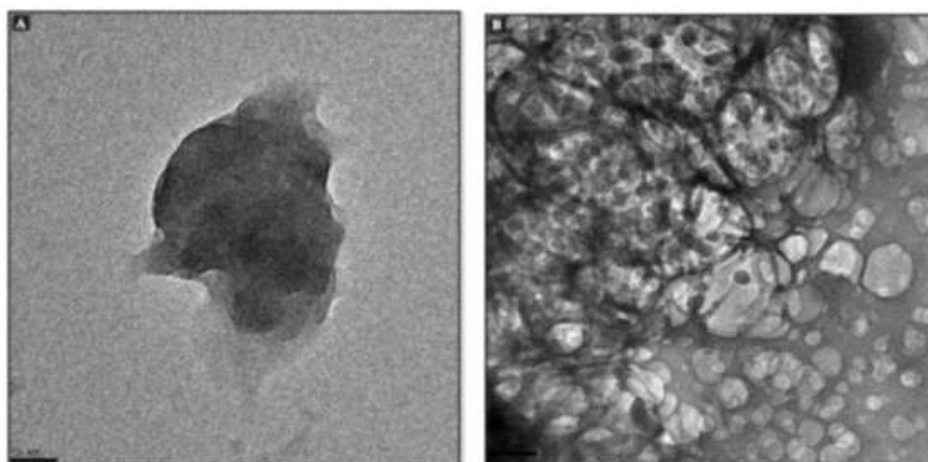


Fig.-4 : TEM images of (A) Sphere shaped Cu-chitosan NCPs and (B) Porous Cu-chitosan NPs.

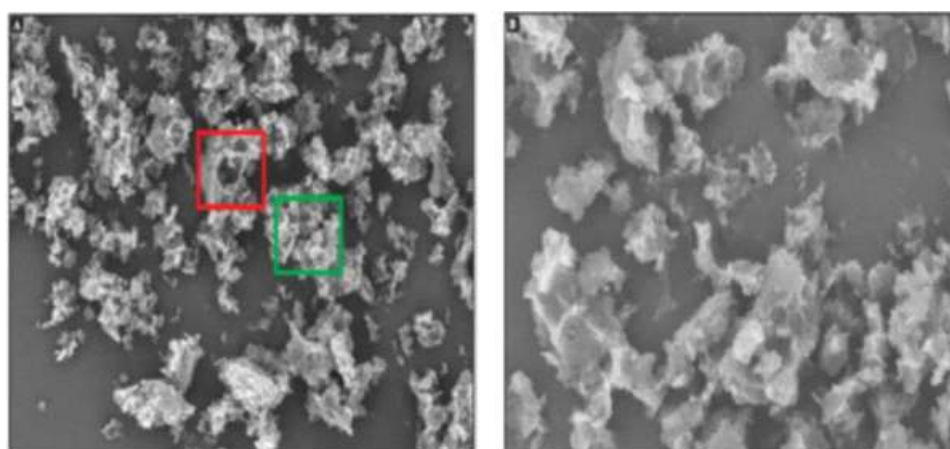


Fig.-5 : SEM micrographs (A) Cu-chitosan NCPs at 9.2 mm $\times$ 1.00 K and (B) Porous Cu chitosan at 9.2 mm $\times$ 3.00K revealed nano (in green rectangular) and micro size pores (in red rectangular).

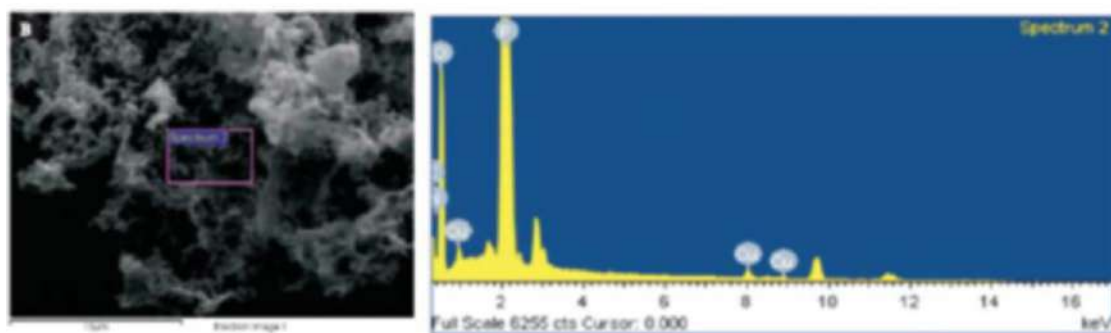


Fig.-6 : SEM-EDS elemental analysis of Cu-chitosan NCPs (A) Spectra of non-porous surface and (B) porous surface.

SEM-Energy Dispersive X-ray Spectroscopy (EDS)

Analysis : In addition to SEM, energy-dispersive X-ray spectroscopies (EDS) of different spots on the samples were taken for determining the elemental composition of Cu-chitosan NP. Energy dispersive X-ray spectroscopy analysis revealed the presence of chitosan+ TPP (as C, O, P and N) and Cu in the NP (Fig.-6A and B; Table-1). EDS analysis at porous surface of Cu-chitosan NP as shown more Cu deposition compared to spectra of non porous

surface. EDS study confirmed the presence of chitosan and Cu in the prepared NP. In present study SEM micrograph of Cu-chitosan NP elucidate well organized spongy porous surface at 9.2mm $\times$ 1.00K (Jaiswal *et al.*, 2012). Presence of Cu in chitosan NP was confirmed by SEM-EDS. EDS spectra at porous and non porous surface of chitosan NPs manifest higher and lower Cu deposition. In present study EDS spectrum undoubtedly explain the mechanism described earlier (Qi *et al.*, 2004), in which Cu sorption could be understood by

Table-1 : Elemental analysis of Cu-chitosan NP.

Elements	At porous spot		At non porous spot	
	Weight %	Atomic %	Weight %	Atomic %
C	54.43	63.02	43.75	52.78
O	30.19	26.24	35.15	31.83
P	6.19	2.78	9.8	4.58
N	7.69	7.63	10.20	10.55
Cu	1.51	0.33	1.09	0.25
Totals	100.00			

ion-exchange resins and surface chelating into porous nanomaterials.

Antibacterial activity : The tasted Cu-chitosan NPs differ in concentration of Cu-chitosan and Cu content. Concentration 1000ppm of Cu-chitosan NPs is more effective followed by 400ppm and 600ppm concentrations against *Pseudomonas syringae* pv. *glycinea*. 100ppm concentrations show lowest antibacterial activity (fig.-7, 8 and table-2).

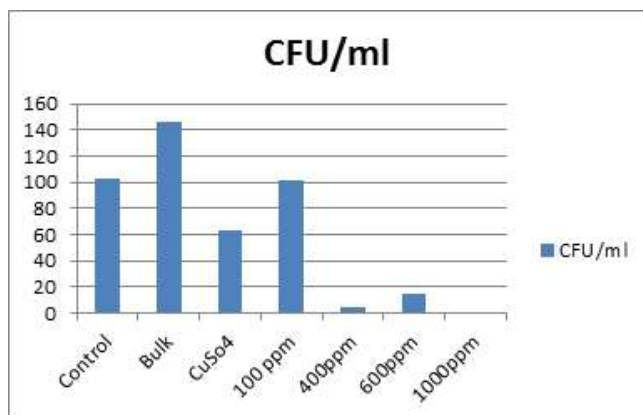


Fig-7 : Effect of Cu-chitosan NPs on bacterial colony forming units.

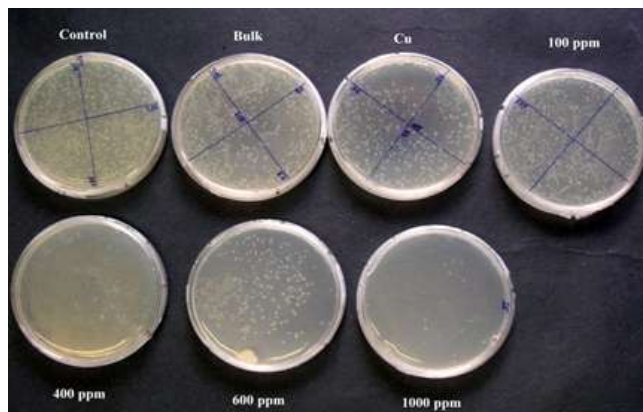
Fig-8 : Antibacterial activity of different concentrations of Cu-chitosan NPs (100, 400, 600 and 1000 ppm) with control, bulk chitosan and Cu against *in vitro* bacterial colony number of *Pseudomonas syringae* pv. *glycinea*.

Table-2 : CFU/ml in different concentrations of Cu-chitosan NPs (100, 400, 600 and 1000 ppm) with control, bulk chitosan and Cu.

Treatment	CFU/ml
Control	103
Bulk	146
CuSO ₄	63.2
100 ppm	102
400 ppm	5
600 ppm	14
1000 ppm	0

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Impact of Irrigation Levels and Nitrogen Fertigation on Yield Attributes and Seed Production of Coriander (*Coriandrum sativum* L.) Varieties

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Abstract

The present study was carried out at Vegetable Research Farm, CCS Haryana Agricultural University, Hisar to study the effect of irrigation and nitrogen fertigation on yield attributes and production of coriander (*Coriandrum sativum* L.) varieties. The application of irrigation scheduled at 1.2 IW/CPE recorded significantly higher values of yield attributes and seed yield of coriander over other irrigation scheduling. Nitrogen levels 70 kg ha⁻¹ recorded significantly maximum yield attributes and seed yield which was statistically at par with nitrogen applied at 60 kg ha⁻¹. Among different varieties, significantly higher yield attributes of coriander were recorded with Hisar Bhumit, while the maximum seed yield of coriander were obtained in Hisar Sugandh. Therefore, Hisar Sugandh found to be superior with respect to yield attributes and yield of coriander when grown at irrigation scheduling at 1.0 IW/CPE and 60 kg/ha of nitrogen level in western region of Haryana.

Key words : Irrigation, nitrogen levels, seed yield, coriander.

Introduction

Coriander (*Coriandrum sativum* L.) a member of *Apiaceae* family, also known as *cilantro* or *dhania*, is one of the earliest herbaceous annual spices used by mankind (Luayza *et al.*, 1996). It is a small bushy herb, thin-stemmed, much branches, grows about 25 to 50 cm tall with alternate and compound leaves, which become highly segmented and linear as they reach upper extremities. Coriander fruits are potentially an important source of petroselinic acid, which has numerous industrial uses (Msaad *et al.*, 2009). All parts of the plant are edible but the fresh leaves and the dried seed powder are most commonly used in cooking for adding taste and flavouring the foodstuff. Its fruits are also known for their medicinal properties and considered carminative and diuretic.

Coriander is native to Mediterranean region, but nowadays, it's grown worldwide mostly in Morocco, Russia, United States of America, Italy, India and Japan. India is known as the "Land of Spices". In India, it is mainly cultivated in Rajasthan, Madhya Pradesh, Gujarat, Andhra Pradesh, Haryana, Punjab and West Bengal. Rajasthan and Madhya Pradesh are the two largest coriander producing states contributing about 80 per cent of total production and tagged with largest producer, consumer as well as exporter of spices and spice products in the world. Out of total 63 spices grown in India, seed spices contribute about 36 per cent and 70 per

cent share in area and production of total spices, respectively (Mishra *et al.*, 2016). In India, it is cultivated on an area of 704 thousand ha with the production of 900 thousand metric tonnes. The average productivity of coriander in India is around 0.9 metric tonne per ha (Anonymous, 2018).

India is exporting about 14 per cent of its production annually and fulfills nearly 50 per cent of world demand (Spices Board of India). In India, coriander is mostly cultivated as rain fed crop but there is an immense potentiality to increase the production of this crop with assured irrigations. Irrigation plays an important role in the plant growth, increase yield and quality of coriander. Rising water crisis and need to produce more food per drop of water requires some efficient irrigation methods to enhance water productivity.

Superiority of drip irrigation in terms of water saving and increased yield along with other benefits over conventional irrigation methods is proved by research evidences (Pandey *et al.*, 2013). Drip Irrigation is also known as trickle irrigation. It is efficient method of application of water in which, the water is applied at low rate over long period of time at frequent intervals with low-pressure delivery system, in order to avoid water stress to the plant. The requirement of water by the crop depends predominantly on the edaphoclimatic condition; however, the uniform and continuous supply of water is desirable (Thamburaj and Singh, 2004). In this context,

inadequate irrigation management stands out among the limiting factors for the cultivation and production of this spice. Reduction in water consumption varies from 30 to 70 per cent with drip method over the surface method of irrigation for different crops (Lal et al., 2013).

In agriculture, water and nutrients are the two most critical inputs and their efficient management is important not only for higher productivity but also for maintaining environmental quality. 'Fertigation' is the technique of supplying dissolved fertilizer to crops through an irrigation system. The correct quantity of fertilizers and irrigation application not only increase the yield but also improve the quality and minimize the cost of production, which is the need of the day. Water and nutrient use is related to water use efficiency, which is expected to be increased under fractional management, as evidenced by Almeida et al. (2015). The production of a crop is controlled by many factors of which the mineral nutrition especially nitrogen is the most important factor. Excess or imbalanced use of nitrogen may reduce the seed yield and quality or deteriorate the soil health to a great extent (Angeli, 2016).

Therefore, keeping in view the above facts, the present investigation was conducted to study the Effect of irrigation and nitrogen fertigation on yield attributes and seed production of coriander (*Coriandrum sativum* L.) varieties.

Materials and Methods

The present experiment to study the effect of irrigation and nitrogen fertigation on yield attributes and production of coriander (*Coriandrum sativum* L.) varieties" was conducted for two years during 2017-18 and 2018-19. The experiment was carried out at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana. Hisar is situated between 29°10' North latitude and 75°46' East longitudes and 215.2 meter above mean sea level. The climate of Hisar is characterized by semi-arid climate. Hot and dry winds during summer and dry severe cold in winter are the common features of this region. The mean maximum and minimum temperature shows a wide range of fluctuation. The average rainfall is around 400 mm, most of which is received from South-West monsoon during July to September. The experiment was laid out in split-split plot design with three replications. Experiment consists of forty eight treatment combinations. The treatments comprising of three varieties (Hisar Bhumit, Hisar Anand and Hisar Sugandh) in main plot, four irrigation levels (0.6, 0.8, 1.0 and 1.2 IW/CPE ratio) in sub plot and four nitrogen levels (nitrogen 40, 50, 60 and 70 kg/ha) in sub-sub plot were laid out in split-split plot design replicated thrice.

After the harvest of previous crop, land was ploughed once with mould board plough and was brought to fine tilth by repeated harrowings. The residues of previous crop and weeds were removed from experimental area. Farmyard manure was incorporated @ 20 t/ha in soil before ploughing the field, and then the experimental field was prepared by three harrowing each followed by planking to prepare suitable seed bed. The fertilizers were applied as per the treatment combinations. Nitrogen was applied in the form of urea and phosphorus in the form of single super phosphate (SSP). Half dose of nitrogen and full dose of phosphorus was applied according to the treatments at the time of sowing as basal dose. The remaining half dose of nitrogen was applied in three split doses after 30 days after sowing through drip fertigation for about 15 days interval at the time of next immediate irrigation. Pre-sowing irrigation (40 mm) was given before the land preparation for better germination of the seeds. Drip irrigation system was used for irrigation and fertigation in the crop. Irrigation through drip was applied on the basis of cumulative pan evaporation of 0.6, 0.8, 1.0 and 1.2 IW/CPE. The total volume of water required per plot was calculated on the basis of area to be irrigated. In drip system, water is delivered to the crop using a network of main lines, sub-mains and lateral lines with emission points spaced along their length. Lateral were laid out at 60 cm spacing (in between each pair row) and at 30 cm spacing drippers. Time of irrigation was decided on the basis of total volume of water required per plot, number of drippers per lateral and discharge per dripper. The required pressure and discharge in drip system was maintained with overflow valve with the supply source.

The seeds of the varieties were procured from the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar. The seed was sown on the raised bed 3.0 m length and 1.2 m width. Four rows were sown on each bed with spacing at 30 cm. To get optimum plant population, thinning operation was carried out when the plants attained a height of 10 cm and bearing 3-4 leaves to keep the distance 20 cm apart by removing weak and unhealthy seedlings. Only one plant was maintained per hill. The necessary aftercare operations such as irrigation, hand weeding and inter-cultivation were attended when required. Harvesting was done from each plot and piled into small stacks in the field for 3-4 days drying. The seeds were separated by beating plants on threshing floor and thereafter cleaned, winnowed and dried again in sunlight before storing.

Total number of umbels emerging from five tagged plants in each plot were counted at the time of harvesting and averaged. Five umbels were selected from the

tagged plants at harvest and total umbellets in each umbel were counted at the time of harvesting. Then the average umbellets per umbel were worked out. Total seeds from five selected umbels of the tagged plants in each plot at harvesting time were counted at the time of harvesting and averaged. The seeds from five selected umbellets of primary umbels of tagged plants of each plot were counted at the time of harvesting and averaged. All the umbels from five selected plants of each treatment were harvested, dried under shade and threshed. The average weight of cleaned seeds from five plants was recorded as seed yield per plants in gram. The seed yield of each treatment plot was weighed on electronic balance machine and was expressed as seed yield per plot in kilograms per plot and then it was converted to seed yield in kilograms per hectare.

The concept of the split-plot design is easily extended to three factors. In split-split plot levels of Factor V (varieties) are assigned to main plots, levels of Factor I (irrigation) to subplots within each main-plot, and levels of Factor N (nitrogen) to sub-subplots within each subplot. The experimental data for various yield attributes and seed yield were statistically analyzed by the methods of analysis of variance (ANOVA) as described by Panse and Sukhatme (1985).

Results and Discussion

Significant effect of irrigation levels and nitrogen doses was observed on yield attributes and seed yield of coriander in different varieties. The data is interpreted in the form of results under the following headings :

Number of umbellets per umbel : The data on number of umbellets per umbel (Table-1) clearly revealed that varieties, irrigation and nitrogen levels significantly influenced the number of umbellets per umbel of coriander at harvest during both the years. Among irrigation levels, significantly maximum number of umbellets (7.11 and 7.27) per umbel was recorded in coriander treated with irrigation level at 1.2 IW/CPE, which was statistically at par with coriander treated with irrigation level at 1.0 IW/CPE (7.03 and 7.19), whereas, the minimum number of umbellets (6.51 and 6.66) per umbel was recorded in coriander treated irrigation at 0.6 IW/CPE during 2017-18 and 2018-19, respectively. Similarly pooled number of umbellets per umbel of two years also followed the same trend and significant maximum number of umbellets (7.19) per umbel was recorded in coriander treated irrigation at 1.2 IW/CPE, which was statistically at par with coriander treated with irrigation level at 1.0 IW/CPE (7.11).

In studying the effect of nitrogen fertigation, significantly maximum number of umbellets (7.16 and 7.22) per umbel was recorded in coriander treated with

nitrogen at 70 kg/ha, which was statistically at par with coriander treated with nitrogen at 60 kg/ha (7.08 and 7.16) during 2017-18 and 2018-19, respectively. Whereas, the minimum number of umbellets (6.39 and 6.60) per umbel was recorded in coriander treated with nitrogen at 40 kg/ha during 2017-18 and 2018-19, respectively. Similarly, pooled number of umbellets per umbel of two years also followed the same trend and significantly maximum number of umbellets (7.19) per umbel was recorded in coriander treated nitrogen at 70 kg/ha over, which was at par with coriander treated nitrogen at 60 kg/ha (7.12). Whereas among varieties, significantly maximum number of umbellets (7.26 and 7.39) per umbel of coriander were recorded in Hisar Bhumit followed by Hisar Sugandh (6.90 and 7.05) during 2017-18 and 2018-19, respectively and pooled data of two years also showed the same trend of significantly maximum number of umbellets per umbel in Hisar Bhumit (7.33) over other varieties *i.e.* Hisar Sugandh (6.97) and Hisar Anand (6.44).

Number of umbels per plant : The data regarding to number of umbels per plant (Table-1) shows that varieties, irrigation and nitrogen levels significantly influenced the number of umbels per plant of coriander during both the years. Among irrigation levels, significantly maximum number of umbels (50.77 and 52.45) per plant were recorded in coriander treated with irrigation level at 1.2 IW/CPE, which was at par with coriander treated with irrigation level at 1.0 IW/CPE (50.46 and 52.11), whereas, the minimum number of umbels (46.66 and 48.25) per plant of coriander was recorded in coriander treated irrigation at 0.6 IW/CPE during 2017-18 and 2018-19, respectively. Also pooled number of umbels per plant of two years also followed the same trend and significant maximum number of umbels (51.61) per plant was recorded in coriander treated irrigation at 1.2 IW/CPE, which was at par with coriander treated with irrigation level at 1.0 IW/CPE (51.28). The next irrigation levels recorded significantly reduced number of umbels per plant.

As regard to the effect of nitrogen levels, significantly maximum number of umbels (52.54 and 54.38) per plant were recorded in coriander supplied with nitrogen at 70 kg/ha, which was statistically at par with coriander treated with nitrogen at 60 kg/ha (52.19 and 53.61) during 2017-18 and 2018-19, respectively. Whereas, the minimum number of umbels (42.95 and 44.61) per plant were recorded in coriander treated with nitrogen at 40 kg/ha during 2017-18 and 2018-19, respectively. Similarly, pooled number of umbels per plant of two years also followed the same trend and significantly maximum number of umbels (53.46) per plant were recorded in coriander treated nitrogen at 70 kg/ha over all the other nitrogen treatment.

Table-1 : Effect of irrigation levels and nitrogen fertigation on number of umbellets per umbel and number of umbels per plant of different coriander varieties.

Treatment	Number of umbellets per umbel			Number of umbels per plant		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties						
V ₁ : Hisar Bhumit	7.26	7.39	7.33	53.22	54.86	54.04
V ₂ : Hisar Anand	6.35	6.53	6.44	45.59	47.30	46.45
V ₃ : Hisar Sugandh	6.90	7.05	6.97	48.50	50.10	49.30
CD at 5%	0.20	0.17	0.19	1.32	1.60	1.46
Irrigation scheduling						
I ₁ : Irrigation at 0.6 IW/CPE	6.51	6.66	6.59	46.66	48.25	47.46
I ₂ : Irrigation at 0.8 IW/CPE	6.70	6.84	6.77	48.53	50.21	49.37
I ₃ : Irrigation at 1.0 IW/CPE	7.03	7.19	7.11	50.46	52.11	51.28
I ₄ : Irrigation at 1.2 IW/CPE	7.11	7.27	7.19	50.77	52.45	51.61
CD at 5%	0.09	0.08	0.08	0.52	0.66	0.56
Nitrogen levels						
N ₁ : Nitrogen at 40 kg/ha	6.39	6.60	6.50	42.95	44.61	43.78
N ₂ : Nitrogen at 50 kg/ha	6.72	6.96	6.84	48.74	50.42	49.58
N ₃ : Nitrogen at 60 kg/ha	7.08	7.16	7.12	52.19	53.61	52.90
N ₄ : Nitrogen at 70 kg/ha	7.16	7.22	7.19	52.54	54.38	53.46
CD at 5%	0.07	0.09	0.08	0.38	0.63	0.47

Table-2 : Effect of irrigation levels and nitrogen fertigation on number of seeds per umbellet and number of seeds per umbel of different coriander varieties.

Treatment	Number of seeds per umbellet			Number of seeds per umbel		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties						
V ₁ : Hisar Bhumit	7.93	8.06	7.99	40.60	44.87	42.74
V ₂ : Hisar Anand	7.02	7.17	7.10	35.95	39.20	37.58
V ₃ : Hisar Sugandh	7.56	7.75	7.66	37.55	43.53	40.54
CD at 5%	0.20	0.13	0.16	0.76	1.36	1.06
Irrigation scheduling						
I ₁ : Irrigation at 0.6 IW/CPE	7.17	7.34	7.26	31.96	35.82	33.89
I ₂ : Irrigation at 0.8 IW/CPE	7.37	7.50	7.43	37.59	42.01	39.80
I ₃ : Irrigation at 1.0 IW/CPE	7.70	7.87	7.79	41.06	45.89	43.48
I ₄ : Irrigation at 1.2 IW/CPE	7.77	7.93	7.85	41.53	46.41	43.97
CD at 5%	0.09	0.08	0.08	0.55	0.58	0.54
Nitrogen levels						
N ₁ : Nitrogen at 40 kg/ha	7.06	7.30	7.18	33.92	37.94	35.93
N ₂ : Nitrogen at 50 kg/ha	7.39	7.63	7.51	38.29	42.81	40.55
N ₃ : Nitrogen at 60 kg/ha	7.75	7.81	7.78	39.86	44.48	42.17
N ₄ : Nitrogen at 70 kg/ha	7.82	7.90	7.86	40.06	44.90	42.48
CD at 5%	0.07	0.09	0.08	0.45	0.47	0.39

Among varieties, significantly maximum number of umbels (53.22 and 54.86) per plant of coriander were recorded in Hisar Bhumit followed by Hisar Sugandh (48.50 and 50.10), while the minimum were obtained with Hisar Anand (45.59 and 47.30) during 2017-18 and 2018-19, respectively and pooled of two years also showed the same trend of significantly maximum number of umbels (54.04) per plant of coriander in Hisar Bhumit over other varieties *i.e.* Hisar Sugandh (49.30) and Hisar Anand (46.45).

Number of seeds per umbellet : The data relevant to number of seeds per umbellet (Table-2) indicates that varieties, irrigation and nitrogen levels considerably influenced the number of seeds per umbellet of coriander during both the years. Among irrigation levels, significantly maximum number of seeds (7.77 and 7.93) per umbellet were recorded in coriander treated with irrigation level at 1.2 IW/CPE, which was statistically at par with coriander treated with irrigation level at 1.0 IW/CPE (7.70 and 7.87) during 2017-18 and 2018-19, respectively. Whereas, the

Table-3 : Effect of irrigation levels and nitrogen fertigation on seed yield (g/plant) and seed yield (kg/ha) of coriander varieties.

Treatment	Seed yield (g/plant)			Seed yield (kg/ha)		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Varieties						
V ₁ : Hisar Bhumit	8.37	8.64	8.51	1,395.7	1,439.8	1,417.7
V ₂ : Hisar Anand	10.08	10.42	10.25	1,679.2	1,737.2	1,708.2
V ₃ : Hisar Sugandh	10.76	10.91	10.84	1,793.0	1,818.5	1,805.7
CD at 5%	0.07	0.07	0.07	13.35	11.36	12.21
Irrigation scheduling						
I ₁ : Irrigation at 0.6 IW/CPE	9.28	9.52	9.40	1,546.8	1,586.6	1,566.7
I ₂ : Irrigation at 0.8 IW/CPE	9.62	9.86	9.74	1,602.9	1,643.6	1,623.3
I ₃ : Irrigation at 1.0 IW/CP	9.99	10.28	10.14	1,665.1	1,713.7	1,689.4
I ₄ : Irrigation at 1.2 IW/CPE	10.05	10.30	10.18	1,675.6	1,716.8	1,696.2
CD at 5%	0.07	0.08	0.08	12.38	12.79	12.58
Nitrogen levels						
N ₁ : Nitrogen at 40 kg/ha	8.47	8.70	8.58	1,411.5	1,449.3	1,430.4
N ₂ : Nitrogen at 50 kg/ha	9.68	9.92	9.80	1,612.4	1,653.1	1,632.7
N ₃ : Nitrogen at 60 kg/ha	10.39	10.66	10.53	1,731.3	1,777.1	1,754.2
N ₄ : Nitrogen at 70 kg/ha	10.41	10.69	10.55	1,735.3	1,781.2	1,758.3
CD at 5%	0.08	0.08	0.08	13.55	13.94	13.74

minimum number of seeds per umbellet of coriander (7.17 and 7.34) was recorded in coriander treated irrigation at 0.6 IW/CPE during 2017-18 and 2018-19, respectively. Similarly pooled number of seeds per umbellet over two years also followed the same trend and significant maximum number of seeds (7.85) per umbellet was recorded in coriander treated irrigation at 1.2 IW/CPE, which was statistically at par with coriander treated with irrigation level at 1.0 IW/CPE (7.79), while minimum were recorded with coriander irrigated at 0.6 IW/CPE (7.26).

The data pertaining to the effect of nitrogen fertigation, pointedly maximum number of seeds (7.82 and 7.90) per umbellet were recorded in coriander treated with nitrogen at 70 kg/ha, which were statistically at par with coriander treated with nitrogen at 60 kg/ha (7.75 and 7.81), whereas, the minimum number of seeds (7.06 and 7.30) per umbellet was recorded in coriander treated with nitrogen at 40 kg/ha during 2017-18 and 2018-19, respectively. Similarly, pooled number of seeds per umbellet of two years also followed the same trend and significantly maximum number of seeds (7.86) per umbellet was recorded in coriander treated nitrogen at 70 kg/ha, which were statistically at par with coriander treated with nitrogen at 60 kg/ha (7.78).

Among various varieties, significantly maximum number of seeds (7.93 and 8.06) per umbellet of coriander was recorded in Hisar Bhumit, which were followed by (7.56 and 7.75) Hisar Sugandh and Hisar Anand (7.02 and 7.17) during 2017-18 and 2018-19, respectively and pooled of two years also showed the same trend of significantly maximum number of seeds per umbellet (7.99) in Hisar Bhumit over other varieties Hisar Anand, which was followed by (7.66) Hisar Sugandh.

Number of seeds per umbel : The data regard to number of seeds per umbel (Table-2) revealed that varieties, irrigation and nitrogen levels suggestively influenced the number of seeds per umbel of coriander during both the years. Among irrigation levels, significantly maximum number of seeds (41.53 and 46.41) per umbel were recorded in coriander treated with irrigation level at 1.2 IW/CPE, which were statistically at par with coriander treated with irrigation level at 1.0 IW/CPE (41.06 and 45.89), whereas, the minimum number of seeds per umbel of coriander were recorded in coriander treated irrigation at 0.6 IW/CPE (31.96 and 35.82) during 2017-18 and 2018-19, respectively. Similarly, pooled number of seeds per umbel of two years also followed the same trend and significant maximum numbers of seeds (43.97) per umbel were recorded in coriander irrigated with irrigation at 1.2 IW/CPE, which was at par with coriander treated with irrigation level at 1.0 IW/CPE (43.48).

Result presented to the effect of nitrogen fertigation, clearly indicated that significantly maximum number of seeds (40.06 and 44.90) per umbel was recorded in coriander supplied with nitrogen at 70 kg/ha, which was statistically at par with coriander treated with nitrogen at 60 kg/ha (39.86 and 44.48) during 2017-18 and 2018-19, respectively. Whereas, the minimum number of seeds (33.92 and 37.94) per umbel was recorded in coriander treated with nitrogen at 40 kg/ha during 2017-18 and 2018-19, respectively. Similarly, pooled number of seeds per umbel of two years also followed the same trend and significantly maximum number of seeds (42.48) per umbel were recorded in coriander treated nitrogen at 70 kg/ha, which was statistically at par with coriander treated nitrogen at 60 kg/ha (42.17), while the minimum number

of seeds (35.93) per umbel were recorded in coriander treated nitrogen at 40 kg/ha.

Among varieties, significantly maximum number of seeds (40.60 and 44.87) per umbel of coriander was recorded in Hisar Bhumit, which was followed by Hisar Sugandh (37.55 and 43.53) and Hisar Anand (35.95 and 39.20) during 2017-18 and 2018-19, respectively and pooled of two years also showed the same trend of significantly maximum number of seeds (42.74) per umbel of coriander in Hisar Bhumit, which was followed by Hisar Sugandh (40.54) and the minimum were recorded with Hisar Anand (37.58).

Seed yield per plant : The data relevant to seed yield (Table-3) shows that varieties, irrigation and nitrogen levels significantly influenced the seed yield of coriander during both the years. Among irrigation levels, significantly higher seed yield (10.05 and 10.30 g/plant) was recorded in coriander irrigated with irrigation level at 1.2 IW/CPE, which was statistically at par with coriander treated with irrigation level at 1.0 IW/CPE (9.99 and 10.28 g/plant), whereas, the lowest seed yield (9.28 and 9.52 g/plant) of coriander was recorded in coriander treated irrigation at 0.6 IW/CPE during 2017-18 and 2018-19, respectively. Similarly, pooled yield of two years also followed the same trend and significantly higher yield (10.18 g/plant) was recorded in coriander treated irrigation at 1.2 IW/CPE, which was statistically at par with coriander treated with irrigation level at 1.0 IW/CPE (10.14 g/plant), while minimum yield was obtained when coriander treated with irrigation level at 0.6 IW/CPE (9.40).

effect of nitrogen levels, significantly higher seed yield (10.41 and 10.69 g/plant) was recorded in coriander treated with nitrogen at 70 kg/ha, which was statistically at par with coriander treated with nitrogen at 60 kg/ha (10.39 and 10.66 g/plant), whereas, the lowest seed yield (8.47 and 8.70 g/plant) was recorded in coriander treated with nitrogen at 40 kg/ha during 2017-18 and 2018-19, respectively. Similarly pooled yield of two years also followed the same trend and significantly higher yield (10.55 g/plant) was recorded in coriander treated nitrogen at 70 kg/ha, which was statistically at par with coriander treated with nitrogen at 60 kg/ha (10.53 g/plant).

Among different varieties, significantly higher seed yield of coriander (10.76 and 10.91 g/plant) was recorded in Hisar Sugandh followed by Hisar Anand (10.08 and 10.42 g/plant), whereas the minimum seed yield obtained with Hisar Bhumit (8.37 and 8.64 g/plant) during 2017-18 and 2018-19, respectively. The pooled data of two years also showed the same trend of significantly higher seed yield of coriander in Hisar Sugandh (10.84 g/plant) over other varieties *i.e.* Hisar Anand (10.42 g/plant) and Hisar Bhumit (8.51 g/plant).

Seed yield : The data related to seed yield (Table-3) depict that varieties, irrigation and nitrogen levels significantly influenced the seed yield of coriander during both the years. Among irrigation levels, significantly higher seed yield (1675.6 and 1716.8 kg/ha) was recorded in coriander treated with irrigation level at 1.2 IW/CPE, which was statistically at par with coriander treated with irrigation level at 1.0 IW/CPE (1665.1 and 1713.7 kg/ha), whereas, the lowest seed yield (1546.8 and 1586.6 kg/ha) was recorded in coriander treated irrigation at 0.6 IW/CPE during 2017-18 and 2018-19, respectively. Similarly, pooled yield of two years also followed the same trend and significantly higher seed yield (1696.2 kg/ha) was recorded when irrigation applied at 1.2 IW/CPE, which was statistically at par with coriander treated with irrigation level at 1.0 IW/CPE (1689.4 kg/ha), while the minimum seed yield was reported with irrigation applied at 0.6 IW/CPE (1566.7 kg/ha).

Data pertaining to the effect of nitrogen levels, significantly higher seed yield (1735.3 and 1781.2 kg/ha) was recorded in coriander treated with nitrogen at 70 kg/ha, which was statistically at par with coriander treated with nitrogen at 60 kg/ha (1,731.3 and 1,777.1 kg/ha), whereas, the lowest seed yield (1411.5 and 1449.3 kg/ha) was recorded in coriander treated with nitrogen at 40 kg/ha during 2017-18 and 2018-19, respectively. Similarly, pooled yield of two years also followed the same trend and significantly higher yield (1,758.3 kg/ha) was recorded in coriander treated nitrogen at 70 kg/ha, which was statistically at par with coriander treated with nitrogen at 60 kg/ha (1754.2 kg/ha), while the minimum seed yield was reported with nitrogen applied at 40 kg/ha (1430.4 kg/ha).

Among various varieties, significantly higher seed yield (1,793.0 and 1,818.5 kg/ha) of coriander was recorded in Hisar Sugandh over rest of the other varieties during 2017-18 and 2018-19, respectively. The pooled data of two years also showed the same trend of significantly higher seed yield of coriander (1805.7 kg/ha) in Hisar Sugandh over Hisar Anand (1708.2 kg/ha) and Hisar Bhumit (1417.7 kg/ha).

Effect of different levels of irrigation on yield attributes might be due to that drip irrigation ensured the availability of higher soil moisture in the root zone all the way through crop period. This resulted in higher irrigation relative leaf water content, growth parameters and dry matter production and yield of coriander. Similar results have also been reported by Lal *et al.*, (2013), Godara *et al.* (2013), Solanki *et al.* (2017), Meena *et al.* (2017) and Harisha *et al.* (2019).

Whereas effect of different doses of nitrogen on yield attributes might be due to healthier nutritional

environment in the root zone for growth and development of plant as nitrogen is considered as one of the major nutrients required for proper growth and development of plant and nitrogen is main constituent of protoplasm, cell nucleus, amino acids, chlorophyll and many other metabolic processes. The present findings are in close agreement with the results obtained by Ehsanipour *et al.*, (2012), Godara *et al.* (2013), Koyani *et al.* (2015), Meena *et al.* (2016), Solanki *et al.* (2017), Meena *et al.* (2017) and Harisha *et al.* (2019).

The numbers of umbelletes per umbel, number of umbels per plant, number of seeds per umbellate and number of seeds per umbel were significantly higher by 12.1, 14, 11.1 and 12.1 per cent in Hisar Bhumit over Hisar Anand, respectively. Similar results were also reported by Bhunia *et al.* (2009).

Conclusions

It is concluded from the finding of experiment that application of irrigation and fertilizer through drip irrigation system in coriander significantly improves the yield attributes and productivity of coriander. Growing of Hisar Sugandh at irrigation level of 1.0 IW/CPE with nitrogen level at 60 kg/ha through drip irrigation method proved to be an effective and a profitable alternative in western region of Haryana.

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Management Studies of *Macrophomina phaseolina* Causing Root Rot of Mungbean through Fungicides *In Vitro* and *In Vivo*

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Abstract

The present study was carried out in Department of Plant Pathology, SKN College of Agriculture, Jobner, Jaipur (Rajasthan), to examine the efficacy of five fungicides in *in vitro* and *in vivo* conditions, against *Macrophomina phaseolina* causing root rot of mungbean. In laboratory conditions, carbendazim was found most effective in inhibiting the mycelial growth (100%) of pathogen followed by carbendazim+mancozeb (86.15%) at 100ppm concentration. Maximum disease reduction was recorded by carbendazim (83.83%) followed by carbendazim + mancozeb (78.85%) through seed treatment method after 60 days of sowing in pot conditions.

Key words : Mungbean, *Macrophomina phaseolina*, fungicides.

Introduction

Mungbean [*Vigna radiata* (L.) Wilczek] is one of the important pulse crop grown in India. It is also known as green gram, moong and celera bean. It is a legume crop, belongs to the family *Fabaceae* and subfamily *papilionaceae*. Being a leguminous crop, It has the capacity to fix atmospheric nitrogen through symbiotic nitrogen fixation and also used as green manure crop, so this crop is beneficial both economically and nutritionally and is widely employed in variety of cropping system (Yakub *et al.*, 2010). It is a self pollinated crop which is grown during *kharif* as well as summer season in arid and semi arid region. It is tolerant to draught and can be grown successfully on well drained loamy to sandy loam soils even in the areas of erratic rainfall. De-Candolle (1986) believes that mungbean has originated in India.

Mungbean is an excellent source of protein (24.5%) with high quality lysine (460 mg/g N) and tryptophan (60mg/g N) 51% carbohydrate, and 3% vitamins. It has also remarkable quantity of ascorbic acid (Vitamin-C) and contains riboflavin (0.21mg/100g) and minerals (3.84g/100g) when sprouted (Gopalan *et al.* 1995). It is a native of India and Central Asia. It is grown in these areas since prehistoric period (Vavilov 1926).

Root rot incited by *Macrophomina phaseolina* (Tassi.) Goid has been rated as most devastating disease of mungbean. The pathogen attacks on all parts of plant *i.e.* root, stem, branches, petioles, leaves, pods and seeds. *M. phaseolina* infected roots show necrotic lesions (Bouhot, 1967). The infection of *Macrophomina phaseolina* occurs most frequently at the flowering and

pod formation stage (Singh *et al.*, 1990) or seed development stage (Trapero-Casas and Jimenez – Diaz, 1985). The infected stems and leaves appear dry and become brittle and straw coloured. The characteristic symptom of root rot was yellowing of the leaves and within two of three days these leaves may drop off. The plant may wilt within a week. On the stem dark lesions may be seen on the bark at the ground level. If the plants are pulled out from the soil and examined the basal stem and main roots show root rot symptoms. In advance stage scattered sclerotial bodies may be seen on the affected tissues (Singh and Srivastava, 1988).

Materials and Methods

Efficacy of fungicides (*in vitro*) : Efficacy of five systemic and non-systemic fungicides captan + hexaconazole, carbendazim, chlorothalonil, trifloxystrobin + tebuconazole, and carbendazim + mancozeb against *Macrophomina phaseolina* was tested at three different concentrations *viz.*, 100, 250 and 500ppm by Poisoned Food Technique (Schmitz, 1930). Required amount of each fungicide was added separately to sterilized medium, mixed properly and poured in sterilized 90 mm diameter glass Petriplates and allowed to solidify. For each treatment four replications were maintained. A control was also maintained where, no fungicides was added in the medium. Each plate was inoculated with 5mm discs taken from the periphery of the fungal culture by using sterilized cork borer and incubated at 30 ± 1 °C for 7 days. The growth of the test fungus was recorded and per cent growth inhibition was calculated by the formula as mentioned. (Vincent, 1947).

Table-1 : Efficacy of fungicides against *Macrophomina phaseolina* by poisoned food technique after 7 days of incubation at 30 + 1°C (*in vitro*)

S. No.	Fungicides	Per cent inhibition of mycelial growth at various concentrations* (ppm)			Mean
		100	300	500	
1.	Captan + Hexaconazole	66.15 (54.42)	73.67 (59.13)	80.35 (63.69)	73.39 (59.08)
2.	Carbendazim + Mancozeb	86.15 (68.15)	100.00 (90.00)	100.00 (90.00)	95.38 (82.72)
3.	Tebuconazole + Trifloxystrobin	78.20 (62.17)	84.10 (66.50)	100.00 (90.00)	87.43 (72.89)
4.	Carbendazim	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
5.	Chlorothalonil	72.33 (58.26)	81.45 (64.49)	92.00 (73.57)	81.93 (65.44)
6.	Control	0.00	0.00	0.00	0.00
	SEm+	CD (p=0.05)			
	F	0.44	1.21		
	C	0.62	1.72		
	F x C	1.07	2.98		

*Average of four replications

Figures given in parentheses are angular transformed values.

Table-2 : Efficacy of fungicides against root rot of mungbean applied through seed treatment (*in vivo*).

S. No.	Fungicides	Dose	Per cent disease incidence (DAS)*		Per cent disease control (DAS)	
			40DAS	60DAS	40DAS	60DAS
1.	Captan + Hexaconazole	2g/kg	19.22 (26.00)	23.54 (29.02)	65.72	63.34
2.	Carbendazim + Mancozeb	2g/kg	10.66 (19.06)	13.56 (21.61)	80.99	78.85
3.	Tebuconazole + Trifloxystrobin	2g/kg	14.32 (22.24)	16.76 (24.17)	74.46	73.90
4.	Carbendazim	2g/kg	8.33 (16.78)	10.38 (18.79)	85.14	83.83
5.	Chlorothalonil	2g/kg	16.37 (23.87)	20.24 (26.74)	70.80	68.48
6.	Control	—	56.08 (53.26)	64.22 (48.49)	0.00	0.00
	SEm+		0.84	0.96		
	CD (p=0.05)		2.59	2.95		

*Average of four replications

Figures given in parentheses are angular transformed values.

$$\text{Per cent growth inhibition} = \frac{C - T}{C} \times 100$$

Where, C = Diameter of the colony in check (average of both diagonals), T = diameter of colony in treatment (average of both diagonals).

Efficacy of fungicides in pot conditions (*in vivo*) : For this experiment, autoclaved soil (Soil : FYM, 3:1 autoclaved at 1.045 kg/cm² for 2 hours on three consecutive days) was filled in 9 x 12 inches sterilized earthen pots. These pots were containing soil, inoculated with inoculum of the pathogen. For inoculation, the upper 5 cm layer of soil of each pot was thoroughly mixed with inoculum multiplied on sorghum medium @ 8 per cent (w/w) in each pot. The pots were covered with polythene bags and kept for 24 hours in cage house. Apparently healthy surface sterilized seeds (1% sodium hypochloride) were rolled on 7 days old culture of fungus on PDA contained Petriplates. The seeds were treated with fungicide @2 gm/kg seeds and sown in pots (with amount @5seeds/pot) separately. The experiment was conducted in CRD with four replications. Surface sterilized

seeds without fungicide sown in inoculated sterilized soil and served as check. Observation on root rot incidence was recorded at 40 and 60 day after sowing. Per cent disease incidence (PDI) and percent disease control in different experiments were calculated as follows :

$$\text{Disease incidence (\%)} = \frac{\text{No. of diseased plants}}{\text{Total no. of plants}} \times 100$$

$$\text{Disease control (\%)} = \frac{\text{PDI in control} - \text{PDI in treatment}}{\text{PDI in inoculated control}} \times 100$$

Result and Discussion

Efficacy of fungicides (*in vitro*) : The results depicted in Table-1 revealed that among the tested five fungicides, carbendazim was found most effective in inhibiting mycelial growth (100, 100 and 100 per cent) of *Macrophomina phaseolina* at 100, 250 and 500ppm, respectively followed by carbendazim+mancozeb (86.15, 100 and 100%). Other fungicides like, chlorothalonil (72.33, 81.45 and 92.00%), captan+hexaconazole (66.15, 73.67 and 80.35%) were found least effective in inhibiting mycelial growth over control.

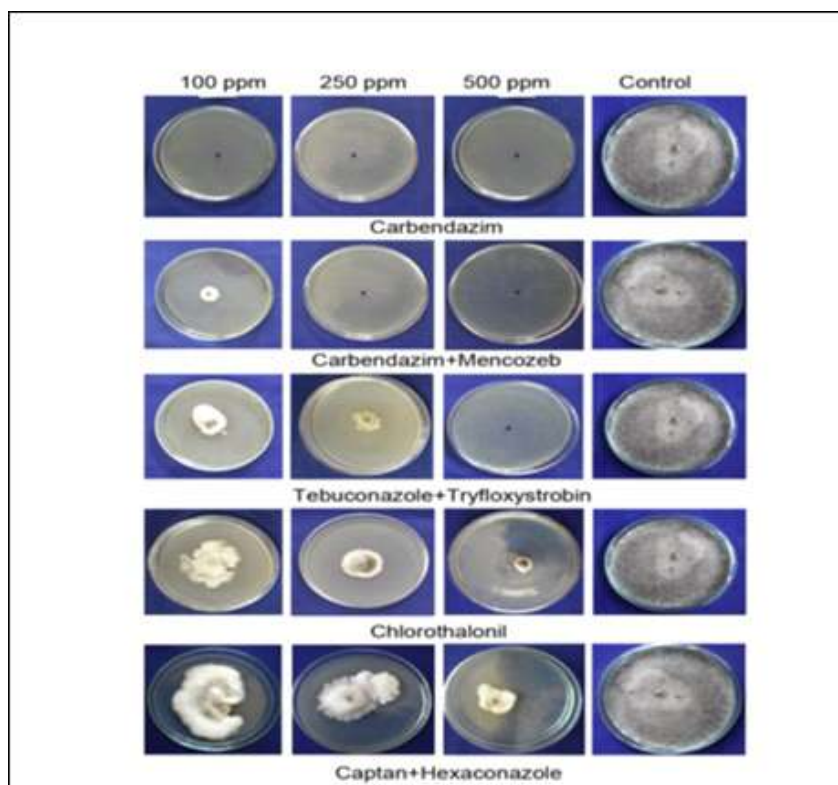


Fig. : Efficacy of fungicides against *Macrophomina phaseolina* by poisoned food technique after 7 days of incubation at 30 ± 1°C.

Efficacy of fungicides in pot condition (*in vivo*) : The results depicted in Table-2 revealed that all fungicides were found significantly superior over control in reducing per cent disease incidence at 40 and 60 days after sowing. Minimum percent disease incidence was recorded with carbendazim (8.33 and 10.38%) followed by carbendazim + mancozeb (10.66 and 13.56%) over control (56.08 and 64.22%) at 40 and 60 days after sowing respectively. Maximum disease control over check was recorded with carbendazim (85.14 and 83.83%), followed by carbendazim + mancozeb (80.99 and 78.85%) over control at 40 and 60 days after sowing, respectively. Per cent disease control was higher at 40 DAS but it was declined in next 20 days. Maximum disease incidence was recorded in tebuconazole + trifloxystrobin (14.32 and 16.76%), chlorothalonil (16.37 and 20.24%) and captan + hexaconazole (19.22 and 23.54%) at 40 and 60 days. Control was recorded with maximum per cent disease incidence (56.08 and 64.22%) over all the treatments.

Similar observations were also made by Sinha and Khare (1977), who found that carbendazim and thiram were highly effective against *Macrophomina phaseolina* in laboratory as well as in field conditions. Ramadoss and Sivaprakasam (1994) also reported that sclerotial production of *Macrophomina phaseolina* was completely inhibited by carbendazim and thiram, which again support the present investigation. Vijay Mohan *et al.* (2006)

recorded that the fungicidal trials on management of dry root rot of chickpea caused by *Macrophomina phaseolina*, carbendazim (0.2%) and etaconazole (0.1%) used as seed treatment, soil drenching and seed treatment plus soil drenching recorded lowest disease incidence of 15.6 and 18.2 percent respectively. Khan and Gangopadhyay (2008) evaluated the fungicides against dry root rot of chickpea and reported that captan and carbendazim were highly effective against *M. phaseolina*.

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Effect of Physical Parameters on Conidial Germination of *Erysiphe cruciferarum* of Mustard under Controlled Condition

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Abstract

Powdery mildew of mustard incited by *Erysiphe cruciferarum* has emerged as a constraint in its cultivation in Rajasthan. Disease is mostly appeared in first week of February and reaches at peak in March. Powdery mildew disease is easily detected by the presence of white floury patches appearing on both sides of the leaves as well as tendril stem, pods etc. In extreme server conditions it causes significant losses in quantity as well as quality of seed. In vitro studies were conducted to know the effect of temperature, relative humidity, incubation period and light and darkness period on conidial germination of *Erysiphe cruciferarum*. The maximum conidial germination was obtained at 25°C, whereas at lower and higher the optimal temperatures, conidial germination significantly lower. Germ tubes initiate to develop at all values of relative humidity (40-90%), reaching the maximum conidial germination at 90% RH. The effect of combination of different duration of darkness and light on the conidial germination was studied at 25°C temperature. While that maximum conidial germination was recorded in 10:14 hours of darkness and light at 25°C temperature. Impact of incubation period on conidial germination was studied by keeping conidia under different incubation periods at optimum temperature (25°C). Whereas that conidial germination was started after 4 hours of incubation. The conidial germination percentage was increased with increasing incubation period. Maximum conidial germination was recorded at optimum temperature (25°C) after 24 hours of incubation period, respectively.

Key words : Mustard, powdery mildew, conidial germination, physical parameters.

Introduction

Mustard [*Brassica juncea* (L.) Czern & Coss] is an important oilseed crop. It belongs to family *Crucifereae* (*Brassicaceae*). India is the one of leading oilseed producing country in the world accounting for 11.2% of the world's rapeseed and mustard production and ranks third in the world next to China and Canada. Mustard is the second most important oilseed crop after groundnut, contributing nearly 30% of the total oilseed production in India. Indian contribution in global rapeseed and mustard production is 9.34 million tones with an area of 6.23 million hectares and average yield of 1499 kg/ha (Anonymous, 2018-19).

In Rajasthan, rapeseed and mustard occupies a prime place amongst all the oilseed crops grown. It occupies 2.37 million hectares area, 4.08 million tones production and 1720 kg/ha average yield (Anonymous, 2018-19). Mustard is hardy crop which grown in arid conditions of Rajasthan, characterized by sandy and loamy sand soils, scanty rainfall (400-600mm), thermal oscillations (5-35 °C) and low relative humidity. Some important fungal diseases which have been reported to cause huge economic losses worldwide to the crop are like powdery mildew (*Erysiphe cruciferarum* (Opiz ex L. Junell), downy mildew (*Hyaloperonospora parasitica* (pers.) constant), alternaria blight (*Alternaria alternata*,

Alternaria brassicae (Berk.) sacc), white rust (*Albugo candida* (Pers.) Kuntze), club root (*Plasmodiophora brassicae* (Wor.), seedling blight /damping off (*Rhizoctonia solani*, *Fusarium* spp., *Pythium* spp.), sclerotinia stem rot (*Sclerotinia sclerotiorum* (Lib.) de bary.), black leg (*Leptosphaeria maculans*), root rot complex and foot rot (*Rhizoctonia solani*, *Fusarium* spp., *Pythium* spp.), fusarium wilt (*Fusarium oxysporum* f.sp. *conglutians*) (Kolte and Mehta *et al.* 2005). Among these powdery mildew incited by *Erysiphe cruciferarum* is the most important disease that causes maximum reduction in yield and quality of mustard. In India, powdery mildew disease affects yield losses from 10-90 per cent with reduction in 6.47 per cent oil content have been estimated from different Brassicas (PD Meena, 2018).

The disease has attained the economic status in the Rajasthan state. By considering the seriousness of disease and the economic damage/exorbitant losses caused by the disease, the present investigation was carried out by using different fungicides for its efficacy against powdery mildew disease of mustard under field condition.

Materials and Methods

(A). Conidial germination : A drop of conidial suspension was put on the sterilized cavity slide supported on glass rods inside the Petri plates. Both halves of the Petri plates

were covered with sterilized filter paper atomized with sterilized water to retain moisture (Prakash and Saharan, 1999). Instead of simple glass slide, cavity slide was used to avoid drying of droplet.

Conidial germination experiments were performed according to the procedures recommended by the committee on standardization of fungicides test of American Phyto pathological Society (1943) and by incubating them (Sain and Sharma, 1999).

The conidial suspension contained approximately 20 conidia per low power microscopic field for 10 x 10 magnifications.

Three replications were maintained for each treatment. At the incubation period, the slides were taken out and a drop of lacto phenol was add immediately to arrest further germination of the conidia. Per cent conidial germination was calculated by formulae given below.

$$\text{Per cent spores germination} = \frac{\text{No. of spores germinated}}{\text{Total No. of spores observed}} \times 100$$

Effect of physical parameters on conidial germination

Temperature : The conidial suspension obtained and placed as above was incubated at 15, 20, 25, 30 and 35°C in separate digital B.O.D. incubator in laboratory. After 24 hours of incubation, percent conidial germination was counted under microscope.

Relative humidity : To study the effect of relative humidity on conidial germination, the conidia of *Erysiphe cruciferarum* were collected and picked as method described above under 3.1. Different relative humidity levels were created in desiccators by dissolving concentrate sulphuric acid and sterilized double distilled water in different proportion by the method suggested by Buxton and Mellan by (1934). The composition of the acid solution was used as followed.

List of Stock solution

Relative Humidity %	Stock solution (ml*)	Distilled water (ml*)
40	510.0	158.0
50	405.0	278.0
60	374.0	396.0
70	348.0	510.0
80	294.0	640.0
90	161.0	712.0

*50v/v solution of concentrate sulphuric acid.

The desiccators were incubated on 25°C temperatures in digital B.O.D. incubator. A drop of conidial suspension collected as above was placed on cavity slides as above but Petri plates were not covered.

These Petri plates were put in sealed desiccators maintaining different relative humidity. After 24 hours observation on conidial germination was recorded.

Incubation period : The experiment was conducted to measure the effect of different incubation periods on conidial germination of *Erysiphe cruciferarum*. Conidia were incubated for 4, 6, 8, 10 and 24 hours at 25°C temperature in digital B.O.D. incubator. The conidial suspension placed in Petri plates as per method describe above. After completion of incubation period germination percent was recorded under binocular microscope.

Darkness and light : To know the effect of dark and light on conidial germination of *Erysiphe cruciferarum*, the experiment was carried out for dark: light for 12:12, 16:8, 14:10 and 10:14 hrs respectively. The conidia were picked up as per procedure describe in 3.3. For observing the effect of different light and dark periods on conidial germination, the Petri plates containing conidial suspension were incubated at 25°C temperature after 24 hrs of incubation conidial germination was recorded.

Results and Discussion

Effect of physical parameters on conidial germination of pathogen

Effect of temperature on conidial germination : The percent conidial germination of *Erysiphe cruciferarum* was greatly affected by atmospheric temperature. Results revealed (Table-1) that maximum 78.13 per cent conidial germination was recorded when conidia were incubated at 25°C temperature followed by 53.53 per cent and 50.18 per cent at 20°C and 30°C temperature, respectively. The minimum 30.26 per cent conidial germination was recorded at 15°C temperature. Temperature of 25°C was found optimum for giving maximum conidial germination of *Erysiphe cruciferarum*.

Table-1 : Effect of temperature on growth of conidial germination of *Erysiphe cruciferarum* of mustard.

Temperature±1°C	Per cent conidial germination*
15	30.26 (33.37)
20	53.53 (47.02)
25	78.13 (62.12)
30	50.18 (45.1)
35	34.1 (35.73)
S.E.m.±	0.54
CD (p=0.05)	1.64
CV	2.43

*Average of four replications. Figure in parenthesis are angular transformed values

Effect of relative humidity : The effect of various levels of relative humidity and temperature on conidial germination of *Erysiphe cruciferarum* was studied using 40, 50, 60, 70, 80 and 90 per cent relative humidity at 25°C temperature (Table-2). Results revealed (Table-2) that

maximum 77.35 per cent conidial germination was recorded at 90 per cent relative humidity followed by 74.83 per cent and 70.44 per cent at 80 and 70 per cent relative humidity, respectively. The minimum 47.4 per cent conidial germination was recorded at 40 per cent relative humidity. Relative humidity of 90 per cent was found for giving maximum conidial germination of *Erysiphe cruciferarum*.

Table-2 : Effect of Relative humidity on growth of conidial germination of *Erysiphe cruciferarum* of mustard.

Relative Humidity (%)	Percent conidial germination*
40	47.4 (43.51)
50	55.33 (48.06)
60	66.32 (54.53)
70	70.44 (57.06)
80	74.83 (59.89)
90	77.35 (61.58)
S.Em.±	0.75
CD (p=0.05)	2.30
CV	2.39

*Average of three replications. Figure in parenthesis are angular transformed values

Effect of incubation period : The effect of incubation period on conidial germination of *Erysiphe cruciferarum* was studied by keeping conidia in buffer solution for 4, 6, 8, 10 and 24 hours at 25°C temperature. Results (Table-3) revealed that conidial germination started after 4 hours of incubation. The conidial percentage was increased after 4 hours of incubation. With the increase in incubation period, per cent conidial germination also increased. Maximum 74.40 per cent conidial germination was recorded at 25°C after 24 hours of incubation.

Table-3 : Effect of Incubation period on growth of conidial germination of *Erysiphe cruciferarum* of mustard.

Incubation periods (in hours)	Percent conidial germination*
4	22.20 (28.10)
6	32.36 (34.65)
8	48.33 (44.02)
10	61.50 (51.63)
24	74.40 (59.58)
S.Em.±	0.25
CD 5%	0.78
CV	1.08

*Average of four replications. Figure in parenthesis are angular transformed values.

Effect of darkness and light : The effect of combination of different duration of darkness and light on the conidial germination of *Erysiphe cruciferarum* was studied at 25°C. The result revealed that maximum 71.05 per cent conidial germination was recorded in 10: 14 hrs of darkness and light at 25°C temperature followed by 50.63 per cent and 43.54 per cent at 12:12 hrs and 14:10 hrs, respectively (Table-4).

It was evident from result that light clearly had a stimulatory effect on conidial germination of *Erysiphe cruciferarum*. Whereas, with the increased exposure of conidia to dark hours, the conidial germination was reduced or we can concluded that exposure of conidia to dark showed inhibitory effects.

Table-4 : Effect of Darkness and light on growth of conidial germination of *Erysiphe cruciferarum* of mustard.

Dark : Light (in hours)	Percent conidial germination*
12:12	50.63 (45.36)
16:08	40.13 (39.31)
14:10	43.54 (41.29)
10:14	71.05 (57.45)
S.Em.±	0.37
CD 5%	1.13
CV	1.60

*Average of four replications. Figure in parenthesis are angular transformed values.

Mustard (*brassica juncea*) is an important oilseed crop. Its because of very important edible oil content ranging from 30-38 per cent and oil is considered the best quality oil for human consumption for cooking and burning purpose as compared to other edible oils (Porter and Crompton, 2008).

Powdery mildew of mustard is known to perpetuate through cleistothecia lying in plant debris in the field or by planting seed mixed with infected plant debris. But maximum spread and damage is caused by secondary spread of the pathogen that takes place through conidia produced abundantly during congenial conditions. The germination of conidia is greatly influenced by environmental factors like, minimum and maximum temperature, morning and evening relative humidity, sunshine hours, cloudiness, rainy days etc.

Dae-Hyun *et al.* (2009) have also been obtain maximum germination of chilli powdery mildew pathogen at 25°C. Pap *et al.* (2013) have studied the effect of temperature on the conidial germination and germ tube elongation of oak powdery mildew (*Microsphaera alphitoides*) in controlled conditions and reported maximum germ tube length at 25°C temperature. Pap *et al.* (2013) studied the effect relative humidity on conidial germination and germ tube elongation of oak powdery mildew (*Microsphaera alphitoides*) in controlled conditions and noted maximum germination and germ tube length at 90 per cent relative humidity. Misra *et al.* (2016) also reported that maximum relative humidity (73.3-83.9%) is more conducive for the rapid spread of mango powdery mildew pathogen. Joseph *et al.* (2019) have also been obtained the highest conidial germination of *Erysiphe cichoracearum* (58.80%) in 10:14 hrs of darkness and light which was significantly higher than

other treatments. Prakash and Saharan (2000) observed maximum conidial germination of *Erysiphe polygoni*, causing powdery mildew of fenugreek after 24 hours of incubation.

Conclusions

Our findings coincide largely with the results of other authors, so it can be concluded that natural conditions can be simulated in a climate chamber and reliable data can be obtained on the impact of various factors on the development of the fungus. The highest conidial germination was recorded at 25°C temperature, 90 per cent relative humidity after 24 hours of incubation and 10:14 hours of darkness and light.

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Effect of Integrated Nutrient Management on Growth and Yield of Cluster Bean (*Cyamopsis tetragonoloba*) Var. Pusa Navbahar

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Abstract

An field experiment was conducted during *Kharif* season 2014-15 at the Research farm of Soil Science, Allahabad School of Agriculture, laid out in factorial randomized block design, consisted twelve treatment and three replications. It was observed that growth and yield of cluster bean in treatment was $T_{11} L_2 V_1 R_1$ (@ $N_{20}P_{40}K_{40}$ NPK kg ha⁻¹ +10 t vermicompost ha⁻¹ +200 g *Rhizobium* 10 kg⁻¹ seed was maximum. Maximum plant height 85.77 cm, no. of leaves plant⁻¹ 70.22, number of cluster plant⁻¹ 11.33, number of pod cluster⁻¹ 10.10, number of seed pod⁻¹ 9.77, length of pod 13.93, pod yield 76 qha⁻¹ were found to be non-significant over all other treatments. Adequate plant nutrient supply holds the key for improving the food grain production and sustaining soil fertility.

Key words : Cluster bean, integrated nutrient, soil properties, yield attributes.

Introduction

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] Var. Pusa Navbahar] popularly known as "Guar" is a vegetative crop of Indian origin belonging to the family fabaceae. It is important legume crop mainly grown under rainfed condition in arid and semi-arid regions of Rajasthan during kharif season. It is very hardy and drought tolerant crop. Its deep penetrating roots enable the plant to utilize available moisture more efficiently and thus offer better scope for rainfed cropping. The crop also survives even at moderate salinity and alkalinity conditions. There is no other legume crop so hardy and drought tolerant as cluster bean, which is especially suited for soil and climate of Rajasthan. It has high calorific and nutritive value and its seed contains 28-32% of gum (Kherawat *et al.* 2013).

Nitrogen is the most important nutrient for plant growth and development. Nitrogen also plays an important role in synthesis of chlorophyll and amino acid, which contributes to the building units of protein and thus the growth of plants. Insufficient nitrogen may reduce yield drastically and deteriorates the quality of produce. The nitrogen application increased crude protein, crude fibre contents, ash percentage, carbohydrates, and leaf area per plant, dry matter and green fodder yield of cluster bean cultivars (Ayub *et al.* 2010).

The phosphorus is the second important plant nutrients. An application of phosphorus influences symbiotic nitrogen fixation yield and quality of cluster pods. Phosphorus has a positive and significant effect on nodulation and crop yield. Phosphorus enhances the

activity of Rhizobia. Phosphorus also improves the quality of cluster bean grain.

The potassium is the 3rd most important essential nutrient after nitrogen and phosphorus. The potassium activates more than 60 enzymes and enzymatically catalyzes the system involved in photosynthesis, metabolism and translocation of carbohydrates and proteins, membrane permeability, stomatal regulation and water utilization. Other benefits ascribed to K include resistance of plants against pests, disease and stresses caused by drought, frost, salinity, sodicity and in assuring improved crop quality characteristics (Kherawat *et al.*, 2013).

Vermicomposts are products derived from the accelerated biological degradation of organic wastes by earthworms and microorganisms. The process accelerates the rates of decomposition of the organic matter, alter the physical and chemical properties of the material, leading to a humification effect in which the unstable organic matter is fully oxidized and stabilized vermicompost are finely divided peat-like materials with high porosity, aeration, drainage, water-holding capacity. These materials contained mineral contents (% dry weight) ranging from 2.2–3.0 N, 0.4–2.9 P, 1.7–2.5 K, and 1.2–9.5 Ca compared to those of a commercial plant growth (Norman *et al.* 2005).

In the view of maintaining the soil health and quality of produce, application of bio-fertilizer plays a vital role. Bio fertilizer is microbial inoculants of selective microorganisms like bacteria, fungi already existing in nature. Bio fertilizer cannot replace chemical fertilizer but

Table-1 : Effect of different levels of N P K, Vermicompost and *Rhizobium* on growth and yield of cluster bean (*Cyamopsis tetragonoloba* L.) at 60 DAS.

Treatment combination	Plant height (cm)	No. of leaves	No. of cluster plant ⁻¹	No. of pod cluster ⁻¹	No. of seed pod ⁻¹	Length of pod (cm)	Pod yield (qha ⁻¹)
T ₀ (L ₀ +V ₀ +R ₀)	72.88	60.77	5.33	4.66	4.99	9.99	28.16
T ₁ (L ₀ +V ₀ +R ₁)	73.77	61.33	5.66	5.10	5.44	10.14	30.66
T ₂ (L ₀ +V ₁ +R ₀)	74.99	63.00	6.33	5.55	5.77	10.59	36.00
T ₃ (L ₀ +V ₁ +R ₁)	76.33	63.44	6.55	5.88	6.10	10.86	37.83
T ₄ (L ₁ +V ₀ +R ₀)	77.66	64.33	6.99	6.33	6.21	11.28	39.00
T ₅ (L ₁ +V ₀ +R ₁)	78.44	64.99	7.33	6.66	6.77	11.73	41.00
T ₆ (L ₁ +V ₁ +R ₀)	79.00	65.55	7.88	6.99	7.10	12.13	43.08
T ₇ (L ₁ +V ₁ +R ₁)	80.66	66.66	8.33	7.44	7.55	12.38	47.16
T ₈ (L ₂ +V ₀ +R ₀)	81.77	67.21	8.77	7.77	7.77	12.89	53.83
T ₉ (L ₂ +V ₀ +R ₁)	82.77	67.99	9.33	8.11	8.21	13.22	58.16
T ₁₀ (L ₂ +V ₁ +R ₀)	84.21	68.88	10.32	9.22	9.21	13.62	67.08
T ₁₁ (L ₂ +V ₁ +R ₁)	85.77	70.22	11.33	10.10	9.77	13.93	76.00
F-test	NS	NS	NS	NS	NS	NS	NS
S. Ed (±)	0.84	0.42	0.36	0.44	0.56	0.56	0.25
C. D. at 5%	-	-	-	-	-	-	-

can meet the increasing demand of chemical fertilizer with its supplementary and complementary use, besides improving physio-chemical properties of soil and also improves the efficiency of applied fertilizer. Bio fertilizers enrich soil fertility and improves soil fertility. (Deshmukh *et al.* 2014).

Materials and Methods

The experiment was conducted during Kharif season 2014-15 on crop research farm of department of Soil Science at Sam Higginbottom Institute of Agriculture, Technology and Sciences, Deemed-to-be-University Allahabad, the area is situated on the south of Allahabad on the right side of the river Yamuna on the South of Rewa road at a distance of about 6 Km from Allahabad city. It is situated at 25°24'23" N latitude, 81°50'38" E longitude and at the altitude of 98 meter above the sea level (MSL).

The treatment consisted of twelve combination of organic and inorganic source of fertilizers T₀ (L₀ V₀ R₀) Control, T₁ (N₀P₀K₀ + vermicompost₀ and *Rhizobium* @ 200 g/10 Kg seed), T₂ (N₀P₀K₀ + vermicompost @ 10 t ha⁻¹ and *Rhizobium*), T₃ (N₀P₀K₀ + vermicompost @ 10 t ha⁻¹ and *Rhizobium* @ 200 g/10 Kg seed), T₄ (N₁₀P₂₀K₂₀ Kg ha⁻¹ + vermicompost₀ and *Rhizobium*), T₅ (N₁₀P₂₀K₂₀ Kg ha⁻¹ + vermicompost₀ and *Rhizobium* @ 200g/10 Kg seed), T₆ (N₁₀P₂₀K₂₀ Kg ha⁻¹ + vermicompost @ 10 t ha⁻¹ and *Rhizobium*), T₇ (N₁₀P₂₀K₂₀ Kg ha⁻¹ + vermicompost @ 10 t ha⁻¹ and *Rhizobium* @ 200 g/10 Kg seed), T₈ (N₂₀P₄₀K₄₀ Kg ha⁻¹ + vermicompost₀ and *Rhizobium*), T₉ (N₂₀P₄₀K₄₀ Kg ha⁻¹ + vermicompost₀ and *Rhizobium* @ 200 g/10 Kg seed), T₁₀ (N₂₀P₄₀K₄₀ Kg ha⁻¹ +

vermicompost @ 10 t ha⁻¹ and *Rhizobium*), T₁₁ (N₂₀P₄₀K₄₀ Kg ha⁻¹ + vermicompost @ 10 t ha⁻¹ and *Rhizobium* @ 200 g/10 Kg seed). The trial was laid out in 3x2x2 factorial randomized block design with three replication, plot size having 2 x 2 m for crop seed rate is 15-20 kg ha⁻¹ (*Cyamopsis tetragonoloba* L.) Var. Pusa Navbahar. Cluster bean grows in 16th July month 2014 and the source of nitrogen, phosphorus, potassium, vermicompost and *Rhizobium* culture as Urea, SSP, MOP, respectively. Basal dose of fertilizer was applied in respective plots according to treatment allocation unfurrows opened by about 5 cm. The seeds were then treated with *Rhizobium* (@ 200 g *Rhizobium*/10 kg seed). The inoculated seeds were dried under shade and sown immediately after drying. All the agronomic practices were carried out uniformly to raise the crop. The crop was harvested on 17th October. During the course of experiment, cluster bean plant data were taken at 30, 45 and 60 days after sowing (DAS).

Results and Discussion

The results given in Table-1 indicate some of the important parameters of plant height (cm), number of leaves plant⁻¹ and number of cluster plant⁻¹ of cluster bean crop. The maximum plant height (cm), number of leaves plant⁻¹ and number of cluster plant⁻¹ were recorded 85.77 cm, 70.22, and 11.33, respectively, at 60 DAS in the treatment T₁₁ that was non significantly higher as compared to other treatment combination. Plant height (cm), number of leaves plant⁻¹ and number of cluster plant⁻¹ of cluster bean crop were increased non significantly and progressively with the increasing level of

NPK, vermicompost and Rhizobium at 60 DAS was found to be non-significant.

The results given in Table-1 indicate some of the important parameters number of pod cluster⁻¹, number of seed pod⁻¹, length of pod and pod yield qha⁻¹ of cluster bean crop. The maximum number of pod cluster⁻¹, number of seed pod⁻¹, length of pod and pod yield q ha⁻¹ were recorded 10.10, 9.77, 13.93, and 76, respectively, in the treatment T₁₁ that was non significantly higher as compared to other treatment combination. The number of pod cluster⁻¹, number of seed pod-1 length of pod and pod yield q ha⁻¹ of cluster bean crop were increased non significantly and progressively with the increasing level of NPK, vermicompost and Rhizobium was found to be non-significant.

Conclusion

It was concluded from trial that the various level of N P K, Vermicompost and *Rhizobium* seed inoculation used from different sources in the experiment, the treatment combination T₁₁ (N₂₀P₄₀ K₄₀ Kg/ha, vermicompost @ 10 t/ha, and *Rhizobium* @ 200 g/10 Kg seed) was found to be the best, in increasing plant height 85.77 cm, number of leaves plant⁻¹ 70.22, number of cluster plant⁻¹ 11.33, number of pod cluster⁻¹ 10.10, number of seed pod⁻¹ 9.77, length of pod 13.93, pod yield 76 qha⁻¹. The treatment T₁₁

that was non significantly higher as compared to other treatment combinations.

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Nutrient Management of Potato (*Solanum tuberosum* L.) under Satpura Zone of Madhya Pradesh by using SSNM Technique

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Abstract

Presently nutrient management research have come out with an advanced technique of supplying nutrient to crop according to variability in soil over space and requirement during a particular growth period. The approach is termed as site specific nutrient management (SSNM). The approach of SSNM involves science based principles for guiding the judicious and efficient application of fertilizers as and when needed by crops. Investigation was conducted at Zonal Agriculture Research Station, Chhindwara under AICRP-Potato Rabi 2017 and 2018 with randomized Block design. Seven treatments on NPK levels were taken out for study purpose on the growth and yield of potato with cultivar Kufri Chipsona-3 was taken under experiment which has processing with medium duration. These were T1- 50% recommended dose of fertilizer (RDF) of NPK, T2- 100% RDF of NPK, T3- 150% RDF of NPK, T4- RDF of PK (without N), T5- RDF of NK (without P), T6- RDF of NP (without K) and T7- absolute control (without NPK). Result revealed that the total tuber yield increased with increasing recommended dose of fertilizers of NPK. There were no significant variations in total tuber yield and benefit cost ratio were recorded between 150% and 100% recommended doses of fertilizers of NPK. Nitrogen was found one of the most limiting nutrients for potato due to maximum reduction in total tuber yield. The second most limiting nutrient was potassium afterward phosphorus.

Key words : Nutrient management, potato, SSNM.

Introduction

The potato is a nutritionally valuable staple food. It is used for fresh consumption, processing into French fries and chips (crisps), as well as for the production of dry products and starch extraction. Thus, there are specific quality requirements for each use. The nutritional composition and other quality traits of potato tubers are influenced by the supply and availability of both macro- and micronutrients. However, the impact of the nutrients on potato quality is influenced or overlapped by many other factors, such as cultivar, soil, and climate conditions (Bártová *et al.* 2013, Lombardo *et al.* 2013, Brazinskiene *et al.* 2014).

Potato originated in South American Andman Mountains and was introduced in India during 17th century by the portuganess from Europe. Potato (*Solanum tuberosum* L.) is an important clasp food of the world. The enormity of any crop is judged by its yield potential, nutrients content, keeping quality and market value. Potato yield potential is many folds higher in comparison to any crops grown during Rabi season. Having this aptitude of yield potential, potato may revolutionize the fortune of agriculture scenario with respect to the food supply capacity to the burgeoning population. Potato contain good amount of vitamin C, vitamin B and essential amino acids like leucine, tryptophane and isoleucine. It is the cheapest source of nutrition for the rural mass hence it

is called as “poor man’s friend”. It contains five alkaline elements like sodium, potassium, magnesium, calcium and aluminum hence it acts as a systemic alkaliser to avoid gastric diseases.

Today, roots and tubers are the third largest carbohydrate food source in the world, with potatoes representing nearly half of all root crops consumed (Anon., 2018). Potatoes contribute key nutrients to the diet including vitamin C, potassium, and dietary fibre (McGill *et al.*, 2013). In fact, potatoes have a more favourable overall nutrient-to-price ratio than many other vegetables and are an important staple worldwide (Drewnowski, 2013).

Madhya Pradesh with high geographical diversity, eleven agro- climatic zones, and varied soil types is better placed for production of various horticultural crops. Madhya Pradesh ranks fourth in India for the production of potato, an area 1,58,177.52 hectares and the production is 3587739.59 tonnes with the productivity of 20.68 t/ha during 2020-21.

The nutrient requisite by the crop either in larger or smaller quantities decides the productivity by its role in plant metabolic activities. Recent advances in nutrient management research have come out with an advanced technique of supplying nutrient to crop according to variability in soil over space and requirement during a particular growth period. The approach is termed as site

Table-1 : Effect of different treatments on growth parameters.

Treatment	% Emergence	Plant height (cm)	No. of shoots/plant	Grade-wise yield of tubers (t/ha)				
				0-25g	25-50g	50-75g	>75g	Total
T ₁	96.00	42.60	5.30	2.16	2.33	5.71	7.23	17.42
T ₂	96.60	50.45	7.50	2.17	4.87	7.23	12.17	26.86
T ₃	97.30	52.50	8.00	2.42	7.08	8.63	11.38	29.51
T ₄	92.50	39.10	5.20	2.22	4.27	5.62	5.55	17.66
T ₅	93.30	43.70	6.00	2.43	5.31	5.43	7.68	20.34
T ₆	94.00	40.20	5.80	2.07	4.66	5.48	7.70	19.91
T ₇	93.00	36.60	4.50	1.68	2.52	4.61	4.05	12.86
SE(d)	1.04	0.94	0.44	0.16	0.46	0.62	0.83	0.47
C.D.	2.21	1.98	0.93	0.33	0.98	1.31	1.76	0.98
C.V.	1.56	3.04	10.22	10.29	14.69	14.35	14.73	3.18

Table-2 : Effect of different treatments on dry yield and NPK concentration.

Treatment	Dry matter content (%)	Yield on dry weight basis (kg/ha)		Concentration of nutrient in haulm			Concentration of nutrient in tubers		
		Tuber	Haulm	N	P	K	N	P	K
T ₁	18.50	3219.23	1120.48	1.76	0.17	0.95	1.73	0.37	1.73
T ₂	18.98	5093.50	1256.83	2.59	0.28	1.75	2.02	0.31	1.79
T ₃	19.45	5740.85	2670.81	2.37	0.19	1.45	2.10	0.15	1.77
T ₄	18.65	3292.46	1178.42	1.11	0.15	1.70	0.61	0.31	1.58
T ₅	18.05	3670.08	1451.89	1.81	5.91	1.69	2.10	0.18	1.82
T ₆	18.90	3760.40	1650.86	2.55	0.24	2.19	2.01	0.30	1.25
T ₇	17.43	2240.37	1025.87	0.84	2.76	0.97	0.54	0.14	1.10
SE(d)	0.22	105.09	587.94	0.02	0.02	0.02	0.02	0.00	0.00
C.D.	0.47	222.51	NS	0.05	0.05	0.05	0.05	0.01	0.01
C.V.	1.68	3.85	56.21	1.84	2.19	2.07	1.88	2.42	0.26

specific nutrient management (SSNM). The approach of SSNM involves science based principles for guiding the judicious and efficient application of fertilizers as and when needed by crops. It recognizes the inherent spatial variability associated with soil during crop production and provides guidelines for optimal use of indigenous nutrients originating from soil, plant residues, manures and irrigation water. Thus, SSNM considers indigenous nutrient supply of the soil and productivity and targets the capability of sustaining higher yields on one hand, and assured restoration of soil fertility on the other. Moreover, these systems are known by less use of inputs, namely, fertilizers, plant protection chemical and thus healthy, safe and high quality food under ecologically sound production system.

Abundant studies document the crop response to N, P, and K fertilizer application. Yield and tuber quality are affected by both excess and lower application of nutrients. While, the negative impacts of over application of nutrients are attributed to salt damage (Bilski *et al.*, 1988), disease (Somani and Shekhawat, 1988) and physiological changes (Westermann *et al.*, 1994), lower availability of nutrients alter the crop productivity by influencing crop water relationships, variability of transpiration rates and increments in plant body

temperature (Yli-Halla *et al.*, 1987). Hence, keeping in view of the importance of nutrient management and its role in crop productivity, experiments were conducted to study the effect of site specific nutrient management in potato under central zone of Madhya Pradesh.

Materials and Methods

Investigation was conducted at Zonal Agriculture Research Station, Chhindwara under AICRP-Potato Rabi 2017 and 2018. The soil of experimental field was sandy loam in texture. Soil was neutral in reaction (pH- 7.33), high in organic carbon (1.52%), available N (332 kg/ha), available P₂O₅ (35 kg/ha) and available K₂O (157 kg/ha). Seven treatments on NPK levels were taken out for study purpose on the growth and yield of potato. These were T1- 50% recommended dose of fertilizer (RDF) of NPK, T2- 100% RDF of NPK, T3- 150% RDF of NPK, T4- RDF of PK (without N), T5- RDF of NK (without P), T6- RDF of NP (without K) and T7- absolute control (without NPK). Recommended dose of fertilizer was 120 kg N, 100 kg/ha P₂O₅, 100 kg/ha K₂O for potato crop. The treatments were applied in randomized block design with four replications. The potato cultivar Kufri Chipsona-3 was taken under experiment which has processing with medium duration. Nitrogen, phosphorus and potassium were applied in form of Urea, NPK (12:32:16) and MOP

Table-3 : Economics.

Treatment	Yield (t/ha)	Inputs (Rs ⁻¹)	Produce (Rs ⁻¹)	Net return (Rs ⁻¹)	B : C ratio
T ₁	17.42	76185	148070	71885	1.94
T ₂	26.86	80420	228310	147890	2.84
T ₃	29.51	84655	250835	166180	2.96
T ₄	17.66	78640	150110	71470	1.91
T ₅	20.34	76158	172890	96732	2.27
T ₆	19.91	77384	169235	91851	2.19
T ₇	12.86	69000	109310	40310	1.58

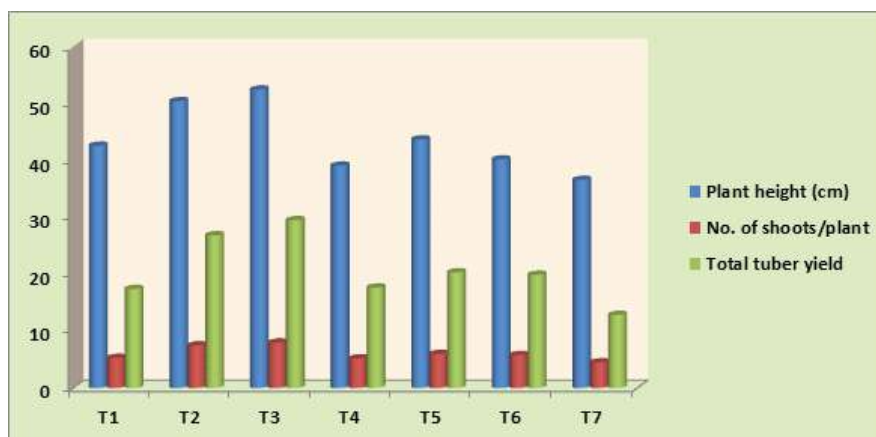


Fig. : Plant height, no. of shoot and tuber yield affected by different doses of NPK.

respectively. Whereas under the treatment–PK (without nitrogen), the phosphate was applied through single super phosphate. Nitrogen applied two split doses at the planting and 45 days after planting (top dressing) and full PK was applied at the time of planting. All recommended agronomic practices as well as plant protection measures were adopted for the potato crop production.

All growth attributing characters and yield parameters were observed from five randomly selected and tagged plants of each plot. The whole plots of each treatment were dehaulmed 10 days before the final harvesting of the conducting tests. The F-test was computed to find out the significance of treatments impact on the potato crop. Standard errors of variance and critical differences of various treatments were computed out at 5% level of significance to assess the authenticity of each respective treatment.

Results and Discussion

The different levels of NPK showed various consequences on crop growth, yield attributing characters and yield of the potato crop. Percent emergence of potato crop at 30 days after planting (DAP) ranged from 97.3 to 92.5 and maximum plant emergence percent (97.3%) was observed in T3 150% NPK (180:150:150 kg/ha). Singh (1995) observed that the highest germination per cent (100%) was recorded at 30 days after planting with the application of nitrogen @ 200 kg/ha. Singh and Lal (2012)

reported that the emergence of seed tubers in potato ranged from 90 to 98%, however, there was no effect of fertilizer treatments on the emergence of seed tubers.

Among the various treatments, treatment T3- 150% NPK (180:150:150 kg/ha) recorded significantly higher plant height (52.50cm), number of shoots/hill (8.00), at the time of 75 DAP followed by T2-100% RDF while T7 (absolute control without NPK) and other treatments gave lower response. Malik *et al.* (1997) observed that the increased levels of nitrogen and potash had significant effect on plant height of potato. Skipping of any nutrients (NP, PK and NK) did not created any significant impact on plant height, number of shoots per hill and number of leaves per plant. Kumar *et al.*, (2004) also reported that the application of 150% of RDF increased the number of shoots per plant. Number of leaves per plant is influenced positively due to increasing level of nitrogen (Pandey *et al.*, 2007).

Dry matter gathering was recorded considerably higher with the application of 150% RDF of NPK at all the growth stages. Patel (2013) also obtained higher dry matter per plant under the treatment of 150% RDF in potato. Likewise the tuber yield per plant was significantly higher with the application of the same treatment (150% RDF of NPK). Further, nitrogen boosts the tuber initiation by more photosynthesis activity and yield on optimum limit beyond which it delays tuber development and increase foliage growth at the expense of tuberisation (Sharma and

Kumar 2014). The findings revealed significant variations in marketable yield among different treatments. The present study showed that the highest marketable potato tuber yield (29.51 t/ha) was obtained with the treatment T₃-150% RDF of NPK fertilizer followed by T₂-100% RDF of NPK fertilizers (26.86 t/ha) and minimum marketable yield was noted in treatment T₇-absolute control. Treatment T₃-150% RDF of NPK was statistically superior over rest of treatments. The increase in marketable tuber yield was due to the increase in levels of N, P and K at each successive level. The nitrogen applied at higher levels was found to be beneficial. This might be due to the accumulation of adequate quantity of photosynthetic transfer from source to sink. This finding is in confirmation with those of Kumar *et al.*, 2008). Sinha (2007) observed that the application of 225 kg/ha nitrogen was found optimum to obtained the higher tuberization efficiency and yield of potato per plot (marketable as well as total tuber yield). Skipping of any major nutrients resulted in a poor all growth parameters, yield attributing characters and ultimately the yield. Uptake of nutrients depends upon available nutrient status of soil, plants vegetative as well as reproductive health, metabolic activity of crop and fertilizer used etc. Data obtained for uptake of N, P and K by tuber, vine and total uptake had significant effect and differences to different treatments. Maximum uptake of N, P and K was obtained under treatment, T₃-150% RDF of NPK, which was statistically superior over rest of treatments. Javed *et al.* (2012) observed highest tuber yield recorded with the highest levels of N and K, were nearly double the yield recorded under control. Similar trend was observed for dry matter yield. The uptake of N, P, K and S significantly increased with increase in N and K application rate. The interaction effect between N and K significantly and synergistically influenced the tuber and dry matter yields, which were observed the highest at 300 kg N in conjunction with 180 kg K₂O.

The economics of potato production were also investigated under the various doses of fertilizers. The results showed that in the absolute control treatment the lowest cost of cultivation (Rs. 69000/ha) was required (T₁). The treatment of (T₃) 150% RDF of NPK needed the highest cost of Rs. 84655/ha.

The administration of 150 % and 100 % RDF of NPK enhanced net returns and the B: C ratio, as evidenced by the data. T₃ (150 % NPK) yielded the highest net return (Rs. 166180/ ha.), followed by T₂ (100 % NPK), and, in terms of economic viability, treatment T₃ and T₂ are better than all other treatments. T₃ (150 % RDF) had the highest B:C ratio (2.96), whereas control had the lowest (1.58). This result is in conformity with result of Kumar *et al.* (2008), and Singh and Lal (2012). Similar results had also

been reported by Sasani *et al.* (2003) and Chettri *et al.* (2005).

Conclusions

Result accomplished that the total tuber yield increased with increasing recommended dose of fertilizers of NPK. There were no significant variations in total tuber yield and benefit cost ratio were recorded between 150% and 100% recommended doses of fertilizers of NPK. Nitrogen was found one of the most limiting nutrients for potato due to maximum reduction in total tuber yield. The second most limiting nutrient was potassium afterward phosphorus.

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Effect of Physical Parameters on Conidial Germination of *Oidium erysiphoides* f. sp. *Ziziphi* of Ber under Controlled Condition

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Abstracts

Ber (*Ziziphus mauritiana* Lamk) is the most important horticulture fruits crop. Ber fruits plant infected by several disease and insect among these diseases powdery mildew are most important and causes huge loss in yield and productivity of the ber fruits and mostly appeared in the last week of October and reaches at peak in the month of December. In vitro studies were conducted to know the effect of temperature, relative humidity, darkness: light and incubation period on the conidial germination of *Oidium erysiphoides* f. sp. *ziziphi*. The maximum conidial germination was obtained at 25°C temperature, whereas at lower and higher the optimal temperatures, conidial germination significantly lower. Germ tubes initiate to develop at all values of relative humidity (40-90%), reaching the maximum conidial germination at 90% RH. The effect of combination of different duration of darkness and light on the conidial germination was studied at different temperature levels. While that maximum conidial germination was recorded in 11:13 hours of darkness and light at 25°C temperature after 24 hours. Impact of incubation period on conidial germination was studied by keeping conidia under different incubation periods at optimum temperature (25°C) and relative humidity (90%) separately. Whereas that conidial germination was started after 4 hours of incubation. The conidial germination percentage was increased with increasing incubation period. Maximum conidial germination was recorded at optimum temperature (25°C) and relative humidity (90%) after 24 hours of incubation period, respectively.

Key words : Ber powdery mildew, conidial germination, physical parameters..

Introduction

Ber (*Ziziphus mauritiana* Lamk) is the most important horticulture fruits crop. Ber is a tropical fruit tree spp. belonging to the family *Rhamnaceae* and there are two different groups of ber in India. *Rhamnaceae* family have 50 genera and 600 species. The genus *Zizyphus* has about 40 spp. (Pareek, 1983) and is distributed throughout the tropical and subtropical regions of the world. Ber fruits plant infected by several disease and insect among these powdery mildew diseases are most important widespread and easily recognizeable and causes huge loss in yield and productivity of the ber fruits.

Ber powdery mildew caused by the fungus *Oidium erysiphoides* f. sp. *ziziphi*, Yan and Wang is certainly the most important common ber disease in north India. The major production regions for Indian jujube are the arid and semi-arid regions of India. In India the production of ber fruits was 5,13,000 million tonnes with the productivity of 10.26 tonnes/ha. In Rajasthan, major production regions for Indian jujube are Bharatpur (mostly Deeg area), Alwar (Tijara and Ramgarh area), Barmer, Sri Ganganagar, Jodhpur, Jaipur (Chomu area), Pali, Chittorgarh and Hanumangarh. In Rajasthan, total area under ber cultivation is 738.4 hectares with an average annual production of 5248 metric tonnes with productivity 7108

kg/ha, Anonymous, (2017-2018). According to professional and scientific literature, this fungus is very detrimental because of its direct impact on plants (nutrient uptake from leaf tissue and immature fruits) and indirect detrimental impact since its superficially mycelium reduces intermingle by covering the leaf and fruits surface. Powdery mildew grows well in environmental conditions with high relative humidity and moderate temperatures. Jamadar and Desai (1996) have been recorded 17.0-71.0 per cent disease index at fruiting stage of ber due to powdery mildew fungus, in Bijapur, India. Jamadar *et al.* (2009) have also been reported 50-60 per cent loss in the fruit yield due to powdery mildew of jujube and reduced market value of the produce. Powdery mildew of ber is the very grave disease and causes heavy yield losses (Misra *et al.*, 2013). The peak per cent disease index (12.69%) of disease is generally observed in the month of December, (Jat and Goyal., 2009). To know the effect of different abiotic environmental factors on the development of the disease, while aim of this study was to examine the importance of basic environmental factors such as temperature, relative humidity, darkness:light and incubation periods, on the conidial germination of *Oidium erysiphoides* f.sp. *ziziphi* of ber and to clarify their roles of this pathogen. The objective of the study was also to assess the importance

of leaf age as a factor of passive resistance of plants to powdery mildew infestation (Pap *et al.* 2013).

Materials and Methods

Conidial germination : A drop of conidial suspension was put on the sterilized cavity slide supported on glass rods inside the Petriplates. Both halves of the Petriplates were covered with sterilized filter paper, atomized with sterilized water to retain moisture (Prakash and Saharan, 1999). Instead of simple glass slide, cavity slide was used to avoid drying of droplet. Conidial germination experiments were performed according to the procedures recommended by the committee on standardization of fungicides test of American Phytopathological Society, 1943 (Sain and Sharma, 1999). The conidial suspension was contained approximately 20 conidia per low power microscopic field at 10x10 magnifications. Three replications were maintained for each treatment. After incubation period, the slides were taken out and a drop of lactophenol was added immediately to arrest further germination of the conidia. Per cent conidial germination was calculated by formula given below.

Per cent conidial germination

$$= \frac{\text{No. of conidial germinated}}{\text{Total No. of conidial observed}} \times 100$$

Effect of physical parameters on conidial germination

Temperature : The conidial suspension obtained and placed as above was incubated at 15, 20, 25, 30 and 35°C in separate digital B.O.D. incubator in laboratory. After 24 hours of incubation, percent conidial germination was counted under microscope.

Relative humidity : To study the effect of relative humidity on conidial germination, the conidia of *Oidium erysiphoides* f. sp. *ziziphi* were collected and picked as method described above under (A). Different relative humidity levels were created in desiccators by dissolving concentrate sulphuric acid and sterilized double distilled water in different proportion as per method suggested by Buxton and Mellanby (1934) and used by Kumawat *et al.* (2016). The composition of the acid solution was used as followed.

List of Stock solution

Relative Humidity %	Stock solution (ml*)	Distilled water (ml*)
40	510.0	158.0
50	405.0	278.0
60	374.0	396.0
70	348.0	510.0
80	294.0	640.0
90	161.0	712.0

*50v/v solution of concentrate sulphuric acid.

The desiccators were incubated at 25°C temperature in digital B.O.D. incubator. A drop of conidial suspension collected and placed on cavity slides as above but Petriplates were not covered. These Petriplates were put in sealed desiccators maintaining different levels of relative humidity with above treatments and three replications. After 24 hours of incubation, conidial germination was recorded.

Effect of darkness and light : To know the effect of dark and light on conidial germination of *Oidium erysiphoides* f. sp. *ziziphi*, the experiment was conducted for dark:light period of 11:13, 12:12, 13:11 and 14:10 hrs. The conidia were picked up as per procedure described in (A). For observing the effect of different dark and light periods on conidial germination, the Petriplates containing conidial suspension were incubated at 15, 20, 25, 30 and 35°C in BOD with above treatments and three replications and after 24 hrs of incubation, conidial germination was recorded.

Effect of Incubation period : The experiment was conducted to observe the effect of different incubation periods on conidial germination of *Oidium erysiphoides* f. sp. *ziziphi*. Conidia were incubated for 4, 6, 8, 10, 12 and 24 hours at optimum temperature (25°C) in digital B.O.D. incubator and optimum relative humidity 90 per cent in desiccators. The conidial suspension placed in Petriplates as per method described above. After completion of incubation period, germination per cent was recorded under binocular microscope.

Results and Discussion

Effect of physical parameters on conidial germination of pathogen

Effect of temperature on conidial germination : The percent conidial germination of *Oidium erysiphoides* f. sp. *ziziphi* was greatly affected by temperature. The maximum conidial germination 72.31 per cent was recorded when conidia were incubated at 25°C temperature followed by 51.21 per cent at 20°C temperature and temperature below and above 25°C significantly reduced conidial germination (Table-1). The minimum conidial germination (34.62% and 13.61%) was recorded at 15°C and 35°C temperature respectively. Temperature at 25°C was found optimum for giving maximum conidial germination of *Oidium erysiphoides* f. sp. *ziziphi*.

Table-1 : Effect of temperature on conidial germination of *Oidium erysiphoides* f.sp. *ziziphi* of ber.

Temperature $\pm$ 1°C	% conidial germination*
15	34.62 (36.04)
20	51.21 (45.69)
25	72.31 (58.25)
30	38.69 (38.46)
35	13.61 (21.65)
SEm $\pm$	0.78
CD (p=0.05)	2.39
CV (%)	3.20

*Average of four replications.

Figure in parenthesis are angular transformed values

Effect of relative humidity : The effect of various levels of relative humidity on conidial germination of *Oidium erysiphoides* f.sp. *ziziphi* was studied using 40, 50, 60, 70, 80 and 90 per cent relative humidity. All the levels of relative humidity were differ significantly except relative humidity 60 per cent and 70 per cent which found at par to each other. Result revealed (Table-2) that maximum conidial germination 75.41 per cent was observed at 90 per cent relative humidity followed by 68.30 per cent conidial germination was obtained at 80 per cent relative humidity after 24 hours. Relative humidity below and above 90 per cent significantly reduced conidial germination of *Oidium erysiphoides* f.sp. *ziziphi*. The least conidial germination (32.16%) was recorded at 40 per cent relative humidity. Relative humidity at 90 per cent was found optimum for giving maximum conidial germination of *Oidium erysiphoides* f.sp. *ziziphi*.

Table-2 : Effect of relative humidity on conidial germination of *Oidium erysiphoides* f. sp. *ziziphi* of ber.

Relative humidity (%)	% conidial germination*
40	32.16 (34.55)
50	46.18 (42.81)
60	55.92 (48.40)
70	57.79 (49.48)
80	68.30 (55.73)
90	75.41 (60.27)
SEm $\pm$	1.00
CD (p=0.05)	3.08
CV (%)	3.09

*Average of four replications. Figure in parenthesis are angular transformed values.

Effect of darkness and light : The effect of combination of different duration of darkness and light on the conidial germination of *Oidium erysiphoides* f.sp. *ziziphi* was studied at 15, 20, 25, 30 and 35°C temperature. The result revealed (Table-3) that maximum conidial germination 71.44 per cent was recorded in 11:13 hours of darkness and light at 25°C temperature followed by 39.69 per cent conidial germination was observed at 20°C at 11:13 darkness:light. Both at 13:11 and 14:10 hours of darkness and light minimum, conidial germination was observed at all temperature levels. The second best combination of darkness and light was 12:12 hours in giving conidial germination 68.82 per cent at 25°C temperature followed other all temperature levels. The least conidial germination 6.98 per cent was recorded at 14:10 hours dark : light combination at 35°C.

Table-3 : Effect of darkness and light on conidial germination of *Oidium erysiphoides* f.sp. *ziziphi* of ber at different temperature levels.

Dark : Light (in hours)	% conidial germination at different levels of temperature*				
	15°C	20°C	25°C	30°C	35°C
11:13	35.00 (36.27)	39.69 (39.05)	71.44 (57.70)	36.39 (37.08)	13.38 (21.44)
12:12	28.62 (32.34)	29.93 (33.17)	68.82 (56.06)	30.92 (33.76)	10.71 (19.09)
13:11	25.96 (30.63)	27.18 (31.42)	41.82 (40.29)	28.68 (32.38)	8.22 (16.66)
14:10	24.63 (29.75)	26.98 (31.29)	33.33 (35.26)	26.98 (31.29)	6.98 (15.32)
SEm $\pm$	0.61	0.62	1.09	0.60	0.15
CD (p=0.05)	1.87	1.92	3.37	1.99	0.49
CV (%)	3.67	3.49	3.52	3.39	2.64

* Average of four replications, Figure in parenthesis are angular transformed values.

Table-4 : Effect of incubation period on conidial germination of *Oidium erysiphoides* f.sp. *ziziphi* of ber.

Incubation periods (in hours)	% conidial germination*	
	25°C temp.	90% RH
4	2.61(9.30)	3.33 (10.51)
6	6.29 (14.52)	8.69 (17.14)
8	35.67 (36.67)	36.91 (37.41)
10	45.74 (42.56)	46.23 (42.84)
12	56.62 (48.80)	57.90 (49.55)
24	74.19 (59.47)	76.81 (61.21)
SEm $\pm$	0.90	0.82
CD (p=0.05)	2.78	2.54
CV (%)	2.82	2.48

*Average of four replications, Figure in parenthesis are angular transformed values

Effect of incubation period : The effect of incubation period on conidial germination of *Oidium erysiphoides* f. sp. *ziziphi* was studied by keeping conidia under different incubation periods (4, 6, 8, 10, 12 and 24 hours) at optimum temperature (25°C) and relative humidity (90%) separately. Results revealed (Table-4) that conidial germination was started after 4 hours of incubation. The conidial germination percentage was increased with increasing incubation period. Maximum conidial germination (74.19% and 76.81%) was recorded at optimum temperature (25°C) and relative humidity (90%) after 24 hours of incubation period, respectively. The least conidial germination (2.61% and 3.33%) was observed at optimum temperature (25°C) and relative humidity (90%) respectively, at 4 hours of incubation period.

Ber (*Ziziphus mauritiana* Lamk.) is an old and important fruit of Indo-China region and has been grown in Indian Subcontinent since ages for fresh fruits. Ber powdery mildew caused by the fungus *Oidium erysiphoides* f.sp. *ziziphi*, Yan and Wang is certainly the most important common ber disease in north India. The fungal mycelia become external on the host while conidiophores are upright, single and measuring 75.8-139.4 × 12.6 µm. Conidia are cylindrical, single celled, hyaline, catenulate measuring about 25.2 - 37.8 × 16.8 - 21.0 µm. Conidia of this fungus germinate and form appressoria (Omprakash and Mishra, 1993). The fungus survives in the bud wood (as dormant mycelia) and also on some alternate host (*Phyllanthus niruri*) in the absence of ber plants. The powdery mildew disease is also occurred on wild and cultivated species of ber (Mehta, 1950). Powdery mildew disease appeared during the period of October-November when temperature is low and relative humidity is high with heavy yield loss (Misra *et al.*, 2013).

Microsphaera is the perfect stage (teleomorph stage) of *Oidium erysiphoides* f.sp. *ziziphi*, which has septate, ectophytically superficial, branched, hyaline and uninucleate mycelia. The ectophytically superficial mycelium produces large number of conidia on the surface of the host plants that appears as white powdery mass, hence called "powdery mildew". Cleistothecial fruiting bodies of the pathogen have several asci with dichotomously-branched appendages at the tips (Dube, 2013).

Dae-Hyun *et al.* (2009) have also been obtain maximum germination of chilli powdery mildew pathogen at 25°C. Pap *et al.* (2013) have studied the effect of temperature on the conidial germination and germ tube elongation of oak powdery mildew (*Microsphaera alphitoides*) in controlled conditions and reported maximum germ tube length at 25°C temperature. Pap *et*

al. (2013) studied the effect relative humidity on conidial germination and germ tube elongation of oak powdery mildew (*Microsphaera alphitoides*) in controlled conditions and noted maximum germination and germ tube length at 90 per cent relative humidity. Misra *et al.* (2016) also reported that maximum relative humidity (73.3-83.9%) is more conducive for the rapid spread of mango powdery mildew pathogen. Joseph *et al.* (2019) have also been obtained the highest conidial germination of *Erysiphe cichoracearum* (58.80%) in 10:14 hrs of darkness and light which was significantly higher than other treatments. Prakash and Saharan (2000) observed maximum conidial germination of *Erysiphe polygoni*, causing powdery mildew of fenugreek after 24 hours of incubation.

Conclusions

Our findings coincide largely with the results of other authors, so it can be concluded that natural conditions can be simulated in a climate chamber and reliable data can be obtained on the impact of various factors on the development of the fungus. The highest conidial germination was recorded at 25°C temperature, 90 per cent relative humidity after 24 hours of incubation and 11:13 hours of darkness and light.

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Reactions of Genotypes of Barley with Aphid (*Rhopalosiphum maidis*) Population

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Abstract

Fifteen genotypes of barley were screened for their comparative resistance to aphid, *R. maidis* in Rabi 2014-15 at the Agronomy farm of SKN College of Agriculture, Sri Karan Narendra Agriculture University, Jobner (Rajasthan). The mean aphid population of all the observations ranged from 19.86 to 49.56 aphids per tiller. The minimum mean aphid population was found on genotype, RD-2035 (19.86 aphids/tiller) followed by RD-2552 (22.41 aphids/tiller), RD-2849 (24.74 aphids/tiller) and RD-2794 (25.84 aphid/tiller), these were differed non-significantly in their degree of infestation each other and differed significantly over rest of the genotypes. The maximum mean aphid population was found on genotype, RD-2624 (49.56 aphids/tiller) followed by RD-2052 (48.97 aphids/tiller), these were statistically at par with each other in their degree of infestation. The genotypes viz., RD-2035, RD-2552 and RD-2794 were found as least susceptible; RD-2503, RD-2508, RD-2793, PL-426, RD-2592, RD-2660, RD- 2668, RD-2715 and RD-2786 and RD-2849 as moderately susceptible; whereas, RD-2052 and RD-2624 as highly susceptible.

Key words : Aphid, barley, genotypes, susceptibility.

Introduction

Barley, *Hordeum vulgare* Linn. (Family: Gramineae) is an important cereal crop of Rabi season grown in India. The chapattis made up of barley flour are very palatable and can be easily digested even by the persons suffering from stomach ailments. Besides an ideal feed and fodder for livestock, the crop has acquired the status of an industrial crop in malting and brewing. This crop could perform better under moisture stress and saline conditions than other cereal crops. The grains of barley contain 12.5 per cent moisture, 11.5 per cent albuminoids, 74.0 per cent carbohydrate, 1.3 per cent fat, 3.9 per cent crude fibre and 1.5 per cent ash. In Rajasthan, it is cultivated in about 307,936 ha area with an annual production to the tune of 957,896 tonnes (Anonymous, 2013). The crop is infested by a number of insect pests, viz., armyworm, *Mythimna separata* (Haworth); ghujhia weevil, *Tanymecus indicus* (Faust); termite, *Odontotermes obesus* (Ramb.); cutworms, *Agrotis* spp.; shoot fly, *Atherigona naquii* (Styskal); pink borer, *Sesamia inferens* (Walker); jassids, *Amrasca basal* (Baly); barley aphid, *Rhopalosiphum maidis* (Fitch) and *R. padi* (Linn.) (Singh, 1983). Among these insect pests, the aphid, *R. maidis* is most serious and regular insect pest of this crop (Sharma, 1990; Kumawat and Jheeba, 1999). Both nymphs and adults cause damage by sucking the cell sap from the leaves, stems and earheads. Due to rapid multiplication of the aphid, usually the entire shoot is covered and with the result of continuous desapping by such a large population, yellowing, curling and subsequent drying of leaves takes

place which ultimately lead to reduction in size of earheads (Bhatia and Singh, 1977). The aphid also acts as a vector of barley yellow dwarf virus. The growing of resistant varieties have utmost importance in the crop protection because it does not incur extra cost to minimize the damage and used as a prophylactic measure against insect pests. In past, some varieties/germplasms of barley were screened against insect pests by many workers (Yadav and Jain, 2000; Singh *et al.*, 2006), however, these have been replaced by new high yielding varieties on which such work is lacking.

Materials and Methods

The experiment was laid out in simple randomized block design (RBD) with 15 treatments (genotypes), each replicated thrice. The plot size was 3.0 x 2.25 m² with row to row distance of 25 cm, respectively. The barley genotypes were sown on 15th November, 2014. The names of different genotypes and their source of supply are given in table 1. The genotypes were allowed to have natural infestation of aphid, *R. maidis*. The observations on the population of aphid were recorded on five randomly selected and tagged plants (5 tillers/plant) from each plot at weekly interval starting from its appearance till harvesting of the crop. Different morphological characters, viz., plant height, number of tillers/metre row, days to earing and days to maturity were recorded.

Interpretation of data

The data obtained on aphid population from the experimental field were transformed into $\sqrt{X+0.5}$ (Gomez

and Gomez, 1976) and subjected to analysis of variance. The peak population of aphid on barley genotypes recorded during the crop season was categorized on the basis of formula :

$$X +$$

Where,

X = Mean of peak population

= Standard deviation

Results and Discussion

The population on different genotypes of barley appeared in the first week of January, 2015. The mean aphid population increased gradually and reached to peak in the fifth observation (01th February, 2015). The aphid population increased considerably which was found in the range of 47.23 to 110.59 aphids/ tiller. The least aphid infestation was observed on genotypes RD-2035 (47.23 aphids/ tiller) and RD-2794 (52.15 aphids/tiller), these were statistically comparable to each other in their degree of resistance. The maximum aphid population was recorded on RD-2624 (110.59 aphids/tiller) and RD-2052 (106.60 aphids/tiller), these were stood at par with each other. The RD-2503 (87.58 aphid/tiller) differed non-significantly with RD-2660 (79.50 aphids/tiller). The other genotypes were grouped in middle order of infestation. In the last observation (22nd February, 2015), the aphid population was drastically reduced, being minimum on RD-2035 (7.63 aphids/tiller) and maximum on RD-2052 (19.70 aphids/tiller). The mean aphid population of all the observations ranged from 19.86 to 49.56 aphids per tiller. The minimum mean aphid population was found on genotype, RD-2035 (19.86 aphids/tiller) followed by RD-2552 (22.41 aphids/ tiller), RD-2849 (24.74 aphids/ tiller) and RD-2794 (25.84 aphid/tiller), these were differed non-significantly in their degree of infestation each other and differed significantly over rest of the genotypes. The maximum mean aphid population was found on genotype, RD-2624 (49.56 aphids/tiller) followed by RD-2052 (48.97 aphids/tiller), these were statistically at par with each other in their degree of infestation. The rest of the genotypes were ranked in middle order of infestation. The descending order of infestation of all the genotypes based on mean aphid population was found to be RD-2624, RD-2052, RD-2503, RD-2660, PL-426, RD-2508, RD-2592, RD-2715, RD-2793, RD-2668, RD-2786, RD-2794, RD-2849, RD-2552, RD-2035 (Table-2). For the sake of convenience in concluding the result, the peak aphid population on barley genotypes was categorized on the basis of formula $X + 6$. The genotypes having aphid population below 56.12, 56.12 to 91.08 and above 91.08 per tiller were categorized as least susceptible,

moderately susceptible and highly susceptible, respectively. Taking the above criterion into consideration, the genotypes viz., RD-2035, RD-2552 and RD-2794 were considered as least susceptible; RD-2503, RD-2508, RD-2793, PL-426, RD-2592, RD-2660, RD-2668, RD-2715 and RD-2786 and RD-2849 as moderately susceptible; and RD-2052 and RD-2624 as highly susceptible. The order of variability in barley genotypes keeping in consideration the peak aphid population and the mean aphid population of all the observations recorded during the crop season was more or less same (Table-3). The morphological characters of different barley genotypes, viz., plant height, tillers per metre row, days to earing and maturity were recorded to find out their relationship with aphid incidence and it could be concluded that these did not affect the aphid population significantly (Table-4). In the present investigation 15 genotypes of barley viz., RD-2035, RD-2052, RD-2503, RD-2552, RD-2508, RD-2552, RD-2592, RD-2624, RD-2663, RD-2668, RD-2715, RD-2786, RD-2793, RD-2794, RD-2849, PL-426 were screened for their comparative resistance to aphid, *R. maidis*. The results revealed that none of the genotypes was found completely free from aphid infestation. The present findings are in conformity with that of Chhillar *et al.*, (1985) and Singh *et al.*, (2006) who reported that out of 30 barley cultivars screened against *R. maidis*, none of them was found resistant to the pest. The data revealed that significant difference existed among the genotypes of barley with regards to aphid population. During peak, maximum aphid population was observed on genotype, RD-2624 (110.59 aphids/tiller) and minimum on RD-2035 (47.23 aphids/tiller).

The genotypes screened in the present investigation were not screened by any other workers in the past except a few. The genotype RD-2035 was least susceptible, RD-2503, RD-2508 was moderately susceptible and RD-2052 was highly susceptible to aphid as reported by Kumawat and Jheeba (1999), supports the present findings. Singh and Jat (2011) found RD-2035 and RD-2552 as least susceptible varieties. Likewise, Sharma (2003) reported that genotype RD-2035 was least susceptible to aphid. Contrary to the present finding, he reported that genotypes RD-2508 was highly susceptible and it was moderately susceptible in the present findings. Chhillar *et al.*, (1985) reported that out of 30 barley varieties screened, BP-454, EB-921, Wocus and BP-464 were found resistant to aphid those were not included in the present study. Pandey *et al.*, (1987) reported that out of 197 barley lines screened against aphid, *R. maidis*, 19 were categorized as tolerant to aphid attack, 75 moderately susceptible, 77 susceptible and 26 highly susceptible, but did not corroborate with the

Table-1 : Different barley genotypes studied for reactions with aphid, *Rhopalosiphum maidis* (Fitch) and their source of supply.

Name of genotypes	Source of supply
RD-2035, RD-2052, RD-2503, RD-2508, RD-2552, RD-2592, RD-2624, RD-2660, RD-2668, RD-2715, RD-2786, RD-2793, RD-2794, RD-2849 and PL-426	Rajasthan Agricultural Research Institute, Durgapura, Jaipur

Table-2 : Reactions of genotypes of barley with aphid, *Rhopalosiphum maidis* (Fitch) population.

Genotypes	Weekly mean aphid, <i>R. maidis</i> population/ tiller*								Mean
	04.01.2015	11.01.2015	18.01.2015	25.01.2015	01.02.2015**	08.02.2015	15.02.2015	22.02.2015	
1. RD-2035	4.20 (2.17)	6.44 (2.63)	19.33 (4.45)	33.02 (5.79)	47.23 (6.91)	28.40 (5.38)	12.63 (3.62)	7.63 (2.85)	19.86 (4.51)
2. RD-2052	18.35 (4.34)	27.54 (5.30)	52.54 (7.28)	78.28 (8.88)	106.60 (10.35)	67.08 (8.22)	21.66 (4.71)	19.70 (4.49)	48.97 (7.03)
3. RD-2503	9.26 (3.12)	20.15 (4.54)	44.60 (6.72)	60.80 (7.83)	87.58 (9.39)	61.26 (7.86)	15.66 (4.02)	13.87 (3.79)	39.15 (6.30)
4. RD-2508	6.12 (2.57)	19.09 (4.43)	35.02 (5.96)	56.82 (7.57)	77.01 (8.80)	47.08 (6.90)	14.60 (3.89)	12.60 (3.62)	33.54 (5.83)
5. RD-2552	5.18 (2.38)	12.62 (3.62)	24.06 (4.96)	35.73 (6.02)	54.52 (7.42)	29.45 (5.47)	9.87 (3.22)	7.87 (2.89)	22.41 (4.79)
6. RD-2592	6.70 (2.68)	16.44 (4.12)	34.00 (5.87)	51.62 (7.22)	70.40 (8.42)	47.08 (6.90)	13.09 (3.69)	11.09 (3.40)	31.30 (5.64)
7. RD-2624	16.17 (4.08)	29.25 (5.45)	54.44 (7.41)	81.70 (9.07)	110.59 (10.54)	68.74 (8.32)	18.29 (4.33)	17.29 (4.22)	49.56 (7.08)
8. RD-2660	6.72 (2.69)	19.23 (4.44)	40.03 (6.37)	57.22 (7.60)	79.50 (8.94)	55.04 (7.45)	13.90 (3.79)	11.90 (3.52)	35.44 (6.00)
9. RD-2668	8.60 (3.02)	11.51 (3.47)	33.47 (5.83)	47.90 (6.96)	67.86 (8.27)	39.44 (6.32)	11.75 (3.50)	9.75 (3.20)	28.79 (5.41)
10. RD-2715	7.16 (2.77)	12.10 (3.55)	28.15 (5.35)	45.80 (6.80)	79.20 (8.93)	40.60 (6.41)	13.30 (3.71)	12.30 (3.58)	29.83 (5.51)
11. RD-2786	5.19 (2.39)	15.50 (4.00)	25.15 (5.06)	52.20 (7.26)	66.40 (8.18)	31.15 (5.63)	10.17 (3.27)	8.17 (2.94)	26.74 (5.22)
12. RD-2793	8.50 (3.00)	11.30 (3.44)	29.40 (5.47)	47.48 (6.93)	72.20 (8.53)	34.68 (5.93)	15.50 (4.00)	13.50 (3.74)	29.07 (5.44)
13. RD-2794	6.20 (2.59)	13.17 (3.70)	32.75 (5.77)	43.40 (6.63)	52.15 (7.26)	28.56 (5.39)	16.25 (4.09)	14.25 (3.84)	25.84 (5.13)
14. RD-2849	9.40 (3.15)	16.15 (4.08)	21.18 (4.66)	32.47 (5.74)	58.20 (7.66)	39.18 (6.30)	11.15 (3.41)	10.15 (3.26)	24.74 (5.02)
15. PL-426	11.50 (3.46)	18.20 (4.32)	35.50 (6.00)	56.15 (7.53)	74.50 (8.66)	52.20 (7.26)	12.16 (3.56)	9.06 (3.09)	33.66 (5.84)
S.Em±	0.10	0.13	0.15	0.17	0.18	0.15	0.12	0.09	0.23
CD (p=0.05)	0.30	0.39	0.42	0.49	0.52	0.44	0.35	0.25	0.67

Figures in the parentheses are $\sqrt{(x-0.5)}$ values. *Mean of three replications** Peak aphid population.

Table-3 : Categories of susceptibility of different barley genotypes to aphid, *Rhopalosiphum maidis* Fitch.

S. No.	Aphid population/ tiller	Categories of susceptibility	Varieties
1.	< 56.12	Least susceptible	RD-2035, RD-2552, RD-2794
2.	56.12-91.08	Moderately susceptible	RD-2503, RD-2508, RD-2793, PL-426, RD-2592, RD-2660, RD-2668, RD-2715, RD-2786, RD-2849
3.	> 91.08	Highly susceptible	RD-2052, RD-2624

present findings due to the difference in varieties included for study. Sharma and Bhatnagar (2003) reported that out of 202 genotypes of barley, ten promising genotypes showed relative resistance to *R. maidis* corroborate the present findings. The significant difference in aphid population among different barley varieties was reported by Sourial and Mitri (2002), Singh and Singh (2009),

Akhtar *et al.*, (2011) and Singh and Jat (2011) support the present findings.

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Table-4 : Morphological characters of barley genotypes and their correlation with aphid, *Rhopalosiphum maidis* (Fitch) population.

Genotypes	Morphological characters				
	Peak aphid population per tiller	Plant height (cm)	Tillers per meter row	Days to earing	Days to maturity
1. RD-2035	47.23	95	162	79	125
2. RD-2052	106.60	86	140	91	126
3. RD-2503	87.58	94	134	90	123
4. RD-2508	77.01	80	145	89	117
5. RD-2552	54.52	85	137	84	128
6. RD-2592	70.40	84	150	85	122
7. RD-2624	110.59	75	112	86	119
8. RD-2660	79.50	84	104	84	122
9. RD-2668	67.86	79	96	86	124
10. RD-2715	79.20	82	135	89	120
11. RD-2786	66.40	74	120	82	118
12. RD-2793	72.20	86	115	88	125
13. RD-2794	52.15	70	139	90	115
14. RD-2849	58.20	78	142	87	123
15. PL-426	74.50	80	125	83	114
Correlation coefficient with peak aphid population (r)	-	0.150	-0.326	0.445	-0.044

*Significant at 5% level

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Comparative Economics of Different IPM Modules in Tomato (*Lycopersicon esculentum* Mill.) against Tomato Fruit Borer (*Helicoverpa armigera*)

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Abstract

Module 7 recorded a maximum fruit yield of 269.73 q/ha with the highest efficacy, whereas, it was lowest in module 8 (173.47 q/ha) kept as untreated control. The maximum increase in yield over control was also obtained in module 7 (96.32 q/ha) with the highest net profit of Rs. 89065 and B: C ratio i.e. 1:12.28. The lowest increase in yield over control was observed in module 2 (17.71 q/ha) and it registered a lower B: C ratio of 1:3.23 with Rs. 13520 as net profit. The range of the B: C ratio for the remaining IPM modules was 1:10.24 to 1:3.54.

Key words : Module, profit, B:C ratio, yield.

Introduction

As the tomato (*Lycopersicon esculentum* Mill.) is a relatively short duration crop and gives a higher yield, it has become economically remunerative to the farmers and the area under its cultivation is increasing day by day. The total area and production of various vegetables in India are 10259 million hectares and 184394 million tonnes, respectively. Out of which tomato is cultivated in an area of 789.2 lakh hectares with a production of about 19759.3 lakh tonnes and productivity of 25 t/ha. In Rajasthan, the tomato crop occupied 18.12 lakh/ha area with a production of 88.73 lakh tonnes and productivity is 4.8 tonnes/ha. (Anonymous, 2017-18). Tomato is high yielding crop but still, various factors bring the about low yield of it such as poor quality seeds, the incidence of diseases and pests and adverse climatic conditions, etc. Among all the known factors, insect pests are of prime importance and significantly affect production. All the stages of the tomato crop right from nursery to maturity are attacked by a large spectrum of insect pests like, jassids, *Amrasca biguttula biguttula* (Ishida); fruit borer, *Helicoverpa armigera* (Hub.); leaf eating caterpillar, *Spodoptera litura* (Fab.); thrips, *Thrips tabaci* (Linn.); aphid, *Aphis gossypii* (Glover), *Lipaphis erysimi* (Kalt.), *Myzus persicae* (Sulzer); whitefly, *Bemisia tabaci* (Genn.) and epilachna beetle, *Epilachna duodecastigma* (Mulsant) (Butani, 1977). Among these insect pests of tomato, fruit borer, *H. armigera* is an important which causes 40-50 per cent damage to the crop (Pareek and Bhargava, 2003). Field studies were carried out by Pathania *et.al*, the effectiveness of biological agents like *Bacillus thuringiensis*, nuclear polyhedrosis virus and

Trichogramma chilonis to assess the impact of their integrated use on fruit damage, yield and cost benefit analysis in tomato. (Usman *et.al*, 2015), concluded that integration of different control measure along with judicious use of pesticide in IPM program not only reduced fruit losses but also increased yield and net return.

Material and Methods

Efforts were made to work out benefit: cost ratio from the experimental data to assess economics of the different treatments against tomato fruit borer. The benefit : cost ratio was calculated by taking into consideration the cost of inputs and labour. The monetary returned received by marketing the produce was recorded and the increase in yield was calculated by subtracting the yield obtained in untreated (control) treatment from the respective treatments. Thereafter, the expenditure incurred on application of different treatments was subtracted from the returns of the respective treatments and the benefit: cost ratio was calculated by using the formula :

$$\text{Benefit : Cost ratio} = \frac{A - B}{B}$$

Whereas,

A = Return over control

B = Cost of treatment and their application

Results and Discussion

From the pooled data in table-1, it can be seen that highest yield of 269.79 q/ha for two consecutive years (2017 and 2018) was recorded in module 7 (Emamectin benzoate 5% SG @ 200 ml/ha + Chlorantraniliprole 18.5 EC @ 150ml/ha + Novaluron 10 EC @ 1 L/ha) followed by

Table-1 : Yield of tomato in different modules evaluated against *H. armigera* during 2017 and 2018 (Pooled).

Modules		Yield (q/ha)		
		2017	2018	Pooled
M1.	NSKE @10% + HaNPV @ 300 LE/ha + Bt.k (dipel SL) @ 1.5 L/ha	204.21	212.29	208.25
M2.	<i>Trichogramma</i> sp. @15,0000/ha + HaNPV @ 300 LE/ha + NSKE @10%	186.53	195.83	191.18
M3.	NSKE @10% + HaNPV@300 LE/ha + Indoxacarb 14.5 SC @ 500 ml/ha	223.26	234.72	228.99
M4.	HaNPV @ 300 LE/ha + Bt.k (dipel SL) @ 1.5 L/ha + Acephate75% SP @ 2 kg/ha	232.36	240.63	236.50
M5.	Bt.k (dipel SL) @ 1.5 L/ha + Spinosad 45 SC @ 200 ml/ha + Flubendiamide 48% SC @ 200 ml/ha	254.17	265.28	259.73
M6.	Trap crop (1 row marigold):15 rows tomato + NSKE @ 10% + HaNPV @ 300 LE/ha	199.15	204.51	201.83
M7.	Emamectin benzoate 5% SG @ 200 ml/ha + Chlorantraniliprole 18.5 EC @ 150 ml/ha + Novaluron 10 EC @ 1 L/ha	261.11	278.47	269.79
M8.	Untreated control	167.34	179.60	173.47
	S Em+			
	Y (Year)	-	-	3.36
	T (Treatment)	2.86	2.62	1.91
	YXT	-	-	2.74
	CD at 5%			
	Y (Year)	-	-	9.73
	T (Treatment)	8.68	7.96	5.53
	YXT	-	-	NS

Table-2 : Comparative economics of different IPM modules in tomato.

Modules	Mean yield (q/ha)	Increase in yield over control (%)	Return on increased yield (Rs.)	Cost of treatments (Rs.)	Net profit over control (Rs.)	Benefit: Cost ratio
M1. NSKE @10% + HaNPV @300 LE/ha + Bt.k (dipel SL) @ 1.5 L/ha	208.25	34.78	34780	4850	29930	1:6.17
M2. <i>Trichogramma</i> sp. (@15,0000/ha + HaNPV @300 LE/ha + NSKE @10%	191.18	17.71	17710	4190	13520	1:3.23
M3. NSKE @10% + HaNPV@300 LE/ha + Indoxacarb 14.5 SC @ 500ml/ha	228.99	55.52	55520	6950	48570	1:6.99
M4. HaNPV @300 LE/ha + Bt.k (dipel SL) @ 1.5 L/ha + Acephate75%SP @ 2 kg/ha	236.49	63.02	63025	5605	57420	1:10.24
M5. Bt.k (dipel SL) @ 1.5 L/ha + Spinosad 45 SC @ 200ml/ha + Flubendiamide 48% SC @ 200 ml/ha	259.72	86.25	86255	8605	77650	1:9.02
M6. Trap crop (1 row marigold):15 rows tomato + NSKE @10% + HaNPV @ 300 LE/ha	201.83	28.36	28360	6240	22120	1:3.54
M7. Emamectin benzoate 5% SG @ 200 ml/ha + Chlorantraniliprole 18.5 EC @ 150 ml/ha + Novaluron 10 EC @ 1 L/ha	269.79	96.32	96320	7255	89065	1:12.28
M8. Untreated control	173.47	-	-	-	-	-

Price of tomato = Rs. 10 per kg, Labour rate = Rs. 245/day

module 5 comprising *Bt.k* (dipel SL) @ 1.5 L/ha + Spinosad 45 SC @ 200ml/ha + Flubendiamide 48% SC @ 200 ml/ha (259.72 q/ha). Further, module 4 comprising HaNPV @ 300 LE/ha + *Bt.k* (dipel SL) @ 1.5 L/ha + Acephate75%SP @ 2 kg/ha, module 3 comprising NSKE @ 10% + HaNPV @300 LE/ha + Indoxacarb 14.5 SC @ 500ml/ha, module 1 comprising NSKE @10% + HaNPV @ 300 LE/ha + *Bt.k* (dipel SL) @ 1.5 L/ha, module 6 comprising Trap crop (1 row marigold):15 rows tomato + NSKE @10% + HaNPV @ 300 LE/ha and module 2 comprising *Trichogramma* sp. (@15,0000/ha + HaNPV @300 LE/ha + NSKE @10% recorded 236.49, 228.99,

208.25, 201.83 and 191.18 q/ha fruit yield of tomato. Lowest fruit yield of 173.47 q/ha was obtained in module 8 (untreated control).

The data in table 2 on the economics of IPM modules tested showed that maximum increase in yield over control was obtained in module 7 (96.32 q/ha) followed by module 5 (86.25 q/ha), module 4 (63.02 q/ha), module 3 (55.52 q/ha), module 1 (34.78 q/ha) and module 6 (28.36 q/ha). The lowest increase in yield over control was observed in module 2 (17.71 q/ha). The economics of different modules presented in table 4.25 evinced that

module 7 was most effective with highest net profit of Rs. 89065 and B: C ratio as 1:12.28. The net profit of Rs. 77650 was obtained in module 5 with 1:9.02 B: C ratio. Though, in module 4, net profit was Rs.57420 but it had higher B: C ratio of 1:10.24 than module 5. In module 3 and module 1 having moderate efficacy, net profit was recorded to be Rs. 48570 and 29930 with 1:6.99 and 1:6.17 B: C ratio. Module 6 and module 2 registered lower B: C ratio as 1:3.54 and 1:3.23 with Rs. 22120 and 13520 net profit and were observed less economic among the IPM modules studied.

During the present investigation of two consecutive years (2017 and 2018), eight IPM modules including untreated control were evaluated against fruit borer, *H. armigera* in tomato. Results showed that all the modules were significantly superior over control. However, with highest efficacy, module 7 comprising Emamectin benzoate 5% SG @ 200 ml/ha + Chlorantraniliprole 18.5 EC @ 150ml/ha + Novaluron 10 EC @ 1 L/ha recorded maximum fruit yield (269.79 q/ha), net profit (Rs. 89065) and B: C ratio (1:12.28). Following the order, module 5 comprising *Bt.k* (dipel SL) @ 1.5 L/ha + Spinosad 45 SC @ 200ml/ha + Flubendiamide 48% SC @ 200 ml/ha was ranked next in efficacy with 259.72 q/ha fruit yield, Rs. 77650 net profit and 1:9.02 B: C ratio. In module 4 comprising *HaNPV* @ 300 LE/ha + *Bt.k* (dipel SL) @ 1.5 L/ha + Acephate 75% SP @ 2 kg/ha, module 3 comprising NSKE @ 10% + *HaNPV* @ 300 LE/ha + Indoxacarb 14.5 SC @ 500ml/ha, module 1 comprising NSKE @ 10% + *HaNPV* @ 300 LE/ha + *Bt.k* (dipel SL) @ 1.5 L/ha, module 6 comprising Trap crop (1 row marigold):15 rows tomato + NSKE @ 10% + *HaNPV* @ 300 LE/ha and module 2 comprising *Trichogramma* sp. (@15,000/ha + *HaNPV* @ 300 LE/ha + NSKE @ 10%, the fruit yield was obtained as 236.49, 228.99, 208.25 and 201.83 q/ha with net profit of Rs. 57420, 48570, 29930 and 22120 13520, respectively. The B: C ratio computed for these IPM modules was 1: 10.24 (module 4), 1: 6.99 (module 3), 1: 6.17 (module 1), 1: 3.54 (module 6), and (module 2). The efficacy of treatment schedules was observed lowest in module 2 which showed 191.18 q/ha fruit yield, Rs. 13520 net profit and 1: 3.23 B: C ratio.

In past, Karabhantanal *et al.* (2005) found IPM module consisting of trap crop (15 rows of tomato : 1 row marigold) ± *Trichogramma pretiosum* (45,000/ ha) ± NSKE (5%) ± *HaNPV* (250 LE/ ha) ± endosulfan 35 EC (1250 ml/ ha) significantly superior in restricting the larval population with lowest fruit damage (11.87%), highest marketable fruit yield (224.56 q/ ha) and higher additional net profit (Rs. 22 915/ ha). Similarly, Chavan *et al.* (2010) revealed that IPM module consisting of collection and disposal of immature stages of *H. armigera* and infested fruits, marigold as trap crop, releases of *Chrysoperla*

larvae @ 10,000/ ha, spraying of NSKE @ 5%, spraying of endosulfan 35 EC @ 0.07%, releases of *T. chilonis* adults @ 1,60,000/ ha, spraying of profenofos 40 % ± cypermethrin 4 % 44 EC @ 0.044% was most promising in reducing *H. armigera* larval population, fruit infestation with higher tomato fruit yield (36,445 kg/ ha). The insecticidal module (2 sprays of thiamethoxam 25 WG 0.005%, single spray of spinosad 45 SC 0.002% and 2 sprays of indoxacarb SC @ 0.01%) was equally effective as IPM module with fruit yield of 34, 684 kg/ ha. The biological module stood next to insecticidal module, whereas botanical module was next to biological module. Jat and Ameta (2013) obtained highest marketable fruit yield of 265.68 q/ha in flubendiamide 480 SC @ 200 ml/ha with highest C: B ratio of 1:2.075. It was followed by Spinosad 45 SC @ 200 ml/ha (251.29 q/ha) and Beta-cyfluthrin 2.5 SC @ 750 ml/ha (238.38 q/ha). Roopa and Kumar (2014) found Spinosad 45 SC @ 0.01% as the best treatment with highest yield of 30050 kg/ ha in tomato. Ambule *et al.* (2015b) recorded higher tomato fruit yield of 25.21, 24.84 and 22.20 tonnes/ha in flubendiamide 0.004% chlorantraniliprole 0.0055% and spinosad 0.0068% treatments. Jakhar and Suman (2015) observed that the IPM module with growing of african marigold after every 8 rows of tomato as well as on the periphery of the plot and two spray of *HaNPV* @ 250 LE/ha on appearance of first instar larvae followed by spray of Decidan 32.8% EC @ 15 ml/10 litre was highly effective and economical for management of tomato fruit borer, *H. armigera* with maximum tomato yield (257.25 q/ha). The findings of these authors are comparable with the findings of present investigation.

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Effect of Newer Insecticides on Coccinellids Population in Cauliflower Ecosystem

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Abstract

The effect of newer insecticides was tested on coccinellids at CSAUAT, Kanpur during *Rabi* season 2014-15 in cauliflower field. The highest mortality of *Coccinella septempunctata* and *Coccinella transversalis* was noticed in fipronil 5 SC @ 1.0 ml/litre plot followed by imidacloprid 17.8 SL @ 0.2 g/litre and neem oil 2% @ 2.0 ml/litre. The safest chemical was found chlorantriliprole 18.5 SC @ 0.3 g/litre and flubendiamide 48 SC @ 0.3 ml/litre which was followed by spinosad 45 SC @ 0.5ml/litre and emamectin benzoate 5 SG @ 0.2 g/litre in cauliflower against *C. septempunctata* and *C. transversalis*.

Key words : Cauliflower, coccinellids, insecticides.

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most important winter vegetable cole crops in our country. This is an important cruciferous vegetable subjected to attack by a large number of insect-pests throughout its growth phase, which act as limiting factor in the profitable cultivation of these crops. The insect pests viz., aphid (*Lipaphis erysimi* Kalt. and *Brevicoryne brassicae* L.), diamond back moth, (*Plutella xylostella* L.), cabbage borer (*Hellula undalis* Fabr.), cabbage looper (*Trichoplusia ni* Hb.), leaf webber (*Crocidolomia binotalis* Zell.), painted bug (*Bagrada cruciferarum* Kirk.) and cabbage butterfly (*Pieris brassicae* L.), tobacco caterpillar (*Spodoptera litura* Fab.) etc., are having more significance on cauliflower which affect the yield and quality throughout the country.

Natural enemies such as predators and parasitoids provide the essential ecosystem service of conservation through biological control (Gardiner *et al.*, 2011). Coccinellids has attracted considerable attention as biological control agent because of its potential to control many soft-bodied insect pests particularly the aphids. The use of agrochemicals, particularly pesticides, can hamper the effectiveness of natural enemies; causing disruption of the ecosystem services they provide (Desneux *et al.*, 2007, Stark *et al.*, 2007, Stavrinides and Mills, 2009). Natural enemies are highly sensitive to the application of pesticides, and it has been shown that pesticide use patterns influence the abundance and species composition of beneficial species in agro-ecosystems (Zhang *et al.*, 2007, Lu *et al.*, 2012).

New chemistry has replaced several broad spectrum

pesticides due to their disruptive effects on various bio-control agents (BCA's) viz., parasitoids and predators. A greater emphasis is being laid on more selective new chemicals which is more compatible in conserving the wide diversity of BCA's. Substances with lower molecular weights have greater capacity to penetrate in the insect cuticle (Stock and Holloway, 1993). In this context, the efficacy of few newer insecticides viz., Flubendiamide, Chlorantriliprole, Emamectin benzoate, Fipronil, Imidacloprid, Spinosad and Neem oil etc., were evaluated under field condition for their comparative effect on natural enemies.

Materials and Methods

The present study was carried out to evaluate the effect on abundance of coccinellids population. The trial was conducted at Student Instructional Farm, Chandra Shekhar Azad university of Agriculture and Technology, Kanpur (UP) during *Rabi* season 2014-15 on cauliflower. The field experiment was laid out in RBD with 8 treatments including control (untreated check). Impact of insecticidal applications on the coccinellids population (*Coccinella septempunctata* and *Coccinella transversalis*) was recorded in the field. Coccinellids were recorded from randomly 5 selected plants in each plot and same expressed as numbers of coccinellid population/ 5 plants. All the leaves of each plant in a sampling area were observed to record the coccinellids population. Pre-treatment counts of coccinellids were taken one day prior in all the plots at each time just before the application of insecticides. Post-treatment counts of coccinellids were taken after 7th and 15th days of application of treatments. The average percent reduction over control coccinellid

Table-1 : Effect of newer insecticides on abundance of coccinellid population in cauliflower during Rabi, 2014-15.

S.N.	Treatment	Dose	No. of Coccinellid / 5 Plant									
			First spray					Second spray				
			DBS	7 DAS	% Reduction over control	15 DAS	% Reduction over control	7 DAS	% Reduction over control	15 DAS	% Reduction over control	Average % Reduction over control
1.	Fipronil 5 SC	1.0 ml/l	4.97 (2.34)*	3.77 (2.07)	27.12	3.90 (2.10)	26.54	3.03 (1.88)	23.67	3.07 (1.89)	21.37	24.68
2.	Chlorantriliprole 18.5 SC	0.3 g/l	4.53 (2.24)	4.17 (2.16)	11.67	4.47 (2.23)	7.83	4.23 (2.18)	6.99	4.27 (2.18)	4.48	7.74
3.	Flubendiamide 48 SC	0.3 ml/l	4.57 (2.25)	4.13 (2.15)	13.02	4.43 (2.22)	9.18	4.17 (2.16)	7.77	4.20 (2.17)	5.26	8.81
4.	Emamectin benzoate 5 SG	0.2 g/l	4.87 (2.32)	4.07 (2.14)	19.70	4.30 (2.19)	17.34	3.73 (2.06)	14.80	3.70 (2.05)	13.95	16.45
5.	Neem oil 2%	2.0 ml/l	4.27 (2.18)	3.47 (1.99)	21.92	3.60 (2.02)	21.07	2.97 (1.86)	19.13	3.00 (1.87)	16.67	19.70
6.	Imidacloprid 17.8 SL	0.2 g/l	4.53 (2.24)	3.60 (2.02)	23.68	3.67 (2.04)	24.34	2.93 (1.85)	21.49	2.97 (1.86)	19.09	22.15
7.	Spinosad 45 SC	0.5 ml/l	4.83 (2.31)	4.23 (2.18)	15.83	4.40 (2.21)	14.84	3.97 (2.11)	11.53	3.93 (2.11)	10.61	13.20
8.	Untreated control	-	4.93 (2.33)	5.13 (2.37)		5.27 (2.40)		5.37 (2.42)		5.27 (2.40)		
	SE (m) ±	-	0.019	0.018		0.017		0.021		0.014		
	CD (P=0.05)	-	0.059	0.055		0.052		0.065		0.042		

DBS-Days before spray, DAS-Days after spray

*figures in parentheses $\sqrt{x}$ 0.5 transformed values

population was worked out for each treatment. The data obtained was corrected by using Abbott's formula (1925) and transformed (Gomez and Gomez, 1976). The data were then subjected to statistical analysis by using analysis of variance. The insecticides used are listed in Table-1.

Results and Discussion

The effect of insecticides was assessed on the basis of population reduction of coccinellids at different intervals after their application during Rabi, 2014-15 the results are in (Table-1). The day before spraying (DBS) mean population of coccinellids varied from 4.27 to 4.97 per 5 plants without any significant difference. After application of insecticides it was observed that all the treatments were found significantly toxic over untreated control. The minimum population of coccinellids was recorded in the treatment of fipronil 5 SC @ 1.0 ml/litre which provided to 24.68 average percent reduction over untreated control, followed by imidacloprid 17.8 SL @ 0.2 g/litre and neem oil 2% @ 2.0 ml/litre which provided 22.15 and 19.70 average percent reduction over untreated control and was somewhat toxic and statistically the treatments were at par in their toxicity. The maximum population of coccinellids was recorded in the treatment of chlorantriliprole 18.5 SC @ 0.3 g/litre with 7.74 average percent reduction over untreated control, followed by flubendiamide 48 SC @ 0.3 ml/litre, spinosad 45 SC @ 0.5ml/litre and emamectin

benzoate 5 SG @ 0.2 g/litre which provided 8.81, 13.20 and 16.45 average percent reduction over untreated control, respectively. They were proved least toxic and at par with each other in their toxicity. The results clearly indicated that most of the newer insecticides or bio-rational pesticides were safer to natural enemies than conventional insecticides. The present findings are in accordance to work done by Ameta and Bunkar (2007) who found that flubendiamide, indoxacarb and spinosad did not cause adverse effect on the population of natural enemies. Muthukumar *et al.*, (2007) also reported similar results which show that besides spinosad, biolep, emamectin benzoate and neem oil proved safer to natural enemies in the cauliflower ecosystem. Venkateswarlu *et al.*, (2011) reported similar results had as neem baan, spinosad, emamectin benzoate and chlorantriliprole were proved safer to natural enemies in cabbage. Jadhav and Shukla (2013) studied relative toxicity of insecticides and found that imidacloprid 0.005% was least toxic to the larvae and adults of *Coccinella transversalis* (F.). Balikai and Mallapur (2015) also tested the safety of the new anthranilic diamide group of insecticides to coccinellid population.

Conclusions

From the ongoing discussion, it can be seen that to reduce risk, newer insecticides have been found more appropriate as compared to conventional broad spectrum

high dose insecticides as they enables to conserve natural enemy fauna and minimize residual effect in vegetables and environment.

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Seasonal Incidence of Insect Pest of Okra, *Abelmoschus esculentus* (L.) Moench. under Semi Arid Region of Rajasthan

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Abstract

Investigations on seasonal incidence of insect pests and assessment of crop loss in okra was carried out at the Department of Entomology, Rajasthan Agricultural Research Institute, Durgapura, Jaipur during *kharif* 2016 and 2017. The major insect pests infesting okra observed during two consecutive seasons were leafhopper, *A. biguttula biguttula*; whitefly, *B. tabaci* and okra shoot and fruit borer and *E. vittella*. The infestation of leafhopper commenced in the second week of July 2016, first week of July 2017, and reached its peak in the fourth and first week of August of 2016 and 2017, respectively. The maximum and minimum temperature had negative correlation with leafhopper population in 2016 and 2017, while relative humidity and rainfall had positive in both the year. Whitefly *B. tabaci* commenced in the second week of July and reached its peak in the 36th and 33th SMW during 2016 and 2017, respectively. The population exhibited non significant correlation with climatic factors during both the year. Shoot infestation reached its peak in second week of September and third week of August in 2016 and 2017, respectively. Infestation of borer on fruits exhibited negative significant effect with maximum temperature, and positive significant correlation with relative humidity ($r = -0.63$, $r = 0.61$) during 2016. The same trend has been recorded in *kharif* 2017.

Key words : Okra, seasonal incidence, insect pests.

Introduction

India is the second largest producer of vegetables in the world (surpassed only by China) accounting for about 10 per cent of the world production. Okra, *Abelmoschus esculentus* (L.) Moench commonly known as *bhindi* or lady's finger (family: Malvaceae) is a popular fruit vegetable crop. In the plains of northern India, it is grown in summer as well as during the rainy season; whereas, in central and south India, the crop can be grown throughout the year. It is cultivated in 528.4 thousand hectares with a total production of 6146.0 thousand metric tonnes with productivity of 11.6 tonnes per hectare in India (Anonymous, 2016-17). Okra fruit is nutritionally very rich with a calorific value of 35. The fruits of okra contain carbohydrate (6.4%), protein (1.9%), fat (0.2%), fibre (1.2%), minerals (0.7%) and moisture (89.6%) (Anonymous, 2016). One of the important limiting factors in the cultivation of okra is insect pests. As high as 72 species of insects have been recorded on okra (Srinivas Rao and Rajendran, 2003), of which, the sucking pests comprising of aphids (*Aphis gossypii* Glover), leafhopper (*Amrasca biguttula biguttula* Ishida), whitefly (*Bemisia tabaci* Gennadius) and mite (*Tetranychus cinnabarinus* Boisduval) causes significant damage to the crop, while at later stage fruit borers like *Earias* spp and *Helicoverpa armigera* (Hb.) cause considerable losses to the crop to the tune of 91.6 per cent (Pareek and Bhargava, 2003).

Jassids and aphids suck the cell sap from the lower surface of the leaves and the former also inject some toxic substances resulting in curling of leaves, as a result, the plant growth is retarded. (Narke and Suryawanshi, 1987). Okra shoot and fruit borer (OSFB), *Earias vittella* is the most serious pest which cause direct damage to tender shoots and fruits. Thus, keeping these thematic areas in view, the present investigation 'Seasonal Incidence of Insect Pest of Okra, *Abelmoschus esculentus* (L.) Moench under Semi Arid region of Rajasthan' was undertaken.

Materials and Methods

Observation methodology : To record the incidence of major insect pests of okra the variety "*Varsha uphar*" was sown at normal sowing time (Second week of June) in five plots of 3.0 × 2.25m size. The observations of insect pests of okra were recorded at weekly interval from their appearance to last picking of fruits. The populations of sucking insect pests (jassid and whitefly) were recorded by counting the pests in early morning hours of the day (before 8 AM) when they remained less active. Five plants were randomly selected and tagged in each plot and the populations of leafhopper and whitefly on three leaves each from 'the top, middle and lower part' were counted visually (absolute counting) The data on shoot and fruit borer, *Earias* spp. were recorded on five randomly selected and tagged plants throughout the crop period by visual count of the plant in which the top portion was

Table-1 : Effect of abiotic factors on incidence of jassid and whitefly on okra during *kharif*, 2016.

SMW	Date of observation	Temperature (°C)		Mean Relative Humidity (%)	Total Rainfall (mm)	Mean population / plants	
		Max.	Min.			Jassid	Whitefly
28	15.07.16	34.9	26.4	71.5	8.8	1.30	1.50
29	22.07.16	32.1	24.6	72.0	66.4	2.60	1.70
30	29.07.16	33.6	25.9	73.5	12.4	3.30	1.30
31	05.08.16	30.8	24.0	84.5	99.0	6.90	1.30
32	12.08.16	31.0	25.4	83.0	97.2	8.30	2.00
33	19.08.16	31.8	24.6	73.5	5.6	9.30	1.90
34	26.08.16	29.6	24.4	81.5	39.2	10.50	3.20
35	02.09.16	31.7	24.6	79.5	32.4	9.10	3.70
36	09.09.16	32.5	23.4	65.5	0.0	8.50	6.90
37	16.09.16	34.6	24.7	55.0	0.0	4.90	4.20
38	23.09.16	36.9	25.3	52.0	2.0	3.20	3.20
39	30.09.16	35.3	23.7	52.5	28.2	1.70	1.90
40	07.10.16	34.2	25.6	60.5	11.6	2.90	1.20
41	16.10.16	34.1	22.5	48.0	0.0	3.70	1.70
Coefficient of correlation values for Max. temperature with (r_1)						-0.79*	-0.05
Coefficient of correlation values for Min. temperature with (r_2)						-0.25	-0.32
Coefficient of correlation values for R.H. with (r_3)						0.60*	-0.12
Coefficient of correlation values for Rainfall with (r_4)						0.25	-0.32

SMW denotes Standard Meteorological Weeks; r-values with an asterisk mark are significant at 5 per cent level of significance.

Table-2 : Effect of abiotic factors on incidence of jassid and whitefly on okra during *kharif*, 2017.

SMW	Date of observation	Temperature (°C)		Mean Relative Humidity (%)	Total Rainfall (mm)	Mean population / plant	
		Max.	Min.			Jassid	Whitefly
27	08.07.17	35.0	25.8	60.5	14.4	2.20	-
28	15.07.17	35.9	27.0	56.0	5.0	2.90	-
29	22.07.17	33.9	25.2	75.0	51.6	4.70	0.20
30	29.07.17	30.3	24.9	81.5	84.2	13.10	1.20
31	05.08.17	29.3	20.4	81.5	7.8	15.50	1.00
32	12.08.17	31.7	25.2	76.0	10.6	11.00	2.50
33	19.08.17	0.4434.1	25.7	65.5	0.0	10.70	3.90
34	26.08.17	33.8	25.4	71.5	95.2	14.20	2.60
35	02.09.17	31.4	24.1	79.0	32.4	9.40	1.80
36	09.09.17	33.4	24.5	63.0	1.0	3.80	2.60
37	16.09.17	34.8	24.9	66.5	60.6	2.40	3.40
38	23.09.17	35.8	24.8	47.0	0.0	1.30	1.50
39	30.09.17	36.5	23.6	46.0	0.0	0.80	1.60
40	07.10.17	37.2	22.6	35.5	0.0	1.00	4.20
Coefficient of correlation values for Max. temperature with (r_1)						-0.84*	0.44
Coefficient of correlation values for Min. temperature with (r_2)						-0.21	0.15
Coefficient of correlation values for R.H. with (r_3)						0.79*	-0.44
Coefficient of correlation values for Rainfall with (r_4)						0.44	-0.21

SMW denotes Standard Meteorological Weeks; r-values with an asterisk mark are significant at 5 per cent level of significance

Table-3 : Effect of abiotic factors on damage by shoot and fruit borer, *Earias* spp. on okra during *kharif*, 2016.

SMW	Date of observation	Temperature (°C)		Mean Relative Humidity (%)	Total Rainfall (mm)	Shoot damage (%)	Mean infestation of fruits (%)	
		Max.	Min.				Number basis	Weight basis
28	15.07.16	34.9	26.4	71.5	8.8	1.30	-	-
29	22.07.16	32.1	24.6	72.0	66.4	2.20	-	-
30	29.07.16	33.6	25.9	73.5	12.4	4.20	4.00	5.00
31	05.08.16	30.8	24.0	84.5	99.0	5.70	6.50	5.15
32	12.08.16	31.0	25.4	83.0	97.2	7.80	8.20	6.00
33	19.08.16	31.8	24.6	73.5	5.6	8.20	10.10	8.70
34	26.08.16	29.6	24.4	81.5	39.2	10.30	11.90	10.20
35	02.09.16	31.7	24.6	79.5	32.4	13.50	12.80	11.30
36	09.09.16	32.5	23.4	65.5	0.0	7.10	16.70	13.90
37	16.09.16	34.6	24.7	55.0	0.0	4.80	19.00	16.50
38	23.09.16	36.9	25.3	52.0	2.0	4.10	20.90	20.00
39	30.09.16	35.3	23.7	52.5	28.2	3.20	23.60	21.55
40	07.10.16	34.2	25.6	60.5	11.6	0.00	24.50	23.50
41	16.10.16	34.1	22.5	48.0	0.0	0.00	26.10	23.80
Coefficient of correlation values for Max. temperature with (r_1)						-0.63*	0.67*	0.72*
Coefficient of correlation values for Min. temperature with (r_2)						-0.06	-0.40	-0.33
Coefficient of correlation values for R.H. with (r_3)						0.61*	-0.88*	-0.89*
Coefficient of correlation values for Rainfall with (r_4)						0.24	-0.55	-0.58*

SMW denotes Standard Meteorological Weeks; r-values with an asterisk mark are significant at 5 per cent level of significance.

Table-4 : Effect of abiotic factors on damage by shoot and fruit borer, *Earias* spp. on okra during *kharif*, 2017.

SMW	Date of observation	Temperature (°C)		Mean Relative Humidity (%)	Total Rainfall (mm)	Shoot damage (%)	Mean infestation of fruits (%)	
		Max.	Min.				Number basis	Weight basis
27	08.07.17	35.0	25.8	60.5	14.4	2.50	-	-
28	15.07.17	35.9	27.0	56.0	5.0	3.80	-	-
29	22.07.17	33.9	25.2	75.0	51.6	4.10	6.60	5.20
30	29.07.17	30.3	24.9	81.5	84.2	5.80	8.50	7.10
31	05.08.17	29.3	20.4	81.5	7.8	8.00	10.00	9.00
32	12.08.17	31.7	25.2	76.0	10.6	9.70	12.10	11.20
33	19.08.17	34.1	25.7	65.5	0.0	11.20	13.00	13.00
34	26.08.17	33.8	25.4	71.5	95.2	10.30	17.20	14.90
35	02.09.17	31.4	24.1	79.0	32.4	7.90	19.50	17.20
36	09.09.17	33.4	24.5	63.0	1.0	6.00	21.50	21.40
37	16.09.17	34.8	24.9	66.5	60.6	4.70	23.00	22.60
38	23.09.17	35.8	24.8	47.0	0.0	0.00	24.10	24.00
39	30.09.17	36.5	23.6	46.0	0.0	0.00	26.50	25.10
40	07.10.17	37.2	22.6	35.5	0.0	0.00	32.70	30.00
Coefficient of correlation values for Max. temperature with (r_1)						-0.66*	0.47*	0.49*
Coefficient of correlation values for Min. temperature with (r_2)						0.10	-0.38	-0.35
Coefficient of correlation values for R.H. with (r_3)						0.75*	-0.51*	-0.63*
Coefficient of correlation values for Rainfall with (r_4)						0.32	-0.21	-0.26

SMW denotes Standard Meteorological Weeks; r-values with an asterisk mark are significant at 5 per cent level of significance

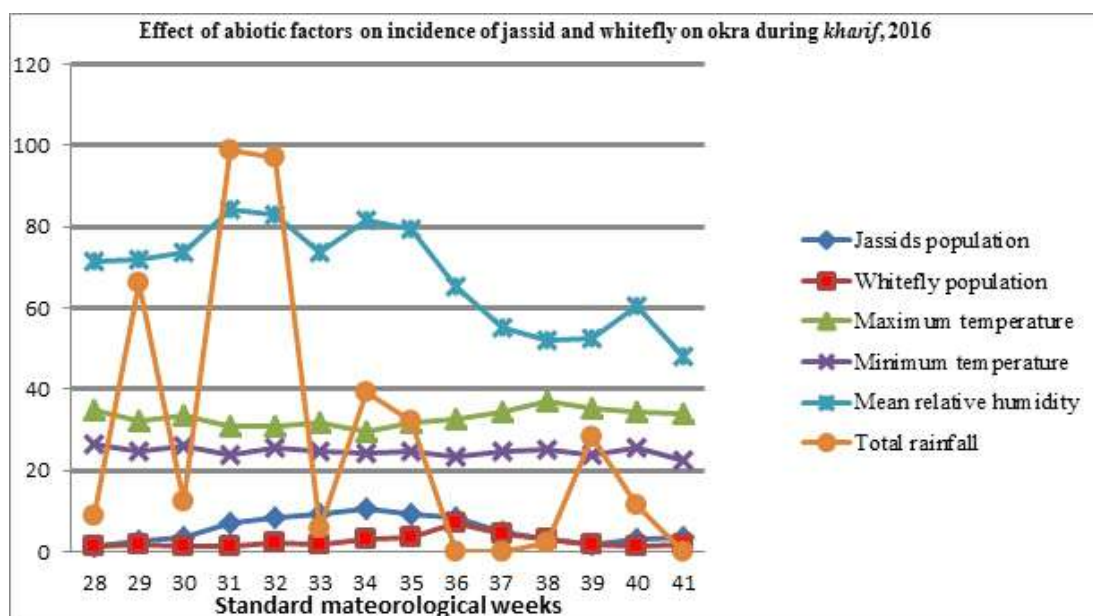


Fig-1 : Effect of abiotic factors on incidence of jassid and whitefly on okra during *kharif*, 2016.

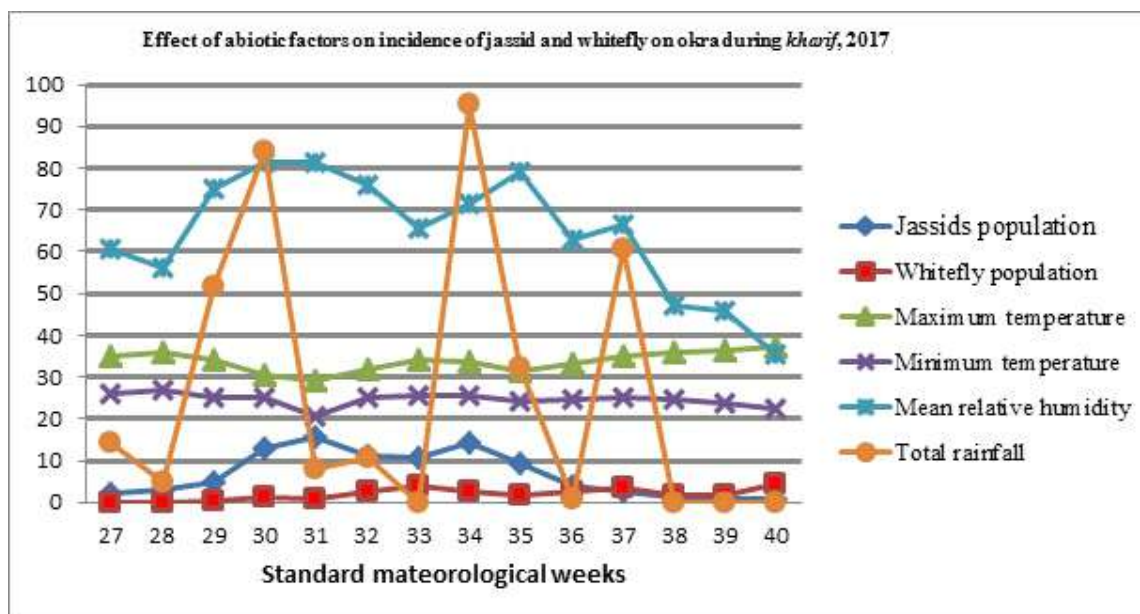


Fig-2 : Effect of abiotic factors on incidence of jassid and whitefly on okra during *kharif*, 2017.

damaged, started after two week of sowing to last picking of the fruits.

$$\text{Infestation (\%)} = \frac{\text{Number of infested fruits}}{\text{Number of total fruits}} \times 100$$

The per cent infestation of fruits on number basis was calculated by counting the infested and healthy fruits separately from selected tagged plants. The weight of both healthy and infested fruits was taken separately and level of infestation was worked out in per cent.

Statistical analysis : To interpret the results of seasonal incidence of major insect pests of okra, simple correlation was computed between pest population, their damage

and abiotic factors, i.e. the minimum and maximum temperature, relative humidity and rainfall.

$$r = \frac{\frac{\sum xy}{N}}{\sqrt{\frac{\sum x^2}{N} \cdot \frac{\sum y^2}{N}}}$$

Where,

r_{xy} = Simple correlation coefficient

X = Dependent variables i.e. abiotic component. (Average temperature, relative humidity and total rainfall)

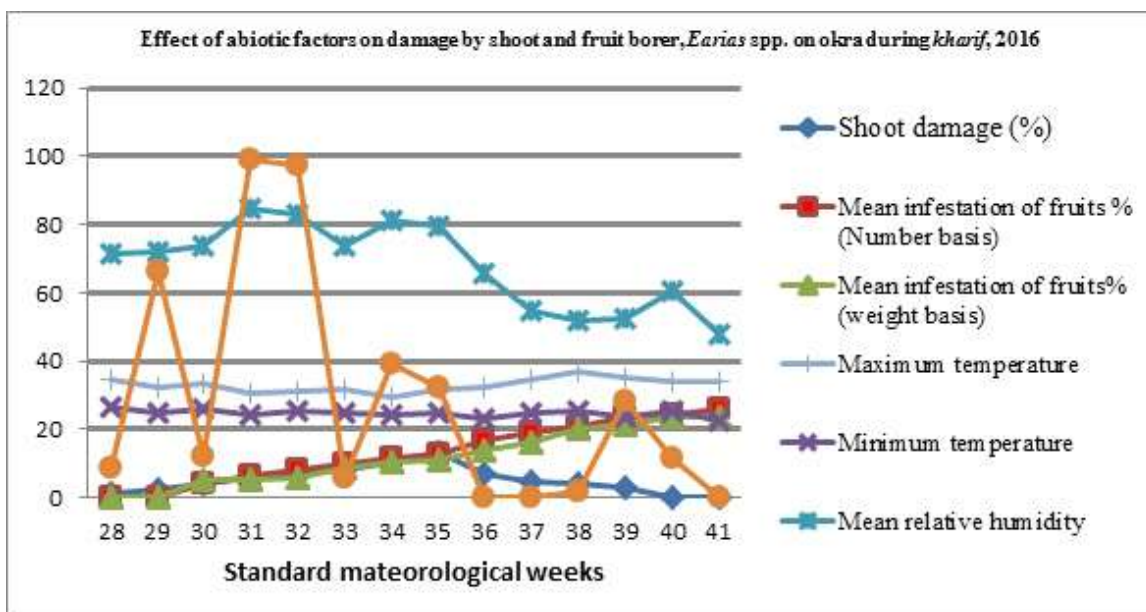


Fig.-3 : Effect of abiotic factors on damage by shoot and fruit borer, *Earias* spp. on okra during kharif, 2016.

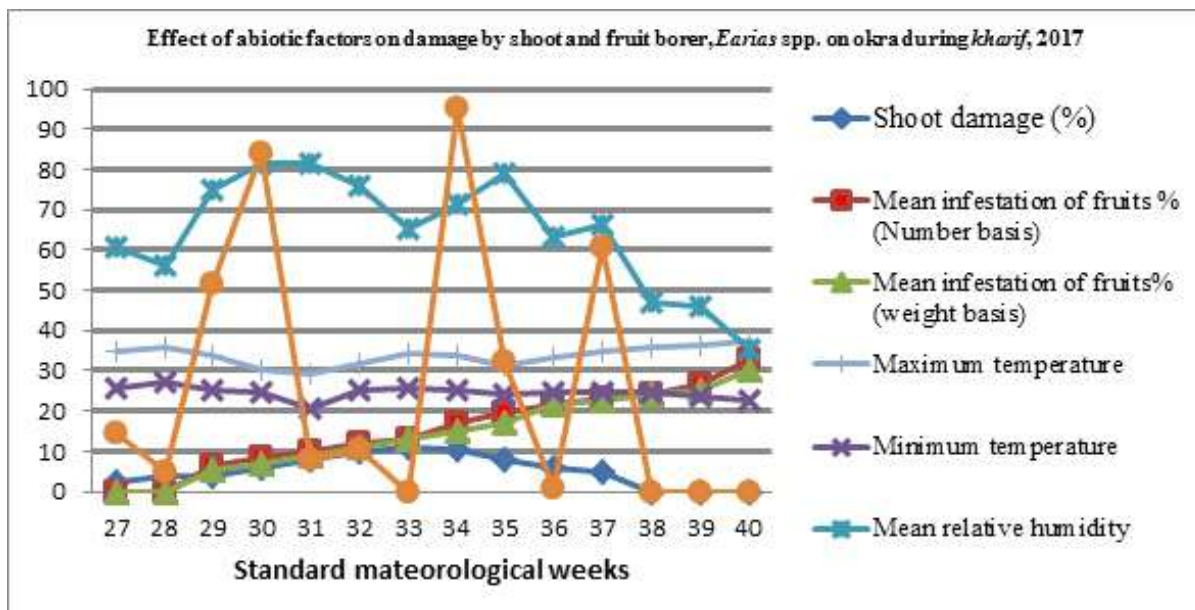


Fig.-4 : Effect of abiotic factors on damage by shoot and fruit borer, *Earias* spp. on okra during kharif, 2017.

Y = Independent variable i.e. mean population of the insect pest

N = Number of observations.

The correlation coefficient(r) values are subjected to the test of significance using t-test :

$$t = \frac{r}{\sqrt{1-r^2}} \sqrt{n-2} \sim t_{(n-2)} \text{ d.f.}$$

Results and Discussion

Seasonal incidence of insect pests of okra : During the crop growth four major insect pest species, viz., leafhopper, *Amrasca biguttula biguttula* (Ishida); whitefly,

Bemisia tabaci (Genn.) and shoot and fruit borer, *Earias vittella* (Fab.) and *E. insulana* (Boisd.) were noticed to attack the crop. On account of high population, these insect pests were categorized as major pests.

Incidence of leafhopper, *A. biguttula biguttula* on okra : The infestation of leafhopper, *A. biguttula biguttula* commenced in the second week of July 2016 (28th standard meteorological week, SMW) and remained active throughout the crop season, i.e. upto second week of October, 2016. During 2017 the infestation was started in the first week of July (27th SMW) and remained upto first week of October, 2017.

Initially, the population of leafhopper was 1.30 and

2.20 per three leaves during *kharif*, 2016 and 2017, respectively (Table 1.2 and Fig. 1, 2). The leafhopper population gradually increased and reached to its peak in the fourth week of August (34th SMW) i.e. 10.50 during 2016, whereas during *kharif* 2017 the population reached its peak in the first week of August (31st SMW) i.e. 15.50. The population of leafhopper ranged between 1.30 to 10.50 and 0.80 to 15.50 during 2016 and 2017, respectively. After reaching the peak, the population of leafhopper started to decline and reached to low level in the first week of October till the crop was matured during both the years.

The appearance of leafhopper population on okra crop started at 34.90 °C maximum, 26.40 °C minimum temperature, 71.50 per cent mean relative humidity and 8.80 mm rainfall during 2016 and at 35.0 °C maximum, 25.8 °C minimum temperature, 60.50 per cent relative humidity and 14.4 mm rainfall during 2017. The maximum leafhopper population (10.50/ three leaves) was recorded at 29.60 °C and 24.40 °C maximum and minimum temperature, respectively, 81.50 per cent mean relative humidity and 39.2 mm rainfall in the first year, i.e. *kharif*, 2016. During *kharif* 2017 the maximum leafhopper population was recorded at 29.30 °C maximum, 20.40 °C minimum temperature and 81.50 per cent mean relative humidity and 7.8 mm rainfall in the second year, i.e. *kharif*, 2017. The maximum temperature had negative significant correlation ($r = -0.79$) and minimum temperature had non significant negative correlation ($r = -0.25$) with leafhopper population, while mean relative humidity had significant positive correlation ($r = 0.60$) and rainfall had positive non significant correlation ($r = 0.25$) with leafhopper population during 2016. Similarly, maximum temperature has significant negative correlation ($r = -0.84$) and minimum temperature had non significant negative correlation ($r = -0.21$), the mean relative humidity had significant positive correlation ($r = 0.79$) and rainfall had non significant positive correlation ($r = 0.44$) with leafhopper population during 2017.

Incidence of whitefly, *B. tabaci* on okra : The observations on population of whitefly, *B. tabaci* on okra crop were recorded starting from, four weeks after sowing up to maturity of the crop. The infestation commenced in the second week of July (28th SMW) and remained active throughout the crop season, i.e. second week of October during 2016. During 2017 the infestation of whitefly was started in third week of July (29th SMW) and prevailed until first week of October (Table 1, 2 and Fig. 1, 2). The infestation of whitefly is evident in plate-I. The population of whitefly gradually increased and reached to its peak in the 36th and 40th SMW during *kharif*, 2016 and 2017, respectively, with peak population of 6.90 and 4.20 per plant was recorded during *kharif*, 2016 and 2017,

respectively. Whitefly population ranged between 1.20 to 6.90 and 0.20 to 4.20 during *kharif*, 2016 and 2017, respectively.

The correlation matrix indicated a negative non significant correlation of whitefly population with maximum temperature, minimum temperature, relative humidity and rainfall during *kharif*, 2016. During *kharif* 2017, it exhibited positive non significant correlation with maximum and minimum temperature ($r = 0.44$ and $r = 0.15$) however, revealed negative non significant correlation with mean relative humidity and rainfall. During both the year of study whitefly population did not exhibited significant correlation with climatic parameters.

Incidence of shoot and fruit borer, *Earias* spp. on shoots of okra : Two species of shoot and fruit borer, *Earias insulana* (Boisd.) and *E. vittella* (Fab.) were recorded to infest okra shoots and fruits during the study of both years. The shoot damage was noticed when the crop was in vegetative stage. The data presented in Table 3, 4 and Fig. 3, 4 revealed that the infestation of shoot and fruit borer on okra commenced in the second and first week of July with shoot damage of 1.30 and 2.50 per cent during 2016 and 2017, respectively. The shoot and fruit infestation by this borer have been depicted in plate-I. Initially, the infestation was low, which gradually increased and reached to its peak 13.50 per cent in second week of September (35th SMW) during first year and 11.20 per cent during second year in the third week of August (33th SMW). As soon as the fruiting started, the incidence of this insect pest on the shoots started to decline and disappeared from shoots during first week of October during *kharif*, 2016 and third week of November during *kharif* 2017.

The infestation of shoot and fruit borer on shoots of okra crop started to appear at 34.90 °C maximum temperature, 26.4 °C minimum temperature, 71.50 per cent mean relative humidity and 8.8 mm rainfall during 2016; and 35.0 °C maximum temperature, 25.8 °C minimum temperature, 60.5 per cent mean relative humidity and 14.4 mm rainfall during 2017. In *kharif*, 2016, the maximum infestation (13.50 %) was recorded at 31.7 °C, 24.6 °C and 79.5 per cent, maximum temperature, minimum temperature and mean relative humidity, respectively, while in *kharif*, 2017, the maximum infestation 11.20 per cent was recorded at 34.1 °C, 25.7 °C and 65.50 per cent, maximum temperature, minimum temperature and relative humidity, respectively. During both the year the percent infestation by fruit and shoot borer on shoot exhibited similar correlation with climatic parameters. The maximum temperature, exhibited negative significant correlation with shoot infestation ($r = -0.63$, -0.66 during 2016 and 2017 respectively), and

minimum temperature exhibited negative non significant correlation during 2016 and exhibited positive non significant correlation during 2017, while mean relative humidity shows positive significant correlation ($r = 0.61$, 0.75 during 2016 and 2017 respectively) and rainfall shows the positive non significant correlation during both the year of study.

Incidence of shoot and fruit borer, *Earias* spp. on fruits of okra : The initiation of fruit damage commenced in the 30th SMW (fourth week of July) during 2016 and 28th SMW (Second week of July) during 2017 with (4.00 and 6.60%) on number basis and (5.00 and 5.20%) on weight basis during 2016 and 2017, respectively, *i.e.* six weeks after sowing of crop which gradually increased and reached its peak, 26.10 and 23.80 per cent on number and weight basis respectively, during 2016, and 32.70 and 30.00 per cent on number and weight basis during 2017, respectively in the first fortnight of October during both the years of study (Table 3 and 4 and Fig. 3 and 4).

The infestation of borer on fruits was at peak at 34.10 °C maximum temperature, 22.50 °C minimum temperature and 48.0 per cent mean relative humidity during 2016; and at 37.20 °C maximum and 22.60 °C minimum temperature and 35.50 per cent mean relative humidity during 2017. The percent fruit infestation on number basis exhibited positive significant correlation with maximum temperature ($r = 0.67$ $r = 0.47$ during 2016 and 2017, respectively), it has shown negative significant correlation with mean relative humidity ($r = -0.88$, $r = -0.51$ during 2016 and 2017, respectively). The correlation with minimum temperature and rainfall was negative non significant during both the year of study. The fruit damage based on weight basis exhibited quite similar trend of correlation during both the year, which was positively significant with maximum temperature ($r = 0.72$ and $r = 0.49$), the correlation with mean relative humidity was negatively significant ($r = -0.89$ and $r = -0.63$). However, it was non significant with minimum temperature and rainfall.

The infestation of leafhopper, *A. biguttula biguttula* commenced in the second week of July 2016 (28th standard meteorological week, SMW) and remained active throughout the crop season. The present results are in agreement with those of Patni (2001), Pareek *et al.* (2001), who reported the incidence of jassid on okra throughout the crop period. The results also corroborate with those of Anita and Nandihalli (2008) who have found incidence from late July to first week of August. In present study, initially, the population of leafhopper was 1.30 and 2.20 per three leaves during *kharif*, 2016 and 2017, respectively. The present results corroborate with the observations of Meena (2010) who reported the peak

population of jassid from the last week of August to September on okra crop.

The correlation statistics of present investigation corroborate with findings by Iqbal *et al.* (2010) resulted that the minimum temperature on cumulative basis during 2006 and 2007 had significant positive correlation, while other factors had non-significant correlation with jassid population. Similarly in case of incidence of whitefly the finding shows similarity with results of Meena (2004) who, concluded that the infestation of whitefly started on okra crop from first week of August with initial mean population of 0.80 and 1.20 per plant during 2002 and 2003, respectively.

The initiation of fruit damage commenced in the 30th SMW (fourth week of July) during 2016 and 28th SMW (Second week of July) during 2017 with (4.00 and 6.60%) on number basis and (5.00 and 5.20%) on weight basis during 2016 and 2017, respectively. The present finding corroborate with the finding of Meena *et al.* (2010) who, find that shoot infestation occurred from the first week of August to the harvesting of crop. The maximum infestation of 23.0 and 25.0 per cent was recorded in the third week of October during 2002 and 2003, respectively. Aziz *et al.* (2011) reported positive effect between the fruit infestation and maximum, minimum and average temperatures, whereas, the relative humidity and rainfall exerted negative effect separately as well as on cumulative basis. The shoot infestation of okra was found to be positively correlated with maximum and average temperature and negatively correlated with relative humidity and rainfall.

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An Optimization of Dahi by Using Antibiotic Resistant Probiotic Lactic Acid Bacteria

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Abstract

Dahi is a popular fermented milk product of great importance in Indian subcontinent. It is being used for its nutritive and therapeutic value. The current study is focused on the optimization of dahi culture by using Antibiotic Resistance Probiotic lactic acid bacteria (LAB). The 24 No's of different brands of dahi samples were collected from BBMP Zones of Bengaluru. The sample is isolated for LAB. The isolated LAB bacteria were analyzed for activity in milk, acidity and DMC. The selected isolates were analyzed for probiotic character like Acid and Bile tolerance by adjusting the pH to 2.0 and by using 0.3% Ox-bile. The maximum acid and bile tolerated isolates were genotypically identified. Identified isolates are further screened for antibiotic resistance property by using E-Strip method. Further the isolates were analyzed for Diacetyl and EPS (Exopolysaccharide) production. The lactic isolates used as starter for dahi preparation is based on Probiotic nature, Antibiotic Resistance, Diacetyl and EPS production. The result showed that the dahi prepared from 1% inoculum was having firm body and there was no syneresis when compared to 0.75% having higher syneresis, thin body and longer curdling time and dahi prepared from antibiotic resistance probiotic lactic isolates provide therapeutic benefits for consumers.

Key words : Lactic acid bacteria, BBMP, antibiotic, diacetyl, EPS, titratable acidity.

Introduction

Indian curd, known as 'Dahi' is a very well-known fermented milk product consumed by large sections of the population throughout the country, either as a part of the daily diet or as a refreshing beverage. The awareness of therapeutic benefits of dahi among consumers is increasing. In Ayurveda, use of dahi is recommended for curing of ailments like dysentery, dyspepsia and other gastrointestinal disorder (Gandhi, 2010). It also improves appetite by stimulating B and T cells of macrophages by lactic acid bacteria (Meydani and Ha, 2000; Sinha and Sinha, 2000). Readily available form of all the nutrients is also present in dahi. Beneficial bacteria are useful in the preparation of fermented foods, production of antibiotic, lactic acid and so on. Lactic acid bacteria (LAB) are one of the beneficial bacteria used in food fermentations. The LAB isolated from the domestic dahi samples have shown commercially important probiotic properties such as acid-bile tolerance, antimicrobial production, antibiotic resistant, microbial cell adhesion which are some prerequisites for the cultures to use them as a probiotic potential cultures (Chakoosari *et al.* 2014). Whereas some wild strains of *Lactobacillus* species isolated from the domestic dahi samples have shown probiotic characters like acid-bile tolerance, production of antimicrobial compounds, and adhesion to intestinal epithelial cells and variable in antibiotic resistance including other functional characters like Exopolysaccharide (EPS) and diacetyl

production. LAB used in the preparation of dahi also produce bioactive compounds such as diacetyl, hydrogen peroxide, and reuterin suppress the normal growth of undesirable flora, especially *E. coli*, *Bacillus subtilis*, and *Staphylococcus aureus* (Sarkar *et al.* 2015). The present study reveal the use of antibiotic resistant probiotic lactic acid bacterial culture along with their functional properties in the preparation of dahi.

Material and Methods

Dahi samples of different brands were collected from Eight Bruhath Bengaluru Mahanagara Palike (BBMP) zones and enumerated for LAB like lactococci, streptococci, leuconostoc and lactobacilli by using the media M17 and MRS (de Mann Rogosa Sharpe) at an incubation temperature of 30°C/24-48hr for lactococci and leuconostoc and 37°C/ 24-48hr for streptococci and lactobacilli. To enumerate Streptococci the first dilution was subjected to laboratory pasteurization at 63°C /30min as they are thermoduric in nature and cooled immediately at room temperature. After enumeration of LAB purified lactic isolated obtained, these isolates were individually inoculated in to sterile skim milk and incubated at 30/37°C until milk get set and examine for Titratable Acidity and DMC. The probiotic character such as acid and bile tolerance examined as per Rajashekar *et al.*(2013), also the isolates with better acid and bile tolerance were genotypically identified by the external source such as macrogen. Genotypically identified maximum acid-bile

tolerated isolates were screened for the antibiotic resistance test phenotypically as per Charteris *et al.* (2008) by using 5 commonly used antibiotics by using E-Strip method. The isolates were further tested for diacetyl production by using 0.5 ml of 40% potassium hydroxide and pinch of creatine also EPS Production by using 17ml/100ml of 85% trichloroacetic acid solution. The inoculum percent used to optimize the dahi culture for preparation of dahi is 0.75%, 1%, 1.5%, 2% with the culture having Probiotic nature, Antibiotic Resistance and functional properties used. The cultures were inoculated into heat treated homogenized milk (85°C/30 min) incubated at 30°C till curdling occurred. After noticing time for curd formation the samples were subjected to Titratable acidity and DMC.

Results and Discussion

Dahi samples 24 No's of different brands collected from 8 BBMP Zones of Bengaluru. The LAB enumerated by using M17 and MRS media shows an average count of Lactococci 4.89 log₁₀ cfu/g, Streptococci 4.48 log₁₀ cfu/g, Leuconostoc 3.82 log₁₀ cfu/g and Lactobacilli 4.98 log₁₀ cfu/g. The total 82 purified lactic isolates were obtained. Further the 82 purified lactic isolates screened for milk setting, acidity and DMC by using sterile skim milk. Among these isolates only 43 isolates showed better activity in skim milk. The 43 screened isolates were subjected to acid and bile tolerance test to assess the probiotic nature by using M17 and MRS broth. To conduct acid tolerance test the pH of the broth is adjusted to 2.0. After 2hr of incubation among 14 lactococci only LL7 and LL10 showed maximum tolerance to acid. Out of 13 streptococci ST1, ST2, ST3, ST7 and ST14 showed minimum reduction in viable count whereas among five leuconostoc LE1 and LE4 showed tolerance acid and also seven isolates of lactobacilli showed tolerance to acid among these LB2, LB5 and LB24 showed most tolerance to low pH. whereas bile tolerance test conducted by using broth containing 0.3% ox-bile. After six hours of an exposure among 14 isolates of lactococci LL7 and LL10 showed tolerance to bile. Out of thirteen isolates of Streptococci ST1, ST2, ST3, ST7 and ST14 showed better tolerance to bile. Among five leuconostoc isolates only LE1 and LE4 showed maximum tolerance to bile. Out of eleven lactobacilli tested only seven isolates has more viable count. The lactic isolates of maximum tolerated to acid and bile were genotypically identified by using an external source macrogen. The result reveals that the lactococci isolates LL7 identified as *Lactococcus lactis* ssp *lactis* and LL10 has *Lactococcus lactis* ssp *lactis* bv *diacetylactis*. The Streptococci isolates ST1, ST2, ST3, ST7 and ST14 identified as *Streptococcus thermophilus*. Leuconostoc isolates LE1 and LE4 identified as

L.mesenteroids ssp *mesenteroids*. whereas lactobacilli isolates LB2 was identified as *L.plantarum* and LB5 as *L.fermentum* and LB24 as *L.helveticus*. All these lactic isolates identity were confirmed by 16S rRNA sequencing.

Antibiotic Screening of Selected Probiotic Lactic Isolates

The identified probiotic lactic isolates (12 No's) screened for antibiotic resistant property against the commonly used five antibiotics such as Gentamycin, Penicillin, Streptomycin, Tetracycline and Vancomycin by using E-strip method which was described by charteries *et al.*, (2008). Table-1 reveal that Out of 2 lactococcal isolates tested the only *L. lactis* ssp. *lactis* bv. *diacetylactis* (LL10) showed resistance to tetracycline at 10 g. In case of 5 streptococcal isolates only 2 isolates *S.thermophilus* ST2 showed resistance to penicillin and tetracycline while ST14 showed resistance to vancomycin. Among 2 Leuconostoc isolates only *L. mesenteroides* ssp. *mesenteroides* (LE4) showed resistance to the vancomycin. Whereas 3 Lactobacillus isolates tested only one *L.plantarum* (LB2) showed resistance to penicillin and tetracyclin. Asharf and Smith (2016) reported that, the seventeen lactic acid bacteria and probiotic strains isolated from dairy based product showed resistance to acid, bile and he conducted antibiotic resistance test using E-test. The *L. reuteri*, *L. rhamnosus*, *L. acidophilus*, *L. delbrueckii* subsp. *bulgaricus*, *S. thermophilus*, *Bifidobacterium lactis* and *S. thermophilus* were susceptible to ampicillin and erythromycin. Vancomycin and streptomycin tolerances were most common among species whereas tolerances for gentamicin, clindamycin and tetracycline were rare.

Functional Properties of Selected Probiotic Lactic Cultures

Commercial dahi requires additional properties such as pleasant flavour and appreciable body and texture apart from lactic acid production, hence the culture possessing such characteristics improves over all acceptability of dahi. In this study Table-2 showed that *Lactococcus lactis* ssp. *lactis* bv *diacetylactis* LL10 produced both diacetyl and exopolysaccharide (EPS) while, *S.thermophilus* ST14, *L.plantarum* LB2 and *L.fermentum* showed positive for the EPS. *L.helveticus* had only probiotic property and did not produce diacetyl and EPS, while *Leuconostoc mesenteroides* ssp. *mesenteroides* LE1 and LE4 produced only diacetyl. Pradeep (2007) has observed Exopolysaccharide production by only three cultures such as *L. lactis* ssp. *lactis*, *L. mesenteroides* ssp. *mesenteroides*, and *L.viridescens*, out of 10 lactic isolates obtained from dahi samples. Rajashekar *et al.* (2013) reported that the dahi prepared from 1% inoculum with the cultures *L.lactis* ssp. *lactis* LC14, *S.thermophilus* ST3, *Leu.mesentroides* ssp. *mesnetroides* Leu8 and *L.delbrueckii* ssp. *bulgaricus*

Table-1 : Antibiotic screening of selected probiotic isolates.

Sl. No.	Code	Minimum inhibitory concentration (mcg/ml)				
		GEN	PEN	STR	TET	VAN
1.	LL7	6.0	0.75	24	1.5	8.00
2.	LL10	4.0	0.50	8.00	NIL	2.00
3.	ST1	1.50	1.50	96	0.75	3.00
4.	ST2	0.50	NIL	1.50	NIL	1.50
5.	ST3	8.0	0.19	12.00	6.00	2.00
6.	ST7	0.75	4.00	1.50	24	16.00
7.	ST14	4.00	6.00	16.00	4.00	NIL
8.	LE1	1.50	0.25	24	8.00	6.00
9.	LE4	3.00	1.50	NIL	16.00	NIL
10.	LB2	4.50	NIL	48	NIL	4.00
11.	LB5	6.00	1.00	64	8.00	1.50
12.	LB24	1.50	25	24	2.00	8.00

Note : All the values are an average of 3 trials.

GEN : Gentamycin, PEN : Pencilin, STR : Streptomycin, TET : Tetracyclin, VAN : Vancomycin

Table-2 : Functional properties of probiotic lactic cultures.

Sl. No.	Name of isolate	Diacetyl production	EPS production
1.	<i>L. lactis</i> ssp. <i>lactis</i> LL7	-VE	-VE
2.	<i>Lactococcus lactis</i> ssp. <i>lactis</i> bv <i>diacetylactis</i> LL10	+VE	+VE
3.	<i>S. thermophilus</i> ST1	-VE	+VE
4.	<i>S. thermophilus</i> ST2	-VE	-VE
5.	<i>S. thermophilus</i> ST3	-VE	-VE
6.	<i>S. thermophilus</i> ST7	-VE	-VE
7.	<i>S. thermophilus</i> ST14	-VE	+VE
8.	<i>L. mesenteroides</i> ssp. <i>mesenteroides</i> LE1	+VE	-VE
9.	<i>L. mesenteroides</i> ssp. <i>mesenteroides</i> LE4	+VE	-VE
10.	<i>L. plantarum</i> LB2	-VE	+VE
11.	<i>L. fermentum</i> LB5	-VE	+VE
12.	<i>L. helveticus</i> LB24	-VE	-VE

Table-3 : Optimizing the dahi culture formulation for preparation of dahi

% Inoculum	Setting time (h)	DMC log ₁₀ cells/ml	Titrateable acidity (%LA)	Sensory score (9-point hedonic scale)
0.75	13	7.12 ^a	0.53 ^a	7.87 ^a
1.0	11	7.89 ^b	0.55 ^a	8.50 ^b
1.5	11	7.82 ^b	0.68 ^a	8.38 ^b
2.0	11	7.21 ^a	0.71 ^a	7.28 ^a
CD	-	0.35	0.05	0.24

Note :

Similar superscripts indicate non-significant at the corresponding critical difference

Lactococcus lactis ssp. *lactis* bv *diacetylactis* LL10 + *S.thermophilus* ST14 + *L.mesenteroides* ssp. *mesenteroides* LE4 + *L.plantarum*

Lb32 contained 1 ppm of diacetyl and 180 ppm of exopolysaccharide.

Optimizing Dahi Culture Formulation for Preparation of Dahi : The selection of lactic isolates used as starter for dahi preparation was based on probiotic nature, antibiotic resistance, curdling time, acidity, diacetyl and EPS production. The selected cultures were *L. lactis* ssp. *lactis* bv *diacetylactis* LL10 + *S.thermophilus* ST14+ *L.mesenteroides* ssp.*mesenteroides* LE4+ *L.plantarum* LB2. To optimize the culture for preparation of dahi, the inoculum per cent used were 0.75, 1, 1.5 and 2 %. The

cultures were inoculated into heat treated homogenized milk (85°C/30min) incubated at 30°C till curdling occurred. Table-3 reveal that the inoculum at 1%, 1.5% and 2% set the milk at 11 h showed titrateable acidity of 0.55, 0.68 and 0.71% LA and DMC log₁₀/g of 7.89, 7.82 and 7.21 respectively but 0.75 % inoculated milk took 15h to set the milk. There fore Dahi obtained from 1% inoculum was having firm body and there was no syneresis when compared to dahi prepared from 0.75% having thin body, higher syneresis and longer curdling time whereas dahi prepared with 1.5 and 2% inoculum were having higher acidity and syneresis. The panel of judges also felt that the

dahi prepared with 1% inoculum was satisfactory. It was also noticed that there was no significant difference in the setting time and DMC of cultures inoculated at 1 and 1.5% ($P>0.05$). Hence, inoculum level 1 % was used for further study, as it holds good for commercial application. Rajashekar *et al.* (2013) *L.lactis* ssp.*lactis* LC14; *S. thermophilus* ST3 *L.mesenteroides* ssp.*mesenteroides* Leu8 and *L.delbrueckii* ssp. *bulgaricus* Lb32 acid and bile tolerated cultures were inoculated into heat treated homogenized milk at the rate of 1, 1.5 and 2 per cent at equal volume and incubated at 30°C curdled the milk at 18 h, while dahi prepared with 1 per cent showed better organoleptic quality, DMC of 8.32 and TA of 0.63%. Dahi prepared using 1.5% and 2.0% showed syneresis which is a defect normally seen in dahi. Hence in further study, 1% inoculum was used in the preparation of dahi added to that, 1% liquid culture is comfortable for bulk preparation of dahi culture. Mahesh *et al.* (2016) also found similar observation that an inoculum of 1% of probiotic cultures *L.lactis* ssp.*lactis* LC1+ *S. thermophilus* ST1 + *Leuconostoc mesenteroides* ssp. *mesenteroides* LEU1 and *L.fermentum* LB4 in equal volume set milk at 10 h.

Conclusions

Dahi is having better nutritive value than milk. Though there is no increase in fat or protein content of milk during fermentation, however, the digestibility of dahi is more than that of milk. Dahi is a rich source of calcium and protein just like milk. Apart from benefits of milk, dahi contributes additional health benefits which includes; the enzymes produced by the live culture continue to work in the intestine. This helps in strengthening and rebuilding the intestinal flora for the better absorption of nutrients. Consumption of dahi helps lactose intolerant to avoid flatulence and diarrhea, beneficial in preventing colon cancer, and to replenish intestines with beneficial microflora following treatment with antibiotics. Antibiotic is necessary to treat the bacterial infection but today the bacteria are resistant to antibiotic, therefore it is a global health burden. It becomes even more problematic with its

entry into food system. For example the probiotic bacteria should contain antibiotic resistant gene to avoid the wash out of healthy bacteria but it should not transfer to other pathogen because it cause it adverse health affects. There fore the present study reveal that the preparation of dahi using antibiotic resistance probiotic LAB along with functional property provide an excellent treatment in the repopulation of healthy bacteria.

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Physico-Chemical Attributes of the Optimized Cow Milk-Oat Milk Blended Iron Fortified Yoghurt

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Abstract

Yoghurt is a dairy product obtained by fermentation of milk using starter culture *Streptococcus thermophilus* and *Lactobacillus delbrueckii ssp. bulgaricus*. Application of dietary fibre and iron salt fortification in the manufacture of yoghurt enhances its nutritive and therapeutic value. In the present investigation an attempt was made to develop iron salt fortified, cow milk and oat milk blended yoghurt. Among the various levels of starter culture, cow milk-oat milk blends, ferrous sulphate and ammonium ferric citrate as fortificants tried in yoghurt, 2% starter culture, 80:20 cow milk-oat milk blend, 10 and 15mg ferrous sulphate and 15mg ammonium ferric citrate /kg of yoghurt respectively, were found to be optimum. Experimental yoghurt samples tested for chemical composition like fat, protein, total solids, moisture, ash, total fiber and analysis of titratable acidity, pH, syneresis is done. The chemical composition of optimized yoghurt is different from control yoghurt. The fat and protein content was higher in optimized yoghurt compare to control yoghurt.

Key words : Yoghurt, oat milk, chemical composition and iron fortification.

Introduction

Fermented milks have been developed throughout the world as a means of preserving milk against spoilage. The important fermented milks in India are dahi, shrikhand, lassi, butter milk etc. These traditional foods have persisted over the centuries in the developing world. But the scale of production ranged from house hold production to large scale production, wherein use of selected starter cultures, automatic processes and modern equipments are involved. (Patel and Schauen, 1997). Yoghurt is similar to dahi in its physical appearance; it possesses excellent nutritional and therapeutic properties. There is a need to introduce yoghurt in the daily diet of Indians, especially in the form of drinking yoghurt with incorporation of probiotic organisms. Yoghurt or yoghurt like products have been used as the most popular vehicle for incorporation of probiotic organisms mainly bifidobacteria and lactobacilli and functional ingredients. It has been recommended that foods containing such bacteria should contain atleast 10^6 live organisms per gram or ml of product at the time of consumption in order to obtain therapeutic benefits (Vedamuthu, 1991). During recent years non-dairy milk types, such as soymilk, coconut milk, almonds milk, mill milk, rice milk and oat milk, have been an increased demand from consumers due to their high functional properties. The cereal and grain milks aqueous extracts also do not contain cholesterol or lactose; hence, these milk types are

preferred by health conscious people and lactose intolerant (Kahraman, 2011).

Materials and Methods

Milk : Milk obtained from Student Experimental Dairy Plant, of Karnataka Veterinary Animal and Fisheries Sciences University (KVAFSU), of Hebbal, Bengaluru-24.

Oat groats : Cleaned and dehulled, oat groats were procured from Sattvic foods, Goa.

Chemicals : The chemicals and reagents used were mainly of highest purity and commercially available analytical and HPLC grades. All the aqueous reagents used were freshly prepared.

Preparation Oat milk : The procedure followed by (Patel and Ghosh, 2015) for preparation of oat milk was adopted with suitable modifications. Oat groats is cleaned and soaked in warm water overnight. The soaked oat goat is blended at the ratio of 1:4 oat to water and filtered through muslin cloth the extract obtained is oat milk and heated to 60°C for 5min and cooled to room temperature and stored at refrigeration temperature.

Experimental procedure for preparation of yoghurt : The procedure followed by Lee and Lucey (2010) for preparation of yoghurt was adopted with slight modifications in fat per cent. Standardized cow milk of 4% milk fat and 8.5% MSNF was homogenized ($60 \pm 1^\circ\text{C}$) at 2000 psi at first stage and 500 psi at second stage and heat treated to $90 \pm 1^\circ\text{C}$ for 10 min followed by cooling to

43±1°C. Starter culture consisting of *Streptococcus* ssp *thermophilus* and *Lactobacillus delbrueckii* ssp *bulgaricus* in the ratio of 1:1 was inoculated at the rate of 2.0 percent and then packed and incubated at 43±1°C for 4 hours followed by storage at 4±1°C.

Compositional analysis of experimental yoghurt

Fat : Fat content of cow and oat milk were determined by Mojonnier's method

Protein : Protein content of cow and oat milk was determined by micro Kjeldahl method as per ISI: SP18 part XI (1981).

Total Solids (TS) : Total solids of cow milk and goat milk were determined by gravimetric method as per ISI: SP 18 (Part XI) 1981

Moisture : Moisture content of cow milk and oat milk were determined by gravimetric method as per ISI: SP 18 (Part XI) 1981.

Total ash : Total ash content of cow and oat milk were estimated by gravimetric method as per ISI: SP18 part XI (1981).

Total fiber : The total fiber of oat milk and cow milk-oat milk blend was determined by AOAC method (1980).

Chemical analysis : Titratable acidity was measured as per method described in ISI:SP (Part XI) 1981. pH was measured using pH meter.

Chemical attributes of the optimized cow milk-oat milk blended fortified yoghurt : The gross composition of the cow milk-oat milk blended yoghurt and fortified cow milk-oat milk yoghurt with different salts and its comparison with the control yoghurt sample is presented in the table-1.

Moisture : The moisture content of the formulated yoghurt varied slightly from 85.20 to 85.46 per cent. The moisture content of the control sample, cow milk-oat milk blended yoghurt without iron fortification (T1), cow milk-oat milk blended yoghurt fortified with 10mg ferrous sulphate /kg of yoghurt (T2) and cow milk-oat milk blended yoghurt fortified with 15mg ammonium ferric citrate /kg of yoghurt (T3) were found to be 85.20, 85.46, 85.45 and 85.45 per cent, respectively. The statistical analysis of the results revealed that there was no significant difference ($P = 0.05$) with respect to moisture content between control and optimized yoghurts.

Protein : There was an increasing trend in the protein content of the formulated yoghurt. The protein content of the control sample, cow milk-oat milk blended yoghurt without iron fortification (T1), cow milk-oat milk blended yoghurt fortified with 10mg ferrous sulphate /kg of yoghurt (T2) and cow milk-oat milk blended yoghurt fortified with

15mg ammonium ferric citrate /kg of yoghurt (T3) were found to be 3.50, 3.52, 3.51 and 3.52 respectively. The statistical analysis of the results showed that there was no statistical significance ($P = 0.05$) between the control and optimized formulated yoghurts with respect to protein content.

Fat : The fat content of the all the optimized fortified yoghurts were higher than the control yoghurt, but it met the standard limits prescribed by FFSAI, (2006). The fat content of the control, cow milk-oat milk blended yoghurt (T1), cow milk-oat milk blended fortified with 10mg ferrous sulphate /kg of yoghurt (T2) and cow milk-oat milk blended fortified with 15 mg ammonium ferric citrate /kg yoghurt was found to be 4.0, 4.10, 4.10 and 4.10 per cent respectively. The statistical analysis of the results revealed that there was no significant difference ($P = 0.05$) with respect to fat content between the control and optimized iron fortified yoghurt samples.

Total solids : There was decrease in the total solid content of the optimized cow milk-oat milk blended iron fortified yoghurts when compared with control. The control sample had 14.70 per cent, where as it was higher in case of cow milk-oat milk blended yoghurt (T1), cow milk-oat milk blended fortified with 10mg ferrous sulphate /kg of yoghurt (T2) and cow milk-oat milk blended fortified with 15 mg /kg ammonium ferric citrate /kg of yoghurt (T3) was 14.58, 14.62 and 14.63 per cent respectively. Statistical analysis of the results revealed that there is significant difference ($P = 0.05$) with respect to total solids content between the control and optimized cow milk-oat milk blended iron fortified yoghurt samples. The results obtained in this study agreed with the findings of Kulkarni, 1990.

Ash : It is also evident from the (Table-1) that, the ash content for the control sample was 0.70 per cent, whereas it was slightly higher in case of cow milk-oat milk blended iron fortified yoghurt samples. Statistical analysis of the results indicated that there is no significant difference ($P = 0.05$) with respect to ash content between the control and optimized yoghurt samples.

Fiber : It is clear from the table that, the fiber content for the control was nil whereas for the cow milk oat milk blended iron fortified yoghurts the trace amount of fibre was present.

Chemical characteristics of the optimized cow milk-oat milk blended iron salt fortified yoghurt : The moisture content in all the yoghurt samples was more or less the same. There was no significant difference in the formulated yoghurt samples with respect to moisture content.

The cow milk-oat milk blended yoghurt (T1) and cow

Table-1 : Gross composition of optimized cow milk-oat milk blended iron fortified yoghurt.

Constituents (%)	Moisture	Protein	Fat	Total solids	Ash	Fibre
Yoghurt						
Control	85.20 ^a	3.50 ^a	4.00 ^a	14.70 ^a	0.70 ^a	-
T1	85.46 ^a	3.52 ^a	4.10 ^b	14.58 ^b	0.76 ^b	0.01 ^a
T2	85.45 ^a	3.51 ^a	4.10 ^b	14.62 ^b	0.76 ^b	0.01 ^a
T3	85.45 ^a	3.52 ^a	4.10 ^b	14.63 ^b	0.78 ^c	0.01 ^a
CD (P = 0.05)	NS	NS	0.08	0.07	0.01	NS

All the samples are average of three trials

Control – Cow milk yoghurt

T1–Cow milk-oat milk blended (80:20) yoghurt

T2–Cow milk-oat milk blended (80:20) yoghurt fortified with 10 mg iron/kg as ferrous sulphate

T3–Cow milk-oat milk blended (80:20) yoghurt fortified with 15 mg iron/kg as ammonium ferric citrate

CD : Critical difference

Similar superscripts indicate non-significant at the corresponding critical difference

NS : Non significant

Table-2 : Physical characteristics of optimized cow milk-oat milk blended iron fortified yoghurt.

Parameters	pH	Acidity (% LA)	Syneresis (%)
Samples			
Control	5.10 ^a	0.80 ^a	19.00 ^a
T1	5.12 ^a	0.79 ^a	19.50 ^b
T2	5.12 ^a	0.78 ^a	20.00 ^b
T3	5.15 ^a	0.76 ^a	21.00 ^b
CD (P = 0.05)	NS	NS	1.31

All values are average of three trials

Control – Cow milk yoghurt

T1–Cow milk-oat milk blended (80:20) yoghurt

T2–Cow milk-oat milk blended (80:20) yoghurt fortified with 10 mg iron/kg as ferrous sulphate

T3–Cow milk-oat milk blended (80:20) yoghurt fortified with 15 mg iron/kg as ammonium ferric citrate

CD : Critical difference

NS : Non significant

milk-oat milk blended yoghurt with iron samples (T2) and (T3) were found to contain slightly higher levels of protein, due to higher percentages of protein in oat milk. Control yoghurt had lower values of protein.

The fat content of the cow milk-oat milk blended yoghurts samples with and without iron salts was higher than the control yoghurt. The values were significantly different from the control which could be attributed to the contribution from oat milk.

The SNF content of the cow milk-oat milk blended yoghurt was lower than the control. The SNF content decreased due to the incorporation of oat milk, as the oat milk contains lower total solids than cow milk.

The total solid content of the optimized yoghurt was less when compared to control. The decreased level of total solids in the cow milk-oat milk blended yoghurt is due to addition of oat milk. The oat milk used in the study contained lower total solids compared to cow milk, whereas total solid content slightly increased in the cow milk-oat milk blended fortified yoghurt samples due to the fortification of iron salts.

The control had an ash content of 0.70 per cent, where as it was slightly higher for the optimized yoghurt prepared using oat milk blend followed by yoghurt fortified with iron salts. Fortification contributed to increase in the ash content of the experimental yoghurt samples.

Cow milk was used for control. It is devoid of fibre, however the traces of fibre content was observed in the cow milk-oat milk blended iron fortified yoghurt which is due to the incorporation of oat milk in yoghurt.

Physicochemical properties of cow milk-oat milk blended iron fortified yoghurt : The effect of blending cow milk-oat milk and fortification of iron salts on the physical properties of the experimental yoghurt samples is depicted (Table-2).

pH : The optimized cow milk yoghurt, cow milk-oat milk blended yoghurt, ferrous sulphate fortified cow milk-oat milk blended yoghurt and ammonium ferric citrate fortified cow milk-oat milk blended yoghurt was analyzed for the physico-chemical parameters are presented in Table (2). The average values obtained for the cow milk yoghurt was 5.10, cow milk-oat milk blended yoghurt was 5.12, ferrous

sulphate fortified cow milk-oat milk blended yoghurt was 5.12 and ammonium ferric citrate fortified cow milk-oat milk blended yoghurt was 5.15. The statistical analysis showed that addition of oat milk and fortification of iron salts in the yoghurt resulted in no significant effect on pH of yoghurt. The slight variations in the pH may be attributed to the difference in buffering capacities and as well as the metabolic activities of yoghurt cultures. Further the, buffering capacity is governed by the concentrations of proteins phosphates and citrates present in milk (Tamime and Robinson, 1999).

Titrateable Acidity : The acidity of the cow milk yoghurt showed an acidity of 0.80 % LA, oat milk blended yoghurt was 0.79% LA, ferrous sulphate fortified oat milk blended yoghurt was 0.78 % LA and ammonium ferric citrate fortified oat milk blended yoghurt was 0.76% LA. It is clear from the (Table-2) that, acidity decreased by oat milk incorporation and fortification with iron salts in the yoghurt. Statistical analysis showed that fortification with different iron salts has significant effect on acidity of cow milk-oat milk blended yoghurt. But there is no significant difference between control and cow milk oat milk blended yoghurt.

Syneresis : 'Syneresis' which is measure whey separation in the cow milk yoghurt, cow milk-oat milk blended yoghurt, ferrous sulphate fortified cow milk-oat milk blended yoghurt and ammonium ferric citrate fortified cow milk-oat milk blended yoghurt was 19%, 19.5%, 20% and 21% respectively. Statistical analysis is revealed a syneresis, between control and the experimental yoghurt

samples significant difference in mean value for the syneresis. The higher syneresis indicates loose casein micelle network resulting in weak gel incapable of retaining water (Singh *et al.*, 2012).

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Study on Carbohydrate Contents of Potato by Using Biocontrol Agent *Trichoderma viride* with FYM

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Abstract

An attempt was made to study the bio-control efficacy of *Trichoderma viride* on carbohydrate contents of potato crop. Three type of treatment soil treatment, seed treatment and foliar treatment in combination with farm yard manure were given. The result was recorded at the time of harvest. The best result was recorded in seed treatment followed by soil treatment and foliar treatment in comparison with control. Therefore from present investigation it is concluded that an eco-friendly biocontrol agent *Trichoderma viride* very easy to use and having no adverse effect on crops, people or animals and they can be applied to prevent and control several pathogenic fungi and grow healthy crop. The *Trichoderma viride* can be used as a bio-control agent as it is low cost and profitable dependent system and it also helps in conserving the natural resource.

Key words : *Trichoderma viride* (bio-control agent), soil treatment, foliar treatment, seed treatment, pathogenic, bio-control, effect on carbohydrate contents .

Introduction

India is fortunate enough to have vast diversity of land soil and agro climatic condition to grow various vegetable. Potato is the one of the most starchy food crops of the world. Today farmer are searching for resource efficient low cost and profitable dependent system, chemical pesticides when especially used indiscriminately have contaminated the environment. A number of plant diseases especially the soil and seed born could not be significantly controlled by chemical means and gain the resistance from the chemicals. So the substitute is only to apply cultural and biological practices, biological control methods are alternative means of disease control and grow healthy crop, which are the otherwise unprotected because of the involved expenses. An ecofriendly biopesticides viz., *Trichoderma viride*, is very easy to use and having no adverse effects on environment (crop, people or animals). They can be applied to prevent and control several pathogenic fungi such as *Fusarium*, *Rhizoctonia*, *Phythium*, *Phytophthora*, *Alternaria* etc. and grow healthy crop.

Materials and Methods

Experimental site : The experiment was conducted in the farm of Allahabad Agriculture Institute-deemed university Allahabad during the Rabi season of 2001-2002 and 2002-2003. Immediately after harvest of the kharif crop, the experimental field was ploughed 20-25 cm deep with soil turning plough. Cross ploughing and one planking was also done to obtain the good tilth fifteen centimeters deep furrows were opened with the help of bullock drawn

furrows maker at the appropriate distance. Seed beds were prepared for respective treatment as per the lay out planned plot for each treatment 2 x 2 square meters. The seed variety selected for the study was Kufri Bahar. farm yard manure was given @ 30t/ha in selected plot and mixed well with the soil and was broadcasted uniformly in the soil.

Types of application

Seed treatment : The seeds of potato were treated and then the seeds were spread on an airy and hygiene place. The uniform sized and well sprouted healthy tubers were collected for sowing.

Soil treatment : Little amount of soil was taken and treated. 15 cm deep furrows were made with the help of hoe. Treated soil was broadcasted informally in to the furrows. Seeds were placed in the furrows and were later covered with soil.

Foliar spray : Foliar spray was given by hand sprayer till the leaves became thoroughly wet. This treatment was given 30 days after sowing. This spray was repeated after 15 days of interval till February.

Detail of Treatments : *Trichoderma viride* (biocontrol agent) with FYM

1-T₁-soil application @ 3 Kg/ha + FYM

2-T₂-Seed application @ 200 g/500 tubers + FYM

3-T₃-Foliar application @ 2.5kg/ha + FYM

4-T₀-control

Observation of carbohydrate content at the time of harvest

Carbohydrate estimation : carbohydrate was estimated with the help of Anthrone methods (Mecreadly *et al.*, 1950).

Results and Discussion

Effect of Bio-control Agent *Trichoderma Viride* with FYM on Carbohydrate Contents of potato.

Treatment	Carbohydrate Contents
T ₀ Control	14.27
T ₁ Soil T.V. + FYM	14.57
T ₂ Seed T.V. + FYM	15.63
T ₃ Foliar T.V. + FYM	14.53

FYM—Farm Yard manure, T.V.—*Trichoderma viride*

Effect of *Trichoderma viride* with FYM on carbohydrate contents of potato : The data recorded on carbohydrate contents of *Trichoderma viride* (biocontrol agent). Treated plot indicated that carbohydrate contents of potato tuber at harvest were increased in treatment T₂ (seed T.V. + FYM.) followed by treatment (soil T.V. + FYM) and treatment T₃ (foliar T.V.+FYM) Sud *et al.* (1991) reported that an abundant supply of Nitrogen increase reflected change in starch content of potato. Barsukot and Kurkesh (1980) reported that the starch content was highest in treatments without fertilizers and it decreased

with increase in nitrogen. Rathore (2000) reported that FYM and neem leaf would increase plant emergence and growth parameters of moth bean.

Conclusions

From all the above we can conclude that biocontrol agent when applied in combination with FYM had beneficial effect on carbohydrate contents of potato.

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A Study on Farmers Required Need of Training and Knowledge for Extent Adoption of Groundnut Production in Satna District of M.P.

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Abstract

Groundnut cultivation originates from South America. Groundnuts were widely grown at the time of the Spanish & Portuguese conquest of South America. They spread to South Asia in the 16th century. In India, credit for groundnut production goes to Jesuit followed by Vasco De Gama. About 1850 Madras Presidency was known for the cultivation of groundnut in India. The current study aimed to extend the knowledge of the extent of the adoption of ground production in Madhya Pradesh. Successful production of Groundnut can prove to be very beneficial in increasing the economic condition of the farmers. For this, it is very necessary to have adequate knowledge of groundnut production technology. This study helps the farmers of Madhya Pradesh to analyze the increase in production after adopting the advanced technology of groundnut. We have studied Location, done interview schedules with farmers, collect the Cross-sectional data of 160 groundnut-producing farmers, divide dependent and independent variables, constraints faced by the farmers in the cultivation of Groundnut, and used Hypothesis, use statistical tools, hypothesis, t-test, correlation, regression, etc. have been used for its analysis. The result showed that the production of groundnut has increased significantly due to the adoption of advanced technology of groundnut. Overall the extent of adaptation is about recommended groundnut production out of total respondent's majority had in Medium level 66.88%. groundnut production, whereas 19.37% and 18.75% of them had low and high levels of adoption respectively. Along with this, many techniques have also been adopted that help in the cultivation of crops other than groundnuts. The introduction of new technologies in place of the old technology for the production of groundnut in Madhya Pradesh should be taken from this type of program, so that more and more healthy and more products can be done in the future. It was found from the study that the farmers who have adopted the advanced technology of production of groundnut, their production has been higher than the average level.

Key words : *Groundnut, adoption, technology, production, schedule.*

Introduction

India is the largest oilseeds grower and importer of edible oils. The oilseed accounts for 13% of the Gross Cropped Area, 3% of the Gross National Product and 10% value of all agricultural commodities. Oilseeds are the second most important and the largest Agri-commodity of India after cereals. Oilseed crops play a very important role in the agricultural economy of India which has the excellence of having large areas under oilseed crops. Every part of the groundnut plant is useful either as food or feed. Groundnut is rich in oil and protein. The kernels have about 25 % easily digestible protein which is 1.3 times higher than meat, times higher than eggs and 8 times higher than fruits. Its oil is also used for the preparation of soaps, hair oil, cosmetics, cold cream and for various industrial uses. Its oil is now used in pharmaceuticals as a substitute to oleic oil. The cake powder is used as laundry starch and in the manufacture of paper, gummed tapes and plastics. Groundnut is also known as a rotation crop. which has a legume with root nodules, it can synthesize atmospheric nitrogen and therefore enhance soil fertility.

Groundnut is used for both edible and non-edible purposes.

Health benefits of Groundnuts : The shell or pod of the groundnuts contains two, hardly three kernels in individual cases like pods. The nuts are egg shaped, and the size depends on the type of cultivar.

Heart Healthy Fats : Groundnuts accommodate monounsaturated and polyunsaturated fats that keep the heart healthy. A good level of both; monounsaturated and polyunsaturated fats results in lowering blood cholesterol level, and thereby reducing the risk of coronary heart diseases.

Proteins : Protein is important to the health of our cells. The cells in our body are constantly being replaced and repaired. To ensure that the new cells are healthy, and the damaged ones are repaired well, we need protein. Groundnuts are an extremely high source of dietary protein composed of fine quality amino acids that are important for growth and development. Groundnuts contain high concentrations of the antioxidant polyphenols, primarily a compound called p-coumaric acid and oleic acid.

Minerals : A rich source of minerals like magnesium, phosphorus, potassium, zinc, calcium, sodium, etc., needed by our body to function well, is ensured by a regular consumption of groundnuts. Adequate supply of these minerals ensures a healthy heart, and minimizes risk of mineral diseases.

Vitamins : Vitamins are important for overall growth and development. Vitamins ensure vital health for cells and tissues and for fighting infections etc., that in return assure smooth functioning of our organs. Peanuts provide our body with essential vitamins that also help in regulating metabolism, converting fat and carbohydrates into energy compounds, and facilitating bone and tissue formation.

Nutritional value per 100 g. :

Principle	Nutrient Value	Vitamin E	8.33 mg
Energy	567 Kcal	Electrolytes	
Carbohydrates	16.13 g	Sodium	18 mg
Protein	25.80 g	Potassium	705 mg
Total Fat	49.24 g	Minerals	
Dietary Fiber	8.5 g	Calcium	92 mg
Vitamins		Copper	1.144 mg
Folates	240 g	Iron	4.58 mg
Niacin	12.066 mg	Magnesium	168 mg
Pantothenic acid	1.767 mg	Manganese	1.934 mg
Pyridoxine	0.348 mg	Phosphorus	76 mg
Riboflavin	0.135 mg	Selenium	7.2 g
Thiamin	0.640 mg	Zinc	3.27 mg

Materials and Methods

The present study was carried out at the experimental field of Satna district located in northern part of Madhya Pradesh having geographical area of 7,425 sq. km. It is bounded by the district of Chitrakoot (M.P.) in the north, by Katni and Umariya districts in south and Panna and Rewa districts form the western and eastern boundaries of the Satna district. The normal annual rainfall of Satna district is 1092.1 mm. The district receives maximum rainfall during the south-west monsoon period (i.e. June to September) and about 88.7% of annual rainfall is received during this period. There are two types of soil viz., black soil and red soil are predominantly found. The black soils may be divided into kabir and mar, red soil into parua and raker. The structured questionnaire serves as a tool for collection of data. In view of this, a questionnaire was prepared on the basis of objectives of the study, which included relevant questions for seeking information in respect of independent and dependent variables.

The researcher personally interviewed the respondents included in the sample. The help of local leaders and progressive farmers were seek for

establishing rapport with the farmers. The farmers were contacted during the time which was convenient to them. This facilitated obtaining free and natural responses from them to the various questions/items included in the schedule. The respondents were assured that the information collected from them will only be used for the research purpose. The replies of the respondents were recorded during the interview. The questionnaire thus filled in was checked before closure of interview for its completion in all respects. The information collected through interview was processed into primary table and then into the secondary table. The qualitative data were quantified and later the quantified data were converted into frequency. The measurement of independent and dependent variables is given below. Independent variables are Age, Education, Caste, Area of groundnut, Annual income, Marketing behavior, contact with extension agencies, Information seeking behavior and Dependent variable is Knowledge level and Extent of Adoption.

The knowledge index (K.I.) was worked as follows :

$$K.I. = \frac{\text{Sum of knowledge score actually obtained by the respondent}}{\text{Maximum possible obtainable knowledge score by the respondent}} \times 100$$

After computing the knowledge level score, the respondents were grouped into low, medium and high knowledge categories based on the mean and standard deviation as indicated below :

Sr. No.	Category	Score assigned
1.	Low	Less than (Mean – SD)
2.	Medium	(Mean – SD) to (Mean + SD)
3.	High	More than (Mean + SD)

The farmer's extent of adoption was ascertained in terms of selected practices of groundnut production technologies adopted. The adoption index (A.I.) was worked out as follows :

$$K.I. = \frac{\text{Sum of adoption score actually obtained by the respondent}}{\text{Maximum possible obtainable adoption score by the respondent}} \times 100$$

The respondents were classified into three categories by using following formula :

Sr. No.	Category	Score assigned
1.	Low	Less than (Mean – SD)
2.	Medium	(Mean – SD) to (Mean + SD)
3.	High	More than (Mean + SD)

Statistical tools and tests used for analysis of data. E.g.: - for Frequency and Percentage.

Mean : The arithmetic mean ($\bar{X}$) is the quotient that results when the sum of all the items in the series is derived by the number (n) of items. The mean will be calculated by using formula :

$$\bar{X} = \frac{\sum X_i}{n}$$

Where, $\bar{X}$ = Mean

n = Total number of observations

X_i = Value of observation

Standard deviation : The standard deviation is the square root of the arithmetic average of the squared deviation of various values from their arithmetic mean.

i = Deviation of the score of Mean

n = number of observations

$$S.D. = \sqrt{\frac{1}{N} \sum X^2 - \frac{(\sum X)^2}{n}}$$

Karl Pearson's correlation coefficient (r) : Coefficient between two variables say x and y was calculated as :

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}}$$

Where,

n = Number of respondents

x = Independent variables

y = Dependent variable

r = Correlation coefficient

$\sum xy$ = Sum of the product of x and y

$\sum x$ = Sum of the independent variable

$\sum y$ = Sum of the dependent variable

$\sum x^2$ = Sum of the squared independent variable

$\sum y^2$ = Sum of the squared dependent variable

$(\sum x)^2$ = Square of the summation of the independent variable

$(\sum y)^2$ = Square of summation of the dependent variable

Results and Discussion

The data collected from 160 farmers from one block of Satna district, were compiled in the primary Table. Later, they were transferred to the secondary Table in view of the objectives of the study. Appropriate statistical tests were used to analyze the data in order to draw the inferences. The results of the investigation have been presented and discussed in this chapter under Socio-personal and economic and communication attributes of the farmers, Knowledge level of the farmers, Relationship between knowledge level and independent variables etc. The perusal of data presented in showed that the majority of the respondents 61.25 per cent pertained partially adoption followed by complete adoption 24.37 per cent and partial adoption 14.38 per cent regarding storage.

Distribution of respondents according to their extent of adoption regarding recommended groundnut production technology :

Sr. No.	Characteristics category	Frequency	Percentage
1.	Low	31	19.37
2.	Medium	99	61.88
3.	High	30	18.75
	Total	160	100.00

The extent of adoption is clearly indicated from the data presented in Table 4.16. Out of total respondents, the majority (61.88%) of them had a medium level of adoption of recommended groundnut production technology, whereas 19.37 and 18.75 per cent of them had low and high levels of adoption respectively.

Distribution of the respondents according to their age :

Sr. No.	Age group (Years)	Frequency	Percentage
1.	Young (Up to 35 years)	50	31.25
2.	Middle (36 to 55 years)	82	51.25
3.	Old (55 and above years)	28	17.50
	Total	160	100.00

Revealed that more than half of the respondents were from middle age group whereas 31.30 per cent belonged to young age group and 17.60 per cent respondents belonged to the old age group. we found that 15.63 per cent had made contacted in a year, 13.13 per cent of the respondents had made contacted monthly and 7.50 per cent of the respondents had occasionally contacted with Govt. Agriculture Department 26.25 percent of the respondents were educated up to primary school level and 18.85 per cent were illiterate, followed by 17.50 per cent of the respondents who were educated up to middle schools, whereas, 14.38 per cent respondents had education up to high school level and 12.60 per cent of the respondents had education up to graduation and above and only 10.63 per cent were educated up to higher Secondary, respectively. With regards to caste, maximum number of the respondents 61.87 per cent belonged to other backward caste, followed by 23.66 per cent who belonged to scheduled tribes, 11.88 per cent of the respondents belonged to scheduled caste and only 3.12 per cent of the respondents belonged to general category. It was found that majority (69.37%) of the respondents had their annual income between Rs.0.51 to 1.00 lakh, followed by 20.63 per cent of respondents who had annual income below to Rs.0.50 lakh. Whereas 10.00 per cent of respondents were having their annual income above Rs.1.00 lakh. The results clearly indicated that majority of the respondents belonged to Rs.0.50 to 1.10 lakh annual income group. that among all respondents, 60.00 per cent had medium market behavior, followed by

23.75 per cent had low and 16.2 percent respondents had high marketing behavior. Thus, it may be concluded that the highest 60.00 per cent of farmers had medium proportion marketing behavior.

The data presented in Table indicated that out of total respondents the majority (63.23%) of them had medium level of knowledge regarding recommended groundnut production technology, whereas 20.01 per cent and 16.88 percent of the respondents had high and low level of knowledge respectively. It can be concluded that most of the respondents had a medium to high level of knowledge regarding recommended groundnut production technology. overall extent of adoption is clearly indicated from the data presented in Table 4.16. Out of total respondents' majority (61.88%) of them had medium level of adoption about recommended groundnut production technology, whereas 19.47 and 18.76 per cent of them had low and high level of adoption respectively. Multiple responses were taken to ascertain the constraints faced by the groundnut growers in knowledge of recommended groundnut production technology which have presented in. So far as the constraints faced by the groundnut growers in knowledge of recommended groundnut production technology are concerned it was found that majority of the respondents (63.50%) reported more incidences of insect pests and diseases, lack of proper price of groundnut at local market (56.25%), high price of improved varieties (53.50%), improper market facilities (48.75%), lack of information about recommended groundnut production technology (45.01%), low production due to local variety (44.50%), complicated technique of seed treatment (42.87%), non-availability of improved varieties at proper time (37.50%), lack of knowledge about improved variety (36.25%), lack of knowledge about diseases symptoms and their control measure (32.50), erratic rainfall (30.00%), losses due to wild animals (30.37%), lack of groundnut processing unit (28.87%), lack of knowledge about of insect pest and their control (25.62%), high price of pesticides (23.75%), non-availability of agricultural labor at proper time (22.87%), lack of irrigation facilities (21.25%), lack of knowledge about proper doses of pesticides (20.72%) and non-availability of fertilizers and pesticides locally (20.75%).

There is a discussion in Relationship between knowledge level and socio personal economic and communication attributes of Farmers. There was a positive but non-significant relationship between age and knowledge level of farmers. The reason for this finding was that, not only the young farmers were more receptive to new ideas and they make efforts to gain higher knowledge to put them into practice but also the older farmers because also acquired information might have

possessed high knowledge on recommended production technology. This finding is in conformity with findings of Singh, Jheenger and Swarnakar who reported that the age had no significant association with knowledge of production technology. Education was positively and significantly related with the knowledge level of farmers. Educated farmers have better opportunities to acquire more scientific information by way of mass media contact, exposure to print media, interaction with scientists and extension workers to get clarification on various scientific aspects of recommended production technology. The relationship between caste of the farmers and their knowledge level was non-significant. Farmer's knowledge about improved production technology was irrespective of the caste from which the farmer belongs. The relationship between area of farmers for groundnut and their knowledge level was negatively and significantly related. Land holding is a criterion to know about improved practices. Profitability of raising a crop makes farmers know about improved technology respective to the size of farm. This finding is in conformity with Jondhale *et al.* who observed that land holding of trained and untrained farmers established significant and positive relationships with the knowledge of improved practices. The relationship between annual income of farmers and their knowledge level was negatively and significantly related. This result was found because every new and technological work needs money. Farmers should have enough income to do a new innovation. The reason is that every producer wants to get a high price for their produce and would try to gather more information which could be used to sell their produce and increase profit. There was a positive and significant relationship between extension contact and knowledge level of farmers. The farmers contacted the extension personnel of different departments. This helped them to gain more knowledge about improved production technology. There was a positive and significant relationship between information seeking behavior and knowledge level of farmers. The reason for this was the regular flow of technical information through all sources of information by the Department of Agriculture and other organizations to promote production technology. This may be due to the fact that interaction with office bearers of many organizations has increased the knowledge of respondents. Also, it is possible that more frequent information helped them to share ideas and information among themselves. Such technical information increased the knowledge level of farmers.

Conclusions

Most of the respondents 51.25 per cent were from middle age group, 26.15 had education up to primary school level

and 61.87 per cent belonged to other backward caste and 33.77 per cent had small area of groundnut with most of the farmers 59.37 per cent who had medium level of annual income. Majority of groundnut growers 60.00 per cent had medium level of marketing behavior, 77.50 per cent had medium contact with extension agencies and 60.38 per cent had medium level of information seeking behavior. As regards level of knowledge and adoption the respondents were under medium category regarding recommended production technology. Independent variables like education, annual income, marketing behavior, contact with extension agencies and information seeking behavior of respondents were found to be positively significantly related with knowledge and adoption level of the farmers. The findings of the study indicated that majority of respondents (63.50 per cent) faced constraint of more incidences of insect pests and diseases so it is implicated that training programs have to be organized exclusively on integrated insect, pest and diseases management for farmers. The present study also revealed that about respondents faced problem of non-availability of improved varieties at proper time (37.51 per cent), non-availability of fertilizers and pesticides (18.76 %) locally when needed so that it implicated that timely and local availability at the village level would enable the farmers in adopting recommended production technology. It was also seen from present study that respondents faced the problem of lack of knowledge about diseases, symptoms and their control measure (32.51 per cent), lack of knowledge about insect pest and their control (25.63 per cent) and lack of knowledge about proper doses of pesticides (20.63 per cent) so it is implicated that folders, leaflets, posters, on groundnut production technology should be published and its coverage through Television A newspaper is needed to educate farmers and other concerned. It is implicit that at least, a minimum number of demonstrations and field days around demonstrations are to be organized tehsil wise to convince farmers on the usefulness of recommended production technology.

Constraints encountered in the adoption of recommended production practices technology by the farmers : Majority of the respondents expressed that more incidences of insect pests and diseases (63.50 per cent) was the major constraint experienced in the adoption of recommended production technology. The other important constraint experience by the farmers were lack of proper price of groundnut at local market, high price of improved varieties, improper market facilities, lack of information about recommended groundnut production technology, low production due to local variety, complicated technique of seed treatment non-availability of improved varieties at proper time, lack of adoption

about improved variety, lack of knowledge about diseases symptoms and their control measure, erratic rainfall, losses due to wild animals, lack of groundnut processing unit, lack of knowledge about insect pest and their control, high price of pesticides, non-availability of agricultural labor at proper time, lack of irrigation facilities, lack of knowledge about actual doses of pesticides and non-availability of fertilizers and pesticides locally.

Majority of the respondents expressed that recommended production technology could increase if they were of the thought that training programs should be organized on plant protection measures at village level. Other important suggestions that government should supply timely and good quality seed of groundnut at proper time, majority of the respondents suggested that government should buy groundnut produce from farmers or groundnut growers like rice etc., government should provide improved varieties seeds at low price, market facilities should be increased, government should provide regular information about recommended groundnut production technology, skill oriented training should be given on proper application of fungicides and fertilizers etc., Extension efforts should be enhanced by the field functionaries at village level, demonstration should be organized at farmers field, government should provide the facilities to control wild animals, management of agricultural labor at proper time of agricultural operation, availability of insect pest and disease resistance/tolerance varieties at local market.

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Studies on the Effect of Plant Growth Regulators on Physical Parameter of Guava (*Psidium guajava* L.) cv. Allahabad Safeda

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Abstract

A field experiment was conducted during the year 2017-18 and 2018-19 at Horticulture Research Farm-I, Department Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.), India on 18- years - old guava plants, "Studies on the effect of plant growth regulators on (physico-chemical) physical parameter of guava (*Psidium guajava* L.) cv. Allahabad Safeda", revealed that days to first bud initiation, days to first flowering, days to 50% flowering, days to 100% flowering, fruit set, fruit retention, fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm³), specific gravity, fruit yield (kg/tree), fruit yield (q/ha) were maximized when foliar spray was done with CCC 1000 ppm NAA 200 ppm and GA₃ 150 ppm) respectively.

Key words : Guava, GA₃, NAA, CCC and physical parameters.

Introduction

Guava (*Psidium guajava* L.) is the most popular fruits grown in tropical, sub-tropical and some parts of arid regions of India. Guava belongs to the family Myrtaceae. It has been in cultivation in India since 17th century and has originated in tropical America perhaps from Mexico to Peru and introduced in India by Portuguese. It can withstand drought up to some extent but only few degree of frost. The importance of guava is due to the fact that it is a hardy fruit and which can be grown in poor alkaline soil or poorly drained soils and pH 8.5, it can with stand to the maximum temperature at 46 °C and annual rainfall of less than 25 mm. Guava fruits are also used for preparation of jam, jelly, RTS, nectar etc. The guava bears flowers and fruits on current season growing twinges and highly cross pollinated crop and pollination occurs through honey bees and andirona insect, fruit of guava developed from inferior ovary on exhibited double sigmoid growth curve, fruit with many seed berry, the fruit take nearly 4-5 month from dark green to yellowish green. The common guava is a diploid 2n=22, but natural and artificial triploid (2n=33) and aneuploid exist triploid generally produce seedless fruit. In northern India guava plant bears flower twice or sometimes thrice in a year. The spring flowering is called "Ambe-Bahar" June or monsoon flowering is called "Mrig-bahar" and third flowering which comes in October is called "Hast-Bahar" Ambe-Bahar fruit ripen from July to September and Mrig-Bahar fruit ripen in from November to February, however, Hast-Bahar fruit ripen in spring season, which also known as summer season crop.

Materials and Methods

18- year- old uniform guava plants of Allahabad Safeda cultivar planted at 6x6 m a part growing in Horticulture Research Farm-I of Babasaheb Bhimrao Ambedkar University Lucknow-226025 were taken for the investigation. T₂ GA₃ 50 ppm, T₃ GA₃ 100 ppm, T₄ GA₃ 150 ppm, T₅ GA₃ 200 ppm, T₆ NAA 50 ppm, T₇ NAA 100 ppm, T₈ NAA 150 ppm, T₉ NAA 200 ppm, T₁₀ CCC 250 ppm, T₁₁ CCC 500 ppm, T₁₂ CCC 750 ppm, T₁₃ CCC 1000 ppm along with T₁ Control (water spray). First spraying of plant growth regulators were done before flowering (first week of August) and second after fruit set (second week of September) during 2017 and 2018, respectively. The experiment was laid out in R.B.D. with three replications. Observations recorded to be days to flowering, days to 50% flowering, days to 100% flowering, fruit set, fruit retention, fruit length (cm), fruit width (cm), fruit weight (g), fruit volume (cm³), specific gravity, fruit yield (kg/tree), fruit yield (q/ha). The data so obtained were analysed statistically.

Results and Discussion

A perusal of data in table-1 shows that significant response in the maximum days to first bud initiations, days to first flowering (7.40 to 7) number of fruit set (71.60 to 72 %) and maximum fruit retention (57.10 to 56.00 %) was noticed with foliar spray of CCC 1000 ppm (T₁₃) followed by (53 to 52.00 %) and (51.55 to 52.40) with foliar spray of NAA 200 ppm (T₉) GA₃ 150 ppm (T₄) in comparison to control (38.15 to 37.52) was recorded under control

Table-1 :

Treatments	Days to flowering		Days to 50% flowering		Days to 100% flowering		Fruit set		Fruit retention		Yield (kg/tree)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T ₁ Control (water spray)	15.00	14.00	25.00	26.00	48.00	47.00	46.00	45.80	38.15	37.52	41.90	42.00
T ₂ GA ₃ 50 ppm	13.00	12.00	22.00	21.00	42.00	42.60	50.20	50.90	47.14	48.00	46.40	47.50
T ₃ GA ₃ 100 ppm	11.00	11.00	21.00	20.00	40.00	40.80	52.40	53.10	49.65	50.50	48.60	49.00
T ₄ GA ₃ 150 ppm	10.00	10.20	19.00	18.00	39.00	38.90	52.60	53.40	51.55	52.40	48.80	49.70
T ₅ GA ₃ 200 ppm	10.00	9.20	18.00	17.80	37.00	37.40	53.20	54.00	49.19	50.00	49.20	50.00
T ₆ NAA 50 ppm	12.00	11.60	20.00	19.60	38.40	38.80	55.00	55.60	46.90	48.93	50.90	51.40
T ₇ NAA 100 ppm	11.00	10.00	18.00	18.00	36.80	37.00	58.00	58.80	50.65	51.46	53.70	54.50
T ₈ NAA 150 ppm	10.00	9.40	17.00	16.80	35.00	35.60	59.80	60.30	50.43	49.87	54.50	55.00
T ₉ NAA 200 ppm	9.00	8.50	16.40	16.00	34.00	34.40	60.20	60.80	53.00	52.00	55.90	55.50
T ₁₀ CCC 250 ppm	10.00	9.80	17.60	17.20	35.60	36.00	64.60	65.40	47.10	48.50	58.90	59.60
T ₁₁ CCC 500 ppm	8.00	8.20	16.20	16.00	33.60	34.00	67.80	68.20	48.06	49.49	61.70	62.00
T ₁₂ CCC 750 ppm	7.00	7.40	15.00	14.80	31.80	32.30	70.00	71.20	50.45	50.00	63.80	64.30
T ₁₃ CCC 1000 ppm	7.60	7.90	14.40	14.00	31.00	31.60	71.60	72.00	57.10	56.00	64.40	64.40
S.Em. ±	0.292	0.468	0.711	0.759	1.717	1.388	2.777	3.237	1.05	1.20	2.198	2.344
C.D. at 5%	0.853	1.365	2.074	2.214	5.012	4.050	8.106	9.449	3.06	3.23	6.416	6.843

Table-1 : Contd

Treatments	Fruit yield (q/ha)		Fruit length (cm)		Fruit width (cm)		Fruit weight (g)		Fruit volume (cm ³)		Specific gravity	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T ₁ Control (water spray)	116.06	116.34	6.70	6.80	5.36	5.45	74.50	75.80	90.00	92.00	0.83	0.84
T ₂ GA ₃ 50 ppm	128.53	131.58	7.20	7.26	5.76	5.81	95.00	96.40	104.00	103.60	0.88	0.89
T ₃ GA ₃ 100 ppm	134.62	135.73	7.40	7.45	5.92	5.96	98.90	99.70	112.00	111.80	0.89	0.90
T ₄ GA ₃ 150 ppm	135.18	137.67	7.48	7.52	5.98	6.02	102.50	101.80	113.40	113.10	0.89	0.90
T ₅ GA ₃ 200 ppm	136.28	138.50	7.50	7.55	6.00	6.05	104.30	105.00	115.20	115.00	0.90	0.91
T ₆ NAA 50 ppm	140.99	142.38	7.60	7.65	6.10	6.15	98.80	99.70	108.00	108.20	0.88	0.89
T ₇ NAA 100 ppm	148.75	150.97	7.70	7.70	6.17	6.20	103.40	103.90	114.00	114.30	0.90	0.91
T ₈ NAA 150 ppm	150.97	152.35	7.76	7.80	6.22	6.25	105.70	106.60	115.60	115.60	0.91	0.92
T ₉ NAA 200 ppm	154.84	153.73	7.55	7.60	6.05	6.10	106.80	108.00	116.20	116.20	0.90	0.91
T ₁₀ CCC 250 ppm	163.15	165.09	7.65	7.70	6.12	6.18	102.90	104.70	114.60	115.00	0.91	0.92
T ₁₁ CCC 500 ppm	170.91	171.74	7.88	8.00	6.30	6.40	112.20	114.50	117.50	118.00	0.92	0.93
T ₁₂ CCC 750 ppm	176.73	178.11	7.92	7.97	6.35	6.38	115.60	117.40	118.80	119.20	0.92	0.93
T ₁₃ CCC 1000 ppm	178.39	178.94	8.0	8.04	6.39	6.42	118.00	120.20	119.20	120.30	0.94	0.95
S.Em. ±	7.519	4.518	0.255	0.395	0.266	0.292	4.025	4.396	3.646	3.217	0.010	0.011
C.D. at 5%	21.947	13.186	0.743	1.154	0.777	0.851	11.747	12.831	10.643	9.390	0.030	0.310

treatment (water spray T₁). These results corroborated the finding of Rubi Rani and Brahmachari (2004) [8] in mango, Kumar *et al.* (2013) [6] in guava and Byas (2014) [3] in ber which are in support of present findings.

The maximum length (8.0 to 8.04) width (6.39 to 6.42) weight (118 to 120.20) and volume (119.20 to 120.30) of fruit recorded with CCC 1000 ppm (T₁₃). The minimum length, width, weight and volume of fruit recorded with under control treatment (water spray.T₁). the increase in, length, width weight and volume of guava fruit by foliar spray might be due to rapid cell division, cell elongation, translocation of sugars and highest fruit size as well as fruit weight, which ultimately increase the yield of guava fruit. The increase in fruit weight by GA₃ NAA, and CCC spray might be due the accumulation of more food material in tree. The importance of the elements in

improving the physiological activities of plant had been released but is not clear whether in influenced directly or in directly. The results are in close conformity.

The data pertaining to specific gravity of guava as presented in table-1 clearly indicated that the foliar application of growth regulators significantly increased specific gravity of guava fruit. The maximum specific gravity (0.94 to 0.95) was noticed with foliar spray of CCC 1000 ppm (T₁₃). followed by foliar spray of NAA 150 ppm (0.91 to .092) (T₈) and GA₃ (0.91 to 0.92) T₄ The minimum specific gravity of guava fruit in comparison to control treatment (water spray T₁). The increase in volume and Specific gravity of guava fruits, application might be due to accumulation of more metabolites resulting higher weight at faster rate than increase in the volume of guava fruits. Similar results have been reported by Kumar *et al.* (2010)

[5] in guava, Rachna and Singh (2013) [7] in ber, Kumar *et al.* (2013) [6] in guava and Byas (2014) [3] in ber.

The maximum fruit yield per plant and fruit yield quintal per hectare (64.40 to 64.00) and (178.39 to 178.94) was noticed with foliar spray of CCC 1000 ppm, GA₃ (T₁₃) followed by (55.90 to 55.50) with foliar spray of NAA 200 ppm (T₉) while the minimum (41.90 to 42.00) was recorded under control treatment (water spray T₁). The importance of this element in improving the physiological activities of plant had been released but it is not clear whether it or indirectly. These activities improve size, influenced directly width, length and weight of fruits which ultimately increased the yield of fruits, similarly micronutrients promotes growth hormones, starch formation and seed maturation, weight of fruit. These results are in quite conformity with the findings of Kumar *et al.* (2010) [5], Awasthi and Lal (2009) [2] in guava and Joon *et al.* (1984) [4] in ber.

Conclusions

The yield and physical parameters of fruit with respect fruit set, fruit retention, fruit length, fruit width, fruit weight, fruit volume, specific gravity, fruit yield per plant (Kg/plant) and yield (q/ha) were obtained maximum with the foliar spray of CCC 1000 ppm. Therefore, combined spray of NAA 100 ppm T₉ and GA₃ 200 ppm (T₅) can be advocated to guava growers for serving higher yield and better of quality of fruits.

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Estimation the Daily Runoff through Conservation Factor Approach

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Abstract

Runoff is the first visible outcome of the interaction between the rainfall and the watershed features. A proper assessment of runoff is crucial for developing plans for soil and water conservation programs including both engineering and agronomic practices. In this study, daily runoff estimation model was developed using the concept of Conservation Factor in modeling temporal water yield from different micro watersheds of Barapani and validated for the different micro watersheds of Burnihat to locate in same agro-ecological region. To develop the daily runoff estimation models, daily rainfall (R), slope factor(s), and conservation factor (CF) combined in the form of $R \times CF$ was termed as water yield producing factor (X). For calculating water yield producing factor (X), the different CF values were used for different AMC status. Regression relationships were developed for correlating water yield with this factor through exponential and power forms. For each farming system, it was found that the form of the equation changes with the change in value of CF-II.

Key words : Daily runoff, conservation factor.

Introduction

Knowledge about the availability and demand of water in a watershed on temporal scale is essential for developing appropriate plan of water resources development and management. The origin of all water in a watershed is rainfall, which is a stochastic hydrologic event. Agriculture is a major user of water resources, proper assessment of runoff becomes important for the development of agriculture. Like the space-time variability of runoff, the agriculture water demand is also a space-time variable. Under a monsoon dominated tropical climate, where agriculture can be practiced throughout the year, there exists considerable mismatch between the variability features of water availability and demand. This calls for conservation of water during the period of its excess and use the conserved water during the lean period of water availability.

Singh (1988) and Bajpai (1999) attempted assessment of water yield on temporal scale from micro watershed through Conservation factor (CF) using readily, available parameters considering the data base status in Indian conditions. In this method monthly, seasonal and annual rainfall, land use, conservation measure; soil type and slope of the watershed were the input parameters. These attributes were numerically indexed by assessing their impact on runoff. There is a scope to incorporate a few more parameters like AMC and improve the modeling for assessing runoff or water yield values from micro watersheds. In their approach, the potential of a watershed, in producing runoff and in causing soil loss through detachment and transport, is

related to a discrete number called Conservation Factor (CF). The CF is a function of land use, conservation measure, soil type and area of the watershed. It is a dimensionless number. The present paper is an attempt to develop CF based models for the estimation of daily runoff by incorporating AMC factor in the original CF approach.

Materials and Methods

Database used for this study is from the sites located at the ICAR Research Complex for NEH region, Barapani and Burnihat (Meghalaya). Barapani is located between $25^{\circ} 39'$ and $25^{\circ} 41'$ N latitude and between $91^{\circ} 54'$ and $91^{\circ} 56'$ E longitude and is 22km away from Shillong on the Shillong-Umroi road. Experimental watersheds at Burnihat site lie between $26^{\circ} 28'$ and $26^{\circ} 30'$ N latitude and between $92^{\circ} 11'$ and $92^{\circ} 15'$ E longitude. The mean annual rainfall in the Barapani watersheds is 2232 mm with more than 88% occurring during the period from May to October. The average annual rainfall of Burnihat is around 1618 mm. Over 80% of the total annual rainfall is received during May to September.

The soil of these sites comprise from very deep, yellowish red soils with very thick B-horizon from watershed metamorphic rocks. Surface soils are more acidic than subsurface soils. The parent material is of sand stone with sandy loam texture; internal drainage of soil is quite good. The detailed land use pattern and soil conservation measures in each of the micro watersheds of Barapani and Burnihat are presented in table-1 and table-2 respectively.

Table-1 : Land Use System and Soil Conservation Measures in Micro Watersheds of Barapani Experimental Area.

Watershed	Land Use	SWCE Measure	Crop Grown
FS-W ₁	Agriculture	Contour bund, bench terraces & contour trenches	Fodder crops
FS-W ₂	Forest	—	Timber, fuel and fodder trees
FS-W ₃	Agro-forestry	—	Timber, fruits, fuel & fodder trees
FS-W ₄	Agriculture	Contour bund & bench terraces	Food & fodder crops
FS-W ₅	Agri-horti-silipasture	Contour bund, bench terraces & half moon terraces	Food & fodder crops
FS-W ₆	Horticulture	Contour bund, bench terraces & half moon terraces	Fruits & vegetable crops
FS-W ₇	Natural fallow	—	Natural flora
FS-W ₈	Degraded land	—	—

Table-2 : Land Use System and Soil Conservation Measures in Micro Watershes of Burnihat Experimental Area.

Watershed	Land Use	SWCE Measures	Crops Grown
W ₁	Shifting cultivation	—	Cereals, Tubers and Cucurbits
W ₂	1/3 (Agril) + 2/3(Horti)	Bench terrace and Contouring	Cereals, Tubers and Cowpea
W ₃	Agriculture	Bench terrace	Cereals and Tubers
W ₄	Agriculture	Contour bund	Cereals and Tubers
W ₅	Agriculture	Bench terrace and Contour bund	Fodder. Legumes and Grasses
W ₆	Secondary forest	—	Bamboo

Daily rainfall and runoff data of Burnihat (1976-83) and Barapani (1983-92) watersheds were collected from the ICAR Research Complex, Shillong. Daily rainfall was recorded using both self-recording and non-recording type of rain gauges. There were hydrological gauging stations installed at the outlet of all the micro watersheds to record runoff and soil loss. Each gauging station consisted of one H flume with F type water level stage recorder to measure the runoff.

The potential of a watershed for water yield was related to the Conservation Factor (CF) depending upon the land use, conservation measures and soil type of the watershed (Bajpai, 1999). He listed them in the order of their potential and possible types and assigned numerical values (number) arbitrarily but keeping in view that the most effective one gets highest value. The conservation factor (CF) over a watershed is given by following equation.

$$CF = \frac{A_1(NL_1 \quad NC_1 \quad NS_1) \quad \dots \quad A_n(NL_n \quad NC_n \quad NS_n)}{A} \quad (1)$$

Where, $A_1 \dots A_n$ = watershed areas under various land uses, ha.

$NL_1 \dots NL_n$ = assigned numbers to various land uses.

$NC_1 \dots NC_n$ = assigned numbers to various conservation measures.

$NS_1 \dots NS_n$ = assigned numbers to various soil type.

Nine land uses that are common in the country were considered in modeling process. Based on the hydrological information available, these land uses were listed and assigned numbers, which varies from 5 to 80

(table 3). The conservation measures have varied effect on the water yield dynamics and accordingly, were listed and assigned discrete number from 10 to 80 (table-3). The six major soil types are also taken in to consideration for hydrological studies of soil and water conservation activities of watershed. Based up on infiltration characteristics of these soil types their impact on water yield was also assessed and used. Accordingly, soil type was listed and assigned number from 10 to 40 (table-3).

For developing daily runoff estimation models, the concept of conservation factor (CF) was adopted to describe the rainfall – water yield relationship under different farming system. Rainfall, steepness and conservation factor were combined in the form of water yield producing factor. For the development of daily runoff estimation model AMC was also used because AMC is one of the watershed parameter that affect the runoff from the watershed. For validation, the data sets of Burnihat watershed were used. The Burnihat watershed is in the same agro-climatic region of Barapani watershed. The average absolute percentage deviation (AAPD) was calculated between observed and predicted runoff to test the validity of the models by following formula :

$$AAPD = (\text{Observed} - \text{Predicted}) * 100 / \text{Observed}$$

Results and Discussion

The main purpose of this study is to develop the daily runoff estimation models. The principle of conservation factor (CF) was adopted and modified to describe the rainfall – water yield relationship for hilly micro watersheds under different conservation based farming land use systems. To develop the daily runoff estimation models,

Table-3 : The assigned numerical values (ANV) to various watershed parameters.

Land Use	ANV	SWCE Measures	ANV	Soil Type	ANV
Degraded land	5	No measures	10	Clay	10
Waste / fallow land	10	Bunding, Contour	50	Clay	15
Development work	20	& Vegetative bunding		Loam	
Agriculture	30	Half moon terracing,	60	Silt	25
Horticulture	40	Terracing & Trenching		Loam	
Agro-forestry	55	Terracing & Gabbian	70	Silty	30
Pasture	60	Structure		Sandy	35
Secondary forest	70	Check dam, Quarry	80	Loam	
Virgin Forest	80	& Mines		Sandy	40

(Source : Bajpai, 1999)

Table-4 : CF values for different micro watersheds for Burnihat.

S.N.	Watersheds	CF-II	CF-I	CF-III
1.	W ₁	40	73	19
2.	W ₂	70	111	37
3.	W ₃	80	121	44
4.	W ₄	60	99	31

daily rainfall (R), slope factor(s), and conservation factor (CF) combined in the form of R*s/CF was termed as water yield producing factor (X). For calculating water yield producing factor (X), the different CF values were used for different AMC status. The values of CF calculated by using eq.1 were considered as CF values for AMC-II. To determine the CF values for AMC-III and AMC-I, the following equations were used (Bhargav, 2003) :

$$CF(III) = 5.94 CF(II) / (14.14 - 0.041CF(II)) \quad \dots(2)$$

$$CF(I) = 32.54 CF(II) / (14.14 + 0.092 CF(II)) \quad \dots(3)$$

Where, CF-I, CF-II and CF-III are the conservation factor for AMC-I, AMC-II and AMC-III respectively.

Regression relationships were developed for correlating water yield with this factor through exponential and power forms. The data set for all the farming systems of micro watersheds of Barapani (FS-W₁ to FS-W₈) were considered for the development of daily runoff estimation models. The value of water yield producing factor 'X' was computed for each micro watersheds. For each farming system, it was found that the form of the equation changes with the change in value of CF-II. For CF-II 60, the form of equation was

$$Y = A X B \quad \dots(4)$$

Where, Y is the daily water yield (mm), X is water yield producing factor and A and B are regression constants. An attempt has been also made to develop regression relationships between constants A and B with the Conservation Factor (CF-II). The developed regression equations are as follows :

$$A = 0.009*CF-II - 0.2477 \quad \dots(5) \\ (R^2 = 0.74)$$

$$B = 0.0075*CF-II + 0.964 \quad \dots(6) \\ (R^2 = 0.78)$$

The constants A and B required to estimate daily runoff using above developed model can be calculated easily using these equations for all micro-watersheds, which have CF-II value = 60.

If the value of CF-II greater than 60, the form of equation becomes

$$Y = A e^{BX} \quad \dots(7)$$

Where, Y is the daily water yield (mm), X is water yield factor and A and B is regression constants.

$$A = 0.0147*CF-II - 0.6721 \quad \dots(8) \\ (R^2 = 0.83)$$

$$B = - 0.0038*CF-II + 0.470 \quad \dots(9) \\ (R^2 = 0.76)$$

The constants A and B required to estimate daily runoff using above developed model can be calculated easily using these equations for all micro-watersheds, which have CF-II greater than 60.

Validation of Developed Models : After the development of two different forms of CF based models for two different ranges of CF-II using the data set of Barapani micro watersheds, the developed models were subjected to validation. The data set of Burnihat micro watersheds were selected for validation because these belong to same agro-climatic region of Barapani. For the validation, daily runoff was predicted from each micro watershed by using appropriate developed model. The model used for prediction of daily runoff for particular micro watershed was selected on the basis of CF-II values of that micro

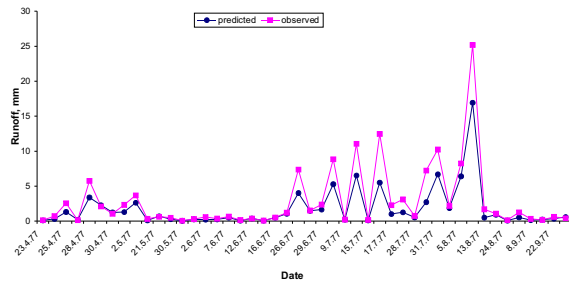


Fig 4.1: Comparison between daily predicted and observed runoff from W1 watershed

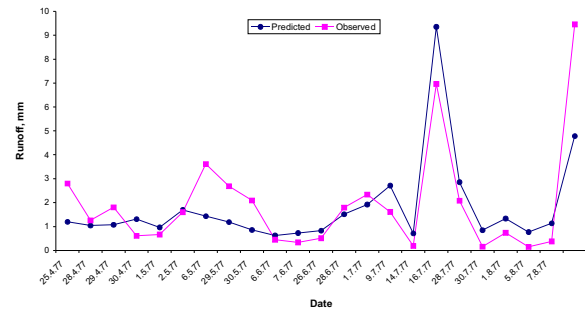


Fig 4.3: Comparison between daily predicted and observed runoff from W3 watershed

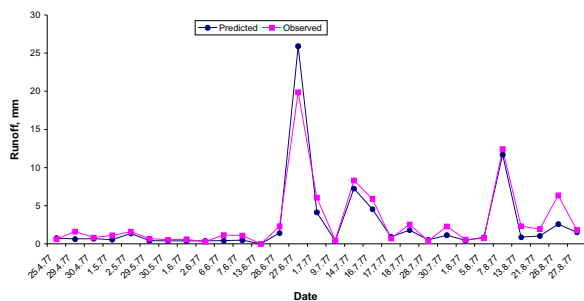


Fig 4.2: Comparison between daily predicted and observed runoff from W2 watershed

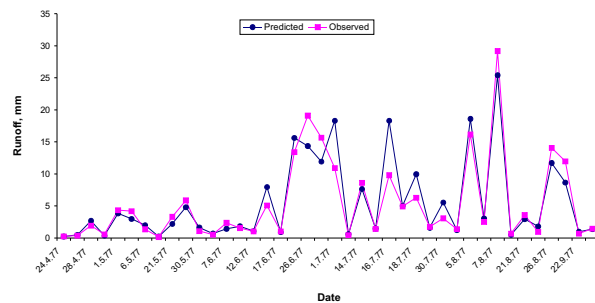


Fig 4.4: Comparison between daily predicted and observed runoff from W4 watershed

watershed. These predicted daily runoff values were compared with the observed runoff.

W₁ Micro Watershed : Conservation factor value for AMC-II of W₁ watershed of Burnihat is 40. Power form model (Eq. 4) was applied to estimate daily runoff because CF of W₁ watershed is less than 60. While estimating daily runoff from daily rainfall data by using model (Eq. 4), CF values used were calculated taking into account the effect of AMC, which are given in Table-4. For each daily rainfall data, AMC were decided based on previous five days rainfall. To compare the model predicted daily runoff and observed daily runoff, average absolute percentage deviation was calculated which was found 12 percent. In hydrological work, 12 percent average absolute deviation is quite acceptable. Graphical presentations of predicted and observed daily runoff, for a year 1977 is shown in Fig 4.1. It can be seen from this figure that the trend of observed and predicted runoff is quite similar.

W₂ Micro Watershed : Values of conservation factor for AMC-I, AMC-II and AMC-III for this micro watershed obtained are 111, 70 and 37 respectively. W₂ micro watershed produced less amount of runoff as compared to W₁ micro watershed of Burnihat for same amount of rainfall, because W₁ micro watershed has low value of CF than W₂ micro watershed. Exponential form of model was

selected to estimate the daily runoff from this micro watershed. Graphical comparison between daily observed and predicted runoff for the year 1977 is presented in Fig 4.2. Average absolute percentage deviation between daily observed and predicted runoff was found to be 23 percent.

W₃ Micro Watershed : Values of conservation factor for AMC-I, AMC-II and AMC-III for this micro watershed obtained are 121, 80 and 44 respectively. Exponential model was selected to estimate the daily (Eq. 7) runoff from this micro watershed because the value of CF-II for the watershed is 80. Graphical comparisons between daily observed and predicted runoff for the year 1977 is presented in Fig-4.3. Average absolute percentage deviation between daily observed and predicted runoff was found 19 percent.

W₄ Micro Watershed : Values of conservation factor for AMC-I, AMC-II and AMC-III of this micro watershed obtained are 90, 60 and 31 respectively. Power form of model was applied to estimate runoff from W₄ micro watershed. The average absolute percentage deviation of the model predicted and observed values of daily runoff was found to be nearly 12 per cent. Graphical presentation of model predicted and observed daily runoff for one year

(1977) from W_4 watershed of Burnihat is presented in Fig.-4. The trends of observed and model predicted daily runoff is similar.

Conclusions

Like in the Curve Number method, the Antecedent Moisture Condition of the watershed can be incorporated in the Conservation Factor method for daily runoff estimation giving a better result. Daily runoff estimation models are of exponential form when CF-II varied from 40 to 60 and of power forms when CF-II more than 60. The average absolute deviation between Conservation Factor estimated and observed daily runoff varied between 12 to 23 per cent for the selected micro watersheds. The same for the weekly runoff varied between 11 and 20 per cent.

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Evaluation of Phalsa (*Grewia subinaequalis* DC.) Germplasm for Variation in Growth Parameters under Semi-Arid Region of Haryana

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Abstract

A field experiment was conducted at the experimental orchard of CCS Haryana Agricultural University, RRS, Bawal (Rewari), Haryana. Thirteen genotypes (4 tall double seeded, 5 tall single seeded, 3 dwarf single seeded) having a wide range of variability in growth parameters which were studied in randomized block design. Results showed that the Bawal Phalsa 4 had the maximum plant height, while the minimum was of Bawal Phalsa 12, whereas the plant spread was maximum in Bawal Phalsa 2 and it was minimum in Bawal Phalsa 13. Internode length was maximum in Bawal phalsa 5, while minimum in Bawal Phalsa 13. Plant habit was observed as spreading in Bawal Phalsa 1 to 10, while it was drooping type in dwarf germplasm. Leaf pubescence on the dorsal side of the leaf in Bawal Phalsa 1 to 4 germplasm was observed as dense leaf pubescence and Bawal Phalsa 5 to 10 observed to have medium leaf pubescence, while dwarf has sparse. Bawal Phalsa 1 to 10 have green leaf surface colour on the dorsal side, while dwarf germplasm observed to be greenish white leaf colour. Maximum leaf length and width were observed in Bawal Phalsa 4 and minimum in Bawal Phalsa 12. Leaf shape and leaf margin showed no variation.

Key words : Phalsa, germplasm, leaf, length and width.

Introduction

Phalsa (*Grewia subinaequalis* DC.) is an important fruit of India and Southern Asia. It is one of few hardy tropical fruit crops because its cultivation needs least inputs and care; and yields delicious fruits of edible quality. It belongs to the family Tiliaceae. India is said to be the home of phalsa because it is originated in India and South-East Asia (Burns, 1918). Among the 140 species of genus *Grewia*, only *Grewia subinaequalis* is of commercial importance and is one of the popular sub-tropical, tropical and arid fruit crops. It is also called as dhamin and shukri in Punjabi and Bengali, respectively. Phalsa is a drought tolerant and hardy plant that can be grown throughout the country except for high altitude regions. It is comparatively less attacked by diseases and pests. It can be grown on marginal land with the least inputs. In Haryana, the phalsa is grown in Hisar, Rewari, Mahendergrah and Bhiwani, while data for phalsa crop in terms of its area, production and productivity in India and Haryana too is not known. As far as its climatic requirements, it is a subtropical fruit plant and can be grown in a wide range of climatic conditions, which can be satisfactorily grown up to an elevation of 1000 m. The plants are deciduous and normally shed leaves on the onset of the winter season and become dormant, however, in warm regions plant does not shed leaves and no dormancy occurs. Optimum growth is observed at a temperature ranging from 3 °C to 45 °C and it can tolerate light frost (Pareek and Sharma, 2009). Fruit

ripening and development of appropriate fruit color requires a good amount of sunlight which ultimately leads to the good eating quality of phalsa. It grows well on different kind of soils but well-drained loamy soil with a pH range of 6.1 to 6.5 is found to be the best for its growth, productivity, and quality fruits. Phalsa is considered a stress-tolerant crop and shows a good response to fertilizer applications (Singh and Singh, 2003). Phalsa is a shrub plant that can attain height up to 4 m or sometimes even more, whereas its leaves are 6-20 cm long with 1-1.5 cm board petiole (Tripathi, 2009). Till now there is no recognized variety of phalsa, but some local germplasm in different growing regions are performing well. In Hisar district of Haryana State, two local varieties *i.e.*, tall and dwarf are adopted and grown in a different locality. In this experiment, the emphasis has been made to study the adaptability of different germplasm. Based on growth, yield and quality performance of different germplasm, the suitable germplasm can be selected for the semi-arid region of Haryana. This will also help the orchardist in the selection of appropriate germplasm of this neglected crop for large-scale cultivation to get higher yield and good quality fruits. The researcher can also plan their breeding experiment based on the characterization of germplasm under this region.

Materials and Methods

The field experiment was conducted at the experimental orchard of CCS Haryana Agricultural University, Regional

Table-1 : Growth characteristics of phalsa germplasm under semi-arid conditions of Haryana.

Germplasm	Plant height (m)	Plant spread (m)	Internode length (cm)	Tree habit
Bawal Phalsa 1	2.72	3.03	7.57	Spreading
Bawal Phalsa 2	2.92	3.47	7.47	Spreading
Bawal Phalsa 3	2.83	3.42	7.23	Spreading
Bawal Phalsa 4	3.12	3.41	7.07	Spreading
Bawal Phalsa 5	2.82	3.24	7.93	Spreading
Bawal Phalsa 6	2.87	3.12	7.83	Spreading
Bawal Phalsa 7	2.82	2.97	7.80	Spreading
Bawal Phalsa 8	2.73	3.26	7.77	Spreading
Bawal Phalsa 9	2.72	3.28	7.73	Spreading
Bawal Phalsa 10	2.82	3.01	7.80	Spreading
Bawal Phalsa 11	1.32	1.62	6.13	Drooping
Bawal Phalsa 12	1.05	1.53	6.10	Drooping
Bawal Phalsa 13	1.25	1.57	6.07	Drooping
C.D. at 5%	0.15	0.23	0.40	—



(a)



(b)

Plate-1 : Plant habit (a) Spreading type (b) Drooping type.

(c)



(d)

Plate-2 : Leaf colour on dorsal side of leaf (a) Greenish white (b) Green.

Research Station, Bawal (Rewari), Haryana situated at an altitude of 266 m above mean sea level with coordinates of 28° 10' N latitude and 76° 50' E longitudes in South-West

zone of Haryana. Bawal is extremely hot in summer (45°C and above) and cold in winter (0°C and below). May and June are the hottest months, while December and January

Table-2 : Leaf Morphological characteristics of phalsa germplasm under semi-arid conditions of Haryana.

Germplasm	Leaf shape	Leaf margin	Leaf pubescence on dorsal side	Leaf surface colour on dorsal side	Leaf length (cm)	Leaf width (cm)
Bawal Phalsa 1	Cordate	Serrate	Dense	Green	15.73	15.37
Bawal Phalsa 2	Cordate	Serrate	Dense	Green	16.03	15.27
Bawal Phalsa 3	Cordate	Serrate	Dense	Green	16.33	15.57
Bawal Phalsa 4	Cordate	Serrate	Dense	Green	17.13	16.33
Bawal Phalsa 5	Cordate	Serrate	Medium	Green	16.80	16.13
Bawal Phalsa 6	Cordate	Serrate	Medium	Green	16.40	15.36
Bawal Phalsa 7	Cordate	Serrate	Medium	Green	16.93	15.30
Bawal Phalsa 8	Cordate	Serrate	Medium	Green	17.03	15.56
Bawal Phalsa 9	Cordate	Serrate	Medium	Green	16.46	15.63
Bawal Phalsa 10	Cordate	Serrate	Medium	Green	16.60	15.60
Bawal Phalsa 11	Cordate	Serrate	Sparse	Greenish White	12.07	10.00
Bawal Phalsa 12	Cordate	Serrate	Sparse	Greenish White	11.93	9.93
Bawal Phalsa 13	Cordate	Serrate	Sparse	Greenish White	12.60	10.03
C.D. at 5%	—	—	—	—	0.44	0.49
Range	—	—	—	—	11.93-17.13	9.93-16.33

are the coldest months in this region. The climate of the study area is arid to semi-arid with an average rainfall of 456 mm. Total rainfall shows large variations and 80-85 per cent of total annual rainfall is received from South West monsoon, *i.e.*, from July to September, and a little showers of rainfall are received from December to February. A field experiment was conducted on 39 year old phalsa trees planted at 3m × 3m spacing. A total of thirty nine uniformly grown plants were selected randomly, earmarked based on visual differences during January, 2018 and maintained under uniform conditions of orchard management during the study period. All the agronomic practices carried out during the experiment were followed as per the recommended package of practices. The experiment was laid down in a randomized block design with three replications. Uniformly ripened healthy fruits free from any injury or disease were harvested for the estimation of physiological characteristics. The growth parameters *i.e.* tree habit, leaf shape leaf margin, leaf pubescence etc. of the phalsa crop were recorded at appropriate growth stages, as recommended in the descriptor of NBPGR (Mahajan *et al.*, 2002), and guidelines for DUS testing of PPV and FRA (Anonymous, 2016). Plant height and plant spread (average of N-S and E-W) were measured with the help of a graduated measuring pole and expressed in a meter. Internodes length, leaf length and leaf width were measured with the help of measuring the scale and mean value was worked out and expressed in centimeter. Leaf colour was observed visually at the appropriate stage as per standard colour chart. The statistical method described by Panse and Sukhatme (1985) was followed for analysis of data. Analysis was done with the software OPSTAT available on www.hau.ac.in.

Results and Discussion

In present investigation, considerable variations have also been reported among different germplasm in different parameters as shown in results. Genetic constitution/variation in individual germplasm or their acclimatization to varied agro-climatic conditions might be the reasons for variations in different characters (Singh *et al.*, 2014). Among the studied germplasm the plant height varied from 3.12 m to 1.05 m (table 1). Maximum plant height (3.12 m) was observed in Bawal Phalsa 4, which was tall double seeded germplasm, while the minimum plant height of 1.05 m was recorded in Bawal Phalsa 12, which was dwarf germplasm. This variation in plant height may be due to the genetic makeup of the plant. Dhawan *et al.* (1993) also reported the plant height of the tall type was 4.5 m, while it was 3.4 m in case of dwarf type at Hisar. The variation in plant height of aonla cultivars was also found by Aulakh *et al.* (2006), Kumar *et al.* (2011), Singh *et al.* (2015) and Singh *et al.* (2017).

However, the variation in plant height of same germplasm in a different area may be due to adaptability and performance of germplasm with the prevailing local climatic conditions. Dwarfness is the desirable characters for the high density planting as it accommodates more number of plants per unit area and thereby increasing the plant population, which can harvest more sunlight and enhance productivity. Plant spread (table 1) was observed maximum in Bawal Phalsa 2 (3.47 m), while the lowest plant spread was found in Bawal Phalsa 12 (1.53 m). This type of variations in plant spread was also found in aonla cultivars by Aulakh *et al.* (2006), Shukla *et al.* (2010), Kumar *et al.* (2011), Kumar *et al.* (2014), Singh *et al.* (2015) and Singh *et al.* (2017). The observed

differences in the growth of germplasm under different agro-climatic conditions might be due to their genetic makeup, prevailing climatic condition and/or the interaction effect of genotype with the environment. The selection of cultivar must be based on the performance of germplasm/ variety under particular condition because the same cultivars behave differently with a change in agro-climatic conditions. Spreading type plant habit was observed in tall double seeded and tall single seeded germplasm, whereas it was observed drooping type in case of dwarf germplasm (table 1). The variation in plant habit of aonla was also observed in different cultivars under different agro-climatic conditions (Pathak *et al.*, 2004; Singh *et al.*, 2015; Kumar *et al.*, 2016). The tree habit might be the varietal/ germplasm characteristic because the variation in tree shape under different agro-climatic conditions remained the same (Singh, 2018).

The range of internode length (table-1) varies from 6.07 cm in Bawal Phalsa 13 (dwarf) to 7.93 cm in Bawal Phalsa 5 (tall single seeded). However, Pareek and Panwar (1981) observed the internode length of 5.1 cm in type-A and 4.8 cm in type-B. The difference in internode length among the genotypes might be due to genetic features of particular germplasm. Leaf characters are commonly used to distinguish and identify the cultivars or species of fruit crops. In the case of leaf shape, no clear variation was observed *i.e.*, all the studied germplasm have similar leaf shape *i.e.* cordate leaf shape (table 2). These types of variation in leaf shape of phalsa cultivars were also reported by Yadav (1999), Haq *et al.* (2013), Mishra *et al.* (2018). There was no variations in the leaf margin, all the germplasm studied have serrated leaf margins (table 2). The similar leaf margin of phalsa was also reported by Haq *et al.* (2013). The similarity in the leaf margin of different germplasm might be due to the close relation of the plant species. In case of leaf pubescence, tall double seeded have dense and tall single seeded have medium leaf pubescence, while dwarf has sparse leaf pubescence on the dorsal side of the leaf (table-2).

These types of variation in leaf pubescence of phalsa were also found by those of Pareek and Panwar (1981). The data presented in the study (table-2) showed that tall double seeded and tall single seeded have green leaf surface colour on the dorsal side, whereas dwarf germplasm have greenish white leaf surface colour on dorsal side. These types of variation in colour on the dorsal side of a leaf of phalsa were also found by those of Dhawan *et al.* (1993) and Mishra *et al.* (2018). Maximum (17.13 cm) leaf length was found in Bawal Phalsa 4 and minimum (11.93 cm) leaf length was found in Bawal Phalsa 11 (table-2). Leaf width was also reported maximum in Bawal Phalsa 4 (16.33cm), however,

minimum leaf width (9.93 cm) was found in Bawal Phalsa 12 (table-2). These types of variation in leaf length and width of phalsa were also observed by Mishra *et al.* (2018), who studied phalsa crop under the arid condition of CAZRI, Jodhpur. The size of plant leaves may vary with the environmental conditions. The leaf size of the plant under humid conditions may be slightly more as compared to arid conditions. However, the variation in leaf size under similar conditions may be due to its genetic variability.

Conclusions

The phalsa germplasm was grouped into three categories such as tall double seeded, tall single seeded and dwarf (single seeded) based on results achieved. Some characteristics in germplasm are common with others; however, some are very distinct with others. Tall double seeded and tall single seeded germplasm have spreading type tree habit and green colour dorsal side on the leaf with dense pubescence, while dwarf germplasm has drooping type tree habit and greenish white colour dorsal side on leaf sparse pubescence.

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Enhancement of Seed Quality of Aged Seeds through Scarification in Guava (*Psidium guajava* L.)

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Abstract

The present study was carried out on fresh, one year, two years and three years aged seeds of variety L-49 (Sardar) in the laboratories of Department of Seed Science and Technology, CCS HAU, Hisar during 2018-2019. The above seeds were subjected to different seed scarification treatments viz., Hot water at 80°C for 1 minute, quick dip in sulphuric acid (concentrated) and water soaking for 48 h. The seeds were assessed for various physiological parameters viz., germination percentage, seedling length, seedling dry weight, seed vigour index-I, seed vigour index-II, speed of germination and accelerated ageing test for 24, 48, 72, 96 h. Hot water treatment at 80°C for 1 minute resulted into maximum germination (36.67%), seedling length (5.61cm), seedling dry weight (328.4mg), seedling vigour index-I (205.7), seedling vigour index-II (12050), speed of germination (1.857) and maximum germination (14.67, 10.4.67 and 2%) at 24, 48, 72 and 96 h accelerated ageing test respectively in fresh seed lot. It is concluded from the study that hot water treatment at 80°C for 1 minute is the best scarification method for removing physical dormancy of guava seed. Concentrated sulphuric acid resulted in no germination and showed poor germination.

Key words : Guava, seed germination, scarification, accelerated ageing test.

Introduction

Guava (*Psidium guajava* L.) is one of the important fruit crops of tropical and subtropical regions of India. It is member of family *Myrtaceae* and popularly known as “Apple of Tropics” (Pandey and Misra, 1984) and claims to be the fourth most important fruit in respect of area and production after mango, banana and citrus (Radha and Mathew, 2007). In Northern India it is harvested twice in a year during rainy season (July-August) and winter season (November to December). Fruit yield is more during rainy season and quality is better during winter season (Diwedi *et al.*, 1991). It is a highly remunerative crop because of its high adaptability to wide range of climate, variable rainfall and various soil conditions, pH (4.5 to 8.2) and tolerant to drought and salinity but susceptible to frost (Purseglove, 1968; Singh, 1969 and Jaiswal and Amin, 1992). It can be grown in all types of soils such as sandy to heavy loam but light sandy loam is best for the cultivation. Guava has earned the popularity as *poor man's apple* available in plenty to every person at very low price during the season. It is not inferior to apple for its nutritive values because the fruit is rich in vitamin C that ranges from 75 to 260 mg per 100 g pulp (Singh, 1988; Das *et al.*, 1995; Ghosh and Chattopadhyay, 1996) and pectin that ranges from 0.5 to 1.8 percent (Adsule and Kadam, 1995). Due to high pectin content, its fruit is used in the preparation of jelly, ice-cream, wine and brandy (Dhawan *et al.*, 1983) and a

good source of thiamine and riboflavin that ranges from 0.03 to 0.07 mg per 100g and 0.02 to 0.04 mg per 100g of pulp, respectively (Wilson, 1980). The vitamin C in guava is 2 to 5 times more than that of citrus fruits (Bose and Mitra, 2001). The most important guava growing states are Uttar Pradesh (49010), Madhya Pradesh (30,310 ha), Bihar (29,630 ha), Maharashtra (12,490), Gujarat (11,640), Haryana (12,030) and Andhra Pradesh (58, 200) (Anonymous, 2018). In India production of guava is 3,648 thousand MT from an area of 262 thousand ha. Production of guava is maximum from Uttar Pradesh and Madhya Pradesh 9,19,940 and 5,23,750 MT, respectively. Production of guava in Haryana is 1,85,630 MT from 12030 ha. The area under guava is increasing rapidly owing to great demand in the international market. Even though the area under guava is increasing, the pace of development is not appreciable.

The greatest bottleneck in the expansion of area under fruits is the non availability of genuine and quality planting materials in adequate quantity from reliable nurseries and suffers from a sudden decline of trees causes of which are still a matter of debate. Healthy and good quality planting material is the foundation of successful fruit industry in the country. Seed propagation is used to obtain seedling for raising rootstocks which later used for getting grafted plants. Seeds of guava are hard and generally have poor and decreased germination

in guava over periods of time. Different methods like water soaking, scarification and chemical treatments are used for improving the seed germination. Scarification is the process of injuring the hard seed coat by any mean to accelerate the water absorption and to improve gaseous exchange for hastening the process of germination. Germination percentage of seed lots provide only limited information because marketing standards are such that most of the seed lots have same germination percentage in storage. Seed lots having same kind, variety, chronological age and germination do not store equally well under same situation. Such type of variations in storage potential of seed lots due to difference in their pre-storage history, exposed condition during the post maturation period until storage. Various methods are used for evaluating the relative storage potential of seeds. Accelerated aging is the best method for evaluation of germinating response of seeds. Small samples of seeds are taken from seed lots for evaluation of storage potential are placed in an incubation chamber at temperature 40°C to 45°C and 100 per cent relative humidity for up to 10 days. These conditions are varying with seed kind. After accelerated aging test seeds still have the capacity to germinate which is determined in regular germination tests, after aging seeds having low survival percentage are considered to be poor storers, and those with high survival are good storers. L-49 variety found resistant to wilt as it is a selection of Allahabad Safeda which is wilt resistant (Chandra and Mishra, 2005). Therefore rootstock can be used to provide wilt free quality planting material to the farmers. Hence, seeds of guava in present study were checked by treating them with different seed scarification treatments for improving the seed quality.

Materials and Methods

The present study was conducted on four seed lots viz., Fresh, One year old, two years old, three years old seed lots of variety-L-49 (Sardar) at laboratory of Department of Seed Science and Technology, CCS HAU, Hisar. Guava seeds were collected from ripe fruits. Seeds were extracted and after extraction seeds were completely cleaned, dried and stored at room temperature. The above seeds of all the lots were subjected to Hot water treatment at 80°C for 1 minute, Quick Dip in Sulphuric acid (Conc.) and water soaking for 48 hrs. The seed quality was assessed with seed quality parameters viz., Germination (%), seedling length (cm), seedling dry weight (mg), seedling vigour indices, speed of germination and accelerated ageing tests at 24, 48, 72 and 92 hours.

Germination (%) was carried out according to ISTA, 2013. Hundred seeds of each treatment in three replicates were placed in the seed germinator at 25°C by

using top of the paper method. The final count was taken on 30 day. The germination percentage was calculated by using the formula given below :

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds used}} \times 100$$

For measurement of seedling length (cm) ten normal seedlings were selected at random and average seedling dry weight (mg) of these ten seedlings was recorded after drying the seedlings in hot air oven at 65±2°C temperature for 48 hours. Seedling vigour index I and II were calculated as per the formula given by Abdul-Baki and Anderson (1973).

1. Seedling Vigour Index-I = [Germination (%) x Average seedling length (cm)]

2. Seedling Vigour Index-II = [Germination (%) x Average seedling dry weight (mg)]

Speed of germination was calculated by formula suggested by Maguire (1962) :

Speed of germination =

$$\frac{\text{No. of normal seedlings}}{\text{Days to first count}} \dots$$

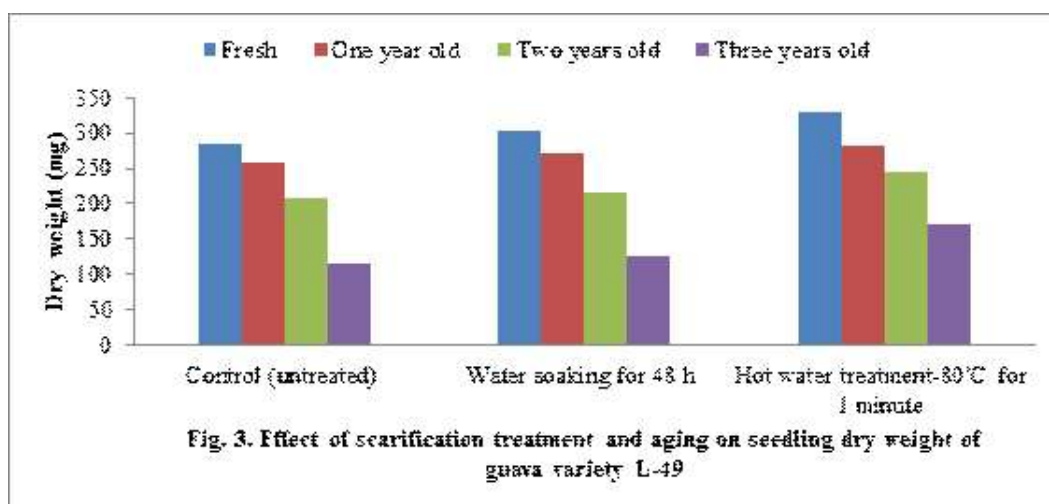
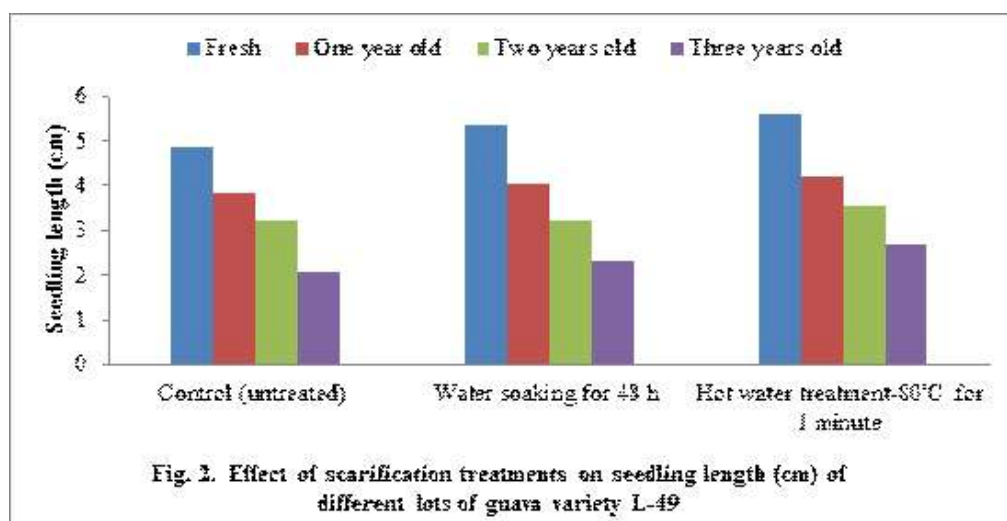
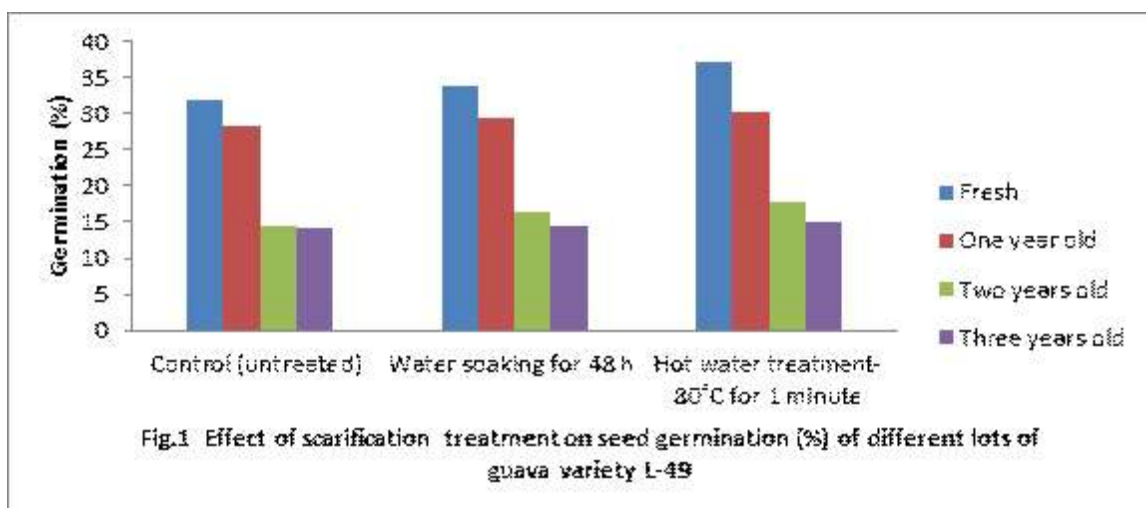
$$\frac{\text{No. of normal seedlings}}{\text{Days to final count}} \quad \frac{n}{t}$$

Accelerated aging test was conducted by putting the seeds in an incubator maintained at (40-45°C) and high relative humidity (100%) for 24, 48, 72, 96 hrs.

The experiment was conducted in CRD (Factorial) design along with three replications and analysis was done with the software OPSTAT available on www.hau.ac.in.

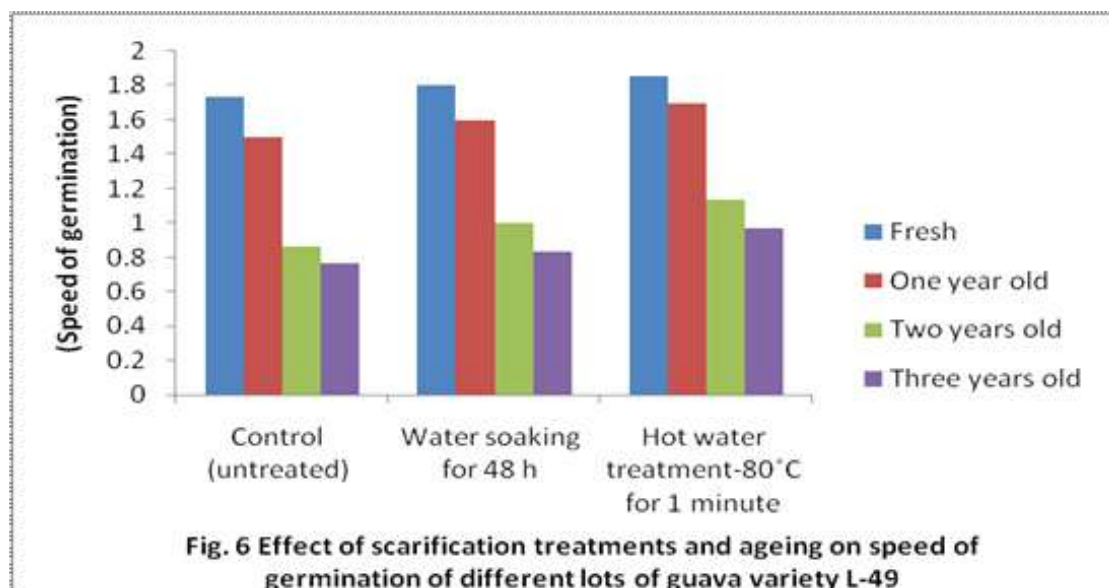
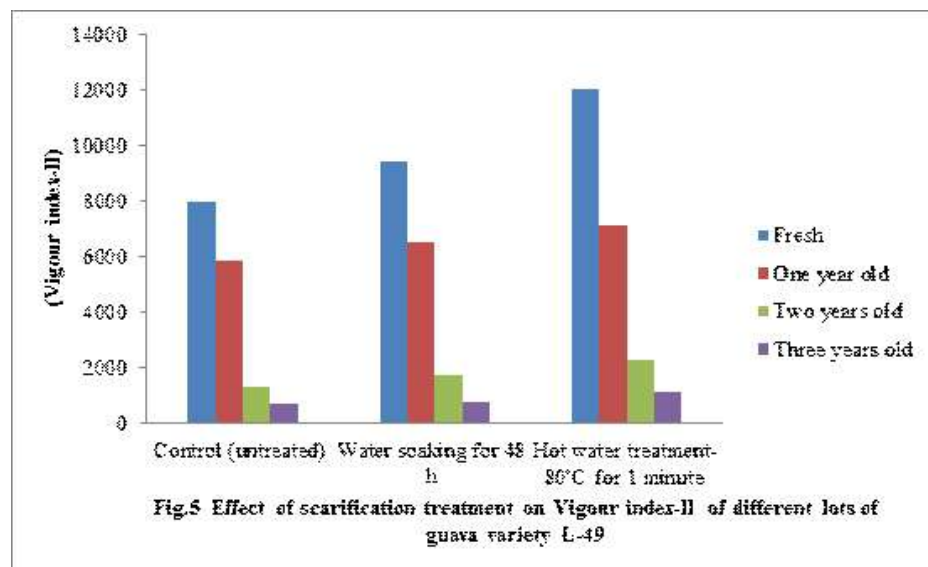
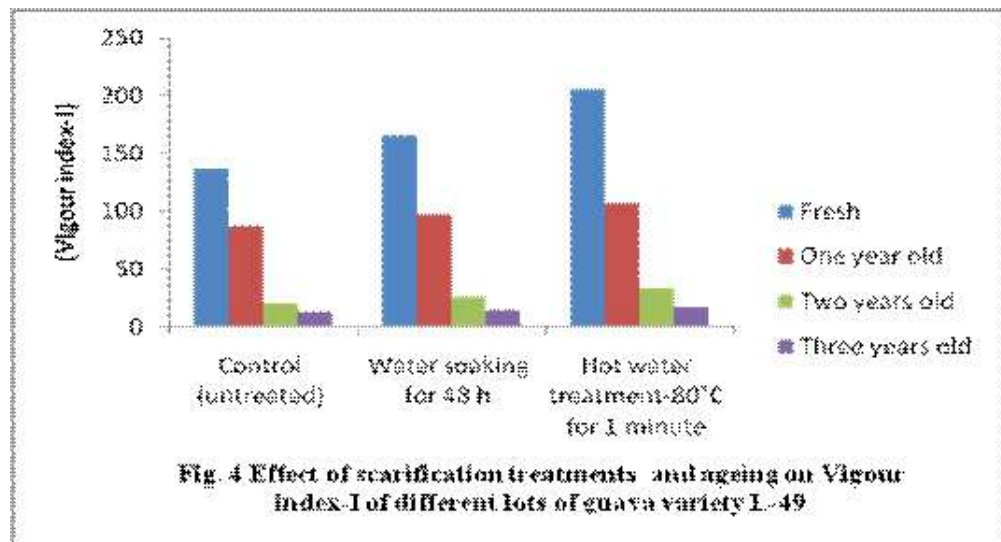
Results and Discussion

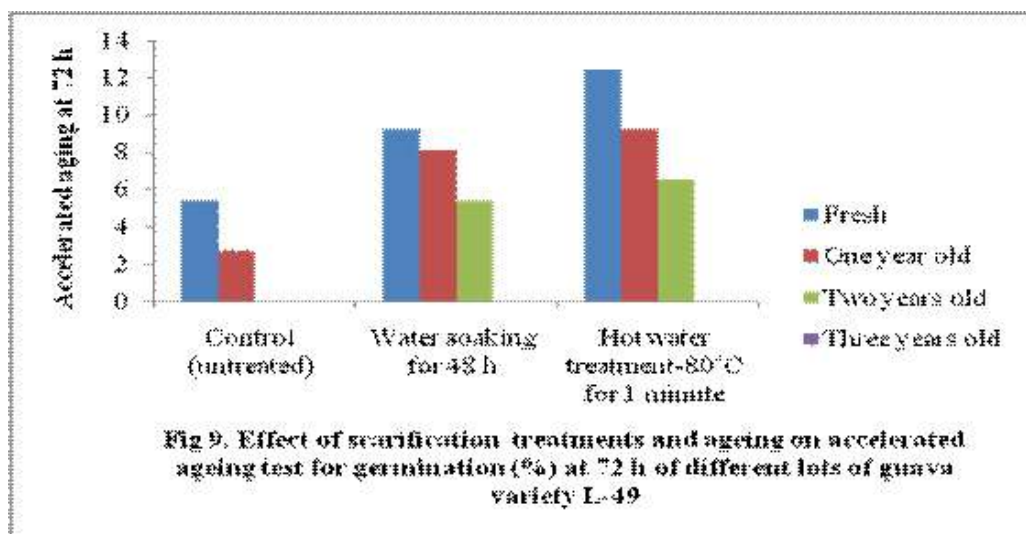
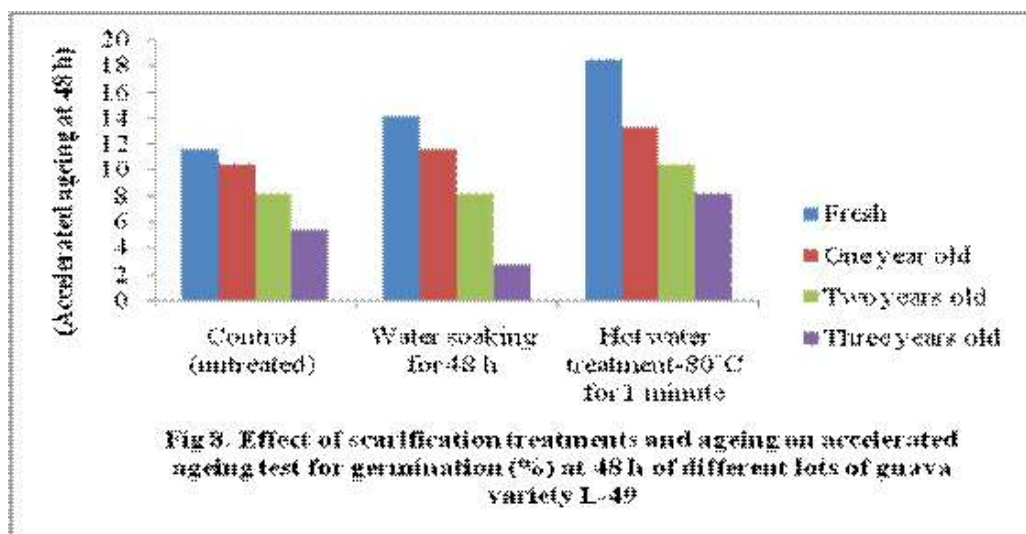
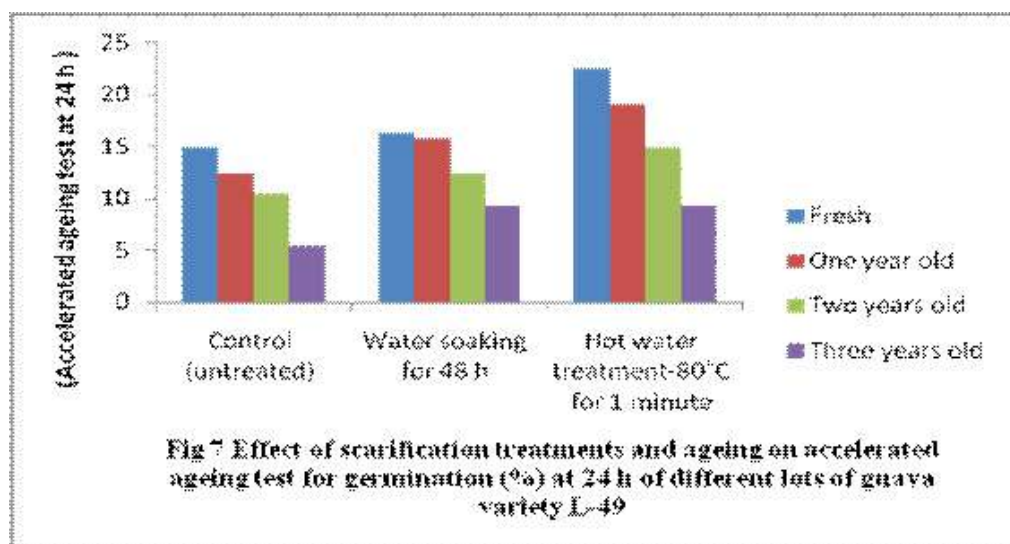
Germination (%) : The results revealed that maximum germination (36.67%) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum mean germination (25.03%) among all treatments followed by water soaking for 48 h. Water soaking of guava seed for 48 h and control are at par with each other in terms of seed germination. and minimum germination was observed in control (15.75%). Fresh seed lot of guava resulted into significantly higher germination (31.89) followed by one year, two year and three year age of seed lot. Minimum germination (14.52%) was observed in three year old seed lot. Concentrated sulphuric acid resulted into no germination (data not shown). Germination was more in hot water because of by rupturing in seed wall there by allowing imbibitions, O₂ diffusion and germination to occur (Egley, 1989; Maslin and Mc Dohald 2004 and Sedbrook,



2006). Lesser germination was observed in control because of hard seed coat imbibitions of water does not takes place so enzymatic reactions are do not occur therefore seed takes more time to germinate and germination percentage also less

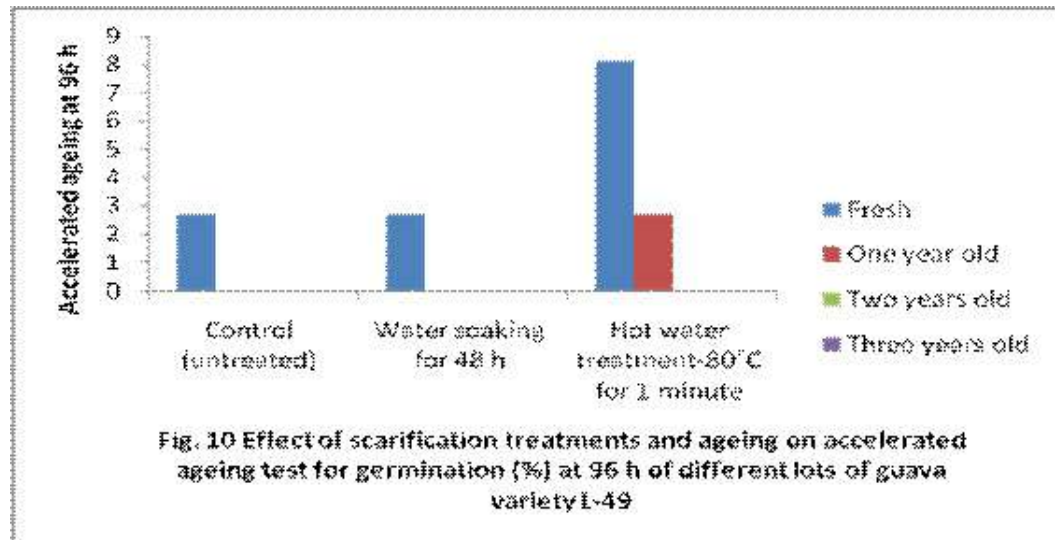
Seedling length (cm) : Seedling length varied from 2.05 to 5.61cm and maximum seedling length (5.61 cm) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum mean seedling length (4.01) cm among all treatments





followed by water soaking for 48 h. Hot water treatment. Water soaking of guava seed for 48 h and control were found at par with each other in terms of seedling length

and minimum seedling length was observed in control (3.50cm). Fresh seed lot of guava resulted into significantly higher seedling length (5.28cm) followed by



one year, two year and three year age of seed lot. Minimum length (2.25cm) was observed in three year old seed lot.

Maximum length occurred because in hot water speed of germination is more and metabolic activities also occur rapidly so resulted into higher shoot and root length and in control because of hard seed coat imbibitions doesn't takes place so metabolic reactions also not occur so resulted less seedling length .The results are in accordance with the findings of David and Midcap (2007) in woody ornamentals.

Seedling dry weight (mg) : Maximum dry weight (328.41 mg) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum mean seedling dry weight (255.87mg) among all treatments followed by water soaking for 48 h. Hot water treatment and water soaking treatment differed significantly with each other. Water soaking of guava seed for 48 h and control also differed significantly with each other in terms of seedling dry weight and minimum seedling dry weight was observed in control (216.66mg). Fresh seed lot of guava resulted into significantly higher seedling dry weight (229.22 mg) followed by one year, two year and three year age of seed lot. Minimum seedling dry weight (116.47mg) was observed in three year old seed lot in control. The reason behind this may be the corresponding seedling height with corresponding treatments.

Seedling vigour index-I : Maximum seedling vigour index-I (205.75) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum mean seedling vigour index-I (90.76) among all treatments followed by water soaking for 48 h (75.79). Seedling igour index-I of hot water treatment and water soaking treatment for 48 h and

control of guava seed differed significantly with each other in terms of seedling dry weight and minimum vigour index was observed in control (64.01). Fresh seed lot of guava resulted into significantly higher vigour index-I (169.3) followed by one year, two year and three year age of seed lot. Minimum vigour (14.90) was observed in three year old seed lot. This may be because of their corresponding germination and seedling length.

Seedling vigour index-II : Maximum seedling vigour index-II (12050.04) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum mean seedling vigour index-II (5648.87) among all treatments followed by water soaking for 48 h (4611.73). Seedling vigour index-II of hot water treatment and water soaking treatment for 48 h and control of guava seed differed significantly with each other in terms of seedling vigour index-II and minimum seedling vigour index-II was observed in control (3958.21). Fresh seed lot of guava resulted into significantly higher vigour index-II (9815) followed by one year, two year and three year age. Minimum vigour (875.30) was observed in three year old seed lot. This may be because of their corresponding germination and seedling dry weight.

Speed of germination : Maximum speed of germination (1.857) was observed in hot water treatment at 80°C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum mean speed of germination (1.414) among all treatments followed by water soaking for 48 h (1.308). Hot water treatment and water soaking of guava seed for 48 h and control are differ significantly with each other in terms of speed of germination and minimum speed of germination was observed in control (1.217). Fresh seed lot of guava resulted into significantly higher speed of germination (1.797) followed by one year, two year and three year age of seed lot. Minimum speed of germination (0.856) was observed in three year old seed lot. This is

due to seed has maximum vigour and viability at the time of physiological maturity, thereafter it start decreasing with the passage of time.

Accelerated ageing test at 24 hours : Maximum germination (22.49%) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum mean germination (16.34%) among all treatments followed by water soaking for 48 h (13.42%). Hot water treatment and water soaking treatment differed significantly with each other. Water soaking of guava seed for 48 h and control are at par with each other in terms of seed germination after Accelerated ageing (24 h) and minimum germination was observed in control (12.25%). Fresh seed lot of guava resulted into significantly higher germination after accelerated ageing (24 h) (17.92%) followed by one year, two year, and three year age. Minimum germination (7.98%) was observed in three year old seed lot.

Accelerated aging test at 48 hours : Maximum germination (18.37%) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum germination (12.55%) among all treatments followed by water soaking for 48 h (9.10%). Hot water treatment and water soaking of guava seed for 48 h and control differed significantly with each other in terms of seed germination after Accelerated ageing (48 h) and minimum germination was observed in control (8.87%). Fresh seed lot of guava resulted into significantly higher germination after Accelerated ageing for 48 h (14.65%) followed by one year, two year and three year age of seed lot . Minimum germination (5.42%) was observed in three year old seed lot.

Accelerated ageing test at 72 hours : Maximum germination (12.41%) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum mean germination (7.05%) among all treatments followed by water soaking for 48 h (5.70%). Hot water treatment and water soaking of guava seed for 48 h and control differed significantly with each other in terms of seed germination after Accelerated ageing (72 h) and minimum germination was observed in control (2.03%). Fresh seed lot of guava resulted into significantly higher germination (9.03%) after Accelerated ageing (72 h) followed by one year, two year and three year age of seed lot. Germination was not observed in three year old seed lot.

Accelerated ageing test at 96 hours : Maximum germination (8.13%) was observed in hot water treatment at 80° C for 1 minute in fresh seed lot. Hot water treatment resulted into maximum germination (2.7%) among all treatments followed by water soaking for 48 h and control (0.68%). Hot water treatment and water soaking of guava

seed for 48 h and control differed significantly with each other in terms of seed germination after Accelerated ageing (96 h) and minimum germination was observed in control (0.67%). Fresh seed lot of guava resulted into significantly higher germination (4.5%) after Accelerated ageing (72 h) followed by one year, two year and three year age of seed lot. Minimum germination (0.00%) was observed in two year and three year old seed lot.

The possible reason of this reduction might be the lowering of biochemical activities in seeds. Aging have damaging effect on enzymes that are necessary to convert reserve food in the embryo to usable form and ultimately production of normal seedling. Alternatively, the reduction in germination might be due to the degradation of mitochondrial membrane leading to reduction in energy supply necessary for germination (Gidrol *et al.*, 1998). Results are in accordance with the findings of Hussein *et al.* (2012) in maize, Kapoor *et al.* (2011) in rice and Iqbal *et al.* (2002) in cotton.

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Reaction of Tomato Varieties against Early Blight (*Alternaria solani*) of Tomato under Field Conditions

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Abstract

Early blight of tomato caused by *Alternaria solani* is a soil-inhabiting and airborne pathogen. *Alternaria* leaf blight is a serious problem in tomato-growing areas, particularly in temperate subtropical, humid tropical regions of the world. The present investigation was carried out at an Experimental farm college of agriculture, (RVSKVV) Gwalior with Thirteen varieties of tomato. The experiment was conducted consecutively during the *Rabi* seasons of 2020 in replicated trails. Only one variety Cherry tomato was found highly resistance while Chenaya and F1 gold current cherry tomato were found resistant.

Key words : *Alternaria solani*, tomato, hybrids.

Introduction

Tomato scientifically known as *Solanum lycopersicum* L., it is originated in Peru of South America and its area and production spread throughout the world. Tomato is grown throughout the world mainly in China, India, U.S.A., Italy, Turkey, Mexico, Russian Federation, Japan etc. China leads in production and productivity of tomato followed by India, all India expected production in 2019-20 is estimated to be 186.08 lakh tonnes (Anonymous, 2020). Tomato cultivation is affected by several diseases caused by fungi, bacteria, viruses, nematodes and other substances. Among these diseases, *Alternaria* blight is the most important foliar fungal disease of tomato, also known as early blight or target spot disease and it is caused by *Alternaria solani* (Ellis and Martin). It can severely damage incurring a loss of 50 to 90 per cent on tomato susceptible hybrids. The infection occurs on all the plant parts, leaves, stems, petiole, calyx and fruits (Abada *et al.*, 2008). The first symptom of a disease is the appearance of minute darkish brown spots on the older leaves of a plant. As the lesions bigger, they develop concentric rings giving them a bull's-eye appearance or target board appearance. Primary methods of controlling early blight include preventing long periods of wetness on the leaf surface, cultural scouting, sanitation, and development of the host plant resistance with the application of fungicides (Namanda *et al.*, 2004; Kirk *et al.*, 2005 and Kumar and Srivastava, 2013). Cultivation of resistant varieties is the ultimate control of this disease. There is a growing interest, in searching for natural plant products (botanical pesticides) and use of resistant varieties that can be used as important sources for the control of plant diseases (Kagale *et al.*, 2004).

Material and Method

Screening of tomato hybrids : Thirteen (Table-2) tomato varieties were evaluated to find out the resistance reaction against *Alternaria solani* under artificial inoculated conditions laid out in randomized block design with replicated two times in a year during 2020-21. From each hybrid, five plants were inoculated and tagged with a price tag from each plant of each replication were investigated. The observations on per cent disease intensity were recorded after 50 days of transplanting. Per cent disease intensity was calculated using the disease rating scale (Table-1) and formula suggested by Mc-Kinney (1923).

$$PDI = \frac{\text{Sum of all numerical ratings}}{\frac{\text{Total number of observations}}{\text{highest grade in the scale}}} \times 100$$

Results and Discussion

Screening of different tomato hybrids against *Alternaria solani* : Thirteen different hybrids (Table-3 and 4) of tomatoes grown under natural conditions were screened against early blight during *rabi* 2020 at the College of Agriculture, Gwalior research field. The disease scoring was done and recorded from each hybrid by using a scale of 0-5 at 50 days after transplanting. At 50 days after transplanting, out of thirteen hybrids, none of the hybrids were found free from disease. Among these hybrids, only cherry tomato (4.21 %) was found highly resistant. Two hybrids *i.e.* chenaya (8.40 %), F1 gold current cherry tomato (11.21 %) were resistant and five hybrids *i.e.* abhiraj (14.37 %), tomato oblate yellow (16.30 %), Deep-s-22 (18.15 %), satyam (20.03 %), local hybrid-4 (21.30%) were moderately resistant. Three hybrids were moderately susceptible *i.e.* tomato S yellow pear

Table-1 : Disease rating scale of tomato hybrids against *Alternaria solani*.

Rating	Reaction description	Reaction
0	Free from infection	Highly resistant
1	One or two necrotic spot on few lower leaves of plant, covering nearly 1-10 surface area of Plant	Resistant
2	A few isolated spot on leaves covering 11-25% surface area of plant	Moderately Resistant
3	Many spot coalesced on the leaves covering 26-50% of the surface area of the plants	Moderately Susceptible
4	Concentric rings on the stem petiole, fruit covering 51-75% leaf area of plant	Susceptible
5	Whole plant blighted leaf and fruits starting to fall covering more than 75% leaf area of the Plant	Highly susceptible

Table-2 : List of tomato varieties/hybrids.

S. No.	Name of variety
1.	Selection-22
2.	Abhiraj
3.	Tomato oblate yellow
4.	Tomato S yellow pear
5.	Local hybrid
6.	Chenaya
7.	Cherry tomato
8.	F ₁ hybrid tomato sachriya
9.	Satyam
10.	Deep – s – 22
11.	F ₁ gold current cherry tomato
12.	Local hybrid 4
13.	Local hybrid tomato

Table-3 : Reaction of tomato hybrids against early blight of tomato.

Degree of Resistance	No. of hybrids	Name of entries
Highly resistant (HR)	01	Cherry tomato
Resistant (R)	02	Chenaya, F ₁ goldcurrent, cherry tomato
Moderately resistant (MR)	05	Abhiraj, tomato oblate yellow, Deep-s-22, satyam, local hybrid 4
Moderately susceptible (MS)	03	Tomato S yellow pear, local hybrid, local hybrid
Susceptible (S)	02	F ₁ hybrid tomato sachriya, selection-22
Highly susceptible (HS)	00	Nil

Table-4 : Screening of tomato hybrids against *Alternaria* blight of tomato under natural conditions.

S. No.	Name of variety	Per cent disease index	Host Reaction
1.	Selection-22	58.65 (49.98)	S
2.	Abhiraj	14.37 (22.28)	MR
3.	Tomato oblate yellow	16.30 (23.81)	MR
4.	Tomato S yellow pear	28.67 (32.37)	MS
5.	Local hybrid	49.40 (44.66)	MS
6.	Chenaya	8.40 (16.85)	R
7.	Cherry tomato	4.21 (11.84)	HR
8.	F ₁ hybrid tomato Sachriya	55.53 (48.17)	S
9.	Satyam	20.03 (26.59)	MR
10.	Deep – s – 22	18.15 (25.22)	MR
11.	F ₁ gold current cherry Tomato	11.21 (19.56)	R
12.	Local hybrid 4	21.30 (27.49)	MR
13.	Local hybrid	43.66 (41.36)	MS
	S Em+	1.22	
	C.D.(p=0.05)	3.68	
	CV (%)	14.94	

*Mean of three replications, Value parenthesis are angular transformed
 S-Susceptible; MR-moderately resistance; MS-moderately susceptible; R-resistance.

(28.67%), local hybrid (43.66%), local hybrid (49.40%) while two hybrids *i.e.* F₁ hybrid tomato sachriya (55.53%) and selection-22 (58.65%) shown susceptible reaction. Different tomato hybrids/varieties were screened field under natural condition of against *Alternaria solani* causing early blight of tomato. The disease severity was calculated based on 0-5 scale. Among the thirteen hybrids screened, none of the hybrids found free from disease. Only one hybrid cherry tomato (4.21%) was found highly resistant, two were resistant [chenaya (8.40%), F₁ gold current cherry tomato (11.21%)] and five hybrids *i.e.* abhiraj (14.37%), tomato oblate yellow (16.30%), Deep-s-22 (18.15%), satyam (20.03%), local hybrid-4 (21.30 %) were moderately resistant. Similar results have also been obtained by Lohith *et al.* (2011); Alsafadi *et al.* (2012); Mahantesha *et al.* (2012); Kumar and Srivastava (2013); Abdussamee *et al.* (2014); Meitei *et al.* (2014); Sahu *et al.* (2014); Yadav *et al.* (2014); Chohan *et al.* (2015); Kumar *et al.* (2015) and Rani *et al.* (2015). Kumar and Barnwal (2017) noted reactions that varied with the cultivars.

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Effect of Plant Growth Retardants and Plant Growth Promoting Rhizobacteria on Seed Yield of Chickpea (*Cicer arietinum* L.)

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Abstract

The present investigation was carried out to study the effect of plant growth retardants and plant growth promoting rhizobacteria on seed yield of Chickpea (*Cicer arietinum* L.) at Research Farm, Department of Seed Science and Technology, Chauras Campus, Hemvati Nandan Bahuguna Garhwal University, Srinagar (Garhwal), Uttarakhand, India during rabi season, 2018-19. The experiment was laid out in Randomized Block Design with three replications. The treatments consisted of FP-37, Cycocel (1000 ppm), TIBA (50 ppm), FP-37 + Cycocel (1000 ppm), FP-37 + TIBA (50 ppm) and FP-37 + Cycocel (1000 ppm) + TIBA (50 ppm). During the investigation, the use of Plant growth-promoting rhizobacteria and plant growth retardants increase yield in chickpea and addition of plant growth retardants to PGPR inoculated plants helps the plant to give a better yield and promote growth in chickpea. However, the maximum growth parameters were obtained by addition of plant growth retardants that is TIBA (50 ppm) and Cycocel (1000 ppm) on plants inoculated with strain FP-37 of *Pseudomonas fluorescens*.

Key words : Chickpea, rhizobacteria, pseudomonas, cycocel and TIBA.

Introduction

Chickpea (*Cicer arietinum* L.), which is also known as Gram, Bengal Gram, Channa is a member of family Fabaceae, subfamily Faboideae. It is a self-pollinated leguminous crop, containing diploid chromosome number (2n=16). Chickpea has tap root system, the roots usually strong and go deep into the soil. According to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) chickpea seeds contain on an average 23% protein, 64% total carbohydrates (47% starch, 6% soluble sugar, 5% fat, 6% crude fibre) and 3% ash. It is reported that high mineral content of phosphorus 340 mg per 100g, calcium 190 mg per 100g, magnesium 140 mg per 100g, iron 7 mg per 100g and zinc 3 mg per 100g also found in chickpea seeds. (Zohary *et al.* 2000).

India is the largest producer of chickpea in the world. About 98 per cent of gram production of the country during 2017-18 under report has been realized by 10 states of MP, Maharashtra, Rajasthan, Karnataka, AP, UP, Gujarat, CG, Jharkhand, and Telangana (Annual Report 2017-18, Directorate of Pulses Development).

Plant growth-promoting rhizobacteria are the rhizosphere bacteria, which can ameliorate plant growth. These microorganisms are able to enhance the recycling of plant nutrients and decrease the use of chemical fertilization (Cakmakci *et al.*, 2007). In few decades a large number of bacteria from the rhizosphere soil have been isolated and identified among which the common

species of *Pseudomonas*, *Azospirillum*, *Azotobacter*, *Klebsiella*, *Enterobacter*, *Alcaligenes*, *Arthobacter*, *Burkholderia*, *Bacillus* and *Serratia* have reported (Kloepper *et al.*, 1989; Okon and Labandera-Gonzalez, 1994; Glick, 1995).

Plant associated *Pseudomonas* live as saprophytes and parasites on plant surfaces and inside plant tissues. Many plant-associated *Pseudomonas* encourage plant growth by suppressing pathogenic micro-organisms, producing growth-stimulating plant hormones and promoting increased plant disease resistance (Preston, 2004). They assist to improve nitrogen fixation in legumes, help to promote free-living nitrogen-fixing bacteria, enhance the supply of other nutrients like phosphorus, sulphur, iron and copper, generate plant hormones, improve other beneficial bacteria or fungi, prevent fungal and bacterial diseases and help manage insect pests (Gaurav and Pallavi, 2018). *Pseudomonas fluorescens* is an aerobic, gram-negative, ubiquitous organism present in agricultural soils and well suited to grow in the rhizosphere. It generates a broad range of bioactive metabolites in the plant rhizosphere, i.e. antibiotics, siderophores, volatiles and growth-promoting substances; competes aggressively with other microorganisms; and adapts to environmental stresses (David *et al.*, 2018).

Application of growth regulators is also a recent technique in this direction. In a wide sense, plant hormones are organic compounds that play a significant

role in plant growth and crop yields to avoid pod and flower fall over a longer period of time. The Plant growth regulators that have been studied for improved yield or quality of field crops are dinoseb, 2,3,5-triiodobenzoic acid (TIBA), ethephon, chlormequat, and mepiquat. TIBA on soybeans has also produced inconsistent results across many environments (Stutte and Davis, 1983). Chlormequat is another anti-lodging agent for small grains; it is used in Europe as a crop protectant (Jung and Rademacher, 1983).

Keeping these aspects in view, and considering their importance in increasing grain yield and quality in chickpea, the present investigation was undertaken to find out the suitability of PGPR and Plant Growth Retardants for increasing the productivity potential in chickpea with the objective to study the effect of Plant Growth Promoting Rhizobacteria and Plant Growth Retardants on seed yield of chickpea.

Materials and Methods

The field experiment was conducted during rabi season, 2018-19 at the Research Farm, Department of Seed Science and Technology, Chauras Campus, Hemwati Nandan Bahuguna Garhwal University, Srinagar (Garhwal), Uttarakhand, India to study the "Effect of Plant Growth Retardants and Plant Growth Promoting Rhizobacteria on seed yield of Chickpea (*Cicer arietinum* L.)". The climate of Research Farm is almost humid and sub-tropical which results into dry summers and heavy winters. The minimum temperature in winters falls to 2°C

and reaches upto 45°C in summers. The data of temperature, relative humidity and rainfall during the experiment was obtained from the meteorological observatory of Horticulture Research Centre, Department of Horticulture, Chauras Campus, Srinagar Uttarakhand has been presented in fig.-1.

The experiment comprised of total seven treatments viz. control, FP-37, Cycocel (1000 ppm), TIBA (50 ppm), FP-37 + Cycocel (1000 ppm), FP-37 + TIBA (50 ppm) and FP-37 + Cycocel (1000 ppm) + TIBA (50 ppm). Chickpea variety GNG-1958 is used for this experiment. The seeds are obtained from National Seeds Corporation Limited, Central State Farm, Jaitsar, Rajasthan. It is suitable for normal sowing in North Western Plain Zone (Punjab, Haryana, Delhi, North Rajasthan, Uttar Pradesh West) of India under irrigated conditions. It matures in 145 days with average yield of 2680 kg ha⁻¹. It has brown seed colour with 25.4g average 100 seed weight. The PGPR *Pseudomonas fluorescens* strain FP-37 is used for seed treatment in this experiment. The strain is precured from Microbiology laboratory, Department of Basic Science, College of Forestry (VCSG UHF), Ranichauri, Tehri Garhwal, Uttarakhand.

The experimental field was thoroughly ploughed and cross ploughed with the help of tractor. The FYM is applied in experimental field and harrowing is done for uniformly mixing the FYM into soil. The beds, paths and irrigation channels are prepared as per layout and Randomized Block Design. The sowing was done on 18 November, 2018 in three replications. Powder formulation

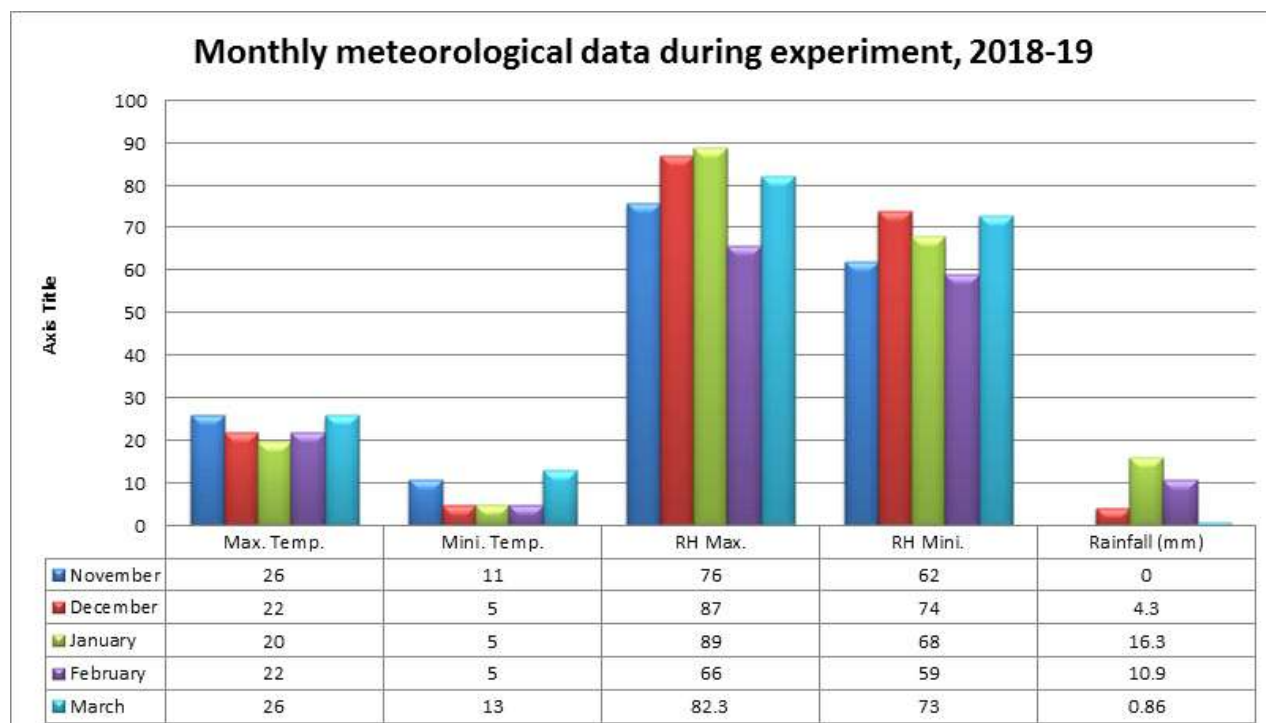
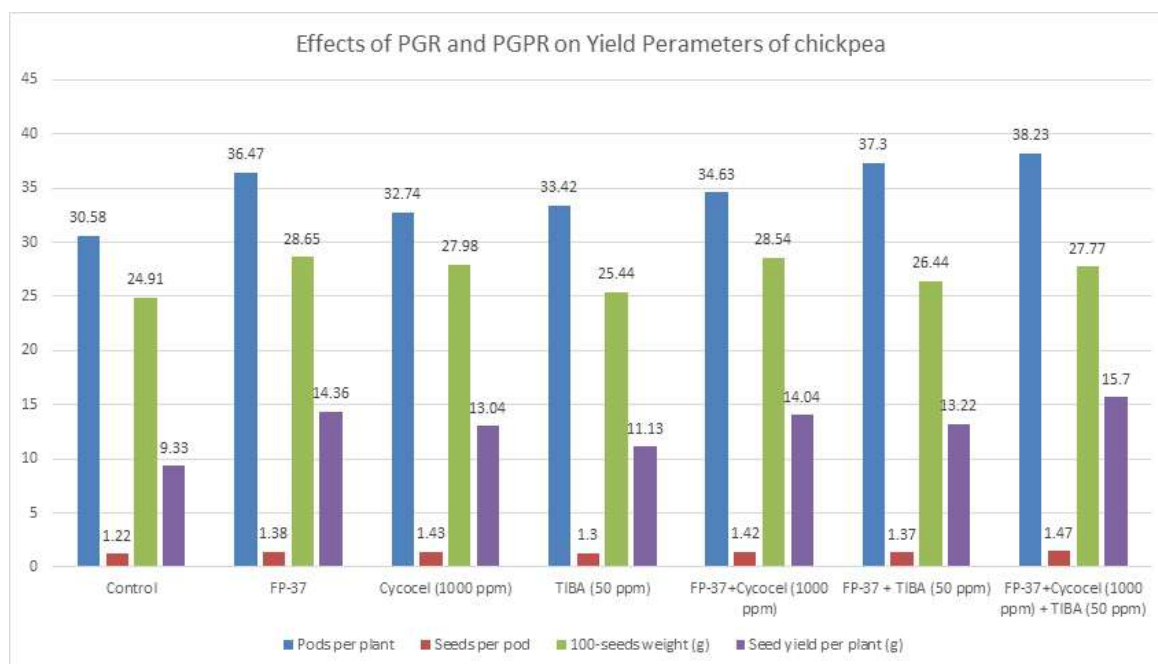


Table-1 : Effect of PGR and PGPR on yield parameters of chickpea.

Sr. No.	Treatments	Pods per plant	Seeds per pod	100-seeds weight (g)	Seed yield per plant (g)	Yield per plot (g)	Yield per ha (q)
1.	Control	30.58	1.22	24.91	9.33	432.33	30.02
2.	FP-37	36.47	1.38	28.65	14.36	622.33	43.22
3.	Cycocel (1000 ppm)	32.74	1.43	27.98	13.04	576.33	40.02
4.	TIBA (50 ppm)	33.42	1.30	25.44	11.13	492.00	34.17
5.	FP-37 + Cycocel (1000 ppm)	34.63	1.42	28.54	14.04	614.67	42.69
6.	FP-37 + TIBA (50 ppm)	37.30	1.37	26.44	13.22	589.67	40.95
7.	FP-37 + Cycocel (1000 ppm) + TIBA (50 ppm)	38.23	1.47	27.77	15.70	656.00	45.56
	Mean	34.77	1.37	27.10	12.97	569.05	39.52
	S.Em	0.50	0.02	0.65	0.38	7.09	0.49
	C.D. (5%)	1.53	0.06	2.00	1.17	21.86	1.52



of strain FP-37 of *Pseudomonas fluorescens* was used in this experiment.

Application of Treatment

Plant Growth Promoting Rhizobacteria : Powder formulation of strain FP-37 was used in this experiment. Healthy seeds of chickpea were selected and moist with water with the help of sprayer. Then, formulation was added at the rate of 8g kg⁻¹ and mixed thoroughly so that formulation uniformly spread over the surface of the seeds. Then it is kept for air drying in shade and used for sowing on the same day after inoculation.

Plant Growth Retardants : Cycocel and TIBA both were applied as foliar spray in the plots as per treatments. The solution was prepared by adding the dose of chemical into 3-4 drops of Acetone than into water as growth retardants do not dissolve in water directly. Cycocel was sprayed @ 1000 ppm on 35 DAS. Similarly, TIBA was also sprayed @

50 ppm on 35 DAS in respective plots. In order to evaluate the effect of treatments on growth parameters of experiment of chickpea, observations were recorded statistically analyzed for level of significance.

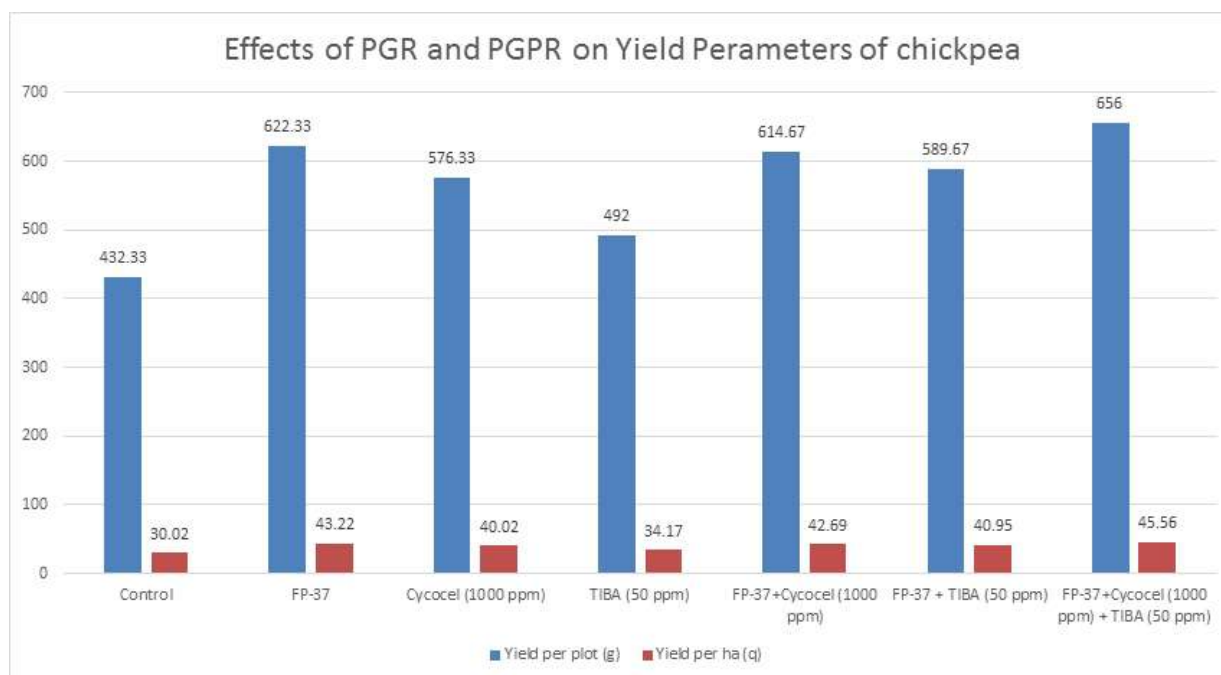
Observation Recorded

Number of pods per plant : The numbers of pods were counted from five randomly selected plants from each treatment and the mean was worked out.

Number of seeds per pod : The total numbers of grains were counted from one hundred pods separated from five plants in each treatment i.e. twenty pods per plant and averages were worked out from it.

Seed yield per plant : The pods obtained from five plants were threshed and cleaned to obtain grains. The grain yield per plant is measured in grams.

Seed yield per plot : All the plants from net plot area of



each treatment were uprooted, dried seeds were threshed and weight was recorded separately and expressed in grams.

Seed yield per hectare : The grain yield obtained from the net plot area was cleaned, dried in the shade and weighed in kilogram. The grain weight from five plants used for taking observations was also added for calculating the grain yield per hectare. On the basis of grain yield in net plot, the grain yield per hectare was computed and expressed in kilograms per hectare.

100-Seeds weight : The weight of hundred seeds selected at random from each replication in each treatment was measured and expressed in gram.

Statistical analysis : To test the significance of variation in data obtained from yield parameters, the technique of analysis of variance was adopted as suggested by Fisher (1950) for randomized block design.

Results and Discussion

The present study revealed various valuable findings in relation to seed yield of chickpea. The application of PGR and PGPR significantly affected the seed yield parameters i.e. number of pods per plant, number of seeds per pod, 100-seeds weight, seed yield per plant and seed yield per hectare in chickpea plants as given in Table-1.

No. of pods per plant : Number of pods per plant at maturity varied significantly due to the various treatments. Significantly maximum number of pods was recorded in T_7 (38.23) followed by T_6 (37.30) and T_2 (36.47). The least number of pods per plant (30.58) was obtained in control.

No. of seeds per pod : The number of seeds per pod was found significantly maximum in the treatment T_7 (1.47) followed by treatments T_3 (1.42) and T_5 (1.43). The minimum number of seeds per pod (1.22) was recorded in control.

Seed yield per plant (g) : The data on seed yield per plant is presented in Table-1. It indicated that various treatments influenced seed yield per plant significantly. Among the treatments, T_7 exhibited significantly higher seed yield per plant (15.70 g) followed by T_2 (14.36 g) and T_5 (14.04 g). Significantly lower seed yield per plant (9.33 g) was recorded in control.

Yield per plot (g) : The data with respect to seed yield per plot indicated that treatment T_7 recorded significantly maximum seed yield per plot (656 g) followed by T_2 (622.30 g), T_5 (614.67 g). The minimum seed yield (432.33 g) was recorded under control which was at par with treatment T_4 (492 g).

Yield per hectare : Amongst the treatment, significantly highest value of seed yield (45.56 q ha⁻¹) was recorded under T_7 as compared to rest of the treatments. Significantly lower seed yield per ha was recorded in control (30.02 q ha⁻¹) which was significantly lower compared to rest of the treatments.

The inoculation of FP-37 and exogenously application of cycocel and TIBA in combination (FP-37 + Cycocel + TIBA) resulted as a greater number of pods per plant, a greater number of seeds per pod and greater yield when compared to control. The per hectare yield was increased by 51.8% in T_7 (FP-37 + Cycocel + TIBA) than

control. While, FP-37 alone in treatment resulted as 43.97% greater yield than control. The effect of exogenously applied plant growth regulators in combination with PGPR was studied in chickpea by Khan et al. (2018). They concluded that addition of Salicylic Acid along with PGPR may render the plant more productive.

100-seeds weight (g) : It is evident from the Table-1. that there were significant differences in 100 seed weight due to various treatments. Among the treatments, T₂ recorded significantly higher 100-seed weight (28.65 g) followed by T₅ (28.64 g) and T₃ (27.98 g). Significantly minimum 100-seed weight (24.91 g) was noticed in control.

The maximum 100-seeds weight was observed in application of FP-37 which was 15.01% greater when compared to control. The increase in seed weight might be due to seed treatment with PGPRs and their PGP activities which enhanced nutrient availability to the host plant by PGPRs is important mechanism to enhance the crop yield. similar results also observed by Iqbal and Hasnain (2013) in wheat. The application of cycocel also increased 100-seeds weight when compared to control. Similar results were obtained by Nisha (2011) in chickpea.

Conclusions

It may be concluded from the present investigation that the use of Plant growth-promoting rhizobacteria and plant growth retardants increase yield in chickpea and addition of plant growth retardants to PGPR inoculated plants helps the plant to give a better yield in chickpea. However, the maximum yield was obtained by addition of plant growth retardants that is TIBA (50 ppm) and Cycocel (1000 ppm) on plants inoculated with strain FP-37 of *Pseudomonas fluorescens*. The above findings are on the basis of one season experiment at Garhwal Region of Himalaya. In order to confirm the present results more experimentation is needed.

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Economics of Cotton Cultivation and Constraints Faced by Farmers

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Abstract

The cotton is main commercial crop in the world as well as in the India. It is nearly grown in the 80 countries of the world on the large scale of area including India. Therefore, to full fill these large area requirements presently more than 400 private companies produce cotton seed and there is high competition between them to stay in the market permanently. The study was carried out in Hanumangarh district of Rajasthan with Simple random sampling method and simple tabular method was used for socio-economic profile of farmers. The data of 100 randomly sampled farmers was analyzed through various appropriate statistical tools for cost of cultivation, multiple linear regression analysis and garret ranking technique. From the study cost of cultivation of KRIBHCO RAJA (PCH – 877) variety of cotton is calculated in Hanumangarh had Rs. 113844.15, gross income was Rs. 183452 and net return was Rs. 69607.85. Production cost of KRIBHCO RAJA (PCH – 877) variety of cotton seed found Rs. 15912.50 per qtl. and processing cost Rs. 1475 per qtl. Return and quality of seeds found as the most determining factors for the buying behaviour of the sample farmers in the study area. The constraints faced by farmers while purchasing KRIBHCO RAJA (PCH – 877) variety of cotton seeds in Hanumangarh area like insect pest and disease attack and effect of weather change on yield secured first and second place. The cost of production and cultivation is feasible and the variety of KRIBHCO RAJA (PCH-877) is profitable to farmers in the Hanumangarh district.

Key words : KRIBHCO RAJA (PCH – 877), cost of production of seed, cost of cultivation, cotton cultivation, cotton seed production.

Introduction

In India, cotton is being grown for 5000 years. India is the pioneer country for the commercial cultivation of hybrid cotton. Over the years, country has achieved significant quantitative increase in cotton production. Till 1970s, country used to import massive quantities of cotton in the range of 8.00 to 9.00 lakh bales per annum. For the season 2019/2020 the Top 10 cotton producers are India, United States, China, Brazil, Pakistan, Turkey, Uzbekistan, Mexico, Australia and Mali. Africa as continent delivers a total of 1.7 Million tons of cotton to its customers (Anon., 2020b). Bt-cotton production is highly profitable in both study areas of India and Nigeria (Nayak and Emula, 2017) . It is found that amongst the different items of costs, human labor and rental value of land was the major item of cost (Nannaware, 2011). This study mainly focuses on the satisfaction of the cultivators of the various varieties of KRIBHCO. KRIBHCO has been successfully marketing hybrid seeds through its own marketing network in KRIBHCO's own brand. During the year 2018-19, KRIBHCO marketed 75,026 (Packets) Bt. cotton, 250.90 quintals of paddy hybrid, 2249.70 quintals of paddy Research, 4476.93 quintals of maize hybrid and 52.20 quintals of hybrid bajra Seeds. To assess cost of cultivation of KRIBHCO RAJA (PCH – 877) variety of

cotton seed in Hanumangarh district of Rajasthan, a study was done. This study based on primary data, which has collected from farmers, so that farmers gave feedback to the company for the improvement of the company's product. This is beneficial for both *i.e.* for farmers and company. Thus, the results are more useful to company officials, farmers and academicians.

Research Methodology

The present study was conducted during the month September and October 2020 in Hanumangarh district of Rajasthan state. The methodology followed in conducting this research is furnished under the following headings.

Location and study area : The district is located in the extreme North of Rajasthan. It has an area of 12,645 km², a population of 1,774,692 (2011 census) and a population density of 184 persons/km². It is bounded on the North by Punjab state, on the East by Haryana state, on the South by Churu district of Rajasthan, and on the West by Ganganagar district of Rajasthan.

Sampling technique : For this study, Hanumangarh district and Hanumangarh tehsil was selected purposively, because the processing unit is situated in the Hanumangarh tehsil and also sale of the company is highest in the selected area and also the farmers of the KRIBHCO company were available in the tehsil. Then

from each tehsil five villages and 20 farmers from each village were selected randomly.

Table : Details of the sample distribution in Hanumangarh tehsil of Hanumangarh district.

Sr. No.	Villages	Cotton Growers
1.	Kohla	20
2.	Gurusar	20
3.	Daulatpura	20
4.	Manak Tibbi	20
5.	Kishanpura	20

Collection of Data

Primary Data : The primary data was collected with the help of the well-prepared questionnaires. The questionnaire contained various parts as follows :

Cost of cotton cultivation of KRIBHCO RAJA (PCH – 877) variety of cotton seed.

Production cost of KRIBHCO RAJA (PCH – 877) variety of cotton seed such as fixed cost, variable cost, total production cost, total processing cost and net return.

Factors affecting fertilizer purchase decision of farmers such as education status, area, return, quality of seed, yield, irrigation facility, income *etc.*

Constraints faced by the farmers.

Secondary data : The necessary secondary information was collected through the following sources :

Directly from the company

Product leaflets and brochures

Information about history of the company, profile, product *etc.* was collected from the company.

Statistical Analysis

Cost Concept : Cost concept was used for estimation of cost of cultivation of cotton seed by following cost concepts (Nayak and Emula, 2017).

The cost concepts and the items of costs included under each concept are given as follows :

Cost of Production : The cost of production of the KRIBHCO RAJA (PCH – 877) variety of cotton seed was calculated on the basis of various cost arises in the production process and lastly total cost was deducted from the total return. The following costs were used to estimate the cost of production of cotton seed.

Garrett's Ranking Technique : To identifying the purchasing constraint face by the hybrid cotton growers Garrett's ranking technique was used. (Kulkarni *et al.*, 2018).

Cost	Items included	Procedure for calculating cost
Cost A	= Cost of hired human labour	Actual wage paid (including kind payments evaluated at market prices)
	+ Cost of bullock labour (owned / hired)	As per the prevailing market rate
	+ Cost of seeds (owned / purchased)	As per the prevailing market rate
	+ Cost of manure (owned / purchased)	As per the prevailing market rate
	+ Cost of fertilizer	Actual paid
	+ Cost of pesticides and insecticides	Actual paid
	+ Cost of Irrigation (owned / purchased)	As per the prevailing market rate
	+ Charges for machineries (owned / hired)	As per the prevailing market rate
	+ Miscellaneous paid out cost if any	Actual paid
	+ Land revenue and other taxes	Actual paid
	+ Depreciation (on farm building, bullock-cart and Kutcha building @ 5% Pucca building @ 2% Bullock-cart @10% tools)	Small tools/implements @20% Proportionate to the area and duration of crop
	+ Rent paid for leased land (If on lease)	Actual rent paid
	+ Interest on working capital (working capital means total cost up to now)	To be calculated @ 12% per annum (for the duration of crop only)
Cost B	= Cost A	
	+ Rental value of owned land (In case of owned land only)	As per the prevailing market rent or @ 16% of gross income
	+ Interest on fixed capital	To be calculated @ 10% per annum. (for the duration of crop only)
Cost C ₁	= Cost B	
	+ Imputed value of family labour	As per the prevailing wage rate
Cost C ₂	= Cost C ₁	
	+ Management charges	To be calculated @ 10% of cost C ₁

Costs	
Fixed cost	Depreciation of machinery
Variable cost	Raw material
	Labour cost
	Grading loss
	Packing cost
	Storage cost
	Electricity charge
	Seed treatment
	Labelling cost
	Miscellaneous expenses
Total production cost	Fixed cost + Variable cost
Total processing cost	Total cost – Raw material cost
Net return	Total production cost

As per this method, respondents have been asked to assign the rank for all constraint and the outcome of such ranking has been converted into score value with the help of the following formula :

$$\text{Percentage position} = 100 (R_{ij} - 0.5)/N_j$$

Where,

R_{ij} = Rank given for the i^{th} variable by j^{th} respondents

N_j = Number of variables ranked by j^{th} respondents

The percent is converted into scores by referring to the table given by Garrett and Woodworth (1969). Then for each constraint the scores of the individual respondents were added together and divided by the total number of respondents for whom score were added. These mean scores for all the factors were arranged in descending order and the most influencing factors were identified the rank assigned.

Results and Discussion

Cost of cultivation prominently divided into two categories fix cost and variable cost. Rent of land consider the fix cost in the crop production, while the expenditures on the inputs of the crop production like land preparation, seed, fertilizer, pesticides, irrigation, labour expenditures and others intercultural expenditures. The variable cost play vital role in crop production and variation noted in expenditures, from the respondents due to variation in inputs used. The cost of cotton cultivation and percentage of input costs in total cost per hectare have been presented in the Table-1. It seems from table that the overall per hectare cost of cultivation (Cost C_2) of farmers was Rs. 113844.15. The share of Cost A in total cost of cultivation for farmers was 74.19 per cent. This shows that

Table-1 : Cost of cultivation of KRIBHCO RAJA (PCH – 877) variety of cotton seed in Hanumangarh district.

Sr. No.	Particulars	Value (Rs. /ha)	(%) to Cost C_2
1.	Labour cost		
	A. Cost of Hired Human Labour (Man days)	11572.47	10.16
	B. Cost of Bullock Labour (Rs.)	68.68	0.06
2.	Cost of Seeds (Kg.)	2800	2.46
3.	Cost of Manure and Fertilizer (Rs.)	18782.85	16.49
4.	Cost of Plant Protection Chemicals	13270.38	11.66
5.	Cost of Irrigation	6762.95	5.94
6.	Charges of machinery/tractor	4357.52	3.82
7.	Miscellaneous cost	22326.94	19.61
8.	Depreciation	530.10	0.46
10.	Interest on Working Capital @ 12%	3944.73	3.46
11.	Cost A	84416.62	74.15
12.	Rental Value of owned Land	17867.09	15.69
13.	Interest on Fixed Capital@10%	1210.98	1.06
14.	Cost B	103494.69	90.91
15.	Cost C1	103494.69	90.91
16.	Management Charges	10349.46	9.09
17.	Cost C2	113844.15	100.00

Table-2 : Gross income cultivation of KRIBHCO RAJA (PCH-877) variety of cotton seed in Hanumangarh district.

Particulars		
Yield	(a) Yield of main product (qtl.)	32.08
	(b) Yield of by product (qtl.)	20.00
Price	(a) Price of main product Rs. / qtl.	5650.00
	(b) Price of by product Rs. / qtl.	110
Gross Income (Rs.)		183452

more amounts of cash is required in cotton cultivation. The breakup of Cost C₂ revealed that among the various components of expenditure, the miscellaneous cost had occupied the first position with 19.61 per cent (22326.94) for farmers. Followed by hired human labour had 10.16 per cent (Rs. 22326.94) of farmers. Uddin *et al.* (2007) also found that most of variable costs were due to human labour and material inputs. Other important incurred costs are cost of manure and fertilizers *i.e.* 16.49 per cent (Rs. 18782.85), cost of pesticides 11.66 per cent (Rs.13270.38), cost of irrigation 5.46 per cent (Rs. 6762.95) of farmers. The share of seed in overall cost was very less is 2.46 per cent (Rs. 2800) because of the government regulation and fixed seed rate per hectare. Thus, it could be inferred that the human labour (hired), chemical fertilizers and manures, pesticides, miscellaneous cost and seed were the major cost components in the cotton cultivation of farmers.

The net return is difference of gross income and cost of cultivation. The net return presented in Table 3. Net returns were Rs. 99035.38, Rs. 79957.31, Rs. 79957.31, Rs. 69607.85 for Cost A, Cost B, Cost C₁ and CostC₂ respectively.

Table-3 : Net income cultivation of KRIBHCO RAJA (PCH – 877) variety of cotton seed in Hanumangarh district.

Costs	Net Return
Cost A	99035.38
Cost B	79957.31
Cost C ₁	79957.31
Cost C ₂	69607.85

Benefit cost ratio is ratio of gross income and total cost of cultivation. Benefit cost ratio is presented in Table 4. Benefit cost ratio were 2.17, 1.77, 1.77, and 1.61 for Cost A, Cost B, Cost C₁ and CostC₂. Benefit cost ratio shows the efficiency of farmers.

Table-4 : Benefit ratio cultivation of KRIBHCO RAJA (PCH – 877) variety of cotton seed in Hanumangarh district.

Costs	Benefit Cost Ratio
Cost A	2.17
Cost B	1.77
Cost C ₁	1.77
Cost C ₂	1.61

Factors affecting purchase of KRIBHCO RAJA (PCH – 877) variety of cotton seeds : Firstly the standard deviation for all variables were calculated and their values are given in the Table 5 their values revealed that standard deviation of irrigation is found zero which is extracted from the analysis also the variable area under hybrid cotton showed positive correlation with purchased seed (0.99) with t value (66.12) which is significant at 1 per cent level of significant that's why it is also excluded from the analysis and then again regression was run by using remains variable and data is present in Table-6.

Table-5 : Standard deviation of factors affecting the purchase of KRIBHCO RAJA (PCH – 877) variety of cotton seeds.

Factors	Standard deviation
Age (years)	9.515
Education (years)	5.137
Return (Rs.)	56825.49
Area under hybrid cotton	2.008
Quality of seed	0.587
Yield (Increase, Moderate, Decrease)	0.493
Income (Rs.)	162338.821
Irrigation	0.00

The factors affecting purchase of KRIBHCO RAJA (PCH – 877) variety of cotton seed is presented in Table 6. The coefficient of multiple determinations (R²) was found to be 0.938 indicates that 93.80 per cent of variation in quantity of KRIBHCO RAJA (PCH – 877) variety of cotton seed purchased by farmers was explained by set of variables included in the model. The coefficients of return KRIBHCO RAJA (PCH – 877) variety of cotton seed was found positive and highly significant at 1.00 per cent level of significance and quality of seed was found positive and significant at 5.00 per cent level of significance hence both these variables found as the most determining factors for the buying behaviour of the sample farmers in the study area. This indicates that the increase in return of 1 acre area of KRIBHCO RAJA (PCH – 877) variety of cotton seed will lead to increase in the purchase of KRIBHCO RAJA (PCH – 877) variety of cotton seed. All the other coefficients were found non-significant.

Constraints faced by farmers while purchasing KRIBHCO RAJA (PCH – 877) variety of cotton seeds

The schedule contains statements under following heads viz.,

- Timely unavailability
- Recommended yield
- Seed viability
- Germination losses
- Pest and disease attack
- Effect of weather change on yield
- Lack of scientific knowledge and technical guidance about crop production and selection of varieties
- Price fluctuations of seed
- Unavailability of quality seed

Constraints Faced by Farmers While Purchasing KRIBHCO RAJA (PCH – 877) Variety of Cotton Seeds :

The constraints faced by farmers while purchasing KRIBHCO RAJA (PCH – 877) variety of cotton seeds in Hanumangarh area presented in Table 7. Problems like insect pest and disease attack and effect of weather change on yield secured first and second place with a

Table-6 : Factors affecting the purchase of KRIBHCO RAJA (PCH – 877) variety of cotton seeds.

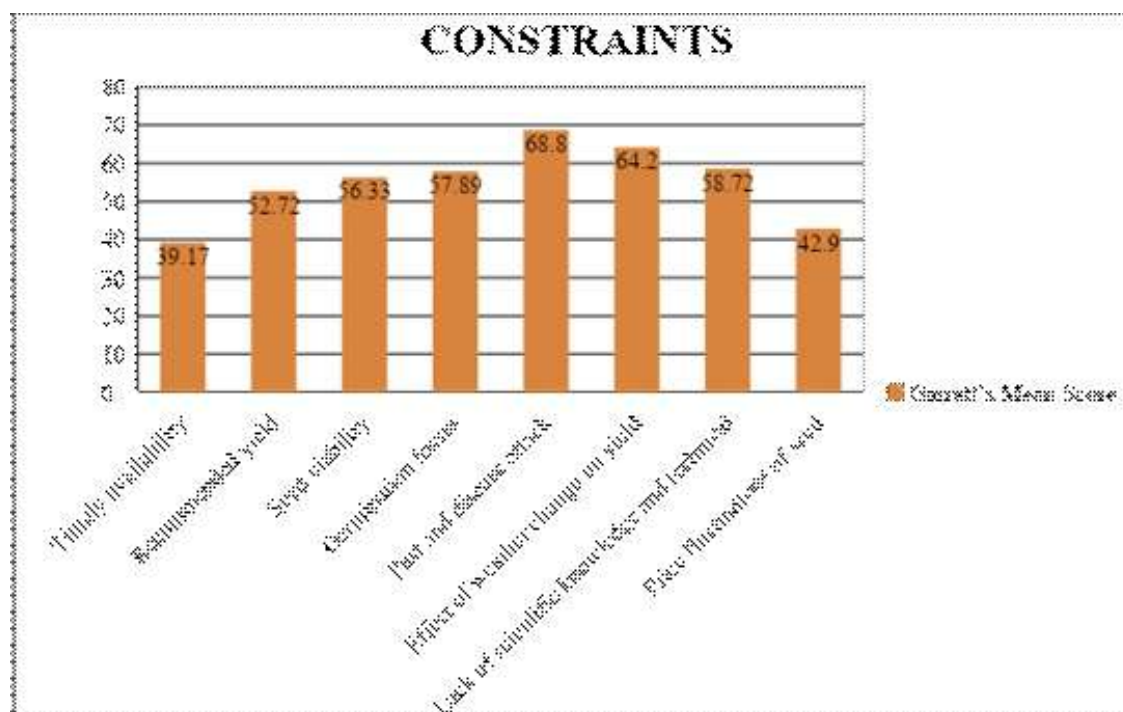
Factors	Coefficient	Standard Error	T Stat	P Value
Intercept	67.300	42.017	-1.602	0.113
Age (years)	.536	.444	1.206	0.231
Education(years)	1.366	.872	1.566	0.121
Return (Rs.)	.159**	.000	1113.364	0.000
Quality of seed	13.822*	7.677	1.800	0.075
Yield (Increase, Moderate, Decrease)	-3.534	8.614	-.410	0.683
Income (Rs.)	2.855	.000	0.571	0.570
R ²	0.938			

** = significant at 1.00 per cent level of significance

** = significant at 5.00 per cent level of significance

Table-7 : Constraints faced by farmers while purchasing KRIBHCO RAJA (PCH – 877) variety of cotton seeds.

Sr. No.	Constraint	Total Score	Garrett's Mean Score	Rank
1.	Timely unavailability	4700.40	39.17	VIII
2.	Recommended yield	6326.40	52.72	VI
3.	Seed viability	6759.60	56.33	V
4.	Germination losses	6946.80	57.89	IV
5.	Pest and disease attack	8256	68.80	I
6.	Effect of weather change on yield	7704	64.20	II
7.	Lack of scientific knowledge and technical guidance about crop production and selection of varieties	7046.40	58.72	III
8.	Price fluctuations of seed	5148	42.90	VII
9.	Unavailability of quality seed	3944.40	32.87	IX



mean score of 68.80 and 64.20 respectively. Kulkarni *et al.* (2018) also found that pest and disease attack is a constraint faced by farmers. These constraints are followed by lack of scientific knowledge and technical guidance about crop production and selection of varieties with a mean score of 58.72, germination losses with a

mean score of 57.89, seed viability, recommended yield, price fluctuations of seed, timely availability and availability of quality seed were the minor constraints with the mean score of 56.33, 52.72, 42.90, 39.17 and 32.87 respectively.

Conclusions

From the present investigation entitled “Economics of Cotton Cultivation and Constraints faced by farmers”, it was found that total cost of cultivation C2 is 113844.15 rupees per hectare. Gross income is 183452 rupees and net return is 69607.85 rupees per hectare. Farmers should reduce the cost of cultivation. It was revealed from the field survey that the first and foremost problem that has faced by farmers was pest and disease attack. Other followed by effect of weather change on yield, lack of scientific knowledge and technical guidance about crop production and selection of varieties, germination losses, seed viability, recommended yield, price fluctuations of seed, timely availability and availability of quality seed.

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Influence of Different Levels of GA₃ on Germination and Seedling Growth of Various Genotypes of Wheat (*Triticum aestivum*)

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Abstract

In this investigation four genotype of wheat such as PBW-502, HD-2967, HD-3086, PBW-373 were treated with aqueous solution of GA₃ each with 50ppm, 75ppm, 100ppm, and 125ppm concentration after 24 hrs. soaking. Germination percentage, Plumule length, Radicle length, seedling length, Seedling dry weight, Vigour index is affected by the interaction between genotypes and GA₃. Genotype PBW-373 had the highest germination rate (23.07%), Radicle length, (7.40cm), Plumule length(11.82cm), Seedling length (19.22cm), Seedling dry weight (0.039g), Vigour index (1691.36) were recorded at 100ppm level of GA₃. Moreover, among all GA₃ levels used in this study, 100ppm was most effective on most parameters that measured. These results suggest that soaking the seed in GA₃ solutions can increase the germination and seedling growth in wheat genotype.

Key words : *Triticum aestivum*, seedling length, GA₃, germination and vigour index.

Introduction

Wheat (*Triticum species*) is a crop of global significance. It is grown in diversified environments. It is a staple food of millions of people. Approximately one-sixth of the total arable land in the world is cultivated with wheat. Whereas paddy is mainly cultivated in Asia, wheat is grown in all the continents of the world. It supplies about 20 per cent of the food calories for the world's growing population. India is the second largest producer of wheat after China. Wheat has a distinct place among the food grain crops. Carbohydrate and protein are two main constituents of wheat. On an average wheat contains 11-12% protein. In the terms of production, wheat occupies the prime position among the food crop in the world. It ranks first in the world among the cereals both in respect of area i.e. 219.51 million ha and production i.e. 758.02 million tonnes (USDA, report 2017-18). In India, it is cultivated on an area of 30.70 million hectare having productions of 98.51 million tones with average productivity of 3200 kg ha⁻¹ (USDA, report 2017-18). Uttar Pradesh rank first with respect to area 9.67 million hectare and production 33.66 million tones the productivity is much lower 3.48 tones ha⁻¹ as compared to Punjab and Haryana 4.50 tones h⁻¹ (Anonymous, 2017).

Major wheat producing countries in world are China, India, USA, France, Russia, Canada, Australia, Pakistan, Turkey, UK, Argentina, Iran and Italy. These countries contribute about 74.82% of the total world wheat

production. As for as india is concerned, about 90 % of the total wheat production is contributed by northern state.

Gibberellins is the most important growth hormone gibberellins or GA₃ Include a large range of chemical that are produced naturally with in plant by fungi unlike auxins, which are classified based on function; gibberellias are classified based on structure as well, as function. Gibberellins are diterpenes synthesized from acetyco-A via the mevalonic acid pathway. Gibberellic acid (GA₃) is a phytohormone that is needed in small quantities at low concentration to accelerate plant growth and development. So favorable condition may be induced by applying growth regulator exogenously in proper concentration at a proper time in a specific crop by GA₃ Gibberellic acid is such a plant growth regulator, which can manipulate a variety of growth and development phenomena in various crops. GA₃ enhance activities to plant, simulate stem elongation (Deotale, *et al.* 1998, Abd, 1997; Lee, 1990), and increases dry weight and yield (Deotale, *et al.*, 1998 and Maske, *et al.*, 1998). Therefore, the present research work was undertaken to evaluate the effect of various concentrations of GA₃ on growth and vigour of wheat. Gibberellins are most abundant in young expanding organ, being synthesized particularly in young apical leaves (possible in chloroplast), buds and seed and root tips. They migrate after synthesized in a non-polar manner that is up or down in phloem and xylem. Young growing meristemetic tissue, embryos, apical root cell, young fruit as well as umpire or germination seed are all rich in gibberellins.

Materials and Methods

The experiment was conducted on wheat varieties viz. PBW-502, HD-2967, HD-3086 and PBW-373. Seeds are collected from NSC, Sikandra, Agra and Hyderabad Seed Store, Etah and Hormone like GA₃ was provided by the Department of seed Technology, R.B.S. College Agra.

The experiment was conducted in petridish (9 cm diameter) The dry petridishes were lined with what's man filter paper. The solutions on different level of GA₃ were added in different petridish in equal quantity (10 ml). The 50 healthy seeds were kept on the wet filter paper of petridishes and allowed to germination in B.O.D. incubator at 25°C. The experiment was replicated 3 times in R.B.D. factorial design.

Preparation of solution : The solution of the growth regulator like GA₃ of different ppm, 1 gm of GA₃ chemical was taken in a individual neat and clean. This chemical was dissolved in few drop of Alcohol. This alcoholic solution was added to 500 ml distilled water with constant stirring. The volume of solution was finally constituted to one liter, This was the 1000-ppm stock solution of chemical. The flask contain chemical was covered with Muslin cloth to avoid any contamination.

For preparation of 125ppm, 100ppm, 75ppm, and 50ppm solution of growth regulator of GA₃, 125ml, 100ml, 75ml, and 50ml of solution from the stock solution were taken in a separate well-cleaned measuring flask and constituted to 1 lit, respectively.

Soaking of the seeds in solution : After preparation of solution of GA₃ seeds of wheat were soaking in desired solution for 24 hrs at 25°C temperature.

After specific time of soaking the solution was drained out from the beaker and soaked. Seeds were air dried to their original weight. For control treatment, dried seeds were used as such. The seeds were put for germination in controlled laboratory conditions.

Standard germination count : For taking observations regarding seed germination, 50 seeds were kept in petridishes on wet filter paper. After 5 days first count, after 7th days, final count were taken.

Observation Recorded

1. Germination percentage : Seed with emergence of 2mm Length were counted for germination (Heydecker 1972, and Lang, 1965). It is recorded daily up to 7th days. The germination percentage was calculated as follows :

$$\text{Germination \%} = \frac{\text{No. of seed germinated}}{\text{Total no. of seeds taken}} \times 100$$

2. Shoot Length and Radicle Length : A sample of 10

normal seedling from each replicated set were taken randomly and the mean length of plumule and radicle from base to the tip was recorded in cm, and means is calculated.

3. Seedling Length : A Sample of 10 normal seedlings from each replication were randomly and measured them in cm., and mean is calculated.

4. Dry Weight of Seedling : Seeds were grown in controlled laboratory condition. Ten seedlings of each replication were collected randomly, after 7th days dried at 100°C for 24 Hours in hot air oven and dry weight was recorded.

5. Vigour Index : Vigour index was calculated for each seed 10 + us per details 'given by Abdul-Baki and Anderson (1973).

$$\text{V.I.} = \text{Germination percentage} \times \text{Seedling length.}$$

Statistical Analysis : The data was analysed by the following the analysis of RBD. Analysis of variance error S.E. (diff.) and critical difference (C.D.) formula.

$$\text{S.E. (diff.)} = \sqrt{\frac{2V_E}{r}}$$

Where,

V_E = mean of sum of square for error

r = number of replication

C.D. = S.E.(diff) x t at 5%

S.E.(diff) = Standard Error

Results and Discussion

Germination : The data on the effect of seed soaking with different levels of GA₃ on germination percentage of wheat genotypes are presented in Table-1 and Appendix-I. The result showed that germination percentage of all the four varieties increase significantly with increasing level of GA₃ i.e. 50ppm, 100 ppm and 125 ppm at all the stage of seedling growth after soaking seeds at 24 hrs over the control.

The maximum germination percentage (88.0%) was recorded in PBW-373 followed by PBW-502 (84.0%), HD-2967 (81.0%), HD-3086 (80.0%) after 24 hour's soaked seed with 100 ppm level of GA₃ solution. However, the lowest germination (68.5%) was recorded in HD-3086 at 50ppm level of GA₃.

The maximum increase percentage in germination (23.07%) was recorded in genotype HD-3086 at 100 ppm of GA₃ treatment over the control. Exogenous application of growth regulators like gibberellins and kinetin often causes metabolic changes in seed and in turn induced germination (Meehanna, *et al.*, 1985). Karseen, *et al.*,

Table-1 : Effect of seed soaking with different concentration of GA₃ on germination percentage of different wheat genotypes.

Variety name	Control	50 ppm	75 ppm	100 ppm	125 ppm
PBW-502	70.0	74.54*	78.0*	84.0*	79.5*
HD-2967	68.0	73.0*	77.5*	81.0*	78.0
HD-3086	65.0	68.5*	75.0*	80.0*	76.5*
PBW-373	74.0	77.5	84.0*	88.0*	85.5*

S.E. = 1.58

CD = 3.44

Table-2 : Effect of seed soaking with different concentration of GA₃ on plumule length of (cm) of different Wheat genotypes.

Variety name	Control	50 ppm	75 ppm	100 ppm	125 ppm
PBW-502	6.75	7.26*	9.62*	11.44*	9.80*
HD-2967	6.0	7.30*	8.62*	10.58*	8.89*
HD-3086	5.86	6.57*	7.77*	9.88*	8.18*
PBW-373	8.79	9.02*	.28*	11.82*	9.30*

SE = 0.119

CD = 0.261

Table-3 : Effect of seed soaking with different concentration of GA₃ on radicle length (cm) of different wheat genotypes.

Genotypes	Control	50 ppm	75 ppm	100 ppm	125 ppm
PWB-502	4.11	5.01*	6.34*	6.78*	6.46*
HD-2967	3.68	4.32*	5.14*	5.96*	5.22*
HD-3086	3.40	3.98*	4.50	5.56*	4.87
PBW-373	4.82	5.56*	6.78*	7.40*	6.90*

SE = 0.165

CD = 0.36

Table-4 : Effect of seed soaking with different concentration of GA₃ on length of seedling (cm) of different wheat genotypes.

Genotypes	Control	50 ppm	75 ppm	100 ppm	150 ppm
PBW-502	10.86	12.27	15.96*	18.22*	16.26*
HD-2967	9.68	11.62*	13.76*	16.54*	14.11*
HD-3086	9.26	10.55	12.27*	15.44*	13.05*
PBW-373	13.61	14.58	16.06*	19.22*	16.20*

SE = 0.738

CD = 1.61

Table-5 : Effect of seed soaking with different concentration of GA₃ on dry weight of seedling (g) of different wheat genotypes.

Genotypes	Control	50 ppm	75 ppm	100 ppm	125 ppm
PBW-502	0.027	0.030*	0.032*	0.038*	0.033*
HD-2967	0.024	0.027*	0.030*	0.035*	0.031*
HD-3086	0.022	0.024*	0.030*	0.032*	0.030*
PBW-373	0.029	0.031*	0.034*	0.039*	0.035*

SE = 0.00142

CD = 0.0031

Table-6 : Effect of seed soaking with different concentration of GA₃ on vigour index of different wheat genotypes.

Genotype	Control	50 ppm	75 ppm	100 ppm	125 ppm
PBW-502	760.2	914.115*	1244.426*	1530.48*	1292.67*
HD-2967	658.24	848.26*	1066.4*	1339.74*	1100.58*
HD-3086	601.9	722.675	920.25*	1235.2*	998.33*
PBW-373	1007.14	1129.95	1349.04*	1691.36*	1385.1*

SE = 69.82

CD = 152.14

(1989) also reported that the treatment of gibberellic acid promotes germination in various crops.

Plumule length : The plumule length of seedling of all genotype with different levels of GA₃ were noted at 8th day after sowing and data were presented in table-2 and appendix II. The maximum plumule length (11.82 cm) was recorded in the genotype PBW-373 with 100 ppm level of

GA₃ and the minimum plumule length (6.57 cm) was recorded in the genotype HD-3086 with 50 ppm level of GA₃ solution. The maximum increase percentage (76.33%) was observed in HD-2967 at 100 ppm level of GA₃ over the control.

Vigour index : The genotype PBW-373 showed maximum (1691.36) vigour index with 100 ppm GA₃

Appendix-1 : Germination percentage of seedling with GA₃ treatment.

Source of variance	D.F.	S.S.	M.S.	Variance ratio	F Value	
					5%	1%
Varieties	3	131.97	43.99	11.67**	3.49	5.95
Treatments	4	590.23	147.55	29.14**	3.26	5.41
Error	12	45.24	3.77			
Total	19					

SE = 1.58

CD = 3.44

* = Significance at 5%

** = Significance at 1%

NS = Non Significant

Appendix-2 : Plumule length of seedling Seed with GA₃ treatment.

Source of variance	D.F.	S.S.	M.S.	Variance ratio	F Value	
					5%	1%
Varieties	3	0.496	0.165	7.88**	3.49	5.95
Treatments	4	1.831	0.4578	21.80**	3.26	5.41
Error	12	0.252	0.021			
Total	19					

SE = 0.0119CD = 0.261

* = Significance at 5%

** = Significance at 1%

NS = Non Significant

Appendix-3 : Radicle length of seedling with GA₃ treatment.

Source of variance	D.F.	S.S.	M.S.	Variance ratio	F Value	
					5%	1%
Varieties	3	1.454	0.484	12.12**	3.49	5.95
Treatments	4	4.76	1.19	29.75**	3.26	5.41
Error	12	0.48	0.040			
Total	19					

SE = 0.165

CD = 0.36

* = Significance at 5%

** = Significance at 1%

NS = Non Significant

Appendix-4 : Seedling length with GA₃ treatment.

Source of variance	D.F.	S.S.	M.S.	Variance ratio	F Value	
					5%	1%
Varieties	3	23.80	7.93	9.93**	3.49	5.95
Treatments	4	80.69	20.17	25.25**	3.26	5.41
Error	12	9.58	0.799			
Total	19					

SE = 0.738

CD = 1.61

* = Significance at 5%

** = Significance at 1%

NS = Non Significant

Appendix-5 : Dry weight of seedling with GA₃ treatment.

Source of variance	D.F.	S.S.	M.S.	Variance ratio	F Value	
					5%	1%
Varieties	3	0.0000549	0.0000183	6.12****	3.49	5.95
Treatments	4	0.000408	0.000102	34.12**	3.26	5.41
Error	12	0.000036	0.0000030			
Total	19					

SE = 0.00142

CD = 0.0031

* = Significance at 5%

** = Significance at 1%

NS = Non Significant

Appendix-6 : Vigour index of Seedling with GA₃ treatment.

Source of variance	D.F.	S.S.	M.S.	Variance ratio	F Value	
					5%	1%
Varieties	3	406268.05	135422.68	18.52**	3.49	5.95
Treatments	4	1253902.88	313475.72	42.87**	3.26	5.41
Error	12	87746.88	7312.24			
Total	19					

SE = 69.82

CD = 152.14

* = Significance at 5%

** = Significance at 1%

NS = Non Significant

soaking seeds. The genotype HD-3086 was showed maximum increase (105.21%) in vigour index with 100 ppm level of GA₃ over the control. While, the genotype HD-3086 was showed minimum (722.67) in vigour index with 50 ppm level of GA₃ treatment. The genotype PBW-373 was exhibited minimum increase percentage (67.93%) in vigour index over the control at 100 ppm GA₃ treatment. The increase vigour index may be because of increase in germination and seedling growth.

Radicle length : The radicle length was recorded at 8th day after sowing all the genotype and the result are shown in table-3 and Appendix-III. The PBW-373 showed maximum radicle length (7.40 cm) with 100 ppm level of GA₃ followed by PBW-502 (6.78 cm), HD-2967 (5.96 cm) and HD-3086 (5.56 cm). While, minimum radicle length (3.98 cm) was recorded in HD-3086 with 50ppm level of GA₃. However, maximum increase percentage was recorded in PBW-502 (64.96%) over the control. Similar results were obtained by Jhorar, *et al.*, (1982).

Seedling length : The length of seedling was recorded at 8th day after sowing all the genotypes and the result are shown in table-4 and Appendix-IV. The maximum length of seedling length (19.2 2cm) was recorded in PBW-373 with 100 ppm level of GA₃. While, the maximum increase percentage (70.86%) in length of seedling was recorded in HD-2967 with 100ppm level of GA₃ over the control. The genotype HD-3086 showed minimum (10.55 cm) seedling length with 50 ppm level of GA₃ treatment. Similar results were recorded by Ashraf, *et al.*, (2002).

Dry weight : The dry weight of seedling was recorded at 9th day after all the genotypes and the results are shown in table-5 and appendix-V. The table showed that increasing level of GA₃. increase dry weight significant in all the genotype at all stages. The maximum dry weight of seedling (0.039g) was recorded in PBW-373 with 100ppm level of GA₃. While, the maximum increase in dry weight of seedling was also recorded (45.83%) in HD-2967 genotype with 100 ppm over the control with GA₃. The genotype HD-3086 showed minimum (0.024g) dry weight of seedling with 50 ppm level of GA₃ treatment.

Conclusions

Among the different genotypes PBW-373 responded well for germination, plumule length, radicle length, seedling length, dry weight and vigour index with 100 ppm level of GA₃. As far as the increasing percentage over the control are concern, the genotype HD-3086 was found most effective for germination and vigour index, However, HD-2967 was found most effective for plumule length, seedling length and dry weight of seedling whereas, the genotype PBW-502 was found most effective only for radicle length with 100ppm level of GA₃ over the control.

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Nano-Fertilizers : A Noval Approach to Increase Nutrient Use Efficiency

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Abstract

Nano-fertilizers are important tools in agriculture for increasing nutrient use efficiency, reducing fertilizer waste and reducing cultivation costs by improving crop growth, yield and quality parameters. It allow for a slow and steady release of nutrients and reducing nutrient loss. They are very effective in precision agriculture for precise nutrient management by matching the crop growth stage for nutrient and can provide nutrient across the crop growth cycle. Nano-fertilizers are used in the soil or on the leaves and Foliar application can be done even if the soil and weather conditions aren't ideal. Furthermore, it encourages the direct entry of nutrients into the plant system, reducing fertiliser waste. The role of nano-fertilizers in the mitigation of biotic and abiotic stress on plants is presented, as well as their application in smart sustainable agriculture.

Key words : Nano-fertilizers, nutrient use efficiency, sustainable agriculture, precise nutrient management.

Introduction

"Nano fertilisers are synthesised forms of traditional fertilisers, fertilisers bulk materials, or extracted from various vegetative or reproductive parts of the plant by various chemicals, physical, mechanical or biological methods with the help of nanotechnology to enhance soil fertility, productivity, and quality of agricultural produce."

Norio Taniguchi coined the term "nanotechnology" in 1974. Word Nanotechnology is derived from the Greek word "nanos," which means "dwarf." Nanotechnology is characterised as the study and control of matter with dimensions ranging from 1 to 100 nanometers, where special physical properties allow for novel applications (EPA, 2007).

Nanotechnology works with the finest particles, raising hopes for increased agricultural productivity by solving problems that have previously been unsolved. Nanotechnology increases bio source use and is environmentally friendly in nature, builds carbon absorption, and enhances soil aggregation, regardless of the form of crop. Nutrients and growth promoters encapsulated in nanoscale polymers are used in these nano fertilizers. Nanofertilizers improve Nutrient Usage Efficiency (NUE) by three times while also having stress tolerance.

Important properties of nano fertilizers : The higher surface area of nano-fertilizers is owing to the smaller particle size, which allows for more sites to assist various metabolic processes in the plant system, resulting in the synthesis of more photosynthets. They have a lot of

interaction with other compounds due to their large surface area and small size. They are highly soluble in a variety of solvents, including water. Nano-fertilizer particles are smaller than 100 nm, allowing for greater penetration of nano particles into plants from surfaces such as soil or leaves.

Nano fertilisers have a huge surface area and particle size that is smaller than the pore size of the plant's roots and leaves, allowing them to penetrate deeper into the plant and enhance absorption and nutrient usage efficiency. Reducing particle size increases the specific surface area and number of particles per unit area of a fertilizer, allowing more nano-fertilizers to come into contact, resulting in greater nutrient penetration and absorption.

Fertilizers encased in nano-particles will enhance nutrient availability and absorption to the crop plant zeolite-based nano-fertilizers have the capacity to slowly deliver nutrients to the crop plant, increasing nutrient availability throughout the growth cycle and preventing nutrient loss via denitrification, volatilization, leaching and fixation in the soil, particularly $\text{NO}_3\text{-N}$ and $\text{NH}_4\text{-N}$. Particle size less than 100 nm nano-particles can use as fertilizer for efficient nutrient management which are reduce pollution and more eco-friendly. Main reason for high interest in fertilizers is mainly their penetration capacity, very higher surface area and size, which is usually differ from the same material found in bulk form. This is partly owing to nano-particles high surface-to-volume ratio. As a result, the reactive surface area of nano-particles is proportionately greater than that of larger particles.

Particle surface area increases as particle size decreases and the particle's surface free energy is proportional to its size.

Delivery of fertilizers : Nanomaterials have more contributions in slow release of fertilizers. Surface coatings or nanocoatings of nanomaterials, on fertilizer particles hold the material strongly from the plant due to higher surface tension than conventional surfaces. Moreover, nanocoatings provide surface protection for larger particles (Brady and Weil, 1999)

The stability of the coating reduced the rate of dissolution of the fertilizer and allowed slow sustained release of sulphur coated fertilizer. In addition to urea, sulphur nanocoatings, phosphate encapsulation and release will be useful to meet soil and crop demands. Other nanomaterials with potential application include kaolin and polymeric biocompatible nanoparticles used biodegradable, polymeric chitosan nanoparticles (78 nm) for controlled release of the NPK fertilizer sources such as urea, potassium chloride and calcium phosphate (Wilson *et al.*, 2008)

Field application of nano- fertilizers : The mode of pesticide and fertilizer application influences their efficiency and environmental impact (Matthews, 2008). The use of the right fertiliser application method and the right amount of fertiliser increased nutrient absorption while lowering pollution. The soil, crop, irrigation type and nutrient applied all have a role in the fertiliser application technique chosen. Broadcasting, side dressing, dusting and banding are all current methods that have run-off issues owing to soil moisture breakdown and leaching. Salt damage was induced by the application of large amounts of fertilizers near the seeds and a reduction in soil moisture. Nitrogen fixing was hindered whereas green algae growth was promoted in the broadcast mode of urea application. The development of nitrogen-fixing blue green algae was not inhibited by deep insertion of urea granules (1–2 g) (Roger *et al.*, 1980). NP coated fertilisers may help to delay the release of the fertilizer, reducing fast disintegration and therefore harm to the environment.

Mechanisms of Nano-fertilizers Uptake by Plants : It is very important to investigate the uptake and movement of nano- fertilizers from soil into plants, because such information can give an idea of suitable applications for NFs to plants. For instance, if nano-fertilizers prefer transport through the xylem, then the optimal application of nano-fertilizers is through an irrigation system. Meanwhile, if nano- fertilizers move through the phloem, then an exogenous application is recommended and suitable. (Feregrino *et al.*, 2018) . Manily two mechanisms of Nano- fertilizers uptake by plants:

1. Foliar Exposure and Uptake of Nano- fertilizers : In foliar applications, nanoparticles face the cuticular barrier before entering plant tissues (Pollard *et al.*, 2008). The cuticle layer on leaves is a waxy covering with two entrance points: the hydrophilic or stomatal pathway and the lipophilic or cuticular pathway. The lipophilic pathway is for nonpolar solutes that can enter the leaves through diffusion, while the hydrophilic pathway is for polar solutes [Eichert *et al.*, 2008]. As a result, NPs or their aggregates with a diameter of less than 4.8 nm can easily enter the cuticle through the cuticular route.

However, several studies have documented that NPs larger than 5.0 nm can enter plants by foliar application (Christie *et al.*, 2019). Polar nanoparticles, on the other hand, can enter though the hydrophilic or stomatal pathway [Eichert *et al.*, 2008]. Wang *et al.* documented that soil-applied CuO Nanoparticles (20–40 nm) translocated from the roots of maize (*Zea mays* L.) to the shoots through the xylem, and then they moved back to the roots through the phloem. Thus, the findings of Wang *et al.* supported the concept that Nanoparticles can circulate within a plant both through the xylem and the phloem.

2. Root Exposure and Uptake of Nano-fertilizers/ Nanoparticles in Plants : Multiple factors such as plant morphology, growth stage, exposure conditions, size of particles and rhizosphere processes affect the root uptake of nanoparticles. Avellan *et al.* observed that the roots of *Arabidopsis thaliana* produced a mucilage that facilitated the taking up of positively-charged gold nanoparticle (12 nm) by the roots, while same size (12 nm) of negatively charged gold nanoparticles did not enter the root tissues. Judy *et al.* noted that the roots of tobacco plants uptake gold nanoparticle ranging from 10 to 50 nm in diameter, whereas wheat roots do not.

Nanoparticles applied to soil are initially adsorbed on the root surface and then cross several barriers to reach vascular system of plant (Christie *et al.*, 2019). The root cuticle layer, which is identical to the leaf cuticle layer in composition, is the initial barrier. Nanoparticles penetrate the root epidermis after crossing the cuticle on the root surface. When nanoparticles reach the root epidermis, they could either follow the apoplastic or symplastic pathways.

In conclusion, Nanofertilizers or Nanoparticles can be taken up by roots when they are applied to the soil or by leaves when they are foliar-applied. The exogenous application of nanoparticles or their aggregates with smaller diameters can allow them to more easily enter the cuticle through the cuticular pathway than bigger nanoparticles; however, the uptake of various NPs with varying diameters can be affected by variations in leaf

Comparison of nanotechnology based formulations and conventional fertilizers applications.

Properties	Nano-fertilizers-enabled technologies	Conventional technology
Solubility and dispersion of mineral micronutrients	Nano-sized formulation of mineral micronutrients may improve solubility and dispersion of insoluble nutrients in soil, reduce soil absorption, fixation and increase the bioavailability	Less bioavailability to plants due to large particle size and less solubility
Nutrient uptake efficiency	Nano structured formulation might increase fertilizer efficiency and uptake ratio of the soil nutrients in crop production and save fertilizer	Bulk composite is not available for roots resource and decrease efficiency
Controlled release modes	Both release rate and release pattern of nutrients for water soluble fertilizers might be precisely controlled through encapsulation in envelope forms of semipermeable membranes coated by resin-polymer, waxes and sulfur	Excess release of fertilizers may produce toxicity and destroy ecological balance of soil
Effective duration of nutrient supply	Nanostructured formulation can extend effective duration of nutrient release of fertilizers into soil	Used by the plants at the time of delivery, the rest is converted into insoluble salts in the soil
Loss rate of fertilizer nutrients	Nanostructured formulation can reduce loss rate of fertilizer nutrients into soil by leaching or leaking	High loss rate by leaching, run off, and drift

shape and the number and size of stomata between plant species. In soil application, nanofertilizers or nanoparticle translocation can follow the apoplastic or symplastic pathways.

Nanoparticles : The size at which fundamental properties vary from those of the corresponding bulk material is what defines a nanoparticle (Banfield and Zhang, 2001). Nanoparticles and colloids are similar in size, with diameters ranging from 1 nm to 1 mm (Buffle, 2006). The surface of nanoparticles has more atoms than the interior due to their small size. This results in a large surface-to-volume ratio, resulting in a higher surface-to-volume ratio nanoparticles with a higher charge density and reactivity. Nanoparticles with a tetrahedral structure have higher catalytic activity than those with a cubic or spherical structure, owing to increased chemical reactivity at the sharp edges and corners of the former. Differences in atomic distribution between nanoparticles are induced by differences in the exposed surfaces of different nanoparticles of various shapes. This has an effect on the kinetics of electron transfer between metal nanoparticles and their adsorbed species.

Nano-nutrients : Many micronutrients such as; silica, zinc, copper and iron have been synthesized in a nanoscale manner and used in the management of plant growth. A study conducted by Heidari *et al.*, (2018) investigated the effects of PGPR and iron nano chelate on the growth, grain yield and physiological responses of maize. They noticed that foliar application of nano Fe and a nitrogen fixer bacterium *Azospirillum brasilens*, improved the maize plant growth and productivity. Dinali *et al.*, (2017) demonstrated that iron oxide Nanoparticles are widely used in sustainable agricultural system, because of their ease of synthesis, modification, and/or coating. Another recent research of Mokarram *et al.*, (2019)

reported that inoculation of the plant with PGPR and an arbuscular mycorrhizal fungus with minimal-dose of Fe-NPS substantially increased the phytoremediation of heavy metals; additionally, the root zone and leaf space of the young plants have been improved.

According to Khodakovskaya *et al.*, (2009), the efficacy of NPs differs from plant to plant depending on its composition, scale, surface area, reactivity and concentration. NPs may have either a good or bad effects on the soil microflora. Combination of the bio-fertilizers or biocontrol agents with nanomaterials may increase the efficacy and vitality of the bio-agents.

Conventional fertilizers v/s Nano-fertilizers : Spraying or broadcasting are the most common methods for applying conventional fertilisers to crops. The ultimate concentration of fertilisers reaching the plant, on the other hand, is a key determinant in determining the manner of application. In practical scenario, very less concentration to the targeted site due to leaching of chemicals, drift, runoff, evaporation, hydrolysis by soil moisture and photolytic and microbial degradation. It has been estimated that around 40-70% of nitrogen, 80-90% of phosphorus and 50-90% of potassium content of applied fertilizers are lost in the environment and could not reach the plant which causes sustainable and economic losses (Ombodi and Saigusa, 2000).

Nano-fertilizer can release their nutrients in 40–50 days, while synthetic fertilizers do the same in 4–10 days. As a result, a synthetic urea fertilizer can rapidly lose more than 70% of its N content after field application through leaching and volatilization, leaving less than 20% to be readily available for plants (Kahrl *et al.*, 2010). Tilman *et al.* (2002) Excessive pesticide and fertiliser usage promotes disease and insect resistance, decreases soil microflora, inhibits nitrogen fixation, leads

to pesticide bioaccumulation and damages bird habitat. Hence, it is very important to optimize the use of chemical fertilization to minimize the risk of environmental pollution and to fulfill the crop nutrient requirements. As a result, it may be beneficial to evaluate and apply different fertilization methods in order to supply required nutrients for plant development and crop production while maintaining excellent soil structure and keeping the environment clean (Miransari, 2011).

Nanotechnology has made it possible to explore nanoscale or nanostructured materials as fertiliser carriers or controlled-release vectors for the development of so-called smart fertilisers as new facilities to improve nutrient usage efficiency and lower environmental pollution costs (Chinnamuthu and Boopati, 2009). Derosa *et al.* (2010) reported that nano-fertilizer refers to a product in nanometer regime that delivers nutrients to crops. Surface coatings of nanomaterial on fertilizer hold the material more strongly due to higher surface tension than the conventional surfaces and thus help in controlled release. The application of nanotechnology in agriculture includes the delivery of agrochemical substances such as fertiliser, which provide macro and micronutrients to plants.

Important Characteristics of Nano-fertilizers for Facilitating High Nutrient Use Efficiency (NUE) : One of the most important features of nano-fertilizers is their ability to enter plants when applied as foliar or soil amendments due to their small particle size (<100 nm) (Liscano *et al.*, 2000). Nano-fertilizers have high surface areas, and this can provide a maximum reactivity and increase both the availability of nutrients and plant nutrient use efficiency (Siddiqi and Husen, 2017). Moreover, Nano-fertilizers are soluble in water and can increase the dispersion of nutrients in soil and further increase their availability to plants, while synthetic fertilizers have a low solubility due to their large particle size and high adsorption and fixation to soil particles. Fertilizers are encapsulated in NPs to increase their uptake and availability to plants, as well as to decrease their bulk requirements (Chhipa, 2017). For example, the high availability of nutrients to plants throughout the growth period is possible via the application of zeolite-based Nano-fertilizers.

Minimization of the environmental toxicity and pollution : The continuous and large-scale application of the fertilizers and pesticides negatively affect the balance of soil nutrients that result in an environmental pollution which affect the normal flora and fauna.

Application of nano-fertilizers diminishes the rate of losing fertilizer supplements; this will decrease the use of the chemical fertilizers and so minimize the soil

contamination. A recent study of Manjunatha *et al.*, (2016) reported that nano-clays or zeolites are examples of encapsulated NPs that increase the efficiency of the used fertilizer, improve the plant health and soil fertility, which have a positive impact on the environmental pollution and agro-ecological degradation. Accordingly, it is vital to adjust the application of mineral fertilizers, to attain the necessities of editing supplementation and to decrease the dangers of the environmental contamination, this will be accomplished by using the nano-fertilizers.

Enhance the activity of bio-agents : Recently, a study conducted by Mahawar and Prasanna, (2018) highlighted that agriculturally important microorganisms are eco-friendly choices which regulate the efficiency and availability of nutrients to the crop plants, thereby enhancing soil fertility by enriching the biodiversity and nutrients in soil. Some of the limitations in extensive use of bio-agents as bio-fertilizers or biocontrol agents are their short shelf life, transportation and storage. Applications of nanotechnology in the form of nano-carriers, nano-encapsulation and nano-nutrients have been reported by Singh and Prasad, (2017) as potential alternative formulations and delivery systems, which could enhance the performance of the bio-agents. Understanding the pathways will increase the nano-carrier's efficiency and boost its controlled distribution and release.

Need to Study : Research is underway to create a nano-composite that will give all of the essential vital nutrients in an appropriate proportion via a smart delivery system which may help in balance supply of nutrient to the crop. It is necessary to investigate nanonutrient delivery in plant systems, to assess the impact of nano fertilisers on soil and soil beneficial microorganisms, and to investigate the fate of nano fertilisers in soil and plants, need to optimize concentration and doses of nano fertilizers for different crop and site specific management of nano fertilizers in precision agriculture these are several issues need to standardise to achieve better result from nano-fertilizers in crop production.

Conclusions

The use of various nano-fertilizers has a higher impact on crop productivity, lowering fertiliser costs and reducing pollution risks. The application of nano-fertilizers in agriculture should have a greater concern to society. Fertilizer nutrient use efficiency in crop production can be enhanced with effective use of nano-fertilizers. Nano fertilisers increase crop development and yield up to the optimal applied dosages and concentrations, but if the concentration is higher than the optimum, they have an inhibitory impact on the crop plant, resulting in reduced crop growth and yield.

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Marigold Cultivation : Income Generation, Health and Livelihood Security for Small and Marginal Farmers of Guna District

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Abstract

Marigolds were well known and valued by ancient people in India. The bright orange and red colours of marigolds are seen everywhere in daily life of the Indian sub-continent. They are mainly decorative plants and the flowers are used in all kinds of ceremonies including weddings. Marigold has been occasionally used in South Asian medicine. Marigold leaves and flowers in particular have been used for various disorders. Marigold species are being investigated for their potential benefits to health. Now a days, they are being used for treatment of various diseases.

Introduction

The golden colour of marigolds was considered to resemble the colour of the Arya, or honourable people¹⁸. They are made into garlands and are offered to the gods and honoured guests, or used to decorate the biers of the dead. They stud cowdung balls which are used to decorate rice-powder drawings. In folk-art of eastern India they are dried and powdered to produce a yellow colour used to decorate village homes. Essential oils are also extracted from marigolds for perfumery.

Description : Two separate species of plant are known as marigolds, both edible, but we will get different results with the two. One is medicinal and not very palatable, the other makes a nice salad ingredient, but it won't cure what ails us. The National Institutes of Health explains that the marigold found in most home gardens is of the targets variety, which is purely ornamental. The marigold variety that delivers health benefits is calendula. The flowers of the calendula marigold have been used for centuries for their health benefits.

Calendula : The most commonly cultivated and used member of the genus is *Calendula officinalis*. Calendula marigolds look more like a daisy with an obvious open center. They lack the closely clustered petals of the decorative marigold and are sometimes referred to as pot marigolds. Calendula should not be confused with other plants that are also known as marigolds, such as corn marigold, desert marigold, marsh marigold, or plants of the genus *Tagetes*. The name Calendula stems from the Latin kalendae, meaning first day of the month, presumably because pot marigolds are in bloom at the start of most months of the year. The common name marigold probably refers to the 'Virgin Mary' or its Old Saxon name 'ymbglidegold', which means 'it turns with the

sun'. Medicinal use of calendula dates back at least to the 12th century, according to the University of Maryland Medical Center².

Botanical name : *Calendula officinalis* reflects the fact that the plant seems to be in bloom the first day of each calendar month.

Family : Calenduleae

Tagetes : The *Tagetes* marigolds, or the common decorative type, are indeed edible, although they do not possess medicinal properties. The fresh flowers may be added to salads or used as an edible garnish; they provide a bitter taste, which can be helpful to balance out an overly sweet dish. The Tangerine Gem and the Lemon Gem varieties are the best-tasting of the *Tagetes*. Botanical names *Tagetes erecta* (African marigold) and *Tagetes patula* (French marigold) and *Tagetes minuta*. Family Compositae, the daisy family (also sometimes known as Asteraceae)

Other names²⁵ : Marigold, French marigold, African marigold (English) Sthulapushpa, sandu, ganduga (Sanskrit)

Chemical constituents²¹ : Flavanoids Have strong anti-inflammatory properties, the University of Michigan Health System reports.

Triterpenoids : May suppress cell fusion and inhibit viral replication, says the Memorial SloanKettering Cancer Center.

Carotenoids : Which prevent the body from free radicals. These are lutein and zeaxanthin, often paired together, and lycopene and Betacarotene. The Linus Pauling Institute reports that lutein and zeaxanthin are the only antioxidants that are found in the retina of the eye, where they protect the eye from the development of

cataracts and macular degeneration. Lycopene is reported to reduce the risk of prostate cancer and heart disease. High iodine, carotene and manganese, which promotes skin cell regeneration, has also been found in the plant.

KVK Intervention : Main role of KVK is technology dissemination through OFTs, FLDs, Literature distribution and training organized for farming community to gain higher income with low cast investment. This approaches is applied for marigold flower cultivation with method of decoration item making through demonstration and trainings programme organized at On / Off campus. KVK provide seed kit and seedling for Marigold cultivation under the monitoring of scientific approach of cultivation.

Farmer- Smt. Lalita Gehlot W/o Harinarayan Gehlot, Village– Nanni Badwani District-Badwani (M.P.) having 01 sons and 02 daughter and has taken guidance from KVK,Badwani for Flower cultivation and Mala Making for Income and Employment generation individually. She has growing Flowers, vegetables and seasonal fruits round the year during Kharif,Rabi and Zaid. Consequently she has receiving fresh flowers owing to supply of garlands and buques on demand from Badwani market. She saving money by garlands and flower sale in local market. Award - Women empowerment award on republic day. Social recognition-20 farm families are also invo lved in flower cultivation and garland making

Cultivation of Marigold

African marigold (*Tagetes erecta*) : Pusa Narangi Gaiinda, Pusa Basanti Gaiinda, Giant Double African Orange, Cracker Jack, Crown of Gold, Guinea Gold, Double Eagle, Dubloon, Climax, Hawaii, New Alaska and Spun Gold.

French marigold (*Tagetes patula*) : Pusa Arpita, Butter Ball, Flash, Colour Magic, Janie Gold, Janie Yellow, Star of India, Red Brocade, Rusty Red, Susana and Valencia

Interspecies hybrids : Pusa Shankar Pusa Shankar-1, Nugget, Red and Gold, Red 1, Nugget, Red and Gold, Red Seven Star and Show Boat.

Soil and Climate

Marigold can be grown in a wide range of soil. African marigold prefers well maured moist soil, while French marigold prefers well drained light soil. The ideal pH for growing marigold is around neutral.

Marigold can be grown in a wide range of climatic conditions throughout year except old winters when temperature is less than 10oC. Ideal growing temperature ranges from 15 to 35oC. Very high temperature also affects adversely growth and flowering. Avoid frost/ chilling injury

Spacing

African Marigold: African Marigold: 40 x 30 cm 40 x 30 cm

French Marigold: French Marigold: 30 x 30 cm

Nutrition

African Marigold: 5 Kg FYM, N 30g, P 10g, K 10g/m².

French Marigold: 3 Kg FYM, N 20g, P 10g, K 10g/m².

Irrigation

Irrigation at 7-10 days interval during 10 days interval during September September-November and twice a week November and twice a week during March-June is ideal. June is ideal.

Harvesting of Marigold : Crop duration is about 4 to 5 month. Normally marigold flower can be picked up once in 3 days after 60 days planting.

Yield of Marigold : Yield depend upon the type of soil, farm management practices and variety of seed cultivated . The average yield is about 90 to 140q/ha

Marigold - Traditional medicine²⁵

Blood purification and to reduce blood flow.

Abdominal cramps and constipation.

Spasmolytic and spasmogenic effects

Culinary and medicinal herb.

Petals are used fresh in salads

Used to color cheese or as a replacement for saffron.

Menstrual discomfort

Ulcers

Varicose veins

Cancer

Marigold - Medicine²⁵ : Skin care Controlling bleeding, and soothing irritated tissue, Bedsores, Skin inflammation, sprains and wounds, acne, burns, radiation induced dermatitis, eczema, sunburn, varicose veins, rashes and scars.

Calendula Products : Topically as an ointment, lotion, cream, oil, cooled calendula tea applied as a poultice, or orally as a tincture, extract or infusion^{11,12} .

Herpes treatment : Calendula Oil and calendula tea is used for herpes infections²⁷ .

Cancer treatment : Calendula shows some potential for fighting cancer. A study published in the 2006 issue of BMC Cancer found that an extract of calendula killed cancerous melanoma cells and stimulated lymphocytes, the white blood cells of the immune system. Another 2006 study, published in the Journal of Natural Products, found that two triterpene glycosides in calendula flowers had a



Assessment of African Marigold Indica Yellow (T-1: Local Ganda/T-23: Indica Yellow)

Yield/(ha)		Cost of input		Incremental income		Net Return		Saving in Rs
T1	T2	T1	T2	T1	T2	T1	T2	
11524 Kg/ha	14263 Kg/ha	33450	42500	182160	280880	148710	238380	89670

toxic effect against colon cancer, leukemia and melanoma¹⁻¹³.

Ear infections : Calendula has been used for generations to treat ear infections in children. The herb relieves the pain an ear infection.

Calendula Products : Tincture, Ear drops^{15,16}.

Insect sting : It has been asserted that a marigold flower, rubbed on the affected part, is an admirable remedy for the pain and swelling caused by the sting of a wasp or bee²⁰.

Joint pains (arthrosis) : Joint pains (arthrosis) are alleviated if the place is greased with Marigold ointment¹⁷.

Psoriasis : A tea from marigold flowers associated with a mixture of oak, willow, meadowsweet, celandine, walnutt rind, white deadnettle, common speedwell and yarrow is effective in many cases of psoriasis as well as in case of doubtful origin eczema.

Antiviral Activity : According to a 1997 article in Biomedicine and Pharmacotherapy, calendula extracts exhibit antiviral activity against the human immunodeficiency virus, or HIV, and a 2006 study published in BMC Cancer attributes calendula with immune-stimulating properties.

Calendula Products : Calendula extracts¹⁴.

Menstrual pain : Marigold tea relieves menstrual pain, especially in anaemic individuals²⁶.

Trichomonas vaginalis : Vaginal douche helps to destroy Trichomonas vaginalis protozoan.

Antibacterial : Calendula is effective against bacteria and is useful as an antiseptic lotion for minor cuts. Calendula is also active against bacteria that cause gastrointestinal infections. A study reported in the 2009 issue of Phytotherapy Research found that calendula was one of the most effective herbs for inhibiting the growth of Campylobacter jejuni, a common bacterial cause of severe diarrhoea in children²⁹.

Digestion : Calendula can relieve some gallbladder problems, since it stimulates the release of bile from the gallbladder, thus relieving congestion. This action also aids digestion and elimination, since bile is a natural laxative¹⁸.

Food colouring and decoration : Marigold flowers contain the yellow carotenoid pigments and are used to produce a yellow dye, which is sometimes used in place of saffron to color rice. Calendula petals are also added to salads and soups to give color and flavor. They have been used to colour pet and livestock foods¹⁻¹⁸.

Crafts : Marigold flowers are used at many religious ceremonies and festivals. Strung together they make colourful garlands and are used as offerings and to decorate religious buildings and statues. Plant dyes have always been important during the Hindu festival Holi, although now synthetic dyes are generally used instead. But Dyes prepared from plants like marigold are safer¹⁸.

Cosmetics : Toners and astringents, lip balms, shampoos and baby oil⁵.

Insect repellent : Calendula also acts as an insect repellent. Skin creams with calendula can deter mosquitoes and pests from the skin¹⁸. HOMEOPATHIC USES Homeopathic form of calendula is primarily used internally for infections resulting from bacterial skin conditions and blood poisoning and fever²⁸.

Homeopathic Products : Topical calendula products include herbal and homeopathic ointments, gels, lotions and creams. Homeopathic calendula remedies also include sprays, oils and sugarbased pellets. Calendula is not typically ingested, with the exception of homeopathic pellets and calendula tea. Cosmetic products such as soaps, moisturizers and lip balms may also contain calendula.

Adverse effects : Herb should be avoided by those who are pregnant or trying to become pregnant, or who are breastfeeding; calendula can cause changes in the

menstrual cycle. People who have an allergy to other members of the daisy family should also avoid treatment with calendula remedies. Calendula might cause too much drowsiness if combined with medications used during and after surgery. Stop taking calendula at least 2 weeks before a scheduled surgery.

Conclusions

Conclusion of this research is Marigold cultivation as well as making usefull items for sale not only a income generating activity and its medicinal uses can be use prevention and healing of disease to remain good health. No scientific study or research has yet proven calendula as an effective remedy for various disorders. But the use of marigold has shown success in curing different diseases. So Marigold can be the most effective remedy of choice for various diseases and this new research will definitely help mankind to lead a disease free and healthy life.

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Biofortification Strategies for Developing Micronutrient Enriched Crop Cultivars and Sustaining Yield Simultaneously : A Review

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Abstract

Micronutrient deficiency is a widespread food-related health problem around the world. Deficiency in minerals especially iron and zinc is a global burden chiefly in developing countries due to poverty and lack of awareness. Among current interventions such as food dietary diversification, supplementation, and fortification available for incorporating micronutrients into diet, breeding-based biofortification is the most feasible and best alternative. It involves the exploitation of genetic diversity present in the mineral-dense germplasm, land races, and wild species to create micronutrient denser lines/variety. In present genomics era, molecular breeding approaches employing molecular markers are being extensively utilized for marker-assisted selection (MAS) to develop mineral-denser lines mainly for iron and zinc. Currently, the focus of plant science is on quantitative trait locus (QTL) detection followed by MAS for the development of mineral-dense crops predominantly wheat, rice, maize, and pearl millet through biofortification. Several QTLs have been mapped for micronutrient concentration in grain/leaf using various mapping population and different marker systems. However, the success of this strategy requires long time and trials as increasing the mineral can cause yield penalty. Thus, a combinatorial approach encompassing the identification and introgression of micronutrient-rich line into locally adapted variety, detection of allergenicity/toxicity, withstanding of nutrient during postharvest processing, and acceptance of new variety by farmers and consumers for a cost-effective intervention is required for the successful development of micronutrient-rich cultivars/lines. Biofortification strategies should be further enhanced with the support from governments for the popularization of varieties through extension workers to reach to the farmers and ultimately acceptance in market.

Introduction

Wheat is an essential constituent of cereal-based diets, and one of the most significant sources of calories. However, modern wheat varieties are low in proteins and minerals. Biofortification is a method for increasing the availability of essential elements in the edible portions of crops through agronomic or genetic and genomic interventions. Wheat is an important staple that acts as a primary source of dietary energy, protein, and essential micronutrients such as iron (Fe) and zinc (Zn) for the world's population. Approximately two billion people suffer from micronutrient deficiency, thus breeders have crossed high Zn progenitors such as synthetic hexaploid wheat, *T. dicoccum*, *T. spelta*, and landraces to generate wheat varieties with competitive yield and enhanced grain Zn that are being adopted by farmers in South Asia.

An excessive intake of monotonous wheat products is a major reason for zinc malnutrition in humans because wheat is inherently low in zinc content and high in phytate, which further limits zinc bioavailability (Welch and Graham, 2004; Cakmak et al., 2010b). Different reports are available indicating that more than 50% of wheat around the globe is cultivated on zinc-deficient soils (Alloway, 2004; Cakmak, 2008), which further lowers grain zinc content. The adoption of high-yielding cultivars

seems to have aggravated this problem (Stein, 2010). Furthermore, wheat processing after harvesting markedly decreases grain zinc and micronutrients such as iron, which enhances the chance of zinc deficiency in humans (Kutman et al., 2011). Hence, there is an urgent challenge and dire need to increase grain zinc content and bioavailability in developing countries (Zhao and McGrath, 2009).

Malnutrition impacts more than two billion individuals, and Asia and Africa are the most affected regions (Grew, 2018). Biofortification is an approach for improving the levels of vital ingredients, like vitamins, minerals, and proteins, in the edible portions of crops through conventional breeding, as well as biotechnological and genomics approaches (Bouis and Saltzman, 2017; Grag et al., 2018). While minerals and vitamins are commonly provided as dietary supplements, they are out of reach for most people living in the developing world (Hosseini-Nezhad and Holick, 2013; Ward, 2014). Biofortification is a one-time expense that provides a cost-effective, long-term, and sustainable method for combating concealed starvation (De Valença, 2017). Much of the population is dependent on cereals for their dietary requirements; therefore, the biofortification of cereals is essential. Wheat is globally traded more than any other crop, and it is the second most-produced cereal,

following maize (Curtis and Halford, 2014). Moreover, annual wheat production has almost tripled since the 1940s, and it is anticipated that this trend will continue, as the population continues to grow (Izumi, 2017). Biofortified wheat could help reduce starvation-related malnutrition, with which primarily low-income countries are faced (Shewry and Hey, 2015).

Many studies have shown that there is a wide variation in grain Fe and Zn concentrations in wild relatives of modern wheat and the concentrations found can significantly exceed those found in modern elite cultivars (Cakmak et al., 2000; Monasterio and Graham, 2000). This natural variation can be utilized to biofortify wheat for Fe and Zn, such as has been achieved using the transcription factor *NAM-B1* (Uauy et al., 2006) which was originally identified for increasing protein content in wild emmer (*Triticum turgidum* ssp. *dicoccoides*). In near isogenic lines the presence of *NAM-B1* increased Fe and Zn grain concentrations by 18 and 12%, respectively, (Distelfeld et al., 2007). This gene is being widely used in breeding programmes across several continents (Kumar et al., 2011; Randhawa et al., 2013; Tabbita et al., 2013). Nutritional quality traits (such as Zn and Fe) tend to be multigenic. Breeding strategies are therefore focusing on novel approaches to broaden the genetic base using wild relatives and landraces, and identifying genetic control and their effects (Cakmak et al., 2010). The biofortification breeding program at CIMMYT emphasizes the development of new spring bread wheat germplasm that combines wide adaptability, high yields, high grain Zn concentration, better processing quality, disease resistance, and stress tolerance.

Genetic biofortification : Genetic biofortification is a strategy that uses plant breeding techniques to produce staple food crops with higher micronutrient levels, reducing levels of anti-nutrients and increasing the levels of substances that promote nutrient absorption (Bouis, 2003). It offers a sustainable solution to malnutrition problems by exploring natural genetic variation to develop mineral-dense crop varieties (Pfeiffer and McClafferty, 2007). Plant breeders screen existing accessions in global germplasm banks to determine whether sufficient genetic variation exists to breed for a particular trait. They then selectively breed nutritious cultivars of major staples, rich in Zn and Fe concentrations and with substances that promote the bioavailability of Zn and Fe.

QTLs for the Grain Fe and Zn Concentrations in Wheat : Marker-assisted breeding is a potential strategy for the development of Fe- and Zn-biofortified wheat. Knowledge of the genetic basis of Fe and Zn concentrations is required for the successful application of MAS. Genes acting through one or more steps, e.g., root uptake,

translocation from root to shoot, storage and remobilization, may be reflected by the QTLs responsible for grain mineral concentrations. Various QTL mapping studies have allowed for the identification of many QTLs for both Fe and Zn. Shi et al. detected four and seven QTLs for the Zn concentration and Zn content, respectively. They suggested a possibility for improving both the grain Zn concentration and content simultaneously, because all four QTLs for the Zn concentration were co-located with the QTLs for the Zn content. The QTLs for the Zn concentration on chromosomes 4A and 4D and four QTLs for the grain Zn content on chromosome 2D, 3A and 4A were co-located with the QTLs for the P contents, indicating a possibility for simultaneously improving the grain Zn and P density in wheat.

Genetic biofortification is a strategy that uses plant breeding techniques to produce staple food crops with higher micronutrient levels and can be a feasible and cost effective means of delivering micronutrients to population that may have limited access to diverse diets. A convergent cross for combining gene(s) for high protein, high yellow pigment, high zinc and rust resistance was performed by Kaur et al., 2019 in wheat. This included crossing BC1F2 introgression lines of cross PBW698/BF22//PBW698 carrying grain zinc QTL introgressed from *Triticum monococcum* with high protein line BWL3560 having Gpc-B1. A set of 192 F3 lines were evaluated for agronomic and quality traits. Molecular marker analysis of F3 progenies for Gpc-B1 gene (Xucw108) revealed 129 F3 lines to be homozygous positive. The progenies showed the range of 8.96-13.92% for grain protein content, 25.1-36.3mg/Kg for grain iron concentration, 34.0-54.0 mg/Kg for grain zinc concentration and 2.01-4.57ppm for grain yellow pigment content compared to 9.65%, 26.7 mg/Kg, 42.9 mg/Kg and 3.74ppm respectively in recipient line PBW698. Therefore, this population constituted a useful material for identifying the nutritionally enhanced lines. (Kaur et al., 2019)

Biofortification for Grain Protein Content : Grain protein content (GPC) is among the important traits that contribute to the nutritional value, processing preference, quality of the end products (bread and pasta) and market value of both the hexaploid (*Triticum aestivum* L.) and durum (*T. turgidum* L. var. durum Desf.) wheat. Based on the extraction methods, grain proteins are grouped into four groups, albumins, globulins, prolamins, and glutelins. The economic value of the wheat grains rely on the GPC; therefore, improvement in GPC and alteration in the composition of storage proteins in wheat grain have been a significant objective in wheat breeding programs, particularly for those working toward raising the nutritional quality (Shewry, 2009). Attempts have been made by

Rice NRAMP (RAP locus ID)	Wheat homolog	Genome	Wheat sequence ^a
<i>OsNRAMP1</i> (Os07g0258400)	<i>TaNRAMP1</i>	A	7AL_4537662 (URGI) ^b
		B	7BL_8744498 (Ensembl)
		D	7DL_3317468 (Ensembl)
<i>OsNRAMP2</i> (Os03g0208500)	<i>TaNRAMP2</i>	A	4AS_5952279 (Ensembl)
		B	4BL_7000373 (Ensembl)
		D	4DL_14450878 (URGI)
<i>OsNRAMP3</i> (Os06g0676000)	<i>TaNRAMP3</i>	A	7AL_4392690 (Ensembl)
		B	7BL_8748183 (Ensembl)
		D	7DL_3360602 (Ensembl)
<i>OsNRAMP4</i> (Os02g0131800)	<i>TaNRAMP4</i>	A	6AS_4346871 (Ensembl)
		B	6BS_2318478 (Ensembl) ^c
		D	Absent
<i>OsNRAMP5</i> (Os07g0257200)	<i>TaNRAMP5</i>	A	4AS_5926812 (Ensembl)
		B	Across multiple contigs
		D	4DL_14404139 (URGI)
<i>OsNRAMP6</i> (Os01g0503400)	<i>TaNRAMP6</i>	A	Across multiple contigs
		B	Across multiple contigs
		D	Across multiple contigs
<i>OsNRAMP7</i> (Os12g0581600)	<i>TaNRAMP7</i>	A	5AS_1501999 (Ensembl) ^b
		B	5BS_2288821 (Ensembl)
		D	5DS_2787814 (Ensembl)
—	<i>TaNRAMP8</i>	A	4AL_7173573 (URGI)
		B	4BS_3944622 (Ensembl)
		D	4DS_2292562 (Ensembl)

^a International wheat genome sequencing consortium chromosome-arm survey sequences are available at EnsemblPlants (Ensembl; <http://plants.ensembl.org/index.html>) and at Unité de Recherche Génomique Info (URGI; <http://www.wheatgenome.org/Tools-and-Resources>)

^b partial sequence

^c premature termination codon

breeders for improvement in GPC using conventional breeding methods, but the desired outputs are not obtained. The reasons for this include (1) high influence of environment on GPC, (2) negative correlation between GPC and grain yield, and (3) quantitative genetic control of GPC and low heritability (Balyan *et al.*, 2013). The QTLs for GPC have been identified and mapped on almost all chromosomes of both tetraploid and hexaploid wheat. To our knowledge, for GPC a total of 325 main effect QTL have been reported so far using biparental populations (Table 1). Here, we listed the closely linked markers or marker intervals for the significant QTLs (PVE>10), which may be useful to introgress the target QTLs in elite lines (Table-1). Although major QTLs with a stable effect on GPC across environments are also identified, most of the identified major QTLs were found unstable across the environments.

Biofortification through wide hybridization and modern biotechnological approaches offers a cost effective and sustainable approach to biofortify cereal crops, for alleviation of micronutrient deficiency. Several

addition/substitution lines of group 2 and 7 chromosomes of related wild *Aegilops* species with high grain Fe and Zn content have been developed. Fine transfers of useful variability from related wild species into elite wheat cultivars have been achieved by induced homeologous pairing and radiation hybridization approach. Intron Targeted Amplified Polymorphic Primers (ITAP) have been developed and used for monitoring the fine transfers of selected metal homeostasis genes (YSL15, NRAMP5, IRT2, IRO3, NAM, NAAT1, NAS2, FRO2, and FRO7) from the donor *Aegilops* species. (Sheikh *et al.*, 2020)

Biofortification for the Anthocyanin Content : A marker-assisted backcross strategy was followed to produce a set of bread wheat near-isogenic lines (NILs), carrying various combinations of *Pp* alleles, such as *Pp3* (chr. 2A), *Pp-A1* (7A) and *Pp-D1* (7D) (Gordeeva *et al.*, 2015). Based on a qRT-PCR-based study, the authors suggested that the *Pp* genes up-regulate the transcription of anthocyanin synthesis-related structural genes [*Chi* (chalcone-flavanone isomerase) and *F3h* (flavanone 3-hydroxylase)] in contrasting ways.

In 2016, Liu *et al.* compared the transcriptomes of purple and white pericarps in common wheat and reported significant differential expression of a total of 23,642 unigenes (9945 up-regulated and 13,697 down-regulated). The analysis found that three unigenes of the *MYB* gene on the long arm of chromosome 7B and three unigenes of *MYC* on the long arm of chromosome 2A are candidate genes for the purple grain trait. Further, they also observed a higher expression level of *TaMYC1* in purple wheat grains, compared to white (amber) wheat grains.

Biofortification for grain selenium content : Selenium (Se), an essential mineral element, incorporates into proteins to make seleno-proteins, which plays a critical role in human health. These seleno- proteins are necessary antioxidant enzymes that prevent cellular damage from free radicals resulting in the prevention of chronic diseases, such as cancer and heart disease (Zhao *et al.*, 2016). The Se-density in wheat grain was about 16µg kg⁻¹ which is insufficient to meet the Se requirement for human (Tveitnes *et al.*, 1995). In 2005, Lyons *et al.* (Lyons *et al.*, 2005), surveyed 665 ancestral and wild relatives of wheat, wheat landrace accessions, populations, and commercial cultivars grown in Mexico and Australia for Se concentration in grain. They found grain Se concentrations in the range of 5–720 gkg⁻¹, but unfortunately, much of this variation was correlated with spatial variation in soil selenium and, no significant genotypic variation in grain Se density was observed. Although, 42% and 35% higher grain Se concentration was found in *Aegilops tauschii* and rye, respectively.

Applying Transgenic Approaches to Wheat : Using knowledge from model species, it is possible now to identify more rapidly and with higher confidence candidate genes that might play a role in Fe and Zn transport. Access to relatively complete genomic sequence for polyploid wheat will allow more comprehensive phylogenetic studies for putative wheat homologs of large gene families. For example we have used the sequences of the rice natural resistance-associated macrophage proteins (NRAMPs) to identify wheat homologs (Table 1). Wheat candidate genes with putative Fe and Zn transporter function inferred from phylogeny, can be taken forward and characterized in yeast mutants, with a view eventually to expressing these in transgenic wheat plants to increase vacuolar export and ultimately nutrient content in the grain.

Conclusions

There is very compelling global human health and nutritional evidence to convince plant breeders that micronutrient density traits should be primary objectives in

their work targeted to the developing world. Furthermore, doing so should also improve crop productivity when micronutrient-dense seeds and grains are planted to micronutrient-poor soils, thus ensuring farmer adoption of the micronutrient-enriched seeds once they are developed.

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Quality and Profitability of Garden Pea Influenced by Plant Growth Regulators

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Abstract

A field experiment was conducted during winter season 2017-2018 to study the effect of different plant growth regulators (Salicylic acid, NAA and GA₃) on quality and profitability of garden pea. The plant growth regulators were applied as foliar application at 30, 45 and 90 days after sowing. The foliar spraying of GA₃ @ 120 recorded the maximum total soluble solid (16.29 °brix), protein content (18.56%) and the application of NAA @ 40 ppm observed highest pod yield per plant (64.49 g), gross returns (392975.00 Rs/ha), net returns (327580.00 Rs/ha) and benefit cost ratio (5.01:1). These results are conclusive that foliar spraying GA₃ @ 120 and NAA @ 40 ppm may positively increase the quality and profitability of garden pea.

Key words : Garden pea, plant growth regulators, salicylic acid, GA₃ and NAA.

Introduction

Garden pea (*Pisum sativum* var. *hortense* L.) is a major vegetable crop produced for fresh market and canning all over the world. It contains highest percentage of digestible protein, carbs, minerals and vitamins. Commercially, it is planted as a winter crop in the northern Indian plains and it is a prominent off-season vegetable crop in India's north western Himalayan region (Sharma *et al.* 2014).

The leading garden pea producing states are Uttar Pradesh, West Bengal, Madhya Pradesh, Bihar and Gujarat. Garden pea is considered as one of the most important sources of nutrition throughout the world which contains high amount of digestible protein and carbohydrates (Hussein *et al.*, 2006).

Garden peas are rich in proteins (5.4 g/100 g), carbohydrates (14.5 g/100 g), fibre (5.1 g/100 g), sugar (6 g/100 g), sodium (5 g/100 g), potassium (242/100 g), iron (1.5 mg/100 g), vitamin A (36 µg/100 g), vitamin C (40 mg/100 g), zinc (1.2 mg/100 g), and other minerals (Bhat *et al.*, 2013 and Dhall, 2017).

The plant growth regulators (PGRs) play an important role in the cultivation of garden pea because their low quantity stimulates or quantitatively change the growth and development of crop.

Gibberellic acid (GA) is a plant growth hormone that is considered the most important biologically active

regulating plant stem in higher plants. It promotes bolting and flowering by stimulating both cell division and elongation, increasing cell wall extensibility and stimulating cell division and elongation (Verma and Verma 2010).

The application of NAA stimulates cell expansion and proliferation through enhancing DNA synthesis in the cell. The plant's juvenile stage was decreased as a result of increased photosynthesis and respiration, as well as increased CO₂ fixation (Murugan *et al.*, 2020).

Salicylic acid (SA) is a phenolic reactive compound, messenger or signalling molecule and growth regulator that stimulates plant growth and performance under various stresses. It promotes plants in responding with a variety of stresses by increasing antioxidant capacity and decreasing ROS overproduction. It also plays an essential role in regulating plant physiology and biochemistry (Choudhary *et al.*, 2016).

The aim of this experiment is to find an optimal concentration of PGRs to use as a foliar spray to improve quality and profitability of garden pea.

Materials and Methods

The experiment was conducted at Vegetable Research Farm, Institute of Agricultural Sciences, B.H.U., Varanasi (Uttar Pradesh) during the winter season 2017- 2018, to find out the role of foliar application of Salicylic acid @ 100,

Table-1 : Effect of plant growth regulators (GA₃, NAA and SA) on yield/plant, TSS and protein content.

Treatments	Yield per plant (g)	TSS (°Brix)	Protein content (%)
T ₁	40.22	13.17	16.30
T ₂	50.61	14.11	17.10
T ₃	51.53	14.10	17.30
T ₄	52.56	14.37	16.80
T ₅	57.43	14.39	17.20
T ₆	60.61	14.59	17.40
T ₇	64.49	14.79	17.80
T ₈	53.36	14.84	17.50
T ₉	55.33	15.50	18.30
T ₁₀	57.1	16.29	18.56
SEm	1.62	0.32	0.45
CD	4.82	0.96	0.65

Table-2 : Effect of plant growth regulators (GA₃, NAA and SA) on total cost of cultivation, gross returns, net returns and benefit-cost ratio.

Treatment	Total cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T ₁	65180	245100	179920	2.76
T ₂	65255	308375	243120	3.73
T ₃	65292	314025	248733	3.81
T ₄	65330	320300	254970	3.9
T ₅	65287.5	349975	284688	4.36
T ₆	65341.3	369350	304009	4.65
T ₇	65395	392975	327580	5.01
T ₈	68780	325175	256395	3.73
T ₉	72380	337150	264770	3.66
T ₁₀	75980	347925	271945	3.58

T₁ – distilled water, T₂ - Salicylic acid @ 100 ppm, T₃ - Salicylic acid @ 150, T₄ - Salicylic acid @ 200 ppm, T₅ - NAA @ 20 ppm, T₆ - NAA @ 30 ppm, T₇ - NAA @ 40 ppm, T₈ - GA₃ @ 40 ppm, T₉ - GA₃ @ 80 ppm and T₁₀ - GA₃ @ 120 ppm at 30, 45 and 90 days after sowing.

150 and 200 ppm, NAA @ 20, 30, and 40 ppm and GA₃ @ 40, 80 and 120 ppm on garden pea plant (*Pisum sativum* L.). The experimental area is located at 25°31'N latitude and 83°03'E longitude and 123.23 meters above from sea level. The climate of research area is tropical and subtropical with maximum variation in the summer and winter temperature. The soil of research trail was light sandy loam with pH value of 6.5, available nitrogen (227 kg ha⁻¹), available phosphorus (19.6 kg ha⁻¹) and potassium (202 kg ha⁻¹). The experiment was laid out in a randomized block design (RBD) with three replications and 10 treatments combination such as T₁ – distilled water, T₂ - Salicylic acid @ 100 ppm, T₃ - Salicylic acid @ 150, T₄ - Salicylic acid @ 200 ppm, T₅ - NAA @ 20 ppm, T₆ - NAA @ 30 ppm, T₇ - NAA @ 40 ppm, T₈ - GA₃ @ 40 ppm, T₉ - GA₃ @ 80 ppm and T₁₀ - GA₃ @ 120 ppm at 30, 45 and 90 days after sowing. The seed of the garden pea cultivar Azad pea-3 was purchased from the Indian Institute of Vegetable Research in Varanasi (ICAR-IIVR). Before to

planting, the research area was ploughing, well levelled and each plot given the appropriate amount of fertilizer. The seed of crop is planted through the dibbling method in well-prepared raised beds (4 X 3 m) at a depth of 4-5 cm and distance between row to row and plant to plant (30 X 10 cm).

The observations was recorded on TSS content of pods were evaluated and expressed as degrees Brix' and the amount of protein in garden pea (Lowry *et al.*, 1951) was calculated in per cent. Yield per plant were also recorded after harvesting of pod through digital weighting machine and economic feasibility were also recorded. The data obtained from various parameters during experiment were analyzed by the method of analysis of variance as described by (Gomez and Gomez, 1984).

Result and Discussion

Quality attributes : The total soluble solid and protein content was significantly affected by foliar application of

plant growth regulators (Table-1). The foliar application of GA₃ @ 120 exhibited 23.69% and 13.86% increase in maximum total soluble solid and protein content of garden pea as compared to untreated plant, respectively. The maximum total soluble solid and protein content was observed in the treatment T₁₀ which was (16.29 °brix and 18.56 %) and it was observed significantly superior over other treatment followed by T₉ (15.50 °brix and 18.30 %). This could be due to the application of plant growth regulators (GA₃) that stimulated and enhanced enzymatic activities through its effect on natural hormones that accelerated plant growth and development. The results are in agreement with Mishriky *et al.* (1990) in peas, Kaur *et al.* (2000) in chickpea, Tavelu *et al.* in pea (2018).

Yield : The application of T₇ treatment recorded highest yield per plant (64.49 g), followed by T₆ (60.61 g) and T₅ (57.43 g). The treatment T₇ found a 1.12-fold greater response as compared to T₅ and T₁₀ showed a 1.07-fold better response as over to T₈ treatment. The treatment T₄ showed a 1.03-fold better response as compared to T₂ treatment. Minimum pod yield per plant (40.42 g) was observed in control plot (Table-1).

The increase in yield per plant by the application of NAA might be attributed to the greater mobilization of metabolites from source (leaves) to sink (pods) and it was able to divert more flow of assimilates towards the developing seeds and resulted in the increase in seed size over the untreated plants (Kalita *et al.*, 1995). Similar finding were also reported by Mohandoss and Rajesh (2003) and Thaware *et al.*, (2006) in green gram and Singh *et al.*, (2015) in pea.

Economics : The data related to economics have been presented in Table 2. The cost of cultivation of garden pea varied from Rs. 65180 to Rs.75980 per ha. The maximum cost of cultivation was observed with treatment T₁₀ and minimum at T₁ treatment. The maximum gross return was found Rs.392975 with treatment T₇ and minimum (Rs. 245100) was observed in control. The foliar application of NAA @ 40 ppm recorded maximum net return and B:C ratio (Rs. 327580 and 5.01, respectively) followed by treatment T₆ (NAA @ 30 ppm) and T₅ (NAA @ 20 ppm) over control. The increase in the value of gross returns, net returns and benefit cost ratio at T₇ treatment could be attributed to higher yield due to foliar application of optimum amount of plant growth regulators at different intervals.

Conclusions

Based on experiment, it may conclude that application of GA₃ @ 120 ppm and NAA @ 40 ppm provide improved quality with acceptable profit in garden pea.

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The Level of Knowledge and Adoption of the Respondents about Recommended Sugarcane Production Technology in Chittorgarh District of Rajasthan

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Abstract

The present investigation was conducted in Chittorgarh district of Rajasthan. Two tehsils Chittorgarh and Kapasan was selected. From each tehsil, five villages were selected. 12 respondents from each of village were selected thus making a sample of 120 respondents. Sugarcane production in Rajasthan: The annual yield of sugarcane across Rajasthan in India amounted to about 71 thousand kilograms per hectare in the fiscal year 2017. The yield of sugarcane produced across India was approximately 69 thousand kilograms per hectare that year. It is the largest sugarcane producing state in India. Uttar Pradesh is an important name in the production of various crops, including sugarcane production. Up's districts known for sugarcane production is Meerut, Bareilly, Saharanpur, and Bulandshahr. Sugarcane is the most important cash crop. India rank first both in respect of area and total Production among the sugarcane growing countries of the world. Even if, there is tremendous opportunity of making further progress in relation to increase the sugarcane production by way of adoption of modern technology in sugarcane cultivation. The adoption of improved technology of sugarcane by the farmers is not uniform due to several reasons. Hence, this study is being undertaken to identify the various factors in relation to adoption of improved agriculture technology for sugarcane cultivation.

Cultivation of sugarcane is very popular due to non-availability of sugar & high price of sugar. The various extension agencies are continuously making efforts to create awareness among the farmers about cultivation of sugarcane. Govt. Institute, Non Govt. Organization, Private agencies and Krishi Vigyan Kendra are playing major role for promoting the cultivation of sugarcane and conducting Training programme, Exhibition, Kisan Mela, Sangosthi and other Programme for dissemination of information about cultivation of sugarcane with low cost and respondents safe condition. Majority of the respondents (60.83%) had medium knowledge level regarding improved sugarcane cultivation technology while 17.50 and 21.67 per cent respondents possessed low and high knowledge level, respectively. The findings of the study indicated that majority of sugarcane growers had adequate knowledge regarding irrigation management followed by harvesting, soil treatment and weed management and seed rate & recommended method of sowing, whereas they had less knowledge regarding Use of high yielding varieties, Time of sowing and Plant protection measures.

Key word : investigation, respondents, cultivation, knowledge, weeds management.

Introduction

Sugarcane (*Saccharum officinarum*) is an important agro-industrial crop in India, occupying 4.0-million-hectare area. Sugarcane belongs to the grass family (Poaceae), an economically important seed plant family that includes maize, wheat, rice, and sorghum and many forage crops. The main product of sugarcane is sucrose, which accumulates in the stalk internodes. Sucrose, extracted and purified in specialized mill factories, is used as raw material in human food industries or is fermented to produce ethanol. Ethanol is produced on a large scale by the Brazilian sugarcane industry.

Sugarcane is the main source of sugar in Asia and Europe. Sugarcane is grown primarily in the tropical and sub-tropical zones of the southern hemisphere. Sugarcane is the raw material for the production of white

sugar, jaggery (gur) and khandsari. It is also used for chewing and extraction of juice for beverage purpose.

Sugarcane (*Saccharum officinarum* L.) belongs to the Graminae family and Saccharum genus. Saccharum genus mainly comprises five species in which three are cultivated and two are wild species. Origin of the sugarcane is New Guinea. Sugarcane is one of the oldest commercial crop viable in tropics and sub-tropics of the world. Sugarcane is a ratoonable crop which can raise 5-6 ratoons before next cultivation. Number of ratoons can vary with different climatic conditions and agronomic practices.

Geographically, Rajasthan is well suited for growing sugarcane. In Rajasthan, it occupies an area of 0.07 lakh hectares with a total production of 4.89 lakh tonnes resulting an average productivity of 69.9 tonnes/ha during 2016-17 (Anonymous, 2016-17). In Rajasthan, sugarcane

in colder temperate regions of the world. Other than sugar, products derived from sugarcane include falernum, molasses, rum, cachaça (a traditional spirit from Brazil), bagasse and ethanol. In some regions, people use sugarcane needs to make pens, mats, screens, and thatch. The young unexpanded inflorescence of tebu telor is eaten raw, steamed or toasted, and prepared in various ways in certain island communities of Indonesia.

Research Methodology

To determine the extent of knowledge, mean per cent score for each practice was worked out and ranked accordingly. The knowledge gap was measured in terms of percentage by subtracting per cent mean score of each practice from 100.

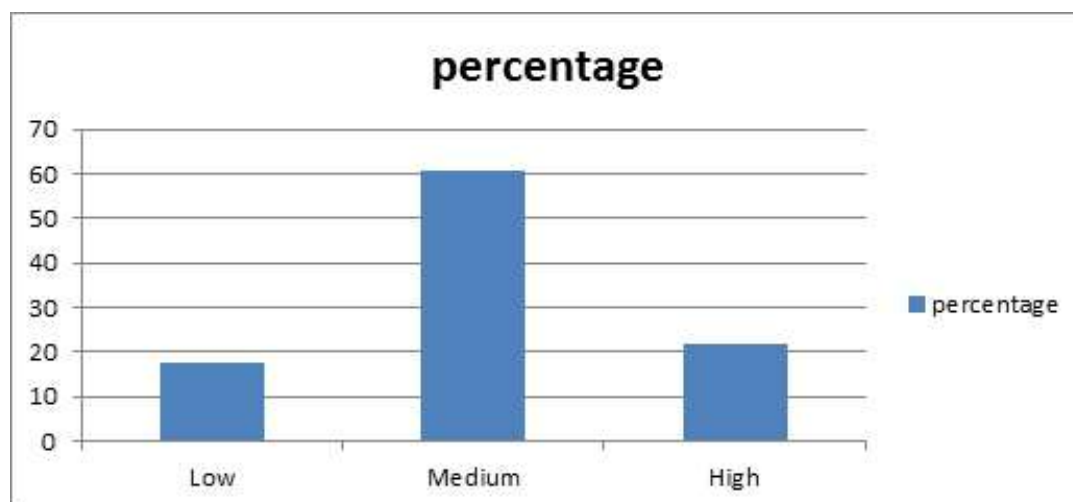
To determine the extent of adoption, mean per cent score for each practice was worked out and ranked accordingly. The adoption gap was measured in terms of percentage by subtracting mean per cent score of each practice from 100.



Fig. : Study area in Chittorgarh.

Table-1 : Distribution of respondents on the basis of level of knowledge about recommended production technology of sugarcane.

Knowledge level	Frequency	Percentage
Low (12-14)	21	17.50
Medium (15-16)	73	60.83
High (17-18)	26	21.67
Total	120	100.00

**Figure-1 : Distribution of respondents on the basis of level of knowledge about-recommended production technology of sugarcane.**

To find out the relationship between personal attributes viz. age, education, land holding, family size and family type with extent of adoption of improved sugarcane production technology. To know the relation of selected characteristics of the respondents with level of adoption Spearman's rank order of correlation co-efficient test was used, to test for the significance of the correlation co-efficient 't' test was used at 5 and 1 per cent level of significance to draw the inferences.

Results and Discussion

Knowledge level of farmers about production technology of sugarcane : Under this section, it was tried to find out the level of knowledge of farmers about recommended production technology of sugarcane. Knowledge as a body of understood information possessed by an individual is one of the important components of behavior and plays an important role in adoption of an innovation. Keeping this view in mind, the level of knowledge of farmers about recommended production technology of sugarcane was assessed. The results are presented in subsequent tables.

Distribution of respondents according to their knowledge about recommended production technology of sugarcane : The data in Table-1 shows that out of 120 respondents, majority of respondents 60.83 per cent fell in medium level knowledge group whereas 17.50 per cent sugarcane growers were

observed in low level knowledge group and remaining 21.67 per cent respondents possessed high level of knowledge about recommended production technology of sugarcane.

Table-1 reveals that majority of the respondents 60.83 per cent fell in the medium knowledge group, whereas 21.67 per cent respondents were observed in the high knowledge group and remaining 17.50 per cent respondents formed low knowledge group. It is concluded that majority of farmers were having medium level of knowledge followed by high and low knowledge level, respectively.

The knowledge of the respondents was measured into eleven major practices which have been given in the table 1.2. Individual practice-wise knowledge of wheat growers was also worked out. For this, mean percent scores were calculated and the findings about the same have been presented table-2.

In overall, it has found that first rank is given to irrigation management with MPS 88.23, followed by harvesting with MPS 86.32, soil treatment with MPS 75.98, weed management with MPS 74.78 and were ranked second, third and fourth respectively. It indicates that sugarcane growers knew very well about harvesting, soil treatment and weed management. Whereas less knowledge regarding Plant protection measures with MPS 66.12, Time of sowing with MPS 62.75 and Use of high yielding varieties with MPS 62.10.

Table-2 : Extent of knowledge of farmers about recommended production technology of sugarcane.

N=120

S. No.	Aspects/ Practices	Total respondents	
		MPS	RANK
1.	Use of high yielding varieties	62.10	XI
2.	Soil and field preparation	72.17	VII
3.	Soil treatment	75.98	III
4.	Seed treatment	73.86	VI
5.	Time of sowing	62.75	X
6.	Shoots with 3 buds setts & recommended method of sowing	74.34	V
7.	Fertilizer application	71.28	VIII
8.	Irrigation management	88.23	I
9.	Weed management	74.78	IV
10.	Plant protection measures	66.12	IX
11.	Harvesting	86.32	II

MPS = Mean Percent Score

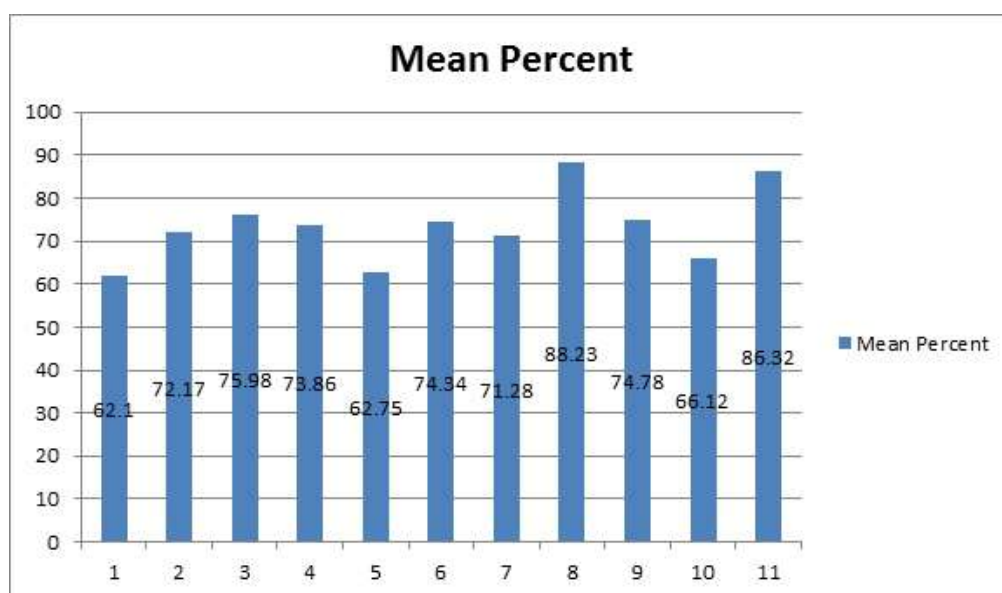


Figure-2 : Extent of knowledge about improved wheat cultivation technology.

1. Use of high yielding varieties	6. Seed rate & recommended method of sowing	11. Harvesting
2. Soil and Field preparation	7. Fertilizer application	
3. Soil treatments	8. Irrigation management	
4. Seed treatments	9. Weed management	
5. Time of sowing	10. Plant protection measures	

Conclusions

Majority of respondents i.e. 57.50 per cent of the total respondents were in the medium level of adoption group, whereas 14.17 per cent respondents were in low adoption group and remaining 28.33 per cent sugarcane growers were observed in the category of high level of adoption about sugarcane production technology. Majority of respondents have medium level of adoption group, knowledge about recommended sugarcane production technology. Followed by low adoption group about

sugarcane production technology. Education from significant association with knowledge and adoption.

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Response of Inorganic Fertilizers and FYM on Soil Health of Cluster Bean (*Cyamopsis tetragonoloba* L.) Cv. Pusa Navbahar

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Abstract

An experiment was conducted to study "Response of Inorganic Fertilizers and FYM on Soil Health of Cluster Bean (*Cyamopsis tetragonoloba* L.) Cv. Pusa Navbahar" during Kharif (July- October) 2016-17. The design applied for statistical analysis was carried out with 3x3 factorial randomized block design having three factors with three levels of NPK @ 0, 50, and 100 % ha⁻¹, three levels of FYM @ 0, 50 and 100% ha⁻¹ respectively. The best treatment was T₈ - [L₂ F₂] (@ 100% NPK ha⁻¹ + 100% FYM ha⁻¹) has effect on physical and chemical property of soil of cluster bean. The observed in post-harvest soil resulted were significantly increased maximum values of % pore space (47.12%), organic carbon (0.39%), nitrogen (328.47 kg ha⁻¹), phosphorus (38.05 kg ha⁻¹) and potassium (235.05 kg ha⁻¹) was with treatment T₈ - (@ 100% NPK ha⁻¹ + 100% FYM ha⁻¹). The combination of T₈ - (@ 100% NPK ha⁻¹ + 100% FYM ha⁻¹) showed slight decrease in pH (7.05), EC (0.23 dsm⁻¹) bulk density (1.07 Mgm⁻³), and particle density (2.21 Mgm⁻³).

Key words : Soil nutrients, yield attributes, FYM, NPK and cluster bean.

Introduction

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] popularly known as guar is an important legume crop mainly grown under rainfed condition in arid and semi-arid regions of Rajasthan during kharif season. It is very hardy and drought tolerant crop. Its deep penetrating roots enable the plant to utilize available moisture more efficiently and thus offer better scope for rainfed cropping. The crop also survives even at moderate salinity and alkalinity conditions. There is no other legume crop so hardy and drought tolerant as cluster bean, which is especially suited for soil and climate of Rajasthan. (Kherawat *et al.*, 2013)

Nitrogen : Nitrogen also plays an important role in synthesis of chlorophyll and amino acid, which contributes to the building units of protein and thus the growth of plants. Insufficient nitrogen may reduce yield drastically and deteriorates the quality of produce. Cluster bean being a legume crop which has the capacity to fix atmospheric nitrogen by its effective root nodules the major part of nitrogen is met through *rhizobium* present in the root nodules hence, crop does not require additional nitrogen for its initial growth and development stage. The nitrogen application increased crude protein, crude fibre contents, ash percentage, carbohydrates, leaf area per plant, dry matter and green fodder yield of cluster bean cultivars (Ayub *et al.* 2010).

Phosphorus : Phosphorus is the second most important

nutrient that must be added to the soil to maintain plant growth and sustain crop yield (Singh *et al.* 2000). Phosphorus plays a vital role in photosynthesis, respiration, energy storage, cell elongation and improves the quality of crops. Deficient plants may have thin, erect and spindly stems and leaves turn into bluish-green colour. Phosphorus is an essential constituent of majority of enzymes, which are of great importance in the transformation of energy, in carbohydrate metabolism, in fat metabolism and also in respiration of plants. It stimulates early root development and growth and thereby helps to establish seedlings quickly. Large quantities of phosphorus are found in seed and fruit and it is considered essential for seed formation. Thus, it helps in fixing more of atmosphere nitrogen in root nodules. Hand book of Agriculture by ICAR, (2010).

Potassium : The potassium is the 3rd most important essential nutrient after nitrogen and phosphorus. The potassium activates more than 60 enzymes and enzymatically catalyzes the system involved in photosynthesis, metabolism and translocation of carbohydrates and proteins, membrane permeability, stomata regulation and water utilization. Other benefits ascribed to K include resistance of plants against pests, disease and stresses caused by drought, frost, salinity, sodicity and in assuring improved crop quality characteristics. (Kherawat *et al.*, 2013).

Farm Yard Manure : The organic manure like FYM is the oldest and cheapest source of nutrient being popular from

the ancient times. Application of FYM on field enrich the soil fertility is an old practice unlike chemical fertilizers which contain only one, two or three plant nutrients. FYM seems to act directly for increasing the crop yields either by acceleration of respiratory process with increasing cell permeability and hormonal growth action or by combination of all these processes. FYM provides plants both macro and micronutrients. It supplies nitrogen, phosphorus, potassium and micronutrients like Fe, S, Mo, Zn etc. in available form to the plants through biological decomposition and improves physical-chemical properties of soil such as aggregation, aeration, permeability, water holding capacity, slow release of nutrients, increasing in cation exchange capacity, stimulation of soil flora and fauna etc. A well decomposed FYM contains 0.5%N, 0.2%P₂O₅ and 0.5% K₂O. Hand book of Agriculture by ICAR, (2010).

Materials and Methods

A field experiment was conducted on research farm of department of Soil Science and Agricultural Chemistry SHUATS Allahabad, (U.P.) India. The soil of experimental area falls in order Inceptisol and the experimental field is alluvial in nature. The design applied for statistical analysis was carried out with 3x3 randomized block design having three factors with three levels of N: P: K, @ 0, 50, and 100 %.three levels of FYM 0, 50 and 100 %.respectively. The source of N: P: K as Urea, SSP, MOP, and FYM respectively.

Treatment details

Table-1 : Treatment combination of different levels of NPK and FYM for cluster bean.

Treatment	Treatment Combination	Symbol
T ₀	Control	L ₀ F ₀
T ₁	@N ₀ P ₀ K ₀ Kg ha ⁻¹ + FYM @ 5 t ha ⁻¹	L ₀ F ₁
T ₂	@N ₀ P ₀ K ₀ Kg ha ⁻¹ + FYM@ 10 t ha ⁻¹	L ₀ F ₂
T ₃	@N ₁₀ P ₂₀ K ₂₀ Kg ha ⁻¹ + FYM @ 0 t ha ⁻¹	L ₁ F ₀
T ₄	@N ₁₀ P ₂₀ K ₂₀ Kg ha ⁻¹ + F YM @ 5 t ha ⁻¹	L ₁ F ₁
T ₅	@N ₁₀ P ₂₀ K ₂₀ Kg ha ⁻¹ + FYM@ 10 t ha ⁻¹	L ₁ F ₂
T ₆	@N ₂₀ P ₄₀ K ₄₀ Kg ha ⁻¹ + FYM@ 0 t ha ⁻¹	L ₂ F ₀
T ₇	@N ₂₀ P ₄₀ K ₄₀ Kg ha ⁻¹ + FYM @ 5 t ha ⁻¹	L ₂ F ₁
T ₈	@N ₂₀ P ₄₀ K ₄₀ Kg ha ⁻¹ + FYM @ 10 t ha ⁻¹	L ₂ F ₂

Physical and chemical analysis of soil : The physical and chemical analysis of pre sowing and using standard procedures for soil analysis as described following table-2.

Results and Discussions

In Table-3 shows the interaction Response of different levels of N P K and FYM are generally influenced physico-chemical properties of post-harvest soil.

Physical properties : Interaction between N P K fertilizer

in conjunction with FYM on bulk density and particle density which was found to be significant. The maximum bulk density was recorded 1.27 (Mgm⁻³) and particle density 2.77 (Mgm⁻³) in treatment T₀ (control). Similar findings were recorded by Verma and Baigh., (2012), Kumar *et al.*, (2008), Reddy *et al.*, (2005), Gupta *et al.*, (2000).

The table-3 shows the interaction between NPK fertilizers in conjunction with FYM on % pore space in soil was non-significant. The maximum % pore space was recorded 47.12 % in treatment T₀₈ (N₂₀P₄₀K₄₀+ FYM@10 tha⁻¹) which was non significantly higher than any other treatment combinations. Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure. Similar findings were recorded by Kumar *et al.*, (2008), Reddy *et al.*, (2005).

Chemical Properties : The table-4 shows the interaction between NPK fertilizers in conjunction with FYM on EC and pH of the soil was significantly. Both EC and pH of the soil was recorded maximum 0.41 dSm⁻¹ and 7.27, respectively in treatment T₀(control). Similar findings were recorded by Takase *et al.*, (2011), Kumar., (2008) and Gupta *et al.*, (2000).

The table-3 shows the interaction between N P K fertilizers in conjunction with FYM on soil pH was non significantly. The maximum soil pH was recorded treatment T₀ (control) Similar findings were recorded by Verma and Baigh., (2012), Takase *et al.*, (2011).

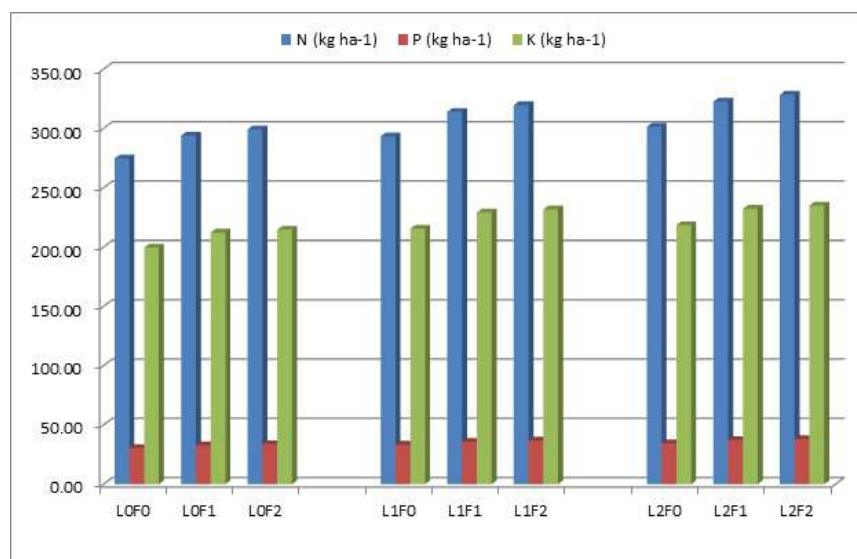
The table-2 shows the interaction between N P K fertilizers in conjunction with FYM on the % organic carbon, available nitrogen and available potassium in soil was non significantly. The maximum % organic carbon, available nitrogen and available potassium was recorded 0.39 %, 328.47 (Kg ha⁻¹) and 235.08 (Kg ha⁻¹) respectively, in treatment T₀₈ (N₂₀P₄₀K₄₀+ FYM@10 tha⁻¹) which was significantly higher than any other treatment combinations. Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure. Similar findings were recorded by Verma and Baigh, (2012), Kumar *et al.*, (2008) and Reddy *et al.*, (2005)

The table-2 shows the interaction between NPK fertilizers in conjunction with FYM on available phosphorus in soil which significant. The maximum available phosphorus was recorded 38.05 (Kg ha⁻¹) in treatment T₀₈ (N₂₀P₄₀K₄₀+ FYM@10 tha⁻¹) which was significantly higher than any other treatment combinations. Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure.

Table-2 : Physical and chemical analysis of soil before sowing of cluster bean.

Parameters	Method employed	Result
Bulk density (Mgm^{-3})	Black, (1965)	1.14
Particle density (Mgm^{-3})	Black, (1965)	2.52
Pore Space (%); 8	Black, (1965)	38.26
Soil pH (1:2)	Jackson (1958)	7.6
Soil EC (dSm^{-1})	Wilcox (1950)	0.26
Organic Carbon (%)	Walkley and Black's (1947)	0.48
Available Nitrogen (Kg ha^{-1})	Subbaih and Asija (1956)	236.81
Available Phosphorus (Kg ha^{-1})	Olsen et al (1954)	20.92
Available Potassium (Kg ha^{-1})	Toth and Prince (1949)	127.86

Treatment combination	BD (Mgm^{-3})	PD (Mgm^{-3})	Pore space (%)	pH (1:2 w/v)	EC (dSm^{-1})	OC (%)	N (kg ha^{-1})	P ₂ O ₅ (kg ha^{-1})	K ₂ O ₅ (kg ha^{-1})
L ₀ F ₀	1.27	2.77	34.97	7.27	0.41	0.25	274.75	30.48	199.57
L ₀ F ₁	1.19	2.60	39.69	7.20	0.35	0.30	293.95	32.84	212.18
L ₀ F ₂	1.17	2.46	41.28	7.16	0.32	0.31	299.29	33.67	214.69
L ₁ F ₀	1.18	2.60	38.79	7.24	0.33	0.29	293.43	33.23	215.47
L ₁ F ₁	1.11	2.44	44.03	7.17	0.28	0.35	313.93	35.81	229.08
L ₁ F ₂	1.09	2.30	45.79	7.13	0.26	0.36	319.64	36.71	231.80
L ₂ F ₀	1.16	2.50	39.91	7.16	0.30	0.31	301.54	34.45	218.52
L ₂ F ₁	1.09	2.34	45.30	7.09	0.25	0.37	322.61	37.12	232.33
L ₂ F ₂	1.07	2.21	47.12	7.05	0.23	0.39	328.47	38.05	235.08
F-test	S	S	NS	NS	S	NS	NS	S	NS
SEm+	0.02	0.10	1.95	0.34	0.02	0.03	11.34	0.90	8.08
CD (P=0.05)	0.06	0.28	5.57	0.98	0.05	0.09	32.42	2.56	23.09

Fig.-1 : Response of different levels of N P K (kg ha^{-1}) in post harvest soil.

Similar findings were recorded by Kumar *et al.*, (2008) and Reddy *et al.*, (2005).

Conclusions

The best treatment was T₈ – [L₂ F₂] (@ 100% NPK ha^{-1} + 100% FYM ha^{-1}) has effect on physical and chemical property of soil of cluster bean.

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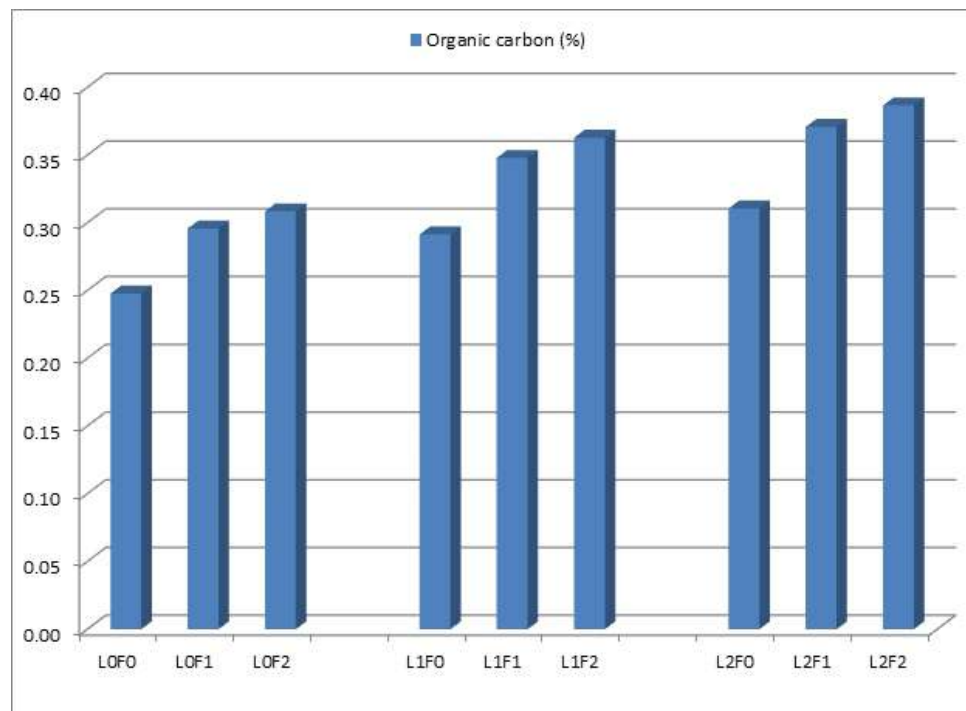


Fig-2 : Response of different levels of N P K and FYM on Organic carbon (%) in post harvest soil.

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Influence of Mulching on Plant Growth of *Khirni* and Soil Nutrient Status

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Abstract

An experiment was conducted during the year 2019-2020, at the Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar for the study of effect of different mulch treatments on plant growth and soil nutrient status of *Khirni*. Among different thickness of mulch treatments, application of T₆- 12 cm thickness of dry grass to individual plant was found significantly superior over all other treatments, but it was found at par with T₅ treatment (10 cm thickness of dry grass). In treatment T₆ the increase in plant height (32.61%) was recorded at the time of final observation during February. In respect to soil nutrient status also T₆ treatment (12 cm thickness of dry grass) also recorded comparatively better effect over other treatments. However, T₅ treatment (10 cm thickness of dry grass) was noted at par with T₆ treatment (12 cm thickness of dry grass). In this treatment (T₅) all soil parameters like soil pH (7.13), electrical conductivity (0.44 dSm⁻¹), organic carbon (0.52%), available N (289 kg ha⁻¹), available P (29 kg ha⁻¹), available K (342 kg ha⁻¹), water holding capacity (48%), bulk density (1.32 Mg m⁻³), particle density (2.63 Mg m⁻³), porosity (46.80%) and soil temperature (18.25°C) were recorded better nearing T₆ treatment (at par) at the time of final observation during February. Overall, the treatment T₆ was found better as far as its impact on plant growth of *Khirni* plant besides soil parameters which formed part of the study.

Key words : *Khirni*, *thar rituraj*, mulching, growth, soil nutrient status.

Introduction

Khirni (*Manilkara hexandra* Roxb.) is one of the important underutilized fruit crops of tropical and sub-tropical region of India. It belongs to the family Sapotaceae or mahua family with a somatic chromosome number, 2n= 26. It is also known as *Rayan*. *Khirni* is a native of tropical south-east Asia. It occurs naturally in forests and common lands particularly in Central and Deccan peninsular India. *Khirni* is a hardy plant and performs well in wide range of soil. It is generally grown on degraded land soil having poor fertility status and low water holding capacity. It can tolerate extreme hot during summer and extreme cold during winter. The individual fruit of *khirni* weighs about 1.76g - 4.44g. Fruit contains (82.12 to 90.33%) pulp and TSS (24 to 25 °Brix). Ripen fruit has good nutritive value, which contains 68.61g water, 0.48g protein, 2.42g fat, 27.74g carbohydrates, 0.75% minerals, 83mg calcium, 17mg phosphorous, 0.92mg iron, 675IU carotene, 0.07mg thiamine, 0.077mg riboflavin, 0.66mg niacin and 15.67mg vitamin C per 100g of pulp. *Khirni* is generally propagated by seed. It is extensively used as a rootstock since it has been found to be the most promising among various rootstock used for sapota propagation. However, poor germination, short viability and slow growth of seedling are

major problem in *Khirni* thereby limiting its rapid multiplication (Shukla and Kumar 2009). Being sweeter in taste, pulpy, juicy in texture and appealing in lusture, *Khirni* is liked by people. During summer the fruit holds good market demand.

Organic mulches such as dry grass are usually a bi-product of farm waste and decompose readily over time. Organic mulch has a number of positive attributes. It conserves soil moisture by reducing water loss thorough evaporation, minimizing soil erosion, moderating soil temperature, inhibiting weed growth, encouraging the growth of beneficial soil microorganism, and reducing the spread of soil-borne pathogen by preventing soil from splashing onto plants during rainstorms and watering. Now-a-days, water is getting scarce day by day. Jhalawar itself falls under dark zone as far as water availability is concerned. During summer month it is very common to observe temperature shooting above 45°C. The district being part of *malwa plateau* the soil is rocky and shallow in depth. During summer months soil gets heated excessively. For better survival, the requirement of water increases considerably. During peak summer months in want of water and due to scorching summer, farmer faces the problem of plant drying. Mulching has beneficial effect

in such conditions. A such no work has been carried out on the effect of mulching related to *Khirmi* plants.

Materials and Methods

The present experiment was conducted at the Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalrapatan, Jhalawar in the newly established orchard of *Khirmi* cv. Thar Rituraj. The experiment consisted of 7 treatments. The detail of treatments are: T₀ (Control), T₁ (2 cm thickness of dry grass), T₂ (4 cm thickness of dry grass), T₃ (6 cm thickness of dry grass), T₄ (8 cm thickness of dry grass), T₅ (10 cm thickness of dry grass) and T₆ (12 cm thickness of dry grass) with randomized block design with three replications (Panse and Sukhatme, 1995). The treatments were applied during first week of March, 2019 after recording initial (base) growth of plants as well as soil parameters. The observations were recorded at 2 months interval for a total period of 12 months. For measuring the height of plant was measured from the base of soil to the highest tip of the plant with the help of measuring scale. Soil parameters were analyzed by different methods i.e. soil pH (Jackson, 1973), electrical conductivity (dS m⁻¹) (Jackson, 1973), determination of soil organic carbon was based on the Walkley and Black (1934) chromic acid wet oxidation method, available nitrogen was determined by using alkaline potassium permanganate method as suggested by Subbiah and Asija (1956), available phosphorus was determined with extraction by 0.5 M NaHCO₃ solution adjusted at pH 8.5 as suggested by Olsen *et al.*, (1954), available potassium was determined by extracting the soil by shaking with N neutral ammonium acetate solution by flame photometer as suggested by Metson (1956), bulk density (Mgm⁻³) (Piper, 1950), for observation of water holding capacity (%) formula;

$$\text{WHC (\%)} = \frac{\text{Total water held by the soil}}{\text{Total weight of soil}} \times 100$$

To calculate soil particle density :

$$\text{Bulk density} = \frac{\text{Mass of dry soil}}{\text{Volume of soil particles only (air removed) (g / cm}^3\text{)}}$$

The porosity was calculated at the end of experiment as per the formula given :

$$\text{Porosity (\%)} = 1 - \frac{\text{Bulk density}}{\text{Particle density}} \times 100$$

Soil temperatures under different treatments were recorded at 0-15 cm depths shall be recorded at weekly with the help of soil thermometers. The minimum and maximum soil temperatures were recorded at 6:00 hrs in morning and 14:30 hrs in afternoon, respectively.

Results and Discussion

From the table-1, it is reflected that the maximum increase in height of the plant (32.61%) was exhibited in T₆. At the end of experiment during February, this treatment was found at par with T₅ (31.72%). Data as regard to effect of mulching on soil parameters i.e. pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, potassium, water holding capacity, bulk density, particle density and porosity presented in table 2. That data indicate minimum pH in T₆- 12 cm thickness of dry grass (7.00) treatment and it was at par with T₅- 10 cm thickness of dry grass (7.13), T₄- 8 cm thickness of dry grass (7.21) and T₃- 6 cm thickness of dry grass (7.30) treatment was found significantly lower as compared to other treatments. T₆ (12 cm thickness of dry grass) treatment was better over all other treatments. The maximum pH (7.49) was recorded at T₀ (Control) treatment at the end of experiment during February. The better electrical conductivity (0.43 dS m⁻¹) was revealed in T₆- 12 cm thickness of dry grass treatment and it was at par with T₅- 10 cm thickness of dry grass (0.44 dS m⁻¹), T₄- 8 cm thickness of dry grass (0.44 dS m⁻¹) and T₃- 6 cm thickness of dry grass (0.44 dS m⁻¹) at the end of experiment during February. T₆- 12 cm thickness of dry grass treatment and it was found better over all other treatments and control. The electrical conductivity (0.48 dS m⁻¹) was recorded the maximum in T₀- Control. The maximum organic carbon (0.53%) was observed under T₆- 12 cm thickness of dry grass treatment and it was found at par with T₅- 10 cm thickness of dry grass (0.52%) during the end of growth period (February). Treatment T₆ was found superior over all other treatments and control at the end of experiment during February. While, minimum organic carbon (0.47%) was recorded in T₀ (Control).

The maximum available N (292 kg ha⁻¹) was recorded in T₆- 12 cm thickness of dry grass. The minimum available N (275 kg ha⁻¹) was observed in T₀ (Control). T₆ (12 cm thickness of dry grass) was found at par with T₅- 10 cm thickness of dry grass (289 kg ha⁻¹) treatment and T₄- 8 cm thickness of dry grass (285 kg ha⁻¹). T₆ (12 cm thickness of dry grass) treatment was found superior over rest treatments. The maximum available P (30 kg ha⁻¹) was recorded in T₆- 12 cm thickness of dry grass. The minimum available P (24 kg ha⁻¹) was observed in T₀ (Control). T₆ (12 cm thickness of dry grass) was found at par with T₅- 10 cm thickness of dry grass (29 kg ha⁻¹) treatment. T₆ (12 cm thickness of dry grass) treatment was found superior over rest treatments. The maximum available K (347 kg ha⁻¹) was recorded in T₆- 12 cm thickness of dry grass. The minimum available K (322 kg ha⁻¹) was observed in T₀ (Control). T₆ (12 cm thickness of dry grass) was found at

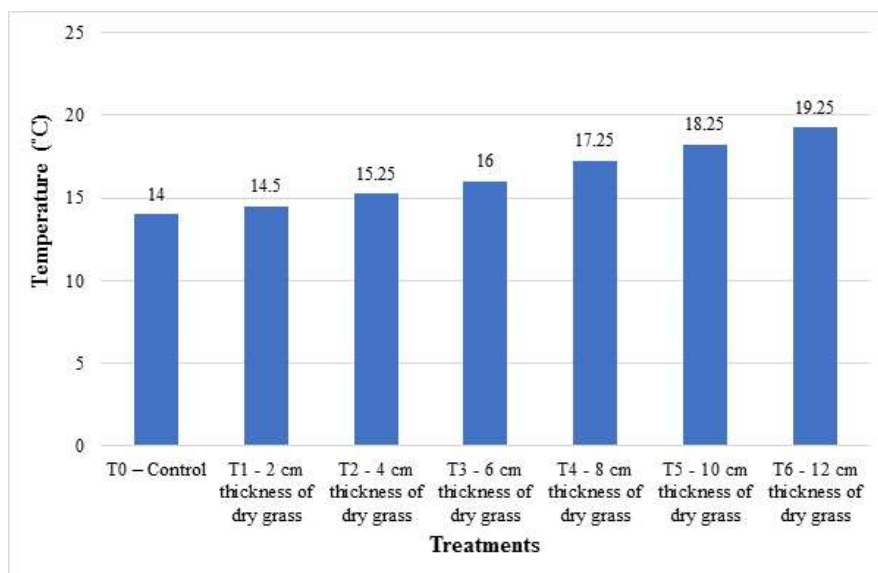
Table-1 : Effect of mulching on height of the plant (cm) of Khirni (*Manilkara hexandra* Roxb.) cv. Thar Rituraj during growth period.

Treatments	Initial value (March)	Height of the plant (cm)					
		April	June	August	October	December	February
T ₀	72.80	73.25 (0.61)	74.69 (2.59)	78.68 (8.07)	79.67 (9.43)	80.10 (10.02)	80.97 (11.22)
T ₁	70.45	71.57 (1.58)	73.24 (3.96)	76.87 (9.11)	78.74 (11.76)	80.13 (13.74)	81.42 (15.57)
T ₂	71.24	72.45 (1.69)	74.31 (4.30)	77.98 (9.46)	81.12 (13.86)	82.87 (16.32)	84.51 (18.62)
T ₃	71.66	73.12 (2.03)	74.84 (4.43)	78.68 (9.79)	81.98 (14.40)	84.35 (17.70)	86.81 (21.14)
T ₄	73.54	75.13 (2.16)	77.23 (5.01)	82.26 (11.85)	85.91 (16.82)	87.75 (19.32)	90.32 (22.81)
T ₅	68.14	70.12 (2.90)	72.35 (6.17)	78.61 (15.36)	83.02 (21.83)	86.14 (26.41)	89.76 (31.72)
T ₆	72.60	74.86 (3.11)	77.32 (6.50)	85.42 (17.65)	89.12 (22.75)	93.05 (28.16)	96.28 (32.61)
SEm ±	-	0.02	0.02	0.07	0.09	0.12	0.30
CD (5%)	-	0.06	0.06	0.22	0.27	0.38	0.91

Note : 1. Data variation lying in the range of 11.22 to 32.61 per cent, they were subjected to Arc sine transformed values. The variation not varying between 0 to 30 or 70 to 100 were subjected to Arc Sine transformation (Gomez and Gomez, 1984) 2. CD has been calculated based on percentage value.

Table-2 : Effect of mulching on soil parameters of Khirni (*Manilkara hexandra* Roxb.) cv. Thar Rituraj during growth period.

Treatments	Soil parameters									
	pH	EC (dS m ⁻¹)	OC (%)	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)	WHC (%)	Bulk density (Mg m ⁻³)	Particle density (Mg m ⁻³)	Porosity (%)
Initial values	7.45	0.44	0.48	278	25	326	37	1.40	2.83	44.75
T ₀	7.49	0.48	0.47	275	24	322	36	1.40	2.80	44.70
T ₁	7.47	0.47	0.49	279	25	326	39	1.36	2.78	44.95
T ₂	7.40	0.46	0.49	279	26	329	42	1.35	2.74	45.10
T ₃	7.30	0.44	0.50	281	27	333	45	1.35	2.73	45.20
T ₄	7.21	0.44	0.51	285	27	336	47	1.33	2.69	46.27
T ₅	7.13	0.44	0.52	289	29	342	48	1.32	2.63	46.80
T ₆	7.00	0.43	0.53	292	30	347	50	1.29	2.60	48.25
SEm±	0.10	0.008	0.005	3.42	0.35	3.84	0.71	0.02	0.04	0.64
CD (5%)	0.31	0.024	0.015	10.65	1.08	11.96	2.21	0.06	0.12	1.99

**Fig-1 : Effect of mulches on soil temperature at 0-15 cm depth of soil (February, 2020).**

par with T₅-10 cm thickness of dry grass (342 kg ha⁻¹) treatment and T₄-8 cm thickness of dry grass (336 kg ha⁻¹). T₆ (12 cm thickness of dry grass) treatment was found superior over rest treatments.

The water holding capacity percentage was found increased after application of treatments and it was obtained maximum (50%) under T₆ (12 cm thickness of dry grass) treatment and it was found superior over all

other treatments and control. T_6 (12 cm thickness of dry grass) treatment was found at par with T_5 (10 cm thickness of dry grass) treatment which had water holding capacity percentage of 48%. The minimum water holding capacity (36%) was recorded at control. The minimum bulk density (1.29 Mg m^{-3}) was observed under T_6 - 12 cm thickness of dry grass and it was at par with T_5 - 10 cm thickness of dry grass (1.32 Mg m^{-3}), T_4 - 8 cm thickness of dry grass (1.33 Mg m^{-3}) and T_3 - 6 cm thickness of dry grass (1.35 Mg m^{-3}). However, the maximum bulk density (1.40 Mg m^{-3}) was recorded in T_0 (Control). T_6 (12 cm thickness of dry grass) treatment was found superior over all other treatments and control. Further during end of experiment (February), the minimum particle density (2.60 Mg m^{-3}) was observed under T_6 - 12 cm thickness of dry grass and it was at par with T_5 - 10 cm thickness of dry grass (2.63 Mg m^{-3}) and T_4 - 8 cm thickness of dry grass (2.69 Mg m^{-3}), while the maximum particle density (2.80 Mg m^{-3}) was recorded in T_0 (Control). T_6 treatment was found superior over all other treatments and control. The treatment T_6 - 12 cm thickness of dry grass had maximum porosity (48.25%). This treatment was found at par with T_5 - 10 cm thickness of dry grass (46.80%). The porosity (44.70%) was recorded minimum in T_0 (Control). T_6 treatment was found superior over all other treatments and control.

Data pertaining to the soil temperature as influenced by various treatments is presented in Fig. 1. The data revealed that there was significant difference in soil temperature due to various treatments. During February better temperature (19.25°C) was recorded in treatment T_6 (12 cm thickness of dry grass). The minimum (14°C) soil temperature was recorded in T_0 (Control). T_6 treatment was closely followed by T_5 treatment – 10 cm thickness of dry grass (18.25°C).

Data as regard to the effect of mulching on plant height (32.61%) in T_6 (12 cm thickness of dry grass) treatment at the time of final observation during February are presented in table-1. Similar effect of the mulching on the plant growth was reported by Mal *et al.* (2006) in pomegranate cv. Ganesh and Angrej and Ali and Gaur (2013) in strawberry cv. Sweet Charlie. Better growth of plant under this treatment may be due to the fact of relatively more amenable effect of this treatment in modification of microclimate, better improvement in texture of soil, conservation of soil moisture, improvement of fertility, control of weeds etc. This treatment might also influence hydrothermal regimes by changing radiation balance, rate of heat, water vapour transfer and minimized hit of soil with sun more effectively in comparison to other treatments. Effective prevention of moisture deficit leading to improved cell division and elongation, perhaps also led to better shoot parameters in

T_6 (12 cm thickness of dry grass) treatments over other treatments evaluated.

Data as regard to effect of mulching on soil pH (7.0), organic carbon (0.53%), available N (292 kg ha^{-1}), available P (30 kg ha^{-1}), available K (347 kg ha^{-1}), water holding capacity (50%), bulk density (1.29 Mg m^{-3}), particle density (2.60 Mg m^{-3}), porosity (48.25%) and soil temperature (19.25°C) along with electrical conductivity (0.43 dS m^{-1}) were reported comparatively better in T_6 (12 cm thickness of dry grass) treatment (Table 2) at the time of final observation during February. Mulches have been reported to markedly influence the hydrothermal regime and physiochemical properties of soil (Hedua and Kumar, 2002).

The better pH in the T_6 (12 cm thickness of dry grass) treatment might be due to higher buffering of temperature (Ali and Gaur 2007 in strawberry) which might via controlling production of organic acid led to better moderation of soil pH. Soil pH low in the more thickness of dry grass mulch due to better conservation of soil moisture. Reduction in EC in T_6 (12 cm thickness of dry grass) treatment might be due to more intensive mineralization under this treatment which perhas consequently generated large amount of CO_2 which might led to the development of more organic acid (Cabilovoski *et al.* 2014) and lessening EC of soil. In this treatment, there was increase in organic carbon and porosity. It possibly led to decline in bulk density and particle density (Das, 2004). Mulching decreases bulk density of the surface soil as has been reported by Ghuman and Sur (2001). Increase in organic carbon (0.53%), available N (292 kg ha^{-1}), available P (30 kg ha^{-1}) and available K (347 kg ha^{-1}) in T_6 (12 cm thickness of dry grass) treatment might be due to better decomposability effect of mulch. Following organic mulching an upsurge in the total content of soil organic carbon, N, P and K in organic mulch has been established by Marinari *et al.* (2010). It is basic fact that organic mulch ultimately breaks down and becomes part of the soil and thus favours improved physical property and nutrient contents (Sharma *et al.*, 1998). Water holding capacity (WHC) capacity of soil increased (50%) in T_6 (12 cm thickness of dry grass) treatment. It may be attributed to better increase in organic matter in the soil comparatively better under T_6 treatment. Reports are there as to increased water holding capacity of the soil with corresponding increase in the level of organic carbon (Ramesh *et al.* 2008). It might be due to the decomposition of applied mulch material. An increase in soil organic carbon contents following applications of crop residue mulches has been reported by Saroa and Lal, 2003.

During February at the end of experiment soil in 0-

15 cm depth was found relatively warmer (19.25°C) in T₆ (12 cm thickness of dry grass) treatment. It might be due to better impact of this treatment in preventing loss of heat from the soil. Increased soil temperature due to mulch has been recorded by Ramakrishna *et al.* (2006) in groundnut.

Conclusions

On the basis of results obtained, it may be concluded that application of the treatment T₆ (12 cm thickness of dry grass) had its better effect on plant growth of *Khirni* and also on the soil parameters were found better in this treatment. Thus, in view of overall study, T₆ treatment (12 cm thickness of dry grass) emerged better in its effectivity on growth and development of *Khirni* plant.

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Effect of Bio-Fertilizers and Micronutrients on Morphological Characters and Phenological Parameters of Broccoli (*Brassica oleracea* var. Italica L.)

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Abstract

The present "Effect of biofertilizers and micronutrient on growth and yield of broccoli (*Brassica oleracea* var. italica L.)" was carried out during *rabi* season of 2019 -2020 at the Horticulture Experimental Field, College of Agriculture, JNKVV, Rewa (M.P.). The significantly maximum plant height, number of leaves per plant, length of leaves, width of leaves, leaf area, stalk length and stalk diameter were recorded in T₁₁ treatment (*Azotobacter* + B 20 kg+ Mo 2 kg /ha at higher rates), followed by T₈ and T₁₂ at 30, 45 and 60 DAT as compared to other treatments. However, the minimum plant height and other morphological characters were observed under the treatment T₁ (control) at 30, 45 and 60 DAT stages of plant growth. The days to first curd initiation, days to 50% curd initiation, days to 50% curd maturity and curd maturity duration were significantly influenced by different treatments. The control treatment and *Azotobacter* treatment recorded minimum days to first curd initiation, days to 50% curd initiation, days to 50% curd maturity and curd maturity duration as compared to other treatments. While, it was observed late in treatments T₁₁, T₈ and then T₁₂ having each of the biofertilizers with B and Mo at the medium to higher rates.

Key words : Broccoli, micronutrients, biofertilizers, (*Brassica oleracea* var. italica L.) Morphological characters, Phenological parameters.

Introduction

Broccoli (*Brassica oleracea* var. Italica L.) is an edible green plant in the cruciferae family whose large flowering head is eaten as vegetable. It is one of the most nutritious cole crops and contains vitamin A (130 times and 22 times higher than cauliflower and cabbage), thiamin, riboflavin, niacin, vitamin C and minerals like Ca, P and Fe (Acharya *et al.*, 2015). It has nutritional value energy (34 Kcal), carbohydrate (6.64 g), fat (0.37 g), protein (2.82 g) and water (89.3 g) per 100 g of raw broccoli. Biofertilizers are one of the best modern tools for agriculture and are used to improve the fertility and quality of the soil. It offers an economically attractive and ecologically sound route for augmenting nutrient supply that enables to plant growth and development of fruit crops (Joseph *et al.*, 2015). PSB solubilizes the native as well as applied phosphorus and also synthesizes growth promoting substances like auxin, IAA, GA, cytokinin and vitamins which augment the plant growth. The non-symbiotic *Azotobacter* sp. provides positive influence on nodulation and N₂ fixing efficiency of *Rhizobium* in legumes (Sarna *et al.*, 2008). Evidence is growing of favourable effect of *Azotobacter* and *Azospirillum* in providing plant nutrients to several crops in supplementing the expensive inorganic fertilizers. The ability of bacteria may be affected by the presence of inorganic fertilizers. Phosphate-solubilizing micro-organism (PSB) convert the insoluble phosphates into soluble forms by acidification, chelation, exchange

reactions and production of gluconic acid (Gupta,2006). Molybdenum is essential component of enzyme nitrogenase or nitrate reductase. It is also essential for N-fixation in pulses and vegetables. Boron is much required for cell division and development in the growth regions of the plants near the tips of shoots and roots. Boron also affects pollination and the development of viable seeds, which in turn affects the normal development of vegetable fruits. Biofertilizers can add 20-200kg. N/ha year (eg. *Rhizobium* spp. 50-100kg. N/ha/year, *Azospirillum*, *Azotobacter* : 20-40kg N/ha, *Azolla* :40-80kg. N/ha BGA :20-30 kg. N/ha) under optimum soil conditions and thereby increases 15-25% of total crop yield.

Materials and Methods

The present experiment was conducted at research farm of college of agriculture Rewa. The observations were recorded for Plant height (cm), Number of leaves per plant, Length of leaves, Width of leaves, Leaf area index, Stalk length (cm), Stalk diameter (mm) and Yield per hectare (q/hac.) from five randomly selected plants from each replication. All the agronomic operations were practices as per recommended and treatments were applied on time. The data on various crop characters were subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Fisher (1958).

Experimental design : R.B.D. (Randomized Block Design)

Experimental details : The experimental material for present investigation was comprised of 12 treatment comprising biofertilizers with and without B and Mo rates which tried in sprouting broccoli. The details of experimental plan of present investigation as per proposed technical programme are given below :

Treatments	Detail of treatments
T ₁	Control
T ₂	Azotobacter 2kg/h
T ₃	Azospirillum 2kg/h
T ₄	Azotobacter + Azospirillum + Phosphate solubilizing bacteria @2kg each/ha
T ₅	Azotobacter + Boron 7.5kg + Mo 1 kg
T ₆	Azospirillum + Boron 7.5kg + Mo 1 kg
T ₇	PSB + Boron 7.5kg + Mo 1.5 kg
T ₈	Azotobacter + Boron 15kg + Mo 1.5 kg
T ₉	Azospirillum + Boron 15kg + Mo 1.5
T ₁₀	PSB + Boron 15kg + Mo 1.5 kg
T ₁₁	Azotobacter + Boron 25kg + Mo 2 kg
T ₁₂	Azospirillum + Boron 20kg + Mo 2kg

Results and Discussion

The significantly maximum plant height of broccoli was recorded in treatments T₇, T₁₁ and T₁₂ (*Azotobacter* Or *Azospirillum* + B 20 kg + Mo 2 kg/ha at higher rates) at 30, 45 and 50 DAT stages as compared to other treatments. However, the minimum plant height was observed under the treatment T₁ (control). These findings are also in agreement with the findings of Singh *et al.* (2014), Islam *et al.* (2015) and Singh (2017). In case of boron, Dubey (2013) found that the plant height of broccoli was responded significantly due to boron at 30, 45 and 60 DAT stages. The significantly maximum plant height was recorded due to boron application (2 kg B/ha), followed by 1.5 kg B/ha. Similar results were reported by Saha *et al.* (2010 a), Singh *et al.* (2014), and Thapa *et al.* (2016), Solanki *et al.* (2018) and Arjun *et al.* (2018).

The number of leaves per plant of broccoli increased significantly with the different treatments comprising *Azotobacter*, *Azospirillum* and PSB with or without B and Mo at lower and higher rates. The equally maximum leaves per plant were observed under the treatments T₁₁ and T₁₂ (biof. with higher rates of 20 kg B and 2 kg Mo/ha) at 30, 45 and 60 DAT as compared to other treatments. The probable reasons for enhanced more number of leaves, may be due to effect of treatments on vegetative growth which ultimately lead to more photosynthetic activities. While, These findings are also in agreement with the findings of Singh *et al.* (2014), Singh *et al.* (2015) and Islam *et al.* (2015), Thapa *et al.* (2016), and Solanki *et al.* (2018). Maurya *et al.* (2008) reported that the number

of fully opened leaves were highest in poultry manure + 50% RDF. Velmurugan *et al.* (2008) revealed that 15 t/ha FYM + 50:100:50 kg NPK/ha and 50 kg N/ha recorded the maximum number of leaves. Dubey (2013) also reported that the maximum number of leaves per plant of broccoli were recorded in case of boron 2 kg /ha, followed by boron 1.5 kg/ha. Similar results were observed by Saha *et al.* (2010a) who revealed that the spraying of borax @ 0.3% at 30 +45 DAT gave significant increased growth of sprouting broccoli.

The stalk length of broccoli increased significantly with the different treatments at 30, 45 and 60 DAT. The equally maximum stalk length were observed under the treatments T₁₁ and T₁₂ compared to other treatments while, it was lowest in treatment T₁ (control). These findings are also in agreement with those of Singh *et al.* (2015a and b), Thapa *et al.* (2016), Singh (2017), Choudhary and Paliwal (2017) and Solanki *et al.* (2018). Dubey (2013) also recorded the maximum stalk length in case of boron 2.0 kg/ha, followed by boron 1.5 kg/ha. Similar results were reported by Saha *et al.* (2010 a). That the spraying of borax @ 0.3% at 30+45 DAT gave significant response on growth, of sprouting broccoli. Similar results were reported by Moniruzzaman *et al.* (2007) where the boron application increased plant vegetative growth and production of broccoli. At 30, 45 and 60 DAT stages ,the equally maximum stalk diameter was observed under the treatments T₁₁ and T₁₂ having bio-fertilizers with higher rates of 20 kg B and Mo 2 kg /ha .While ,it was found lowest in control treatment (T₁). These findings are also in agreement with the findings of Singh *et al.* (2015a and b), Thapa *et al.* (2016) , Pal *et al.* (2016), Meena *et al.* (2017) and Arjun *et al.* (2018).

The length of leaves per plant of broccoli increased significantly with the different treatments having *Azoto.* *Azosp.* and PSB with or without B and Mo at lower and higher rates. The significantly maximum length of leaves was observed under the treatment T₁₁ and T₁₂ (*Azoto.*, or *Azosp.*) with higher rates of B and Mo) as compared to other treatments. These findings are in close agreement with the findings of Singh *et al.* (2015) and Thapa *et al.* (2016) and Arjun *et al.* (2018). Dubey (2013) also found the significantly maximum length of leaves under treatment boron 2.0 kg /ha, followed by boron 1.5 kg /ha. Similar results were reported by Saha *et al.* (2010a) also reported that the spraying of borax @0.3% at 30+45 DAT gave significant response on growth and yield of sprouting broccoli. These findings also agree with those of Moniruzzaman *et al.* (2007) who found that the boron application increased vegetative growth and curd production of broccoli. Application of *Azoto.* or *Azosp.* With higher rates of B and Mo i.e. T₁₁ and T₁₂ registered equally highest leaves width (13.92 to 14.85 cm).

Table-1 : Plant height and No. of leaves per plant (cm) of broccoli at different growth stages as influenced by biofertilizers and micronutrients.

Tr.	Treatments details	Plant height (cm)			No. of leaves per plant (cm)		
		30	45	60 DAT	30	45	60 DAT
T ₁	Control	17.06	37.28	43.47	4.52	7.69	8.76
T ₂	<i>Azotobacter</i> 2kg/ha	18.87	37.70	44.44	4.71	8.35	9.59
T ₃	<i>Azospirillum</i> 2kg/ha	19.35	37.96	44.56	4.75	8.50	9.66
T ₄	<i>Azotobacter</i> + <i>Azospirillum</i> + phosphate solubilizing bacteria @ 2kg/ha	20.03	38.70	45.03	5.42	9.26	10.14
T ₅	<i>Azotobacter</i> + Boron 7.5 kg + Mo1 kg/ha	21.98	38.98	46.71	5.57	9.46	10.86
T ₆	<i>Azospirillum</i> + Boron 7.5 kg + Mo 1kg/ha	22.40	39.99	46.69	5.85	9.67	10.78
T ₇	PSB + Boron 7.5 kg + Mo 1.5 kg/ha	22.68	40.07	47.47	5.98	10.51	11.67
T ₈	<i>Azotobacter</i> + Boron 15 kg + Mo 1.5 kg/ha	23.66	40.92	48.03	6.46	10.48	11.67
T ₉	<i>Azospirillum</i> + Boron 15 kg + Mo 1.5 kg/ha	22.45	40.49	46.37	6.21	9.42	9.57
T ₁₀	PSB + Boron 15 kg + Mo 1.5 kg	17.13	36.54	43.33	3.96	7.55	8.45
T ₁₁	<i>Azotobacter</i> + Boron 25 kg + Mo 2kg/ha	23.94	41.62	48.57	6.70	11.48	11.87
T ₁₂	<i>Azospirillum</i> + Boron 20 kg + Mo 2kg/ha	23.38	39.44	45.87	5.32	10.19	10.48
	S.Em+	0.09	0.08	0.11	0.07	0.07	0.08
	C.D. (5%)	0.26	0.23	0.32	0.22	0.21	0.23

Table-2 : Stalk length (cm) and Stalk diameter (mm) of broccoli at different growth stages as influenced by biofertilizers and micronutrients.

Tr.	Treatments details	Stalk length (cm)			Stalk diameter (mm)		
		30	45	60 DAT	30	45	60 DAT
T ₁	Control	3.25	6.32	8.95	18.57	27.28	33.06
T ₂	<i>Azotobacter</i> 2 kg/ha	3.37	4.55	9.08	19.02	27.72	33.42
T ₃	<i>Azospirillum</i> 2 kg/ha	3.50	6.44	9.33	19.16	28.13	34.48
T ₄	<i>Azotobacter</i> + <i>Azospirillum</i> + phosphate solubilizing bacteria @ 2kg/ha	3.85	6.75	9.54	19.49	28.41	34.68
T ₅	<i>Azotobacter</i> + Boron 7.5 kg + Mo 1 kg/ha	3.99	6.92	9.54	19.82	29.02	34.74
T ₆	<i>Azospirillum</i> + Boron 7.5 kg + Mo 1 kg/ha	3.85	7.27	10.07	20.38	29.06	35.09
T ₇	PSB + Boron 7.5 kg + Mo 1.5 kg/ha	4.32	7.38	10.35	19.92	29.46	35.68
T ₈	<i>Azotobacter</i> + Boron 15 kg + Mo 1.5 kg/ha	4.36	7.66	10.62	20.42	29.68	35.91
T ₉	<i>Azospirillum</i> + Boron 15kg + Mo 1.5 kg/ha	3.95	7.65	8.51	18.72	29.52	34.60
T ₁₀	PSB + Boron 15 kg + Mo 1.5 kg	2.75	6.19	8.54	18.19	27.06	32.38
T ₁₁	<i>Azotobacter</i> + Boron 25 kg + Mo 2 kg/ha	4.85	7.76	10.91	20.96	30.61	36.73
T ₁₂	<i>Azospirillum</i> + Boron 20 kg + Mo2 kg/ha	4.54	6.46	10.49	20.30	30.70	35.26
	S.Em+	0.04	0.05	0.05	0.04	0.04	0.04
	C.D. (5%)	0.13	0.16	0.14	0.11	0.12	0.12

Significantly lowest leaves width (11.17 cm) was noted from the control treatment. These findings corroborate with the findings of Kannan *et al.* (2014), Thapa *et al.* (2016) and Singh (2017). Dubey (2013) found the significantly maximum width of leaves under treatment boron 2kg/ha. Similar results were also recorded by Saha *et al.* (2010a), where the spraying of borax @ 0.3% at 30+45 DAT gave significant response on growth of sprouting broccoli.

The leaf area increased significantly with different treatments having Azoto. or Azsp. or PSB with B and Mo at lower and higher rates. The significantly maximum leaf area was observed under the treatments T₁₁ (5685 cm²), followed by T₁₂ (5389 cm²) and then T₉ (5186 cm²) treatments, while, it was significantly lowest in control T₁ treatment (3879 cm²). Similar result were reported by

Mishra *et al.* (2012) who revealed that the application of different micronutrients individually or in combination significantly increased leaf area of tomato. The concept of the leaf area was the basis to growth analysis of community on which the photosynthetic production it is also responsible for yield. When leaf area is more causes the fast growth of top which leads to growth of root and shoot was favoured. Dubey (2013) found the maximum leaf area of broccoli due to application of boron 2kg/ha, followed by boron 1.5 kg/ha.

The days to first curd initiation, days to 50% curd initiation, days to 50% curd maturity and curd maturity duration was significantly influenced by different treatments. The treatments T₂ to T₃ having only biofertilizers (singly) have taken the minimum period to

Table-3 : Length of leaves (cm), Width of leaves (cm), Leaf area (cm²), Days to first curd initiation, Days to 50% curd initiation and Days to curd harvesting of broccoli at different growth stages as influenced by biofertilizers and micronutrients.

Tr.	Treatments details	Length of leaves (cm)	Width of leaves (cm)	Leaf area (cm ²)	Days to first curd initiation	Days to 50% curd initiation	Days to curd harvesting
T ₁	Control	33.63	11.58	3259	47.55	53.97	70.27
T ₂	<i>Azotobacter</i> 2 kg/ha	34.10	12.26	3943	48.29	54.61	71.28
T ₃	<i>Azospirillum</i> 2 kg/ha	34.31	12.44	4015	48.81	54.70	72.55
T ₄	<i>Azotobacter</i> + <i>Azospirillum</i> + phosphate solubilizing bacteria @ 2kg each/ha	34.94	12.66	4284	48.82	54.90	72.64
T ₅	<i>Azotobacter</i> + Boron 7.5 kg + Mo1 kg/ha	35.41	13.28	4756	49.25	56.47	73.66
T ₆	<i>Azospirillum</i> + Boron 7.5 kg + Mo 1kg/ha	36.61	13.45	4903	50.04	56.84	74.78
T ₇	PSB + Boron 7.5 kg + Mo 1.5 kg/ha	37.00	13.97	5196	51.44	57.63	75.27
T ₈	<i>Azotobacter</i> + Boron 15 kg + Mo 1.5 kg/ha	37.57	14.56	5389	52.35	58.68	77.42
T ₉	<i>Azospirillum</i> + Boron 15 kg + Mo 1.5 kg/ha	36.63	13.57	4152	52.20	57.60	70.62
T ₁₀	PSB + Boron 15 kg + Mo 1.5 kg	33.42	11.14	3879	47.51	54.30	69.84
T ₁₁	<i>Azotobacter</i> + Boron 25 kg + Mo 2 kg/ha	37.71	14.91	5685	52.33	58.92	76.58
T ₁₂	<i>Azospirillum</i> + Boron 20 kg + Mo2 kg/ha	37.66	14.86	5350	51.56	58.83	69.91
	S.Em+	0.08	0.05	96.80	0.04	0.14	0.06
	C.D. (5%)	0.22	0.15	283.90	0.12	0.41	0.17

first curd initiation, days to 50% curd initiation, days to 50% curd maturity and curd maturity duration as compared to other treatments. While, it was observed equally late in treatments T₁₁ and T₁₂ having higher rates of 20kg B and 2 kg/ha Mo with biofertilizers. The higher levels of nutrients delayed flowering and also first picking. This may be due to the fact that macro and micro nutrients in plants increased cell division and cell differentiation. Thus, plant remained in vegetative phase and resulted in imbalance between C:N ratio thus delayed flowering at higher nutrient levels. They found that the days to anthesis significantly improved with increasing concentrations of N and P. Supe and Marbhal (2008) have also revealed that the days required for harvesting of cabbage were found significantly earlier. Where 50% N was applied through organic sources over in organic sources (100:50:50 NPK kg/ha). Dubey (2013) also found significantly lowest days for first curd initiation, days to 50% curd initiation, days to 50% curd maturity and curd maturity duration in case of no boron treatment, followed by boron 1 kg/ha. Shah *et al.* (2010 b) observed that the combined foliar and soil application of zinc @ 100 ppm and 15 kg/ha, respectively, took more days (59.66) to marketable maturity. However, soil application of B @ 15 kg/ha or combined foliar and soil application of B @ 100 ppm and 15 kg/ha, respectively, recorded 57.33 days to marketable maturity.

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Effect of Foliar Application of Zinc Sulphate on Growth and Yield of Guava (*Psidium guajava* L.) cv. Gwalior 27

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Abstract

A field experiment on foliar application of Zinc sulphate on growth and yield of guava (*Psidium guajava* L.) cv. Gwalior 27 was carried out at department of horticulture, college of agriculture, Gwalior (M.P.) during the period 2016- 2017. Three different concentration of zinc sulphate viz., Z₀ (control), Z₁ (0.4%) and Z₂ (0.6%) were sprayed on guava trees and various growth and yield parameters were recorded. The data pertaining to various parameters revealed that spray of zinc sulphate @ 0.6% was found tertiary shoot length, number of fruits per plant, fruit weight, fruit yield per tree, yield per hectare, radial diameter, pulp weight and spray of zinc sulphate @ 0.4% was effective for polar diameter and diameter of shoots.

Key words : *Psidium guajava*, zinc sulphate, guava, yield, growth.

Introduction

Guava (*Psidium guajava* L.), the apple of the tropics, is one of the most popular fruit plant grown in tropical, sub-tropical and some parts of arid regions of India. The fruit belongs to the family Myrtaceae. It is the fifth most important fruit in area after mango, citrus, banana, and apple and fifth most important fruit in production after banana, mango, citrus and papaya. This fruit originated in tropical America and seems to have been growing from Mexico to Peru. Guava fruits are rich in nutritional and medicinal properties. The fruit is an excellent source of vitamin- "C" (210-305mg/100g fruit pulp) and pectin (0.51.8 %) but has low energy (66 cal/100 g fruit pulp). The ripe fruits contain 12.3-26.3 % dry matter, and 77.9-86.9% moisture. The fruits are also rich in minerals like Phosphorus (22.5-40.0 mg/100 g fruit pulp), Calcium (10.0-30.0mg/100g pulp) and Iron (0.60-1.39 mg/100 g fruit pulp) as well as vitamins like Niacin (0.20-2.32 mg/100 g fruit pulp), Thiamine (0.03-0.07 mg/100 g fruit pulp), Riboflavin (0.02-0.0 mg/100 gm fruit pulp) and Vitamin- "A" (Bose and Sanyal, 2001).

Two types of wines viz., guava juice and guava pulp wines are also prepared from guava fruits (Bardiya *et al.*, 1974). The roots, bark, leaves and green fruits are used as medicine in the tropical world to halt gastroenteritis, diarrhea and dysentery (Rathore, 1976).

Guava fruit is relished when mature or ripe, and

freshly plucked from the tree. Excellent salad and pudding are prepared from the shell of the ripe fruit. It can be preserved by canning with or without seeds. It is wholly edible along with the skin. Several delicious preserved products like Jam, Jelly, Cheese, Puree, Ice cream, canned fruit and Sharbat are prepared from ripe fruits of guava. In some countries, the leaves are used for curing and also for dyeing and tanning. Zinc sulphate increases the growth and development of fruit. Zinc is an essential nutrient for plants, being involved in many enzymatic reactions and is necessary for good growth and development. Zinc is also involved in regulating the protein and carbohydrate metabolism. Similarly zinc also increases the chlorophyll content of leaves and essential for enzyme activities like catalase, peroxidase and cytochrome chlorophyll oxidase.

Materials and Methods

The experiment was conducted at Agrotechnology Park of Krishi Vigyan Kendra, College of Agriculture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during 2016-2017. The investigation was conducted on 7 years old guava plants planted at 6 X 6 m apart under square system of planting. In order to assess the effects of various treatments, all the plants were subjected to uniform cultural practices during the period of experimentation. The experiment was laid out in Randomized Block Design with three replications with a

Table-1 : Effect of foliar spray of Zinc sulphate on tertiary shoot length, shoot diameter, number of leaves, number of fruits per plant, fruit weight of guava.

Zinc sulphate	tertiary shoot length (cm)	shoot diameter (cm)	number of leaves	number of fruits per plant	fruit weight(g)
Z ₀	3.70	0.33	15.65	59.80	128.67
Z ₁	5.82	0.34	20.24	63.13	134.67
Z ₂	6.49	0.34	22.70	64.27	139.00
S.Em. ±	0.034	0.005	0.116	0.944	1.880
CD at 5% level	0.101	0.016	0.349	2.830	5.635

Table-2 : fruit yield per tree, yield per hectare, polar diameter, radial diameter, pulp weight and seed weight of guava.

Zinc sulphate	fruit yield per tree	yield per hectare	polar diameter	radial diameter	pulp weight	seed weight
Z ₀	37.92	105.31	5.80	5.68	150.60	3.63
Z ₁	40.27	111.80	6.47	5.8	183.33	1.95
Z ₂	44.13	122.53	6.01	6.69	201.00	1.73
S.Em.±	0.700	1.944	0.118	0.190	0.333	0.060
CD at 5% level	2.099	5.828	0.352	0.560	0.999	0.180

unit of one plant in each replication of a treatment. The stock solution of different concentrations of zinc sulphate (neutralized with hydrated lime) Z₀ (control), Z₁ (0.4%) Z₂ (0.6%) were prepared by dissolving the required amount of zinc sulphate in required amount of water. Observations on various characters of plant *i.e* tertiary shoot length (cm), shoot diameter(cm) ,number of leaves ,number of fruits per plant, fruit weight (g), fruit yield per tree (kg), yield per hectare (q), polar diameter (cm), radial diameter (cm), pulp weight (g) and seed weight (g) of guava were recorded. The data obtained from set of observation for each character were subjected to "Analysis of Variance" as advocated by Panse and Sukhatme (1985).

Results and Discussion

The growth parameters of the guava plant were significantly improved by the sprays of Zinc sulphate over the control. The maximum tertiary shoot length (7.19 cm) was recorded in Z₂ (ZnSO₄ @ 0.6 %) and the minimum tertiary shoot length (4.26 cm) noticed under control. The increased (0.36 cm) shoot diameter was recorded in Z₂ (ZnSO₄ @ 0.6%), which was superior to other treatments while, the minimum shoot diameter (0.33 cm) was recorded in the control. The mean maximum number of leaves per shoot (23.78) was recorded under the treatment Z₂ (ZnSO₄ @ 0.6%), while the minimum number of leaves per shoot (18.94) was recorded under control (Z₀). It is clear from the findings of the study that Zinc sulphate significantly influenced the growth and yield attributes. Nitrogen is an important component of protoplasm helpful in chlorophyll synthesis. The increase in photosynthetic activity due to spray of Zinc sulphate and consequently Zinc sulphate stimulated the synthesis of endogenous hormones which prevents the abscission and

facilitated the ovary to remain attached with the shoot, resulting in lower flower drop.

The data pertaining to various yield attributing parameters of the guava plant viz., number of fruits per plant, fruit weight, fruit yield per tree, yield per hectare, polar diameter, radial diameter, pulp weight and seed weight were significantly improved by the spray of Zinc sulphate. The maximum number of fruits per plant (322.5), fruit weight (142.72 g), yield per plant (46.25 kg) and yield per hectare (128.42 q), polar diameter (6.57 cm) , and radial diameter (6.5 cm) were recorded under the treatment Z₂ (ZnSO₄@ 0.6%) , maximum pulp weight (217 g) under treatment Z₁ (ZnSO₄ @ 0.4), and maximum seed weight (2.56 g) under control (Z₀) which were significantly superior to other levels of Zinc sulphate while, the minimum number of fruits per plant (300.33), fruit weight (132.28 g), fruit yield per tree (40.31 kg) , yield per hectare (111.95 q),polar diameter (6.21cm),radial diameter (6.13 cm) and pulp weight (174.87cm) noticed under control, Seed weight minimum (1.78 g) under treatment Z₂(ZnSO₄ @0.6%).Meena *et al.* (2005) studied the combined effect of foliar application of urea (2.0, 2.5 and 3.0%) and ZnSO₄ (0.5, 1.0 and 1.5%) on the fruit quality and yield of pruned guava (cv. Sardar) under high-density planting system and reported that foliar application of 3.0% urea + 1.0% ZnSO₄ increased fruit size, weight and pulp/seed ratio. Similar findings were also reported by Hoda *et al.*, (1978); Dixit *et al.*, (1978), and Rajkumar *et al.*, 2014 in guava cv. Pant Prabhat. The increase in fruit yield with foliar application of zinc sulphate may be ascribed to increase in the fruit retention on the tree consequently reducing the pre-harvest fruit drop.

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Clustering and Principal Component Analysis Barley (*Hordeum vulgare* L.) Genotypes for Yield and Yield-Contributing Traits under Northern Indian Conditions

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Abstract

In the present study clustering and Principal Component Analysis were estimated among eighteen promising barley (*Hordeum vulgare* L.) genotypes including one check under northern Indian conditions. The main objective of the study was to determine of genetic divergence among the existing breeding materials. The genotypes were grouped into four clusters, and there was a high degree of genetic divergence between the results obtained based on D^2 values. The number of genotypes were included in Cluster I (2), cluster II (6), cluster III (6), and cluster IV (4). The variation studied through principal component analysis five principal components (PC1: 24.6 percent, PC2: 23.3 percent, PC3: 14.7 percent, PC4: 11.4 percent and PC5: 09.3 percent) together contributing 83.3 percent to the total variation. The biplot graph identified barley genotypes 14, 12 and 11 had the largest score in the first PC and located in the positive direction on this PC which indicated that the genotypes were highly correlated with traits that the highest positive loading in PC1 like day to 50% heading, day to maturity, tiller per plant, harvest index, kernel per spike, spikelet per spike, plant height, test weight.

Key words : Clustering, principal component analysis, genetic divergence, D^2 and biplot.

Introduction

Barley (*Hordeum vulgare* L.) is belongs to the tribe Triticeae and the grass family Poaceae. It is a diploid self-pollinating cereal crop having seven pairs of chromosomes ($2n=2x=14$) and genome size of about 5.1 GB (Mekonnen, 2015). It's one of the most valuable cereals crop globally cultivated in the world. It is recognized one of the most significant sources of protein and calories in the human diet. Barley is one of the world's earliest domesticated grains, hundreds of millions of years. Its cultivation started between 9500 and 8400 years ago and it played a vital role in the revolution of civilizations by providing food to humans and animals (Shtaya and Abdallah, 2021).

Its long-term mutations, gene recombination, hybridization, natural and human selection in diverse conditions which aren't suitable to edaphic factors have found a wide range of barley genotypes across the country. The magnitude of variation has not yet been explored, despite the fact that there are multiple collections with various traits that may be unrelated or connected. Breeders can now leverage existing genetic

resources for future breeding operations by classifying genotypes based on morphological characteristics. Breeding for high yielding varieties generally leads to reduce genetic diversity that can change gene frequencies of plant material (Malik *et al.*, 2013). Knowledge regarding the amount of variation in germplasm arrays and relationships between genotypes are important considerations for efficient conservation and utilization of genetic resources.

Multivariate analysis is the most commonly used approach to illuminate the patterns of variation in germplasm collections. Multivariate analysis refers to all statistical methods that simultaneously analyze multiple measurements on each individuals or object under investigation. Among multivariate techniques, PCA and cluster analysis are preferred tools for morphological characterization of genotypes and their grouping on similarity basis (Mohammadi and Prasanna, 2003). Multivariate data analysis facilitates a graphic display of the underlying latent factors and interface between individual samples and variables (Eticha *et al.*, 2010; Nielsen and Munck, 2003). The present study was undertaken with the objective to assess and evaluate the

Table-1 : Eigen values and Eigen vectors of the first five principal components (PC) of eleven quantitative traits from eighteen barley genotypes were calculated.

Trait's	PC1	PC2	PC3	PC4	PC5
Day to 50% heading	0.820	-0.144	-0.036	0.388	-0.318
Day to maturity	0.795	-0.102	-0.195	0.279	-0.438
Plant height (cm)	0.066	-0.128	0.184	0.588	0.563
Tiller per plant	0.510	0.653	0.204	-0.041	0.334
Spike length	-0.415	0.327	-0.366	-0.264	-0.323
Spikelet per spike	0.189	0.883	0.217	-0.052	0.006
Kernel per spike	0.366	0.824	0.247	-0.198	-0.102
Test weight (g)	0.007	0.232	-0.768	-0.082	0.193
Biological yield	-0.658	0.429	0.107	0.526	-0.243
Harvest index	0.444	0.083	-0.697	-0.051	0.291
Grain yield	-0.407	0.526	-0.420	0.530	-0.033
Eigenvalues	2.705	2.561	1.621	1.254	1.018
Proportion	0.246	0.233	0.147	0.114	0.093
Cumulative Proportion	0.246	0.479	0.626	0.740	0.833

Table-2 : D² cluster analysis was used to determine the clustering pattern of eighteen barley genotypes.

Cluster	No. of genotypes	Genotypes
Cluster I	2	BHS 400, Local check
Cluster II	6	BHS 352, RD 2849, RD 2899, RD 2592, RD 2794, RD 2907
Cluster III	6	RD 2052, DWRB 123, VLB 118, RD 2552, RD 2035, RD 2715
Cluster IV	4	BHS 400, DWRB 137, BH 902, BH 946

diversity of eighteen barley genotypes based on yield and yield contributing traits.

Materials and Methods

A collection of eighteen barley genotypes from different states, mainly from Rajasthan Agricultural Research Institute (RARI) Durgapura, Vivekananda Parvatiya Karishi Anusandhan Sansthan (VPKAS) Almora and Indian Institute of Wheat and Barley Research (IIWBR) Karnal was used in the experiment. The field experiment was conducted at the experimental farm of the Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu is situated at an altitude of 293 m above mean sea level with 32° 40' N altitude and 78° 48' E longitude and represent the sub-tropical belt of Jammu province. Data collection, observation were recorded on five plant from each replicated on each barley genotypes.

Data Analysis : All data measured on yield and yield contributing traits were subjected to analysis of variance using R version 4.1.3. The multivariate analysis serves as a basis for grouping the genotypes collection into many, more or less cohesive groups, hence reducing the size of the genotypes collection to be assessed. The R version 4.1.3 tool was used to perform agglomerative (beginning with single elements and aggregating them into clusters) hierarchical clustering based on the Unweighted paired group method using the arithmetic mean (UPGMA) approach. The UPGMA approach gives more precise grouping information on breeding materials utilised after pedigrees, as well as computed findings that are more

congruent with recognised heterotic groupings than the other clusters (Bhandari *et al.*, 2017).

Principal Component Analysis : In a principal component analysis, the general formula for calculating scores on the first component extracted was :

$$PC1 = b_{11}(X_1) + b_{12} + \dots + b_{1p}(X_p) \text{ using R version 4.1.3,}$$

The using R software the loadings of the genotypes and the traits were determined to clarify the association among principal components and traits, principal components and genotypes, genotypes and their traits and the different agronomic traits. In addition, the biplot graph was constructed from PC1 and PC2 or PC3 and PC4 to display the association of the different yield and yield contributing traits and genotypes.

Results and Discussion

In the present study, eighteen barley genotypes were clustered into four clusters (Table-2; Figure-1) based on D² values. The number of genotypes were included in Cluster I (2), cluster II (6), cluster III (6), and cluster IV (4). The genotypes were grouped in four clusters and there was a high genetic divergence. Hence, the improvement can be achieved by the hybridization of diverse parents with desirable traits between clusters I and II, II and III, II and IV, III and IV as well as I and III to develop a dynamic population.

Principal component analysis (PCA) simplifies the complex data by transforming the number of correlated variables into a smaller number of variables called principal components. PCA provides variable

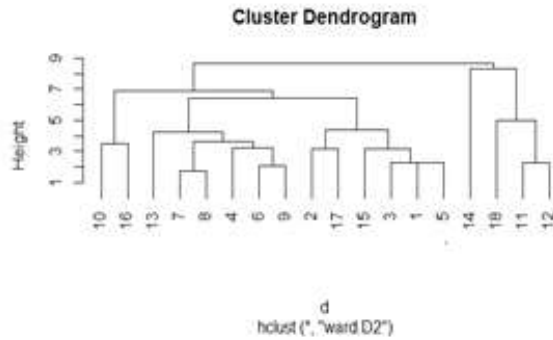


Figure-1



Figure-2

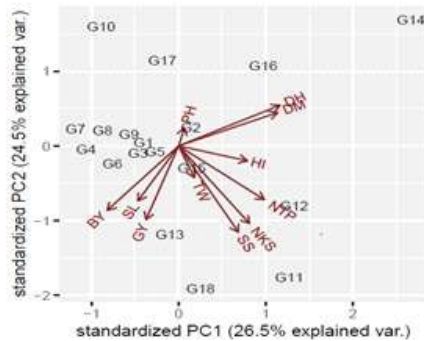


Figure-3

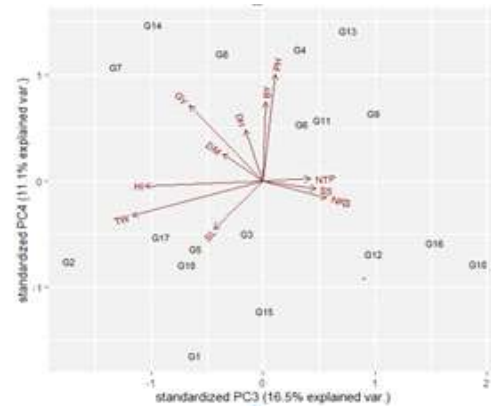


Figure-4

independence and balanced weighting of traits, which leads to an effective contribution of different characters based on respective variation (Jalata *et al.*, 2020). The variation studied through PCA revealed that the first five principal components (the value of PC1: 24.6 percent, PC2: 23.3 percent, PC3: 14.7 percent, PC4: 11.4 percent and PC5: 09.3 percent) having eigenvalues greater than 1 are contributing about 83.3 percent of the total variation (Table-1). The sign of the loading indicates the direction of the relationship between the components and the variable. According to Chahal and Gosal (2002) characters with a lower absolute value closer to zero influence the clustering less than those with the largest absolute value closer to unity within the first principal component.

Accordingly, first principle component had positive component loading from day to 50% heading (0.820) followed by day to maturity (0.795), tiller per plant (0.510), harvest index (0.444), kernel per spike (0.366), spikelet per spike (0.189), plant height (0.066), test weight (0.007) and maximum negative lodging for biological yield (-0.658) followed by spike length (-0.415) and grain yield (-0.407) (Table-1). The characters which load positively or negatively contributed more to the diversity and they were the ones that most differentiated the clusters. Similarly, Jalata *et al.*, (2020) report of the first four principal components having greater than 1 eigenvalue contributed

more than 83.40 percent of the total variation as well as the trait contributing more positively to PC1 coincides with this study.

The major contributing traits for the diversity in the second principal component (PC2) were spikelet per spike (0.883) followed by kernel per spike (0.824), tiller per plant (0.653), grain yield (0.526), biological yield (0.429), spike length (0.327), test weight (0.232) and harvest index (0.083) (Table-1). Similarly, the traits which lodging positively or negatively in PC3, PC4 and PC5 (Table-1) contributed more to the diversity and they were the ones that most differentiated the clusters, therefore, PC1 accounted for the largest contribution to total genetic diversity. Some potentially important traits have been identified which is positively correlated with PCA and these can be exploited for specific trait improvement. Another study indicated characters such as test weight, plant height, days to 50 percent heading, and days to maturity accounted for variation and played important role in differentiating genotypes collected from different regions and altitude classes into principal components (Abebe *et al.*, 2010).

Biplot Analysis : The biplot graph in figure-3 also indicated the variability of genotypes for the eleven characters under study. The graph was plotted by scaling each character independently to separate genotypes. This

biplot graph depicted to visualize the association among principal components and traits, principal components and genotypes, genotypes and their traits, and among the different morphological traits as shown in Figure-3. Those genotypes close to the center are more closely related with each other and the distant genotypes are more divergent. Thus, barley genotypes 14, 12 and 11 had the largest score in the first PC and located in the positive direction on this PC which indicated that the genotypes were highly correlated with traits that the highest positive loading in PC1 like day to 50% heading, day to maturity, tiller per plant, harvest index, kernel per spike, spikelet per spike, plant height, test weight. Thus, the genotypes have better performance in these yield and yield contributing traits than other genotypes. Similarly, Enyew *et al.*, (2019) report of the first PC and located in the positive direction on this PC which indicated that the genotypes were highly correlated with traits that have the highest positive loading in PC1 like grain yield, biomass yield, days to maturity, test weight, grain filling period, effective tillers per plant and plant height.

Similarly, the biplot graph in figure 4 also indicated the barley genotypes 10, 16, and 12 had the largest score in the third PC and located in the positive direction on this PC which indicated that the genotypes were highly correlated with traits that the highest positive loading in PC3 like tiller per plant kernel per spike and spikelet per spike.

Conclusions

There exists high genetic diversity among barley genotypes tested which is useful to combine favorable alleles for desirable yield and yield contributing traits. The genotypes were grouped in four clusters and there was a high genetic divergence. Hence, the improvement can be achieved by the hybridization of diverse parents with desirable traits between clusters I and II, II and III, II and IV, III and IV as well as I and III to develop a dynamic population. The principal component analysis had grouped the estimated barley genotypes into five main components (PC1: 24.6 percent, PC2: 23.3 percent, PC3: 14.7 percent, PC4: 11.4 percent and PC5: 09.3 percent) together contributing 83.3 percent to the total variation. The biplot graph identified barley genotypes 14, 12 and 11 had the largest score in the first PC and located in the positive direction on this PC which indicated that the genotypes were highly correlated with traits that the highest positive loading in PC1 like day to 50% heading, day to maturity, tiller per plant, harvest index, kernel per spike, spikelet per spike, plant height, test weight.

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Effect of Nitrogen and Carbon Sources on the Growth of *Alternaria brassicae* Causing Alternaria Blight of Rapeseed-Mustard

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Abstract

Rapeseed-mustard is India's second largest indigenous oilseed crop, accounting for 26 percent of the country's total oilseed production. *Alternaria brassicae* causing Alternaria blight of Rapeseed-Mustard is a serious constant in Rapeseed-Mustard production. In the present investigation, *Alternaria brassicae* mycelial growth and sporulation were studied using five nitrogen sources, Sodium nitrate, Ammonium nitrate, Ammonium chloride, Potassium nitrate and Urea and two carbon sources, Maltose and Glucose. Among all sources, *A. brassicae* grew the most in Glucose (82.67 mm), which was comparable to Potassium Nitrate and Maltose (81.33 mm and 79.33 mm, respectively). Among all the sources, Glucose, maltose, and potassium nitrate were shown to have excellent sporulation.

Key words : *Alternaria blight, Alternaria brassicae, nitrogen sources, carbon sources, mycelial growth, sporulation.*

Introduction

Brassica rapa, *Brassica napus*, *Brassica juncea*, and *Brassica carinata* are the key components of India's rapeseed-mustard crop. Rapeseed-mustard is farmed throughout India in a variety of agro-climatic zones, from the north-eastern/north-western hills to the south. It is India's second-largest indigenous oilseed crop, accounting for 26.24 percent of the country's total oilseed output (Anon, 2019-20). Mustard is grown on 6.12 million hectares in India, with a total production of 9.26 million tonnes and an average yield of 1513 kg/ha (Anon, 2019-20). The states of Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana, West Bengal, and Assam accounted for 86.29 percent of the country's land area and 88.46 percent of its production (Anon, 2019-20). Despite significant increases in productivity and production as a result of the Technology Mission, a significant amount of money is spent on edible oil imports. The potential yield and the yield realised in the farmer's field are vastly different, due to the numerous biotic and abiotic stressors to which the rapeseed-mustard crop is subjected. Fungal diseases are one of the most prominent factors contributing to yield losses in oilseed crops in India (Anita and Gowthaman, 2003). *Alternaria blight*, caused by *Alternaria brassicae*, has been documented from all continents of the world, affecting most cruciferous crops and is one of the most serious rapeseed-mustard diseases, producing severe production losses with no documented source of transferable resistance in any of the hosts (Meena *et al.*, 2010). The disease manifests itself in a severe form every year during cropping season, infecting both leaves and siliquae, reducing crop quantity

and quality (Saharan, 1992). *A. brassicae* causes chlorotic and necrotic foliar lesions in aerial plant parts (Verma and Saharan, 1994). Aside from a reduction in production, this disease has a significant impact on seed quality, including seed size, colour, and germination (Randhawa and Aulakh, 1981). Saharan *et al.* (2003) recorded yield losses of up to 71.4 percent and oil content losses of 14.6-36 percent (Ansari *et al.*, 1988).

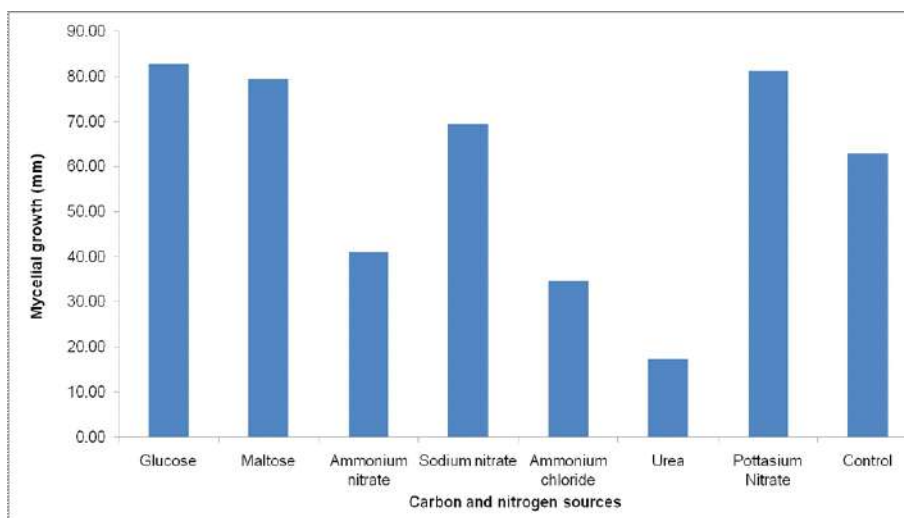
Materials and Methods

The current study was carried out in the laboratory of Department of Plant Pathology, College of Agriculture, Gwalior (Madhya Pradesh). Gwalior is located in Madhya Pradesh's northern region, at an elevation of 211.52 metres above sea level, between the latitude and longitude of 26°14' North and 78°15' East, respectively. Five nitrogen sources *viz.*, Sodium nitrate, Ammonium nitrate, Ammonium chloride, Potassium nitrate, and Urea, as well as two carbon sources *viz.*, Maltose and Glucose, were tested in a laboratory experiment for *Alternaria brassicae* mycelial growth and sporulation. Two per cent of all the nitrogen and carbon sources were added in Richard's agar media, and the medium was sterilized in autoclave at 15 lbs pressure (p.s.i) for 15 minute. As a control, used a medium that was absent of nitrogen and carbon sources. A 5-day-old 5 mm pathogen culture disc was used to inoculate the pathogen in the centre of petriplate. The pathogen used in present investigation was isolated from *Alternaria blight* infected leaf of rape-seed mustard. Three replications of each nitrogen and carbon source were maintained and incubator at 25±1 °C in BOD incubator. The radial growth of the fungus was

Table-1 : Effect of Carbon and nitrogen sources on mycelial growth and sporulation of *Alternaria brassicae*.

Carbon and nitrogen sources	Mean mycelial growth (mm)*	Sporulation
Glucose	82.67	++++
Maltose	79.33	++++
Ammonium nitrate	41.00	++
Sodium nitrate	69.33	+++
Ammonium chloride	34.67	++
Urea	17.33	+
Pottasium Nitrate	81.33	++++
Control	63.00	+++
SEm±	1.87	
C.D. at 5%	5.61	

*Mean of three replications +: Poor, ++: Fair, +++: Good, ++++: Excellent

Fig.-1 : Effect of Carbon and nitrogen sources on mycelial growth of *Alternaria brassicae*.

measured seven days after inoculation (DAI). 15 days following inoculation, the number of sclerotia per plate was counted.

Results and Discussion

Five nitrogen and two carbon sources were used to study *Alternaria brassicae* mycelial growth and sporulation *in vitro*. The purpose of this study was to see what influence carbon and nitrogen sources play in the development of *Alternaria brassicae* inducing Alternaria blight of rapeseed-mustard. The highest growth of *Alternaria brassicae* was recorded in Glucose (82.67 mm), which was comparable to Potassium Nitrate and Maltose (81.33 mm and 79.33 mm, respectively) (Table-1 and figure-1). Sodium nitrate (69.33 mm) also increased pathogen mycelial growth when compared to control (63.00 mm), however three nitrogen sources, Ammonium nitrate, Ammonium chloride, and Urea (41.00, 34.67 and 17.33 mm, respectively) significantly reduced pathogen growth when compared to control.

The sporulation of *Alternaria brassicae* was likewise observed for all carbon and nitrogen sources. All carbon and nitrogen sources are divided into four groups based

on sporulation: excellent, good, fair, and poor. Three sources, Glucose, Maltose, and Potassium nitrate, had excellent sporulation, while Sodium nitrate and Control had good sporulation. In Ammonium nitrate and Ammonium chloride, fair sporulation was seen, whereas in Urea, poor sporulation was reported.

Ramjegathesh and Ebenezar (2012) performed a similar experiment and found that sodium nitrate, potassium nitrate, peptone, and ammonium nitrate all have a substantial impact on *A. carthami* mycelial growth and sporulation. They also found that among the carbon sources, Maltose had the highest mycelial growth, followed by Glucose, Sucrose, and Fructose, all of which substantially enhanced pathogen mycelial growth and spore production. Kumari *et al.* (1998) reported that sucrose had the most mycelial growth and sporulation of *A. brassicae* among the carbon sources, followed by galactose and maltose. Potassium nitrate, sodium nitrate, and asparagine were the most effective nitrogen sources examined. Asparagine produced the best sporulation. Thaware *et al.* (2010) found that using Maltose as a carbon source resulted in good growth and sporulation of *Alternaria alternata*, while using Ammonium nitrate as a

nitrogen source resulted in good growth and sporulation of *Alternaria alternata*. These findings are in agreement to those of Goyal (1977), who found that maltose was the optimum carbon source for *Alternaria alternata* growth and sporulation, followed by sucrose, starch, and lactose. Shinde (1991) also found that maltose was the optimal carbon source for *A. alternata* growth and sporulation.

Conclusions

Five nitrogen and two carbon sources were used to study *Alternaria brassicae* mycelial growth and sporulation *in vitro*. Glucose, Potassium Nitrate and Maltose were significantly increased the growth of *Alternaria brassicae* and also enhanced the production of spores.

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Quality Profiles of Market Paneer in Agra District of Uttar Pradesh

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Abstract

An attempt was made to evaluate the physical, chemical and microbial quality of paneer marketed in Agra city and Agra rural markets. The quality of paneer was assessed in terms of physical, chemical and microbial attributes. The samples collected from three randomly selected shops from each zone of Agra City (east, west, north, south) and Agra rural (Kiraoli, Kheragarh, Agra and Fatehabad). The moisture content (44.95 – 59.05%) Protein content (13.73-18.61, Lactose content (1.62-2.30 %), Ash content (1.19-2.30%) and Lactic acid content (0.96-1.41) were significantly lower in paneer samples of Agra city markets than that of Agra rural markets. However, the Fat content in paneer of Agra rural market was appreciably higher as compared to Agra city markets. The yeast and mould count per gram of paneer samples obtained from Agra city was recorded as 40 to 9400 counts per gram while it was 270 to 16200 counts per gram in paneer samples of Agra rural markets and the difference was statistically significant. The range of coliform count per gram of paneer samples collected from Agra city markets was significantly lower as compared to paneer samples collected from Agra rural markets.

Key words : Paneer, quality analysis, yeast and mould count, chemical analysis.

Introduction

Paneer is an important acid coagulated indigenous milk product and is used as base material for preparation of culinary. It is prepared by the combined action of acid and heat treatment. Paneer is similar to unripe cheese because both products contain same milk solids mainly fat and casein. Good quality paneer is characterized by its acidic flavour with slight sweet taste, firm and compact body and texture. Paneer contains entire milk casein, some part of denaturated whey proteins, all fat, colloidal salts and lactose. In preparation the moisture is retained in the product. About 90% of fat and protein, 50% of ash and 10% of lactose milk are retained into paneer citric acid. It should not contain more than 70% moisture and milk fat content and dry matter should not be less than 50% but in skimmed milk paneer, milk fat content should not exceed 13% of dry matter.

Indian Standard Institution (1983) have laid down that paneer is prepared by acid coagulation and heating treatment of buffalo or cow milk with subsequent drainage of whey. It should have less than 60% moisture, more than 50% fat on dry basis matter, less than 0.05% titrable acidity (as lactic acid), less than 50,000 bacteria, less than 90 coliform and less than 250 yeast and mould per gram. The general composition of paneer is as moisture 52-54 per cent, fat 24-28 percent, protein 16-19 per cent, lactose 2.0-2.2 per cent and ash 2.0-2.3 per cent (Dairy India, 1992).

In Agra city paneer is one of the most popular milk products and a significant portion of milk is being utilized for paneer making in this city. Survey of market quality of any edible product is part and parcel of quality control program which ensures wholesome and safe food to the consumers. The manufacture of paneer is mostly at present limited to small scale and unorganized sector for meeting the local demands. The production and subsequently handling practices adopted by the inherent traders generally favours the multiplication of variety of micro-organisms resulting in rapid deterioration at room temperature. Thus, an attempt has therefore, been made to investigate the quality of paneer sold in the markets.

Materials and Methods

Before the collection of paneer samples, whole district was divided into Agra city and Agra Rural. Agra city was then divided into four zones viz., east, west, north and south. Agra rural was also divided into four zones on tehsil wise viz., Kiraoli, Kheragarh, Agra and Fatehabad. Then four shops were randomly selected from markets of each zone. Paneer samples were aseptically collected from these shops in the sterilized polythene sachets. These collecting bags were kept in the ice bags. In the laboratory, samples were stored below 5°C till the analysis. Thus total 32 samples were received from both markets. The samples collected were subjected for sensory evaluation, chemical and microbial analysis.

Table-1 : Sensory and Chemical analysis of paneer samples.

Markets	Overall sensory score (100-point scale)	Moisture content (%)	Fat content (%)	Protein content (%)	Lactose content (%)	Ash content (%)	Lactic acid content (%)
Agra City	74.29-92.72	44.95-59.05	21.70-31.30	13.73-18.61	1.62-2.30	1.19-2.46	0.96-1.41
Agra Rural	66.93-82.57	46.72-63.00	17.80-27.50	15.38-19.88	1.88-2.79	1.72-2.59	1.22-1.19
t-value	53.77*	24.15*	32.02*	10.65*	4.05*	1.75*	45.39*

*Significant at 5.0 per cent level of significance

Table-2 : Microbial analysis of paneer samples.

Markets	Standard plate count (per gm.) of paneer			Coliform count (per gm.) of paneer	Yeasts and mould count (per gm.) of paneer
Agra City	10	105-77	10 ⁵	98-3800	40-9400
Agra Rural	85	105-180	10 ⁵	2700-9200	270-16200
t-value	987.23*			17.23*	8.26*

*Significant at 5.0 per cent level of significance

Results and Discussion Physical quality : It was assessed on the basis of 100-point scale which include 50 marks for flavor, 35 marks for body and texture and 15 marks for colour and appearance. It was observed that the paneer samples obtained from Agra city marked higher sensory score than that collected from Agra Rural. It varied from 74.29 to 92.72 and 66.93 to 82.57 in the samples collected from Agra city and Agra Rural, respectively which was significantly different.

Chemical quality : Moisture content : The paneer samples obtained from Agra rural had highest moisture content and it ranges from 46.72-63.00 as compared to Agra City in that ranged from 44.95 to 59.05% and the difference was significant. **Fat content :** The fat content was highest in Agra city paneer samples. Samples obtained from Agra rural possess significantly low-fat content (17.80-27.50%) as compared to Agra city having fat content 21.70-31.30 per cent.

Protein content : The highest protein content was observed in the samples of Agra Rural sample (15.38-19.88) which was significantly higher than that of Agra city i.e. 13.73-18.62. The low protein content in market samples of Agra city could be due to use of poor-quality milk. **Lactose content.**

The lactose content was observed highest in the samples collected from Agra rural i.e. 1.88-2.79 per cent which was significantly better than that of Agra City (13.73-18.61%).

Ash content : The ash content was also significantly higher in paneer samples of Agra rural and it ranged from 1.72-2.59% when compared to Agra city samples which contain 1.19-2.46 per cent ash content. The probable reason might be the use of open process for the manufacture of paneer.

Lactic acid : The lactic acid content in paneer samples obtained from Agra market varied from 0.96 to 1.41 percent which was significantly lower than samples collected from market of Agra rural i.e. 1.22 to 1.19 percent. **Microbial analysis Standard plate Count** Paneer samples obtained from Agra rural market showed lower standard plate count than Agra city market. It varied from 10 x 105 to 77 x 105 and 85 x 105-180 x 105 in the samples collected from markets of Agra city and Agra rural, respectively. The statistical analysis of data revealed that markets of both the areas of Agra were significantly different with respect to standard plate count of paneer. None of the samples of both markets conformed the BIS specification in this regard which is maximum 2.5 lakh per gm. It showed unsanitary condition during production / handling / marketing.

Coliform count : The coliform count was highest in paneer samples obtained from market of Agra rural, it ranged from 2700 to 9200 per g, while it was 98 to 3800 per gm in paneer samples of Agra city. The higher coliform count in Agra rural market samples could be due to contamination of product during manufacture and sale.

Yeast and mould count : The yeast and mould count were also higher in paneer samples obtained from Agra rural market when compared to Agra city market. It ranged from 40 to 9400 and 270 to 16200 per gm in Agra city and rural markets, respectively. Higher yeast and mould count of Agra rural market samples indicated unsanitary conditions during preparation and sale of the product.

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Response of Gamma Irradiation on Bulb and Bulblet Parameters of Tuberose (*Polianthes tuberosa* L.) cv. Pearl Double

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Abstract

The present investigation was carried out to study the Response of gamma Irradiation on bulb and bulblet parameters of tuberose (*Polianthes tuberosa* L.). The results revealed that lowest decline trends were recorded on bulb per clump (2.87, 10.00), bulb fresh weight (g) (67.17, 239.86), bulblets per clump (19.13, 32.00), bulblet fresh weight (g) (42.11, 53.21), clump weight (g) (221.89, 339.62) and propagation coefficient (%) (466.48, 523.51) parameters at 2.50 Gy gamma irradiation in V₁M₁ and V₁M₂ generation respectively as compare to control.

Key words : Tuberose, gamma radiation, bulbs and bulblets.

Introduction

Tuberose is a bulbous ornamental plant. It's native of Mexico and belongs to the family Amaryllidaceae. It is commonly known as Gulcheri in Hindi. In India, four types of tuberose cultivars viz. single, semi-double, double and variegated are cultivated commonly. Tuberose gained considerable economic importance and grown on large scale for medicinal, aesthetic and commercial purposes. Waxy white flowers spikes of tuberose have longer shelf life and remained fresh for pretty long time. It with stand long distance transportation and fill a useful place in the flower market. Tuberose florets are mainly used for prepare garlands, bouquets, floral ornaments for bridal makeup, floral arrangements and also as cut flowers. The loose flowers of Single type are used for making garlands and floral decorations and extraction of concrete, while the cut flowers of Double type are used in vase decoration, hand bunches and bouquets. The natural flower oil of *Polianthes tuberosa* remains today one of the most expensive of the perfumers raw materials (Trueblood, 1973; Guenther, 1952; Singh *et al.*, 2010). The longevity of flowers imparts sweet and lingering pleasant fragrance to atmosphere. The genetic variability is necessary in any plant breeding programme for crop improvement Khush and Brar (2002). Non-availability of genetic variability is major constraint in tuberose breeding programme especially by conventional breeding.

Materials and Methods

The research work carried out during (January to March) in 2017 to 2019 conducted at Horticulture Farm, Rajasthan College of Agriculture, Maharana Pratap

University of Agriculture and Technology, Udaipur (Rajasthan), which is situated at 24°35' N latitude and 73° 42' E longitudes at an elevation of 579.5 meters above mean sea level. The region falls under Agro Climatic Zone IV A (Sub-humid Southern Plain and Aravali Hills) of Rajasthan. The field had fairly levelled topography and clay loam texture. The bulbs treated with different level of gamma radiation are viz., Control, 2.50, 5.0, 7.50, 10.0, 12.50, 15.0, 17.50 and 20.0 Gy replicated thrice with nine treatments in a Randomized Block Design (RBD).

Results and Discussion

It is evident from the data presented Table-1 and 2 in the preceding chapter that different gamma rays level had significant effect on bulb and bulblet parameters viz., bulb per clump, bulb fresh weight (g), bulblets per clump, bulblets fresh weight (g), clump weight (g) and propagation coefficient (%). The lowest declined trends for bulbs per clump of tuberose cv. Pearl Double were observed at 2.5 Gy (2.87, 10.00) gamma irradiation dose followed by 5.0 Gy (2.80, 9.87), while highest declined trends for bulbs per clump of tuberose (1.60, 8.60) were recorded at 20 Gy gamma irradiation dose treated planted tube of tuberose in V₂M₁ and V₂M₂ generation respectively over the control. The lowest declined trends for bulbs fresh weight of tuberose cv. Pearl Double were observed at 2.5 Gy (67.17, 239.86 g) gamma irradiation dose followed by 5.0 Gy (64.08, 231.92 g), however highest declined trends gamma irradiation dose treated bulbs planted of tuberose cv. Pearl Double for bulbs fresh weight of tuberose (31.02, 179.24 g) were recorded at 20 Gy in V₂M₁ and V₂M₂ generation respectively over the control. The lowest declined trends of bulblets per clump tuberose

Table-1 : Response of gamma irradiation on bulb per clump, bulb fresh weight and bulblets per clump in Tuberose cv. Pearl Double.

Treatments	Bulb per clump		Bulb fresh weight (g)		Bulblets per clump	
	V ₁ M ₁	V ₁ M ₁	V ₁ M ₁	V ₁ M ₂	V ₁ M ₁	V ₁ M ₂
Control	3.00	10.33	72.09	252.62	20.73	33.20
2.50 Gy	2.87	10.00	67.17	239.86	19.13	32.00
5.00 Gy	2.80	9.87	64.08	231.92	19.00	31.80
7.50 Gy	2.73	9.93	62.32	233.97	19.33	30.80
10.00 Gy	2.67	9.67	61.71	216.60	18.87	29.67
12.50 Gy	2.53	9.53	55.54	207.76	18.47	27.60
15.00 Gy	2.40	9.33	52.45	202.24	16.73	27.33
17.5.0 Gy	2.33	8.93	46.41	184.16	16.93	27.00
20.00 Gy	1.60	8.60	31.02	179.24	15.20	26.67
S.Em.±	0.12	0.33	2.96	4.72	0.74	0.91
C.D. (P=0.05)	0.36	0.98	8.87	14.14	2.23	2.74
C.V. %	8.20	5.90	9.00	3.77	7.04	5.36

Table-2 : Response of gamma irradiation on bulblets fresh weight, clump weight and Propagation coefficient (%) in Tuberose cv. Pearl Double.

Treatments	Bulblet fresh weight (g)		Clump weight (g)		Propagation coefficient (%)	
	V ₁ M ₁	V ₁ M ₁	V ₁ M ₁	V ₁ M ₂	V ₁ M ₁	V ₁ M ₂
Control	47.18	58.65	242.14	342.39	496.14	558.33
2.50 Gy	42.11	53.21	221.89	339.62	466.48	523.51
5.00 Gy	40.11	52.62	215.32	334.50	455.24	508.86
7.50 Gy	39.83	53.13	211.52	330.88	447.92	507.84
10.00 Gy	38.18	52.21	208.66	326.00	441.92	474.88
12.50 Gy	36.87	50.77	203.53	323.54	421.21	451.15
15.00 Gy	32.93	46.54	196.61	320.34	390.67	440.32
17.5.0 Gy	33.10	46.66	192.15	315.97	399.82	408.22
20.00 Gy	28.72	41.13	174.49	312.65	308.32	394.95
S.Em.±	2.15	1.63	7.39	6.28	9.38	8.33
C.D. (P=0.05)	6.43	4.88	22.15	18.84	28.14	24.99
C.V. %	9.87	5.58	6.17	3.33	3.82	3.04

were observed at 2.5 Gy (19.13, 32.00) gamma irradiated dose bulb treatment of tuberose cv. Pearl Double followed by 5.0 Gy (19.00, 31.80), while highest declined trends for bulblets per clump of tuberose (15.20, 26.67) were recorded at 20 Gy gamma irradiated bulb planted of tuberose cv. Pearl Double in V₂M₁ and V₂M₂ generation respectively as compared to control. The lowest reduction trends for bulblets fresh weight of tuberose cv. Pearl Double were recorded at 2.5 Gy (42.11, 53.21 g) followed by 5.0 Gy (40.11, 52.62 g), while lowest reduction trend of bulblets fresh weight of tuberose (28.72, 41.13 g) were recorded at 20 Gy gamma irradiation of bulb in tuberose planted in V₂M₁ and V₂M₂ generation respectively as compared to control. The lowest reduction trend for clumps weight of tuberose cv. Pearl Double were observed at 2.5 Gy gamma irradiated dose (221.89, 339.62) followed by 5.0 Gy (215.32, 334.50 g), while highest declined trends for clumps weight of tuberose (174.49, 312.65 g) were recorded at 20 Gy gamma irradiation dose of bulb treatment in V₂M₁ and V₂M₂

generation respectively over the control. The minimum declined trends for propagation coefficient were observed (466.48, 523.51 %) at 2.5 Gy followed by 5.0 Gy (455.24, 508.86 %), while maximum declined trends for propagation coefficient of tuberose cv. Pearl Double (308.32, 394.95 %) were recorded at 20 Gy gamma irradiation of bulb treated and planted in V₂M₁ and V₂M₂ generation respectively as compare to control. Production of bulbs influenced due to doses of gamma irradiation. Higher dose of gamma irradiation exhibited less number of bulbs in comparison to control. The changes in number of bulb per clump may be attributed to the fact that due to irradiation treatment damage, physiology of the plant at higher doses was disturbed, which affected photosynthesis and root system resulting in the improper growth of the plant and hampered root system. It further lent support of the earlier observation made by Anu *et al.* (2003) who conducted an experiment on induced mutation in tuberose by gamma rays and reported that number of bulbs increased at lower dose of gamma irradiation and

decreased at higher doses of gamma in comparison to control. They also observed size of bulbs increased at lower doses and drastically decreased at higher doses in tuberose. Similarly weight of bulbs per clump decreased with higher doses of gamma irradiation. However, control produces bigger size of bulb than treated bulbs. Krasaechai (1992) observed that doses of 10 Gy or above of gamma radiation significantly inhibited growth of bulb and bulblets of irradiated plants of tuberose. Rasamee (1993) irradiated bulblets of liliun cv. Mont Blanc with gamma ray (0-10 Gy) and observed that survival rate decreased with increasing dose, GR 50 was at 3 Gy. In other cultivars, the number of leaves was decreased but size of leaves, length of guard cells and number of chromosomes was not changed in irradiated bulblets as compared to control. Mahesh (1995) similarly observed lower doses 1.5 kR of gamma radiation was found maximum propagation coefficient % and increase gamma rays 4.5 Gy gamma dose level with maximum declined propagation coefficient (%) in Gladiolus.

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Evaluation of Six Strains of Milky Mushroom from DMR, Solan

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Abstract

Milky mushroom is the third most largely growing mushrooms and has the good demand in the market and world trade too. An experimental was carried out with Six strains of *Calocybe indica* viz. CI-19-202, CI-19-203, CI-19-204, CI-19-205, CI-19-206, CI-19-207 for growth behavior and yield potential. Strain CI-19-206 performed best with higher fruit body yield (985 g kg⁻¹ of substrate dry weight) with maximum biological efficiency (98.5 per cent) and produced maximum number of fruiting bodies. Whereas, strain CI-19-203 showed the fastest spawn run (16.4 days) and pin head emergence (25.4 days).

Key words : *Calocybe indica*, yield, growth behavior, strains, spawn, casing.

Introduction

Calocybe indica, popularly known as Milky mushroom, is a n edible white summer mushroom. It grows well at temperatures between 25-30 degrees Celsius. Purkayastha and Chandra were the first to report it from India in 1974. Under ideal conditions, it has moderate protein content and high biological efficiency. It has sporophores with a long shelf life. The major advantage is that it is best suited for relay cropping when no other mushroom can be produced at higher temperature. After button and oyster mushrooms, it has become India's third commercially produced mushroom. This mushroom is becoming more popular in many regions of the world because of its full-bodied size, excellent Milky appearance, delicious taste, attractive colour, great long-term preservation, and distinctive texture (Chang, 2007; Alam *et al.* 2010). In the tropical region, *Calocybe indica* grows on organic rich substrate. This Mushroom blooms well from April to September. Mature fruit body of *C. indica* contains highest protein (17.2% on dry weight basis), 4.1% fat, 3.4% crude fibre and 64.26% carbohydrates and eleven amino acids (Kumar *et al.* 2017). In addition, it contains all mineral salts required by the human body, including potassium, sodium, phosphorus, iron, and calcium. Because of its alkaline ash and high fibre content, it is ideal for persons who suffer from hyperacidity and constipation (Doshi *et al.* 1988). Now a days in Rajasthan mushroom production is increasing. Two mushrooms viz. *Agaricus bisporus* and *Pleurotus species* have occupied a significant place among progressive growers. Milky mushroom, *Calocybe indica* is becoming popular day by day in Southern and North Western states of India. Several *C. indica* strains have been recorded, with a wide range of yield potential.

Farmer's decision to produce any crop variety is

based on its yielding capabilities. It implies that the benefit-cost (B:C) ratio should always be in the farmer's favour. Scientists are suggesting farmers for growing the high yielding mushroom strains. Therefore, current study was based on a comparison of six strains of Milky Mushroom for their growth behaviour and yield potential

Materials and Methods

Procurement of pure culture of *Calocybe indica* P and C : The pure culture of different strains i.e. CI-19-202, CI-19-203, CI-19-204, CI-19-205, CI-19-206, CI-19-207 of summer mushroom *Calocybe indica* was procured from Directorate of Mushroom research (DMR) Solan, Himachal Pradesh.

Spawn preparation : The master spawn of *C. indica* was prepared on wheat grains. Healthy and cleaned wheat grains were selected and washed thoroughly with tap water; then soaked overnight in clean water. Next morning, grains floating on the surface of water were removed and the remained healthy were boiled in water upto semi cooked conditions for 20-25 minute. After boiling, the excess water was drained off and the grains were uniformly spread on a clean plastic sheet/clean muslin cloth on a table. Calcium carbonate (1%) was mixed on wet weight basis of the grains for maintaining the pH of the grains at 7.0-8.0 as well as for avoiding the sticking and clumping of the grains. About 250-300g quantity of treated grains was filled in 500ml milk bottle and 500 g polypropylene bags up to 2/3rd of capacity. These were plugged with cotton and covered by paper with rubber band and sterilized in an autoclave at 20 lbs psi pressure (121.6°C) for two hours. After cooling at room temperature, the flasks were transferred in a Bio-safe cabinet, where they were exposed to UV light for 30 minutes and then inoculated with fresh mycelial bits of the

Table-1 : Growth Period of six strains of Milky mushroom (*Calocybe indica*)-(in days).

Treatment	Days taken in spawn run	Days taken for case run	Days taken to fruit body initiation	Days taken for maturing fruit body from date of pinhead initiation	Duration of fruiting post casing (d)
CI-19-202	23.5	6.8	30.3	8.1	57.3
CI-19-203	16.4	9.0	25.4	6.9	63.6
CI-19-204	19.0	7.2	26.2	6.5	53.2
CI-19-205	20.7	8.5	29.2	7.4	58.7
CI-19-206	18.5	7.5	26.0	6.2	65.4
CI-19-207	21.6	10.2	31.8	9.2	48.4
SEm±	0.5	0.4	1.1	0.4	1.6
CD (p=0.05)	1.3	1.1	3.3	1.2	4.8

All the observations are average of five replications.

Table-2 : Growth parameters and fruit bodies of six strains of Milky mushroom (*Calocybe indica*).

Treatment	Number of fruiting bodies	Yield (g)	Biological efficiency %	Fruit Body Measurement		
				Pileus diameter (cm)	Stipe Length (cm)	Stipe diameter (cm)
CI-19-202	26.2	766.9	76.6	8.1	8.9	2.5
CI-19-203	26.4	890.4	89.0	7.2	10.6	2.7
CI-19-204	25.6	960.2	96.0	7.9	10.3	2.6
CI-19-205	22.0	774.2	77.4	6.7	8.3	2.4
CI-19-206	38.2	985.0	98.5	8.6	10.2	2.5
CI-19-207	23.0	753.8	75.3	6.4	10.0	2.2
SEm±	1.1	21.0	2.1	0.3	0.4	0.3
CD (p=0.05)	3.3	61.3	6.1	0.9	1.2	NS

All the observations are average of five replications.

mushroom culture and incubated at 24 ± 2 °C for 16-18 days. The fresh spawn with profuse mycelial growth was used for further experiments on cultivation aspects of *C. indica*.

Preparation of substrate : Milky mushroom is grown on various substrates viz. paddy straw, wheat straw and sorghum straw etc. The experiment was laid out by using wheat straw, since wheat straw is easily available and cheap, it is widely used and recommended for growing Milky mushroom, Wheat Straw was chopped into 3-5 cm pieces and soaked in fresh water for 24 hrs, along with chemical treatment to sterilize the substrate, however threshed wheat straw has been found better for this. Excess water from straw was drained off by spreading it on clean sloppy surface lined with polypropylene sheet or it can be kept on 150 mesh iron structure for decanting.

Spawning : The sterilized substrate got ready for filling and spawning in polybags when it cools down to room temperature and the substrate moisture content remains about 65%. 8 small holes of 1 square cm size were made at the equal distances in the polybags by using scissors before filling them with substrate and spawn. Spawning was done in layers. For layer spawning, substrate filled in bag was pressed to a depth of 2-3 inches and broadcasted with spawn above it. Similarly, 2nd and 3rd layers with

equi-distribution of entire substrate were put simultaneously and after spawning, some amount of substrate is put on it, and then the bags were closed and tied up with rubber bands.

Spawn run and casing : Suitable temperature for spawn run is 25 ± 2 °C and the bags should be kept in a clean room. Before completion of spawn run casing material is prepared and it is usually composed of spent compost and cocopeat in 1:1 ratio. Prior to casing the material mixture is leached and sterilized by using either hot water treatment or chemicals like formaldehyde 0.4%, carbendazim-0.2% and dichlorvos-0.1%.

Statistical analysis : Various data were statistically analysed by using OPSTAT software developed by department of mathematics statistics, CCS HAU, Hisar.

Results and Discussion

Spawn run period : The spawn run period of six strains viz. CI-19-202, CI-19-203, CI-19-204, CI-19-205, CI-19-206 and CI-19-207 of Milky mushroom (*Calocybe indica*) were presented in Table-1. Results showed that minimum time of 16.4 days was required for completion of spawn run by the strain CI-19-203, followed by strain CI-19-206 taking 18.5 days. Maximum time of 23.5 days taken for completion of spawn run by the strain CI-19-202.

Case run : time taken for case run, the minimum time of 6.8 days was required for complete case run in strain CI-19-202 followed by strain CI-19-204 taking 7.2 days and maximum time *i.e.* 10.2 days for case run completion was recorded in strain CI-19-207.

Initiation of pin head : Minimum days were recorded for initiation of pinning with the strain CI-19-203 *i.e.* 25.4 days followed by CI-19-206 *i.e.* 26.0 days and longest duration was reported with the strain CI-19-207 *i.e.* 31.8 days

Days taken for maturing fruit body : Minimum 6.2 days were taken for maturing fruit body with the strain CI-19-206 followed by *i.e.* 6.5 days in the strain CI-19-204 and maximum days of 9.2 days were taken for the maturing fruit body with the strain CI-19-207.

Duration of fruiting post casing : Maximum duration of fruiting after casing was recorded with the strain CI-19-206 (65.4 days) followed by strain CI-19-203 (63.6 days) and minimum duration of fruiting after casing was recorded with the strain CI-19-207 (48.4 days).

Total number of fruit bodies : The growth parameters of fruiting bodies like average number of fruit bodies, length of stalk, diameter of stalk, length of fruit bodies' minimum & maximum weight of fruit bodies and diameter of cap were measured and results showed in Table-2. Maximum number of fruiting bodies *i.e.* 38.2 were obtained from the strain CI-19-206 followed by *i.e.* 26.4 obtained from the strain CI-19-203.

Stalk length : The average stalk length was observed from six strains of Milky mushroom (*Calocybe indica*). Maximum length of stalk was observed in strain CI-19-203 (10.6 cm) followed by CI-19-204 (10.3 cm), CI-19-206 (10.2 cm), CI-19-207 (10.0 cm), CI-19-202 (8.9 cm), CI-19-205 (8.3 cm).

Cap diameter : Maximum cap diameter was recorded from strain CI-19-206 (8.6 cm) followed by CI-19-202 (8.1 cm), CI-19-204 (7.9) and CI-19-203 (7.2 cm), CI-19-205 (6.7 cm), CI-19-207 (6.4 cm).

Stipe diameter : Maximum Stipe diameter was recorded from strain CI-19-203 (2.7 cm) followed by CI-19-204 (2.6 cm), CI-19-203 (2.7 cm) and CI-19-206 (2.5 cm), CI-19-205 (2.4 cm), CI-19-207 (2.2 cm).

Total yield : The results from Table-2 shown that strain CI-19-206 was better in performance, yielded 985.0 g/kg of dry wheat straw substrate. Strain CI-19-204 was found

second in given production with 960.2 g followed by CI-19-203 (890.4 g) and CI-19-202 (766.9g), CI-19-205 (774.2). Minimum yield (753.8 g) was obtained from strain CI-19-207. Finally highest Biological efficiency (98.5 %) was obtained from strain CI-19-206 followed by CI-19-204 (B.E.- 96.0%).

Evaluation of various strains is a continuous feature in AICRP, Mushroom set up and this is multilocal in nature which gives a perfect idea of higher yielding strains and suitability in existing climate. There are various strains available for production of Milky mushroom. In the present investigation, six strains of *C. indica* were evaluated for proper selection of strains. Finally strain CI-19-206 of Milky mushroom has been performed better for yield potential while CI-19-207 showed lowest yield and it also shows that growth parameter for strain CI-19-206 were better than other strains of Milky mushroom.

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Assessment of Genetic Variability Parameters in Cluster Bean (*Cyamopsis tetragonoloba* (L.) Taub.)

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Abstract

Ten genotypes of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub] were evaluated to estimate variability, broad sense heritability and genetic advance over mean for yield and related attributes, during Kharif 2019 were evaluated in Randomized Complete Block Design with three replications. Substantial amount of genetic variations were observed with low influence of environment indicated consistence performance of the genotypes. GCV and PCV were highest for number of braches per plant followed by biological yield and harvest index. Greater magnitude of heritability coupled with high to moderate genetic advance as per cent of mean was observed for Number of branches per plant, plant height and Number of clusters per plant indicates predominance of additive component for these traits and hence direct selection would be more effective in improving these traits.

Key words : Genetic variability, Heritability, Genetic advance, clusterbean.

Introduction

The Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] known as *Gavar*, *Guwar*, or *Guvar* in Hindi, is an annual, self-pollinated leguminous crop belonging to the family *Fabaceae* of kingdom *Plantae*, which is generally grown under rainfed conditions of arid and semi-arid regions of tropical India during *Kharif* and summer (*Zaid*) seasons. It is an important short duration (90-120 days) crop of high nutritive value and nitrogen fixing ability. It is a diploid crop with $2n=2x=14$ chromosome number. It is assumed to have developed from the African species *Cyamopsis senegalensis*. It was further domesticated in India and Pakistan, where it has been cultivated for many centuries. Clusterbean grows well in semi-arid areas, but frequent rainfall is necessary.

Vavilov (1951) suggested India as a geographic center of variability for guar, although it is not found to exist in wild state in this region. Gillet (1958) emphasized that *Cyamopsis* is distinct genus with tropical Africa as its probable center of origin. Hymowitz and Matlock (1963) on the other hand believed that African wild species *C. senegalensis* appears to be of African origin, yet it has been domesticated through centuries in the North eastern region of Indo-Pakistan sub- continent.

It is an excellent source of carbohydrate (38.8 to 59.1%) with high crude protein (28.3 to 35.0%) and endospermic gum (23.9 to 35.0%), crude fiber (4.1 to 8.0%), ash (3.5 to 6.0%) and fat content (1.8 to 5.2%)

(Pathak *et al.*, 2011). Its kernel consists of a protein rich germ (43-46%) and a relatively large endosperm (34-40%) containing higher amount of the galactomannan. It is generally cultivated for vegetable purposes (immature green pods) and seed production. Green pods of clusterbean are nutritionally rich in protein (3.2 g), fat (1.4 g), carbohydrate (10.8 g), vitamin-A (65.31 IU), vitamin-C (49 mg), calcium (57 mg) and iron (4.5 mg) per 100 g of edible portion (Kumar and Singh, 2002). Thus, it exhibits a great hydrogen bonding activity having a viscosifying effect in liquids. This legume is a very valuable plant within a crop rotation cycle, as it has symbiosis with nitrogen fixing bacteria. In fact, agriculturists in semi-arid regions of Rajasthan follow crop rotation and use guar as a source to replenish the soil with essential nutrients and nitrogen fixation, before the next crop.

India is one of the main producers of clusterbean contributing up to 80 per cent of total production of world, whereas Rajasthan occupies the largest area (82.1%) under clusterbean cultivation in the country. In India, clusterbean is grown on 5.35 million hectare with the annual production of 3.28 million tonnes and productivity of 615 kg/ha (Anonymous, 2017-18 a). The maximum contribution in respect of area is from Rajasthan (3.43 million hectare) with the annual production of 1.54 million tonnes and productivity of 450 kg/ha (Anonymous, 2017-18 b). In Rajasthan, this crop is mostly grown in

Table-1 : Analysis of variance for grain yield and other traits of cluster bean.

Source of variation	D.F	DF	DM	PH (cm)	No. of branches per plant	No. of clusters per plant	No. of pods per cluster	No. of seeds per pod	Pod length (cm)	100-Seed weight (g)	Biological yield per plant (g)	Harvest index (%)	Seed yield per plant (g)
Replication	2	12.476	0.553	679.140	0.117	32.562	2.523	6.241	0.999	0.223	56.644	86.848	3.829
Treatment	9	3.430*	9.454*	179.939*	1.803*	6.227*	0.371*	0.932*	0.562*	0.073*	130.030*	39.971*	1.557*
Error	18	0.735	2.949	24.200	0.200	1.235	0.127	0.281	0.227	0.029	33.309	16.137	0.633

*Significant at 5% levels.

Table-2 : Estimates of genetic parameters of variation for 12 characters of clusterbean.

Characters	GCV	PCV	Heritability	Genetic Advance	Genetic Advance value % means
Days to 50% flowering	2.10	2.97	49.90	1.37	3.06
Days to maturity	1.72	2.64	42.37	1.97	2.30
Plant height (cm)	11.16	13.51	68.21	12.26	18.98
Number of branches per plant	21.10	24.74	72.75	1.28	37.08
Number of clusters per plant	15.17	20.03	57.39	2.01	23.68
Number of pods per cluster	7.32	11.72	38.99	0.37	9.41
Number of seeds per pod	8.16	12.36	43.57	0.63	11.09
Pod length (cm)	7.29	12.70	32.98	0.40	8.63
100-Seed weight (g)	3.48	6.07	32.76	0.14	4.10
Biological yield per plant (g)	15.12	21.55	49.18	8.20	21.84
Harvest index (%)	11.26	21.21	28.18	2.75	12.31
Seed yield per plant (g)	6.01	10.50	32.75	0.65	7.08

Barmer, Churu, Sriganganagar, Nagaur, Jalore, Sikar, Jaisalmer, Bikaner, Jaipur and Alwar districts.

Assessment of genotypes to evaluate the existing variability is considered as pre-requisite step in any crop improvement programme. Availability of information on the magnitude of variation in the existing genetic materials and the part played by the environment on the expression of plant characters are prime significance for the assessment of the magnitude of possible improvement. Variability for different traits in the source population is a preliminary requirement for crop improvement since all attempts of breeding and selection would be futile unless major portion of variability is heritable. Further, estimation of genetic advancement and heritability would give the best picture of the extent of improvement expected from selection and reliability of selection based on phenotype.

Materials and Methods

The present investigation was carried out during *Kharif* 2019 at Agronomy Farm, M.J.R.P. University, Achrol, Jaipur. The experimental farm is situated between 27° 11' N latitude and 71° 54' E longitudes at an altitude of 228.5 meters above sea level. Mean weakly weather parameter for the season recorded at M.J.R.P. University, Achrol, Jaipur. In this experiment ten clusterbean genotype taken, each genotype was grown in 4 m long plot with plant to plant distance was maintained at 10 cm in Randomized Complete Block Design (RBD) with three replications

during kharif season, 2019-20. The analysis of variance for individual characters and for the character pairs respectively, were carried out using the mean values of each plot following the method given by Panse and Sukhatme (1985). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed, following Burton and Devane, (1953) and Johnson *et al.* (1955) method. Heritability in broad sense h^2 (broad sense) was calculated as a ratio of genotypic variance to phenotypic variance (Allard, 1960). The expected genetic advance under selection for the different characters was estimated as suggested by Johnson *et al.*, (1955).

Results and Discussion

The analysis of variance (Table-1) revealed highly significant variation among the accessions for growth, yield and quality parameters in cluster bean, indicates sufficient variability existed for the characters studied and considerable improvement could be achieved.

The estimates of GCV, PCV, heritability (BS), GA and Genetic advance as percentage of mean for all studied characters are given in Table-2. In the present investigation, high GCV and PCV were observed for Number of branches per plant, Number of clusters per plant, Biological yield per plant (g), Harvest index (%) and Plant height (cm). Similar results were also observed by Singh *et al.* (2003), Malaghan (2012) and Rai *et al.* (2012)

for Number of branches per plant and Number of clusters per plant. It indicates existence of broad genetic base, which would be amenable for further selection.

Moderate GCV and PCV were observed for Number of seeds per pod, Number of pods per cluster, Pod length (cm) and Seed yield per plant (g). Similar finding observed by Malaghan (2012) and Girish *et al.* (2013) for Number of seeds per pod and Number of pods per cluster.

Low GCV and PCV were observed for Days to 50% flowering, 100-Seed weight (g) and Days to maturity. Earlier, Singh *et al.* (2002) have also noted low GCV and PCV for days to flowering and 100-seed weight, Hanchinamani (2004) and Girish *et al.* (2013) for days to 50% flowering. This indicated the narrow genetic base and hence, variability has to be generated in these characters either through introduction or hybridizing divergent genotypes.

Coefficient of variation indicates only the extent of variability present in germplasm for different characters, but for the prediction of response to selection, heritability estimates are useful. Very high (>60%) broad sense heritability was observed for Number of branches per plant and Number of clusters per plant. Similar results were also obtained by Hanchinamani (2004), Anandhi and Oommen (2007), Malaghan (2012) and Rai *et al.* (2012) for number of branches per plant and number of clusters per plant.

The high estimates of heritability coupled with high values of genetic advance over mean (GAM) were observed for the characters Number of branches per plant, Plant height (cm), Number of clusters per plant and Biological yield per plant (g). These results are in accordance with the findings of Hanchinamani (2004), Anandhi and Oommen (2007), Prakash *et al.* (2008), Rai *et al.* (2012) and Girish *et al.* (2013) for plant height, number of branches per plant. This indicates predominance of additive component for these traits and hence direct selection would be more effective in improving these traits.

High heritability coupled with moderate to low values of GAM were observed for Plant height (cm), Number of seeds per pod, Days to 50% flowering and Days to maturity indicated the prevalence of non additive components and there can be little response to selection and these traits can be exploited through heterosis breeding.

Moderate to low heritability coupled with high GA indicates the importance of additive gene effects. Low to moderate heritability with high GAM was obtained for Number of clusters per plant and Biological yield per plant (g). This indicated the importance of additive gene effects

for these traits and there can be better response to selection.

Moderate to low heritability with moderate to low values of GAM were observed for the characters like Number of pods per cluster, Pod length (cm), Seed yield per plant (g), 100-Seed weight (g). These findings elucidate prevalence of higher influence of environment on these traits and hence, selection would be ineffective. Similar findings were also obtained by Manivannan and Anandakumar (2013).

Conclusion

The results of the present investigation the presence of adequate genetic variability within and among the genotypes, which suggests scope for further genetic improvement in clusterbean. High heritability coupled with high genetic advance were observed for the traits like Plant height (cm), Biological yield per plant (g) and Number of branches per plant. Hence, in the improvement programme importance may be given for this trait to improve genetic yield potential in clusterbean. Therefore, induced genetic variability can be successfully utilized to develop new cultivars of clusterbean.

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Genetic Variability, Heritability and Genetic Advance Studies in Maize Hybrids over Environments

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Abstract

Maize (*Zea mays* L.; 2N=20) is an important cereal crop belonging to the tribe Maydeae, of the grass family, Poaceae. The selection efficiency for certain traits in crops can be broadened using estimates of genetic parameters, which are fundamental for plant breeding. Breeding of crops for high yield requires information on nature and magnitude of variation in the available material. The experimental material consisted of 45 hybrids and 18 parents (15 lines and 3 testers) along with 2 checks. These all 65 genotypes were evaluated at three environments viz., E1 (Kharif-2019, Instructional Farm, RCA, Udaipur), E2 (Kharif-2019, ARSS, Vallabh Nagar) and E3 (Rabi-2019-2020, Instructional Farm, RCA, Udaipur) in randomized block design with three replications. The mean squares due to genotypes were found significant for all the traits in all the environments E1, E2 and E3 under study. Similarly, on pooled basis sum of squares due to genotypes were also found significant for most traits under the study indicated significant amount of genetic variability was present in genetic material. The magnitude of PCV and GCV were found relatively moderate for plant height, ear height, ear length, ear girth, grain rows per ear, 100-grain weight in most of the environments under the study. The estimates of GCV and PCV were found higher for grain yield per plant in all the three environments. The moderate estimates of heritability coupled with genetic advance (per cent of mean) were observed for most of yield contributing traits as ear length, ear girth, grain rows per ear as well as for 100 grain weight, indicated these characters may be under the control of additive gene action and the consequent high-expected genetic gain from selection for these traits.

Key words : Genetic variability, heritability, genetic advance, maize.

Introduction

Maize (*Zea mays* L.) or Corn which literally means “that which sustains life” (1) is one of the most important food crops in the world with its huge ears, packed with starch and oil. The crop is a key source of calorie, protein, vitamins and minerals to billions of people world-wide, particularly in Africa, South America and Asia and forms a critical role in global food security (2). It is diclinous, allogamous species which belongs to the monocot family Poaceae, Genus *Zea* and Species *mays*. It was domesticated from Teosinte (*Zea mays* L. spp. *Parviglumis*) about 10,000 years ago in the Balsas River Basin of South Western Mexico (3). Teosinte, is the closest living relative as evident from morphology, crossability, chromosome morphology and molecular genetic studies (4). Cultivated maize was introduced in India by the Portuguese during the seventeenth century. Globally, it is grown in 196.76 M ha across 165 countries, with a total production of 1162.38 MMT, and average productivity of 5.91 metric t/ha (5). It is ranked among the top three most widely cultivated cereal crops globally in 2019 and projected increase in 6.47 per cent in production for the year 2020 (5). In Asia, eight major maize growing

countries - China, India, Indonesia, Nepal, Pakistan, Philippines, Thailand and Vietnam produce 98 per cent of Asia's maize and 28 per cent of the global maize (6). In India, it is grown in 9.20 M ha with a total production of 28.00 MMT, and average productivity of 3.04 metric t/ha (5). It is grown both in *kharif* and *rabi* seasons with a share of 85 per cent and 15 percent, respectively. About 25 per cent of maize produced is used for human consumption (7). The major producing states are Andhra Pradesh (20%), Karnataka (17%), Maharashtra (11%), Bihar (9%), Tamil Nadu (8%), Madhya Pradesh (6%) and Rajasthan (6%) (8). In Rajasthan, it occupied an area of 9.34 lakh ha with production of 17.64 lakh tonnes and productivity of 1889 kg/ha (9). The demand for maize is expected to double by 2050 (10) and in Indian context the projected demand is expected to be 42 million tonnes by the year 2025 (11). Thus, improving maize productivity is urgent and challenging also due to limited crop land and a growing population. Furthermore, global crop yields were stagnant across 24-39 per cent of the main growing areas (12). It is estimated that the maximum part of the increasing food demand in near future will be fulfilled from maize and half of the increased world food demand in terms of cereals as a whole will be produced from maize

Table-1 : Analysis of variance for eleven traits in all the three environments in maize.

Source	d.f.	Environ- ment	Mean sum of squares										
			Days to 50 per cent tasseling	Days to 50 per cent silking	Days to 75 per cent brown husk	Plant Height (cm)	Ear height (cm)	Ear length (cm)	Ear girth (cm)	Grain rows per ear	100-grain weight (g)	Grain yield per plant (g)	Harvest index (%)
Replication	2	E1	2.78	16.75**	10.76*	142.99	49.35	3.13	0.56	0.78	11.86	122.96*	3.74
		E2	3.10	5.88	1.40	132.60	52.41	5.90**	0.56	0.47	39.80**	169.19**	3.09
		E3	11.75*	7.89*	5.11	108.35*	73.99	2.26	0.64	2.04	17.44*	71.79	58.26
Treatments	64	E1	24.17**	25.78**	21.58**	1063.89**	324.63**	6.56**	5.86**	5.84**	15.14**	779.50**	48.42**
		E2	24.36**	21.03**	21.66**	936.35**	274.45**	2.72**	2.48**	2.83**	19.92**	673.07**	42.00**
		E3	28.028**	26.67**	30.22**	864.31**	276.82**	5.85**	3.20**	4.60**	14.03**	800.45**	60.35**
Error	128	E1	2.58	2.74	2.46	62.94	17.46	1.05	0.75	0.96	4.80	32.89	3.63
		E2	3.89	2.48	2.47	52.52	23.95	0.72	0.57	0.93	4.61	34.96	5.90
		E3	2.69	2.47	2.86	33.92	26.69	1.39	0.68	1.39	5.37	39.76	31.79

* and ** represent level of significance at 5% and 1%, respectively.

Table-2 : Pooled analysis of variance for eleven traits in maize.

Source	d.f.	Mean sum of squares										
		Days to 50 per cent tasseling	Days to 50 per cent silking	Days to 75 per cent brown husk	Plant Height (cm)	Ear height (cm)	Ear length (cm)	Ear girth (cm)	Grain rows per ear	100-grain weight (g)	Grain yield per plant (g)	Harvest index (%)
Genotypes	64	57.05**	53.92**	49.07**	2582.60**	736.33**	13.04**	8.62**	10.65**	45.08**	2077.15**	125.84**
Environments	2	214491.38**	230746.79**	249140.35**	8879.40**	2243.73**	189.41**	100.19**	93.77**	395.57**	10016.7**	845.58**
Replication/Environments	6	5.88	10.17**	5.76	127.98*	58.58*	3.76**	0.58	1.09	23.03**	121.31**	21.69
Genotype X Environment	128	9.75**	9.78**	12.2**	140.97**	69.79**	1.04	1.46**	1.31	2.04	87.93**	12.46
Error	384	3.05	2.56**	2.59	49.78	22.70	1.04	0.66712	1.09	4.92	35.86	13.77

* and ** represent level of significance at 5% and 1%, respectively.

Table-3 : Categorization of different estimates of genetic variability.

S. No.	Categories	Estimates of genetic variability			References	
		GCV (%) and PCV (%)	Heritability (%)	Genetic advance (Percent of mean)		
1.	Low	0-10	0-30	0-10	Sivasubramanian and Menon (1973)	(30)
2.	Medium	10-20	30-60	10-20	Robinson et al. (1949)	(29)
3.	High	>20	>60	>20	Johnson et al. (1955)	(20)

Table-4 : The estimates of genetic variability in E1, E2 and E3 environments for eleven traits in maize.

S. No.	Particulars	Days to 50 per cent tasseling	Days to 50 per cent silking	Days to 75 per cent brown husk	Plant Height (cm)	Ear height (cm)	Ear length (cm)	Ear girth (cm)	Grain rows per ear	100-grain weight (g)	Grain yield per plant (g)	Harvest index (%)
1.	Mean	E1 56.76 E2 58.57 E3 115.09	58.80 60.79 119.35	86.09 87.57 148.73	152.60 147.30 160.70	67.96 63.70 70.40	13.83 12.97 14.93	12.84 12.52 13.89	13.69 12.93 14.31	27.63 26.59 29.40	74.63 68.95 83.19	32.74 30.83 34.99
2.	Range	E1 51.66-62.00 E2 52-65.33 E3 107.66-120.33	53.00-63.33 54.33-66.67 111.33-124.00	80.33-91.67 81.33-93.00 143.00-156.00	109.08-181.83 107.43-177.82 128.39-191.84	42.21-84.36 44.20-82.00 51.74-89.90	10.66-16.67 11.13-15.10 11.99-17.56	9.78-15.80 10.28-14.22 12.09-15.84	10.67-16.57 10.33-15.00 11.57-16.50	21.84-32.18 21.60-32.60 24.80-34.29	41.25-112.33 42.60-99.33 46.34-119.33	23.28-42.21 23.24-39.76 27.27-53.84
3.	σ^2_g	E1 7.20 E2 6.83 E3 8.45	7.68 6.19 8.07	6.38 6.40 9.12	333.65 294.61 276.80	102.39 83.50 83.38	1.84 0.67 1.49	1.70 0.64 0.84	1.63 0.63 1.07	3.45 5.11 2.89	248.87 212.70 253.56	14.93 12.03 9.52
4.	σ^2_p	E1 9.78 E2 10.72 E3 11.13	10.43 8.67 10.54	8.84 8.87 11.98	396.59 347.13 310.71	119.85 107.45 110.07	2.88 1.39 2.88	2.46 1.21 1.52	2.59 1.57 2.47	8.25 9.71 8.26	281.75 247.66 293.32	18.57 17.94 41.31
5.	σ^2_e	E1 2.58 E2 3.89 E3 2.69	2.74 2.48 2.47	2.46 2.47 2.86	62.94 52.52 33.92	17.46 23.95 26.69	1.05 0.72 1.39	0.75 0.57 0.68	0.96 0.93 1.39	4.80 4.61 5.37	32.89 34.96 39.76	3.63 5.90 31.79
6.	GCV	E1 4.73 E2 4.46 E3 2.53	4.71 4.09 2.38	2.93 2.89 2.03	11.97 11.65 10.35	14.89 14.35 12.97	9.81 6.30 8.17	10.17 6.37 6.61	9.31 6.16 7.23	6.72 8.50 5.78	21.14 21.15 19.14	11.80 11.25 8.82
7.	PCV	E1 5.51 E2 5.59 E3 2.90	5.49 4.84 2.72	3.45 3.40 2.33	13.05 12.65 10.97	16.11 16.27 14.90	12.28 9.08 11.36	12.21 8.78 8.87	11.75 9.69 10.97	10.39 11.72 9.77	22.49 22.82 20.59	13.16 13.74 18.37
8.	ECV	E1 2.83 E2 3.37 E3 1.42	2.82 2.59 1.32	1.82 1.80 1.14	5.20 4.92 3.62	6.15 7.68 7.34	7.39 6.54 7.88	6.76 6.04 5.92	7.16 7.48 8.25	7.93 8.07 7.88	7.68 8.57 7.58	5.82 7.88 16.11
9.	H^2_{bs} (%)	E1 73.65 E2 63.70 E3 75.87	73.69 71.37 76.60	72.14 72.12 76.15	84.13 84.87 89.08	85.43 77.71 75.75	63.76 48.15 51.82	69.34 52.67 55.47	62.84 40.43 43.44	41.82 52.57 34.96	88.33 85.88 86.44	80.42 67.09 23.05
10.	GA (%)	E1 8.36 E2 7.33 E3 4.53	8.34 7.12 4.29	5.13 5.05 3.65	22.62 22.11 20.13	28.35 26.05 23.26	16.13 9.01 12.12	17.44 9.53 10.14	15.21 8.07 10.08	8.95 12.72 7.07	40.93 40.38 36.66	21.80 18.98 8.72

(13). The starting point of any breeding programme is to ascertain the genetic variability present in the germplasm and this forms the basis for crop improvement. It is important to find out the nature and magnitude of variability for different important characters as part of crop improvement programmes. The efficiency with which genotypic variability can be exploited by selection depends upon heritability and the genetic advance (GA) of individual trait. Genetic improvement of plants for quantitative traits requires reliable estimates of heritability in order to plan an efficient breeding program (14). Heritability provides information on the extent to which a particular morphogenetic character can be transmitted to successive generations (15). Heritability coupled with high genetic advance (GA) would be more useful in predicting the resultant effect in the selection of the best genotypes for yield and its attributing traits (16). Therefore, this study was designed to assess the magnitude of genetic variability, heritability and genetic advance of traits in maize genotypes.

Materials and Methods

The experimental material for the study comprised of 18 parents, 45 hybrids and 2 check cultivars of maize. These 65 genotypes were evaluated at three environments viz., E1 (Kharif-2019, Instructional Farm, RCA Udaipur), E2 (Kharif-2019, ARSS Vallabhnagar) and E3 (Rabi-2019, Instructional Farm, RCA Udaipur) in randomized block design with three replications at each environment. The each treatment was sown in single row plot of 4.0 m length with geometry of 60 x 20 cm row to row and plant to plant spacing, respectively. The Udaipur district is located in the Aravalli Hill Ranges of Southern part of the Rajasthan with latitude 24°35'31.5" longitudes 73°44'18.2" with an altitude of 582.17 m above mean sea level. The Vallabhnagar is a village in Vallabhnagar tehsil of Udaipur district of Rajasthan. The soil of both experimental fields were clay loam, deep, well drained, alluvial in origin and have good moisture holding capacity. All the recommended package of practices of zone IV-A (Sub-Humid Southern Plains of Rajasthan) were used to raise a healthy crop. The data were recorded for 11 traits including phenological, grain yield and other component traits on ten competitive plants selected from each plot in each replication.

Statistical Analysis : The analysis of variance was carried out separately for all the environments as E1, E2 and E3 as well as on pooled basis using the mathematical model of Panse and Sukhatme (1985) (17) and Singh and Choudhary (1985) (18). The genotypic and phenotypic coefficient of variations were calculated by the standard statistical procedure suggested by Burton (1952) (19) for each trait in each of the environment. The estimates of broad sense heritability (h^2_{bs}) were estimated as per the

method suggested by Johnson *et al.* (1955) (20). The expected genetic advance (GA) for each character in each of the environment was calculated according to the method suggested by Johnson *et al.* (1955) (20).

Results and Discussion

The analysis of variance (Table-1) for each of the environments depicted that mean squares due to genotypes were found highly significant ($P < 0.01$) for all the characters in all the environments as E1, E2 and E3 indicated inherent differences among the genotypes for all the characters under the study which can be exploited for improvement of seed yield in maize. Similarly, the sum of squares due to replications were found non-significant in all the environments under the study. The ANOVA on pooled basis (Table-2) revealed highly significant ($P < 0.01$) mean squares due to genotypes for all the characters under the study suggesting the material had adequate variability and response to selection may be accepted in the breeding programmes aiming for improvement in seed yield or any of its supporting characters. The mean squares due to G x E interaction were also found significant for grain yield and most of the traits under the study indicated influence of environmental factors on the character expression. The estimates of different parameters of genetic variability as mean, range, genotypic variance (σ^2_g), phenotypic variance (σ^2_p), environmental variance (σ^2_e), genotypic coefficient variance (GCV), phenotypic coefficient variance (PCV), environmental coefficient variance (ECV), heritability (H^2_{bs}) and genetic advance (GA) as per cent of mean for all characters in all the environments are presented in Table 4. The overall mean of genotypes for grain yield and its components traits were found higher in E3 environment than both the two environments as E1 and E2 indicating superiority of E3 environment (*Rabi* Season). The overall mean for the phenological traits as days to 50 per cent tasseling, days to 50 per cent silking and days to 75 per cent brown husk were also found higher in E3 environment due to longer duration of *rabi* season. The categorizations of different parameters of genetic variability are presented in Table 3. The magnitude of genotypic and phenotypic variances was found higher in E3 environment for all the three phenological traits and grain yield per plant. For the traits plant height, ear height, ear length, ear girth, grain rows per ear, the magnitude of genotypic and phenotypic variances was higher in E1 environment. This indicated the influence of varied environmental conditions on character expression by the genotypes under the study. The phenotypic coefficient of variations (PCV) was found higher than the corresponding genotypic coefficient of variation (GCV) for all the characters, which indicated effect of environments on the character expression. However, the differences were

relatively narrow which implied their relative resistance to environmental variations. It also described that genetic factors were predominantly responsible for expression of those attributes and selection could be made effectively on the basis of phenotype performance. The parameters of genotypic and phenotypic coefficients of variations are useful in detecting the amount of variability present in the available genotypes. The estimates of PCV and GCV were found relatively moderate for plant height, ear height, ear length (PCV in both E1 and E2), ear girth (GCV, PCV in E1), grain rows per ear (PCV E1, E3), 100-grain weight (PCV E1, E2). The estimates of GCV and PCV were found higher for grain yield per plant in all the three environments, similarly moderate estimates of GCV and PCV were also obtained for the trait harvest index this indicated that simple selection may be more effective for these characters because response to selection is directly proportional to the variability present in the experimental material. The above results of GCV and PCV are found in general agreement with the findings of Manju *et al.* (2002) (21) and Shakoor *et al.* (2007) (22) in maize. The heritability helps in determining the influences of environment on expression of the characters and extent to which improvement is possible after selection. It is heritable portion of the phenotypic variance and a good index of the transmission of characters from parents to their offspring's. The estimates of heritability help the breeder in selection of elite genotypes from diverse genetic populations. The breeder appreciates the proportion of variation that is due to the genotype (broad sense heritability) or additive (narrow sense heritability) effects i.e. the heritable portion of variation of the first case and the portion of genotypic variation that is fixable in pure lines in the later case. If heritability of a character is high (>60%), selection for such a characters should be fairly easy. This is because there would be close correspondence between genotypic and phenotypic variation due to a relatively smaller contribution of environment to the phenotype, but for a character with a low heritability (<30%), selection may be considerably difficult or virtually impractical due to masking effect of environment on the genotypic effect. The estimates of heritability were found comparatively higher for ear height, ear length, ear girth, grain rows per ear, grain yield per plant and harvest index in E1 environment than both three remaining environments. Similarly, the estimates of heritability were found comparatively higher in E3 environment for all the three phenological traits and plant height than both E1 and E2 environment. The estimates of broad sense heritability (h^2_{bs}) were found moderate for ear length, ear girth, grain rows per ear and 100-grain weight in all the three environments E1, E2 and E3 under the study. The magnitude of broad sense heritability (h^2_{bs}) was found higher for grain yield per plant in all the three

environments. This indicated these traits was least influenced by the environmental effects and selection for improvement of such traits might be advantageous. Similar findings of high and moderate heritability for above traits in maize were also reported by Hefny (2011) (23), El-Badawy (2012) (24), Ghimire and Timsina (2015) (25). The Heritability estimates alone do not provide information on the amount of genetic progress that would result from the selection of the best genotype. Therefore, genetic advance as percentage of mean was calculated in order to determine the relative merits of different characters that can be further utilized in the selection programme. Genetic advance (GA) is also of considerable important because it indicates the magnitude of the expected genetic gain from one cycle of selection. The estimates of genetic advance were found comparatively higher in E1 environment for all the traits under study than E2 and E3 environment. The magnitude of genetic advance as percent of mean was found higher for plant height, ear height and grain yield per plant in all the three environments, whereas except E2 environment, moderate estimates of genetic advance were found for the three yield component traits as ear length, ear girth, grain rows per ear as well as for 100 grain weight (except E1, E3 environments). This indicated that these traits were governed by additive gene action and selection will be rewarding for improvement of such traits. The low estimates of genetic advance were found for three phenological traits as days to 50 per cent tasseling, days to 50 per cent silking and days to 75 per cent brown husk in all three environments indicated that these traits were governed by non-additive gene action and heterosis breeding may be useful for improvement of such traits. Johnson *et al.* (1955) (20) has pointed out that heritability estimates along with genetic advance are more useful than heritability estimates alone in predicting the response to selection and thus both parameters should be considered for making an effective selection. Therefore, relative higher or moderate estimates of heritability coupled with genetic advance as percentage of mean are more reliable to determine the relative merits of different characters that can be further utilized in the selection programme. In present investigation higher estimates of heritability coupled with genetic advance as percentage of mean was found for grain yield per plant. The relatively moderate estimates of heritability coupled with genetic advance as percentage of mean were observed for the traits ear length, ear girth, grain rows per ear as well as for 100 grain weight. This indicated these characters may be under the control of additive gene action and selection for these characters may be effective. Thus, in breeding programmes above traits can be considered as favourable attributes for crop improvement through selection. Likewise, the high heritability combined with high genetic advance could be regarded as an indication of additive

gene action and the consequent high-expected genetic gain from selection for these traits. Similar findings of importance of the traits as ear length, ear girth, grain rows per ear and 100 grain weight in selection were also reported by Bello *et al.* (2012) (15), Nzuve *et al.* (2014) (26) and Bartaula *et al.* (2019) (27) in maize.

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Economic Empowerment of Rural Women through Self Help Group in Bikaner District of Rajasthan

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Abstract

The study was conducted in Bikaner district of Rajasthan. There are seven panchayat samities in Bikaner district. These are namely – Bikaner, Lunkaransar, Sri Dungargarh, Khajuwala, Kolayat, Nokha and Panhu. Kolayat panchayat samiti was selected purposively because maximum no. of SHGs (794) are running there. There are total 37 Gram panchayat which comes under kolayat panchayat samiti of Bikaner district. For study purpose, a total of 10 Gram panchayat were selected randomly. From each selected Gram panchayat 1 SHGs was selected. Therefore total 10 SHGs were selected present investigation. After that 12 members from each SHG were selected for the study. Hence, the total sample constitutes 120 SHG respondents. Majority of the members belonged to middle age category, general caste, had education up to primary level, nuclear and small family, service as family occupation, marginal land holding, Most of the members were attended training regularly, and used loan for productive purpose. Major findings Regarding impact of SHGs it was found there was significant impact of SHG on increasing income of members. Majority of members reported noticeable change to significant change due to membership in SHGs regarding income level, credit availability, access to formal institutions, saving habit, Income generating assets, Monthly expenditure, Employment throughout year, Cost of credit. Socio economic impact of SHGs on members was positive. Rural women better improvement in Confidence levels, better decision making ability, improved interpersonal skills, good Awareness about new schemes legal rights & responsibility, banking linkage programme, better access to amenities, improved health and hygiene, financial independence, good managerial skills and better knowledge on banking during post-SHG period when compared with pre-SHG period.

Introduction

Women empowerment is the most important instrument for the socio-economic development of a nation. Bringing women into the mainstream is one of the major challenges for every government. A self-help group consists of 10-20 members drawn from a relatively homogeneous economic class (i.e. poor), self-selected on the basis existing affinities and mutual trust; members meet regularly at a fixed time and place and collect their savings into a common fund from which they take need based loans. The group develops its own rules and regulations. Therefore, Self -Help Groups (SHGs) have emerged as the tool to create a socio- economic revolution and play a major role in poverty alleviation in the rural areas. SHG has become a ladder for the poor to bring them up not only economically but also socially, mentally and attitudinally. One of the primary benefits of participation in a SHG is the opportunity to save regularly, access formal savings institutions and participate in the management of these savings.

Research Methodology

There are total 37 Gram panchayat which comes under kolayat panchayat samiti of Bikaner district. For study purpose, a total of 10 Gram panchayat were selected randomly. From each selected Gram panchayat 1 SHGs was selected. Therefore total 10 SHGs were selected present investigation. After that 12 members from each SHG were selected for the study. Hence, the total sample constitutes 120 SHG respondents.

Results and Discussion

Information on various attributes of related socio-economic empowerment of women was accessed to know the extent of the empowerment achieved by the selected respondents. Impact was measured in terms of their confidence levels, decision making, inter personal skills, access to amenities, awareness, health and hygiene, finance, managerial skills, banking knowledge. The percentage values of social impact were furnished in the table-1.

Table-1 : Distribution of the respondents according to their impact of SHGs on socio economic empowerment.

(n=120)

S. No.	Category	PRE SHG	POST SHG
1.	Confidence levels		
	(a) Having confidence	12 (10.0)	108 (90.0)
	(b) Participation in local affairs	26 (21.7)	94 (78.33)
	(c) Facing difficult situations	30 (25.0)	90 (75.0)
	(d) Self reliance	36 (30.0)	84 (70.0)
	(e) Self esteem	28 (23.33)	92 (76.7)
2.	Decision making		
	(a) Family matters in general	40 (33.3)	80 (66.66)
	(b) Children education	17 (14.2)	103 (85.8)
	(c) Decisions about self	26 (21.7)	94 (78.33)
	(d) Decisions in financial matters	25 (20.8)	95 (79.2)
3.	Inter personal skills		
	(a) Understanding officials language	10 (8.3)	110 (91.6)
	(b) Interacting with officers freely	16 (13.3)	104 (86.6)
	(c) Hesitation in talking with strangers	12 (10.0)	108 (90.0)
4.	Access to amenities		
	(a) Sanitation facilities	21 (17.5)	99 (82.5)
	(b) Medical facilities	31 (25.8)	89 (74.2)
	(c) Market facilities	18 (15.0)	117 (97.5)
	(d) Hygienic conditions at home	40 (33.3)	80 (66.6)
	(e) Schooling for children	44 (36.6)	76 (63.4)
5.	Awareness		
	(a) To new scheme	19 (15.8)	101(84.2)
	(b) Legal rights & responsibilities	22 (18.4)	98 (81.6)
	(c) Banking and BL-SHG programme	44 (36.7)	76 (63.3)
6.	Health and hygiene		
	(a) Knowing child vaccination	59 (49.0)	61(50.8)
	(b) Importance of good diet	23 (19.2)	97 (80.8)
	(c) Importance of tidiness	28 (23.4)	92 (76.6)
	(d) Washing hands before cooking	45 (37.5)	75 (62.5)
7.	Finance		
	(a) Contribution to family income	22 (18.3)	98 (81.7)
	(b) Dependence on family for money	42 (35.0)	78 (65.0)
	(c) Wise spending	36 (30.0)	84 (70.0)
	(d) Habit of saving	26 (21.7)	94 (78.3)
	(e) Investing in IGA	5 (4.2)	115 (95.8)
	(f) Having a bank saving account	7 (5.8)	113 (94.2)
	(g) Having insurance	22 (18.3)	98 (81.7)
8.	Managerial skills	28 (23.3)	92 (76.7)
9.	Banking knowledge		
	(a) Opening a/c	10 (8.3)	110 (91.7)
	(b) Operating ATM	58 (48.3)	62 (51.7)
	(c) Deposit/withdrawal knowledge	13 (10.8)	107 (98.2)

Confidence levels : Information regarding confidence levels was assessed from the respondents data in table-1 was show that of resent of respondents have and enquired about their ability to exuding confidence levels, participating in local affairs, facing difficult solutions, self esteem and self reliance. Only 10 per cent of respondents have the sample households exuded confidence levels during pre-SHG situation, which was improved to about 90 per cent during post-SHG situation. Nearly 21 per cent of the respondents were active in participating in the local affairs during pre-SHG period, which was improved to about 78.33 per cent during post –SHG situation. 25 per cent of respondents said that they were having daring to face the difficult situations during pre-SHG situation which was improved to 75 per cent. about 30 per cent respondents have Self reliance pre-SHG, which was improved to about 70 post SHG situation and 23.33 per cent respondents was low self esteem during pre-SHG period and it was 76.7 per cent increased enormously during the period of post-SHG. It was found that women's confidence level was in all 4 attributes is improved after joining of SHGs.

Decision Making : The data present in table-1, decision making ability of the respondents was assessed to know the social impact of SHGs. Near about 33.3 per cent of the respondents expressed that, they played an active role in the decision making of family matters during pre- SHG but it was increased to 66.66 per cent during post-SHG period. Decision making in the matters of children education was better during (85.8%) post-SHG period in comparison to (14.2%) pre-SHG period. Near about 21.7 per cent respondents expressed that; they take decisions about themselves on their own in pre SHGs situation and their independence was increasing greatly during (78.33%) post-SHG period. Member's decision making role was limited in financial matters of a family during (20.8%) pre-SHG whereas it was increased during (79.5%) post SHG period.

Inter personal Skills : During pre-SHG period, only 8.3 per cent of the respondents said that they understand official's language freely. 13.3 per cent spoke that, they can interact with officials freely and 10 per cent opined that they don't feel hesitate while talking with strangers. There was a great improvement in interpersonal skills of members during post-SHG. 91.6per cent said that capacity to understand official's language, (86.6%) and (90.0%) spoke that their ability to interact with officials and strangers were improved during Post-SHG situation.

Access to Amenities : Empowerment also depends upon the respondents access to basic amenities. After joining SHGs, rural women access to basic amenities was

improved. During pre-SHG period near about 17.5 per cent said that they have access to sanitation facilities, 25.8 per cent opined that they have better medical facilities as well as marketing facilities (15.0%), better hygienic condition at home (33.3%) and 36.6 per cent agreed that their children have access to school. During post-SHG period, it was increased to (82.5%), (74.2%), (97.5%), and (66.6%), (63.4%), respectively.

Awareness : Knowledge about new schemes and their legal rights and responsibilities was low among rural women before joining SHGs. Only 15.8 per cent of total respondents accepted that they don't know about new schemes related to women empowerment but it was improved during post-SHG i.e. 84.2 %. Members' awareness levels regarding legal responsibilities and rights (18.4 per cent) and bank linkage SHG programs (36.7%) were very low during pre-SHG. It was observed after joining the SHG, the awareness level was improved up to 81.6 per cent regarding legal rights and responsibility as well as about 63.3 per cent of members expressed that they were aware about SHG-Banking linkage programs.

Health and Hygiene : It was evaluated from the Table-1 that, nearly 49 per cent of respondents were aware about child vaccination followed by 19.2 per cent of respondent knowing the importance of diet, importance to keep surroundings tidy (23.4%), and washing hands before cooking (37.5%) before joining SHGs. It was observed that membership in SHGs affected their knowledge and perception levels which was improved up to (50.8%), (80.8%), (76.6%), and (62.5%) respectively.

Finance : The level of economic empowerment was also improved during post-SHG situations. Respondents' contribution to family income in pre-SHG situation was only 18.3 per cent whereas majority (81.7%) of respondents expressed that their contribution to family income was improved during post-SHG periods. Members who depend on family for money in pre- SHG situations were about 35 per cent; it was observed that after becoming member in SHG independency of members (65%) was increased. Only 30 per cent of members were wisely spending their money during pre-SHG situations, where as it was increased to 70 percent during post-SHG situation. However, 21.7 cent per cent of members replied that their saving habit was increased up to 78.3 per cent after joining the SHG.

Managerial Skills : The level of managerial skills was also improved during the post-SHG situations. Only 23.3 per cent of the respondents expressed that their managerial skill were good before group formation but it was improved to 76.7 per cent during post SHG conditions.

Banking Knowledge : Banking knowledge was considered as a parameter for their social empowerment. Having knowledge of opening an account, operating an ATM card and knowledge of cash depositing and withdrawal was enquired to understand the extent of empowerment. It was felt that banking knowledge of respondents was very low during pre-SHG period which was improved a bit during post-SHG period. About half (51.7%) of respondents were operate ATM during post-SHG period. Only 8.3 of members know how to open a bank account during pre-SHG situation which was near about 91.7 per cent during post-SHG period. Knowledge on cash deposits and withdrawal of money was improved up to 98.2 per cent during post-SHG conditions.

From above analysis it can be generalized that membership in a SHG had a positive impact on rural women. Social impact of SHGs in terms of confidence

levels, decision making skills, managerial skills, and interpersonal skills, access to amenities, awareness, health and hygiene, finance and banking knowledge was significant. Similar finding was also reported by Vivek (2012).

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Constraints Faced by Self Help Group Women Economic Empowerment of Rural Women

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Abstract

The study was conducted in Bikaner district of Rajasthan. There are seven panchayat samities in Bikaner district. These are namely – Bikaner, Lunkaransar, Sri Dungargarh, Khajuwala, Kolayat, Nokha and Panhu. Kolayat panchayat samiti was selected purposively because maximum no. of SHGs (794) are running there. There are total 37 Gram panchayat which comes under kolayat panchayat samiti of Bikaner district. For study purpose, a total of 10 Gram panchayat were selected randomly. From each selected Gram panchayat 1 SHGs was selected. Therefore total 10 SHGs were selected present investigation. After that 12 members from each SHG were selected for the study. Hence, the total sample constitutes 120 SHG respondents. Main constraints faced by the SHG members were Work load in the family is too much to cope with SHG's programme activities, Illiteracy among the beneficiary women, The fund provided to run the enterprises are too meager, There is no common place where all women can gather and work together, Faulty planning of SHG activities, The activities of SHG are not according to the group member, Lack of leadership skills among member.

Key word : SHG, Women Empowerment.

Introduction

Women empowerment is the most important instrument for the socio-economic development of a nation. Bringing women into the mainstream is one of the major challenges for every government. A self-help group consists of 10-20 members drawn from a relatively homogeneous economic class (i.e. poor), self-selected on the basis existing affinities and mutual trust; members meet regularly at a fixed time and place and collect their savings into a common fund from which they take need based loans. The group develops its own rules and regulations. Therefore, Self -Help Groups (SHGs) have emerged as the tool to create a socio- economic revolution and play a major role in poverty alleviation in the rural areas. SHG has become a ladder for the poor to bring them up not only economically but also socially, mentally and attitudinally. One of the primary benefits of participation in a SHG is the opportunity to save regularly, access formal savings institutions and participate in the management of these savings.

Research Methodology

There are total 37 Gram panchayat which comes under kolayat panchayat samiti of Bikaner district. For study purpose, a total of 10 Gram panchayat were selected randomly. From each selected Gram panchayat 1 SHGs was selected. Therefore total 10 SHGs were selected

present investigation. After that 12 members from each SHG were selected for the study. Hence, the total sample constitutes 120 SHG respondents.

Results and Discussion

The third parts describe the finding pertaining to constraints faced by SHGs members. The constraints were categories different sub heads such as Personal and family, Technical, financial, infrastructural, administrative, operation/ resources, social ect.

A. Personal and family constraints : Table-1 show that among the various personal and family constraints faced by respondents , work load in the family too much to cope up with SHGs activities was perceived as the most important constraints by the respondents, as evident by its high mean score (0.95). Second most important constraints was neglecting of their domestic work with mean score (0.93). Due to fatigue and debility, they were not able to do extra work which ranked third important constraints by the members with mean score (0.86). The fourth rank was assigned to the Children are left uncared due to their participation in SHG members with mean score (0.85). The five rank was assigned to the family members do not co-operate for attending regular activities of SHGs programme with mean score (0.65). The last rank was assigned to the programme activities of SHGs are organization at odd hours with mean score (0.27).

Table-1 : Distribution of respondents according to Constraints faced by them.

(n=120)

Constraints	Mean Score	Rank
A. Personal and family constraints		
i. Work load in the family is too much to cope with SHG's programme activities.	0.95	I
ii. Domestic work is neglected	0.93	II
iii. Due to fatigue and debility no extra work can be taken up now	0.86	III
iv. Children are left uncared due to their participation in SHG	0.85	IV
v. Family member do not co-operate for attending regular activities of SHG's programme.	0.65	V
vi. The programme activities of SHG's are organized at odd hours	0.27	VI
B. Technical constraints		
i. Illiteracy among the beneficiary women	0.78	I
ii. Language barrier	0.77	II
iii. In accessibility to communication media	0.75	III
iv. No technical guidance for establishment of new enterprises is available	0.25	IV
C. Financial constraints		
i. The fund provided to run the enterprises are too meager	0.88	I
ii. Lack of resources to establish the enterprises in area	0.69	II
iii. Funds provided are not judiciously utilized by the member	0.65	III
iv. no revolving fund with programme	0.37	IV
v. difficulty in getting financial assistance from bank	0.33	V
D. Infrastructural constraint		
i. The is no common place where all women can gather and work together	0.95	I
ii. Basic amenities like water, urinal, tea stall are not available at the SHG center.	0.76	II
iii. There is no facility like Anganwadi/ Day care center for small children during our presence at the Centre.	0.72	III
iv. Centre is far away from residence	0.66	IV
v. No conveyance facility is available	0.65	V
E. Administrative constraint		
i. Faulty planning of SHG activities	0.75	I
ii. Poor information system	0.65	II
iii. No supervision and evaluation by official	0.62	III
iv. Poor documentation of the work done by the SHG secretary	0.58	IV
F. Operation /resources constraint		
i. The activities of SHG are not according to the group member	0.95	I
ii. Income from selling the product is not satisfactory	0.77	II
iii. Problem in selling of product	0.74	III
iv. The programme activities get adversely affected during peak agriculture season	0.39	IV
v. There is considerable delay in flow of fund to the group member	0.29	V
G. Social constraints		
i. Lack of leadership skills among member	0.91	I
ii. Social relation cannot be maintained due to involvement in programme	0.87	II
iii. Interpersonal relation between group member are adversely affected	0.71	III
iv. Participation in the activities of SHG's in taken up by our society in a low esteem	0.55	IV

B. Technical constraints : The number of technical constraints faced by respondents in the study in which, illiteracy was observed as very important constraints as it gained first rank with mean score (0.78). Language barrier was ranked as second constraints with mean score (0.77). The third rank was assigned to inaccessibility to communication media constraints with mean score (0.75). The fourth rank was assigned to no technical guidance for

establishment of new enterprises is available with mean score (0.25).

C. Financial constraints : The fund provided to run enterprise too meager was appeared as first constraints with mean score (0.88). Lack of resources to establish the enterprise in area was ranked as second constraints with mean score (0.69). The fund provided not judiciously distributed was appeared as third important constraints

with mean score (0.65). The fourth rank was assigned to no revolving fund with programme with mean score (0.37). The fourth rank was assigned to the difficulty in getting financial assistance from bank with mean score (0.33).

D. Infrastructural constraints : Table-1 there is no common place where all women can gather and work together was perceived as the most important constraints with highest mean score (0.95). The second constraints was assigned to basic amenities like water , urinal, tea stall are not available at the SHGs center perceived by the respondents with mean score (0.76). The third constraints perceived by respondents that there is no facility like Anganwadi / day care center for small children during our presence at the center with mean score (0.72). Fourth constraints was assigned to center is far away from residence with mean score (0.66). The last rank was assigned to no conveyance facility is available with mean score (0.65).

E. Administrative constraints : Faulty planning of SHG activities was found to be first important constraint by the respondents and assigned first rank with mean score (0.75). The second rank was assigned to poor information system with the mean score (0.65). No supervision and evaluation by official members was assigned third rank with mean score (0.62). Poor documentation of work done by SHG secretary was ranked fourth constraints by the members with mean score (0.58).

F. Operational / resources constraints : The activities of SHG are not according to the group members was found to be first most important constraints by the respondents and assigned first rank with mean score (0.95). Second

rank was assigned to income from selling the product is not satisfactory with mean score (0.77). Problem in selling of product was assigned third rank with mean score (0.74). The program activities get adversely affected during peak problem in selling assign fourth rank with mean score (0.39). The last rank was assigned to there is considerable delay in flow of fund to the group members with mean score (0.29).

G. Social constraints : Lack of leadership skill among respondents was found to be first important constraints by the respondents and assigned first rank with mean score (0.91). Social relations cannot be maintained due to involvement in programme was ranked second by respondents with mean score (0.87). The third rank was assigned to interpersonal relation between group members are adversely affected with mean score (0.71). Fourth rank was assigned to participation in the activities of SHGs in taken up by our society in a low esteem with mean score (0.55). Similar finding was also reported by Kappa Kondal (2013) and Singh (2013).

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Response of Inorganic Fertilizers and FYM on Yield and Yield Attributing Characters of Cluster Bean (*Cyamopsis tetragonoloba* L.) cv. Pusa Navbahar

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Abstract

A field experiment entitled "Response of Inorganic fertilizers and FYM on Yield and Yield attributing characters of Cluster Bean (*Cyamopsis tetragonoloba* L.) cv. Pusa Navbahar." was laid out in 3x3 factorial with randomized block design with three levels of Nitrogen 0, 10 and 20 kg ha⁻¹, Phosphorus 0, 20, and 40 kg ha⁻¹, Potassium 0, 20 and 40 kg ha⁻¹, and three level of FYM 0, 5t and 10t ha⁻¹. With increase in the level of NPK fertilizers N₂₀P₄₀K₄₀ kg ha⁻¹ to there was significant increase in vegetative growth and yield attribute, with increase in the level of FYM @ 10 t ha⁻¹ there was significant increase in vegetative 1st growth and yield attributes. The interaction between NPK fertilizer in conjunction with FYM increased all the yield and yield attribute with the treatment T₀₈ (i.e. 100% N: P: K kg ha⁻¹ + FYM 10 t ha⁻¹ was also highest in this combination.

Key words : Growth, fertilizer, yield.

Introduction

The clusterbean (*Cyamopsis tetragonoloba* (L.) Taub.) is belong to Fabaceae family, multifunctional desert crop. India is the world's leading producer of cluster beans (2.7 million tonnes), accounting for 80% of global output on a land area of 4.25 million hectares with a yield of 567 kilogrammes per hectare (Singh, 2014). For the manufacturing of guar gum, cluster bean is mostly farmed in the states of Rajasthan, Haryana, Gujarat, and Punjab. However, it is mostly farmed for vegetable use in southern India (Patel *et al.*, 2018).

Agriculture is shifting back to organic farming as a result of the widespread use of chemical fertilisers and pesticides, which has resulted in a slew of negative repercussions (Saritha *et al.*, 2013). Organic agriculture is a comprehensive method that does very little harm to the earth's ecology. It will lower the risk of crop failure and increase the quality and production of the crop while also lowering the cost of cultivation (Chandrasekhar, 2010). Aside from that, there is a lot of demand for organically cultivated items on the national and international markets. Elnesairy *et al.*, 2016 and Rawat *et al.*, 2016) found that organic manure treatment improved clusterbean crop development.

Various agronomical approaches, including fertiliser management, can help increase cluster bean yield. The proper application of fertiliser and organic manures is critical for achieving better cluster bean yields. The use of FYM alone as an inorganic fertiliser alternative will not be sufficient to sustain current crop production levels of high

yielding varieties. As a result, the most effective strategy for maintaining a healthy and sustainably productive soil is integrated nutrient management, which uses both organic manures and inorganic fertilisers at the same time. Emerging research suggests that careful use of mixed organic and inorganic resources as part of integrated soil fertility management is a viable way to overcoming soil fertility restrictions. Hence a study was made to evaluate the organic source (FYM) of nutrients and inorganic nutrition (NPK) for enhancing the growth and production of cluster bean.

Materials and Methods

The investigation on "Response of Inorganic fertilizers and FYM on Yield and yield attributing characters of Cluster Bean (*Cyamopsis tetragonoloba* L.) cv. Pusa Navbahar." comprise of a field experiment which was carried out at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences Allahabad. The soil of experimental area falls in order Inceptisol and the experimental field is alluvial in nature. The design applied for statistical analysis was carried out with 3x3 randomized block design having three factors with three levels of N: P: K, @ 0, 50, and 100 %.three levels of FYM 0, 50 and 100 %.respectively. The source of N: P: K as Urea, SSP, MOP, and FYM respectively.

The area of Allahabad district comes under subtropical belt in the South east of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46°C – 48°C and seldom falls as low as 4°C – 5°C. The

relative humidity ranged between 20 to 94 percent. The average rainfall in this area is around 1100 mm annually.

Treatment combination of different levels of NPK and FYM for cluster bean.

Treatment	Treatment Combination	Symbol
T ₀	Control	L ₀ F ₀
T ₁	@N ₀ P ₀ K ₀ Kg ha ⁻¹ + FYM @ 5 t ha ⁻¹	L ₀ F ₁
T ₂	@N ₀ P ₀ K ₀ Kg ha ⁻¹ + FYM@ 10 t ha ⁻¹	L ₀ F ₂
T ₃	@N ₁₀ P ₂₀ K ₂₀ Kg ha ⁻¹ + FYM @ 0 t ha ⁻¹	L ₁ F ₀
T ₄	@N ₁₀ P ₂₀ K ₂₀ Kg ha ⁻¹ + F YM @ 5 t ha ⁻¹	L ₁ F ₁
T ₅	@N ₁₀ P ₂₀ K ₂₀ Kg ha ⁻¹ + FYM@ 10 t ha ⁻¹	L ₁ F ₂
T ₆	@N ₂₀ P ₄₀ K ₄₀ Kg ha ⁻¹ + FYM@ 0 t ha ⁻¹	L ₂ F ₀
T ₇	@N ₂₀ P ₄₀ K ₄₀ Kg ha ⁻¹ + FYM @ 5 t ha ⁻¹	L ₂ F ₁
T ₈	@N ₂₀ P ₄₀ K ₄₀ Kg ha ⁻¹ + FYM @ 10 t ha ⁻¹	L ₂ F ₂

Results and Discussion

The maximum height (Table-1) in the levels of N P K was recorded 16.23 cm, 124.18 cm and 198.84 cm at 30 DAS, 60 DAS and 90 DAS respectively; in FYM levels the recorded height was 16.19 cm, 123.74 cm and 194.71 cm respectively. Interaction between N P K fertilizers in conjunction with FYM on plant height (Table 4.1) at 30DAS, 60 DAS and 90 DAS which were found to be significant. The maximum plant height was recorded 16.37 cm, 154.58 cm and 246.30 cm in T₀₈ (N₂₀P₄₀K₄₀+ FYM@ 10 t ha⁻¹ at 30 DAS, 60 DAS and 90 DAS respectively. The increase in nodulation and nitrogen fixation leads to more plant height. Similar findings were reported by, Chavan *et al.*, (2015), Deshmukh *et al.*, (2014), Ayub *et al.*, (2012), Sajid *et al.*, (2009).

The number of leaves plant⁻¹ (Table-2) increased with the increase in levels of N P K fertilizers and FYM at 30 DAS, 60 DAS and 90 DAS. The maximum number of leaves was recorded 14.99, 27.64 and 33.59 in levels of N P K, 15.00, 28.50 and 33.41 in levels of FYM, 30 DAS, 60 DAS and 90 DAS respectively. Interaction between N P K fertilizers in conjunction with FYM on number of leaves plant⁻¹ (Table 4.1.) were found significant. The maximum number of leaves was recorded 18.62, 35.74 and 42.74 in treatment T₀₈ (N₂₀P₄₀K₄₀+ FYM@ 10 t ha⁻¹ at 30 DAS, 60 DAS and 90 DAS respectively that was higher than any other treatment combination. Increase in number of leaves may be due to adequate nutrients supply which enhanced the vegetative growth of plant and subsequently the number of leaves. Similar findings were reported by, Chavan *et al.*, (2015), Ayub *et al.*, (2012).

The number of clusters plant⁻¹ of cluster (Table-3) bean was found to be increased significantly with the increase in levels of N P K and FYM inoculation. The maximum number of cluster plant⁻¹ was recorded as 25.05 in L₂ (*i.e.* N₂₀P₄₀K₄₀ Kgha⁻¹), 25.15 in F₂ (*i.e.* 10 t FYM ha⁻¹). Interaction between N P K fertilizers in

conjunction with FYM on number of clusters plant⁻¹ (Table-4) which was found significant. The maximum number of cluster plant⁻¹ was recorded 31.89 in treatment T₀₈ (N₂₀P₄₀K₄₀+ FYM @10 tha⁻¹) respectively which was higher than number of clusters plant⁻¹ any other treatment combination. Increased in number of clusters may be due to adequate availability of nutrients during reproductive stage of crop results in the formation of more clusters. Similar results were also reported by Chavan *et al.*, (2015), Ayub *et al.*, (2012), Sajid *et al.*, (2009).

The number of pod cluster⁻¹ of cluster (Table-3) bean was found to be increased significantly with the increase in levels of N P K and FYM. The maximum number of pod cluster⁻¹ was recorded as 10.05 in L₂ (*i.e.* N₂₀P₄₀K₄₀ Kgha⁻¹), 10.01 in F₂ (*i.e.* 10 t FYM ha⁻¹). The maximum number of pod cluster⁻¹ was recorded 12.46 in treatment T₀₈ (N₂₀P₄₀K₄₀+ FYM@ 10 tha⁻¹) respectively which was higher than number of pod cluster⁻¹ any other treatment combination. Increased in number of pods may be due to adequate availability of nutrients during reproductive stage of crop results in the formation of more pods. Similar results were also reported by Chavan *et al.*, (2015), Deshmukh *et al.*, (2014).

The number of pod plant⁻¹ of cluster (Table-4) bean was found to be increased significantly with the increase in levels of N P K and FYM. The maximum number of pod plant⁻¹ was recorded as 81.48 in L₂ (*i.e.* N₂₀P₄₀K₄₀ Kgha⁻¹), 78.43 in F₂ (*i.e.* 10 t FYM ha⁻¹). The maximum number of pod plant⁻¹ was recorded 98.62 in treatment T₀₈ (N₂₀P₄₀K₄₀+ FYM@ 10 tha⁻¹) respectively which was higher than number of pod plant⁻¹ any other treatment combination. Increased in number of pod may be due to adequate availability of nutrients during reproductive stage of crop results in the formation of more pods. Similar results were also reported by Chavan *et al.*, (2015), Deshmukh *et al.*, (2014).

The number of seed pod⁻¹ of cluster (Table-4) bean was found to be increased significantly with the increase in levels of N P K and FYM. The maximum number of seed pod⁻¹ was recorded as 7.11 in L₂ (*i.e.* N₂₀P₄₀K₄₀ Kgha⁻¹), 7.05 in F₂ (*i.e.* 10 t FYM ha⁻¹). (Table-4) shows the interaction between N P K fertilizers in conjunction with FYM on number of seeds pod⁻¹ which was found significant. The maximum number of seed pod⁻¹ was recorded 8.62 in treatment T₀₈ (N₂₀P₄₀K₄₀+ FYM@ 10 tha⁻¹) respectively which was higher than number of seeds pod⁻¹ any other treatment combination. Increased in number of seeds may be due to adequate availability of nutrients during reproductive stage of crop results in the formation of more seed. Similar results were also reported by Chavan *et al.*, (2015), Deshmukh *et al.*, (2014).

The pod yield of cluster bean was found to be

Table-1 : Interaction response of different levels of N P K and FYM on Yield and yield attributing characters of cluster bean [*Cyamopsis tetragonoloba* L.]

	Plant Height (cm)			Leaves per plant			Number of cluster per plant	Number of pod per cluster	Number of pod per plant	number of seeds per pod	pod yield (qha ⁻¹)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS					
L ₀ F ₀	15.52	53.38	79.45	5.71	11.15	12.31	11.58	4.54	34.50	3.18	32.85
L ₀ F ₁	15.84	73.79	111.03	8.98	16.54	19.16	15.78	6.10	48.02	4.49	44.58
L ₀ F ₂	15.88	90.19	133.97	10.39	20.97	23.19	20.16	7.50	55.81	5.20	51.21
L ₁ F ₀	15.93	74.84	120.91	8.80	15.31	18.21	13.44	6.09	49.99	4.48	36.51
L ₁ F ₁	16.27	103.46	168.96	13.84	22.72	28.35	18.32	8.18	69.58	6.33	42.58
L ₁ F ₂	16.31	126.45	203.87	16.00	28.81	34.29	23.41	10.06	80.86	7.33	52.85
L ₂ F ₀	15.99	91.49	146.08	10.24	19.00	22.69	18.31	7.55	60.96	5.27	54.69
L ₂ F ₁	16.33	126.47	204.14	16.11	28.19	35.33	24.96	10.14	84.86	7.44	57.68
L ₂ F ₂	16.37	154.58	246.30	18.62	35.74	42.74	31.89	12.46	98.62	8.62	62.25
SEm+	0.65	4.36	7.48	0.64	1.16	1.28	0.74	0.32	2.74	0.23	1.75
CD (P=0.05)	1.86	12.45	21.39	1.83	3.31	3.65	2.10	0.90	7.84	0.64	5.01

Table-2 : Response of different levels of N P K and FYM on the plant height (cm) at 30, 60 and 90 DAS.

Treatments	30 DAS				60 DAS				90 DAS			
	L0	L1	L2	MEAN	L0	L1	L2	MEAN	L0	L1	L2	MEAN
F0	15.52	15.93	15.99	15.82	53.38	74.84	91.49	73.23	79.45	120.91	146.08	115.48
F1	15.84	16.27	16.33	16.15	73.79	103.46	126.47	101.24	111.03	168.96	204.14	1161.38
F2	15.88	16.31	16.37	16.19	90.19	126.45	154.58	123.74	133.97	203.87	246.30	194.71
MEAN	15.75	16.17	16.23		72.45	101.58	124.18		108.15	164.58	198.84	
F-test	SEm+		CD (p=0.05)		F-test	SEm+	CD (p=0.05)		F-test	SEm+	CD (p=0.05)	
L	S	0.38	1.08		S	2.51	7.19		S	2.51	7.19	
F	S	0.38	1.08		S	2.51	7.19		S	2.51	7.19	
LxF	S	0.65	NS		S	4.36	12.45		S	4.36	12.45	

Table-3 : Response of different levels of N P K and FYM on number of Leaves per plant at 30, 60 and 90 DAS.

Treatments	30 DAS				60 DAS				90 DAS			
	L0	L1	L2	MEAN	L0	L1	L2	MEAN	L0	L1	L2	MEAN
F0	5.71	8.80	10.24	8.25	11.15	15.31	19.00	15.15	12.31	18.21	22.69	17.74
F1	8.98	13.84	16.11	12.98	16.54	22.72	28.19	22.48	19.16	28.35	35.33	27.61
F2	10.39	16.00	18.62	15.00	20.97	28.81	35.74	28.50	23.19	34.29	42.74	33.41
MEAN	8.36	12.88	14.99		16.22	22.28	27.64		18.22	26.95	33.59	
F-test	SEm+		CD (p=0.05)		F-test	SEm+	CD (p=0.05)		F-test	SEm+	CD (p=0.05)	
L	S	0.37	1.06		S	0.67	1.91		S	0.74	2.10	
F	S	0.37	1.06		S	0.67	1.91		S	0.74	2.10	
LxF	S	0.64	1.83		S	1.16	3.31		S	1.28	3.65	

increased significantly with the increase in levels of N P K and FYM. The maximum pod yield (Table-4) of 58.20 (qha⁻¹) was obtained at NPK L₂ (i.e. N₂₀P₄₀K₄₀ Kg ha⁻¹) which was significantly greater than the control. The pod yield increased significantly by the increasing levels of FYM. The grain yield of 55.43 (qha⁻¹) was obtained in F₂ (i.e. 10 t FYM ha⁻¹). Table 4.7.2 shows the interaction between N P K fertilizers in conjunction with FYM on pod yield (qha⁻¹) (Table-4) which was found significant. The maximum pod yield (qha⁻¹) was recorded 62.25 (qha⁻¹) in

treatment T₀₈ (N₂₀P₄₀K₄₀+FYM@ 10 tha⁻¹) respectively which was higher than pod yield (qha⁻¹) any other treatment combination. Deshmukh *et al.*, (2014), Ayub *et al.*, (2012), Sajid *et al.*, (2009).

Conclusions

The increase in the level of NPK fertilizes N₂₀P₄₀K₄₀ kg ha⁻¹ to there was significant increase in vegetative growth and yield attributes and with increase in the level of FYM @ 10 t ha⁻¹ there was significant increase in vegetative 1st

Table-4 : Response of different levels of N P K and FYM on the number of cluster plant¹ and Number of pod per cluster of cluster bean [*Cyamopsis tetragonoloba* L.].

	Number of cluster plant				Number of pod per cluster			
	L0	L1	L2	MEAN	L0	L1	L2	MEAN
F0	11.58	13.44	18.31	14.44	F0	4.54	6.09	7.55
F1	15.78	18.32	24.96	19.69	F1	6.10	8.18	10.14
F2	20.16	23.41	31.89	25.15	F2	7.50	10.06	12.46
Mean	15.84	18.39	25.05		MEAN	6.05	8.11	10.05
	F-test	SEm+	CD (p=0.05)			F-test	SEm+	CD (p=0.05)
L	S	0.43	1.21		L	S	0.18	0.52
F	S	0.43	1.21		F	S	0.18	0.52
LxF	S	0.74	2.10		LxF	S	0.32	0.90

Table-5 : Response of different levels of N P K and FYM on Number of pod per plant, number of seeds per pod and pod yield (qha⁻¹) of cluster bean [*Cyamopsis tetragonoloba* L.].

	Number of pod per plant				Number of seeds per pod				pod yield (qha ⁻¹)			
	L0	L1	L2	MEAN	L0	L1	L2	MEAN	L0	L1	L2	MEAN
F0	34.50	49.99	60.96	48.48	3.18	4.48	5.27	4.31	32.85	36.51	54.69	41.35
F1	48.02	69.58	84.86	67.49	4.49	6.33	7.44	6.09	44.58	42.58	57.68	48.28
F2	55.81	80.86	98.62	78.43	5.20	7.33	8.62	7.05	51.21	52.85	62.25	55.44
Mean	46.11	66.81	81.48		4.29	6.05	7.11		42.88	43.98	58.21	
	F-test	SEm+	CD (p=0.05)		F-test	SEm+	CD (p=0.05)		F-test	SEm+	CD (p=0.05)	
L	S	1.58	4.53		S	0.13	0.37		S	1.01	2.89	
F	S	1.58	4.53		S	0.13	0.37		S	1.01	2.89	
LxF	S	2.74	7.84		S	0.23	0.64		S	1.75	5.01	

growth and yield attributes. The interaction between NPK fertilizer in conjunction with FYM increased all the yield and yield attribute with the treatment T₀₈ (i.e. 100% N: P: K kg ha⁻¹ + FYM 10 t ha⁻¹ was also highest in this combination.

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A Review on Effect of Use of LCC (Leaf Colour Chart) in Rice

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Abstract

Site specific nutrient management is a set of nutrient management principles combined with good crop management practices that will help farmers to attain high yield and achieve high profitability both in the short and medium-term. The principles of SSNM are generic and also applicable to other crops including rice. In this series LCC is one of the most common used tool to access the nitrogen content in rice plant. The LCC is easy to use and is an low cost tool for monitoring the relative greenness of a rice leaf as an indicator for the plant N status and can be used as an alternative to chlorophyll meter. It offers significant opportunities to farmers for timely application of nitrogen for efficient N use and high rice yield. This also reduces the extra uses of fertilizer which leads to reduction of cost of cultivation and also helpful in balancing the B:C ratio.

Key Words : LCC, Nitrogen, growth, yield attributes and yield.

Introduction

Site-specific nutrient management (SSNM) is a plant-based approach that provides principles that can be used everywhere. SSNM also gives guidelines for effective N, P, and K management so that rice farmers give their crop the right amount of essential nutrients. With SSNM, plant-essential nutrients are supplied as and when required to ensure the feeding of the rice crop to optimally meet its nutrient needs. SSNM enables the tailoring of nutrient management to field- and location-specific conditions. Soil does not usually supply all the essential nutrients to produce high and profitable yield therefore need to add supplements in form of fertilizers. The growth and needs of a rice crop for nutrients can vary greatly among fields, seasons, and years as a result of differences in crop-growing conditions, crop and soil management, and climate. Hence, the management of nutrients for rice requires an approach that enables adjustments in applying N, P, and K to accommodate the field-specific needs of the rice crop for supplemental nutrients. SSNM provides guidelines, tools and strategies that allow farmers to determine when and how much nutrients they need to apply to their rice fields under actual growing conditions in a specific season and location. Applying the right nutrient source, at the right rate, at the right time, in the right place is essential to nutrient stewardship and is the core of the 4 R. Such 4 R nutrient stewardship for fertilizer best management practices is an approach that considers economic, social and environmental dimensions of nutrient management.

Effect on growth and yield attributes

Ali *et al.* (2015) conducted an experiment with four N

levels of 0, 120, 150 and 180 kg N ha⁻¹ applied as urea in three equal splits with or without basal dose at sowing. The three splits were applied at 0, 35 and 63 days after sowing (DAS). In the real-time N management strategy, fertilizer N was applied whenever leaf color was less than the established threshold (4 for LCC and 37 for SPAD) between 42 and 98 DAS. In the fixed-time N management strategy, prescribed fertilizer doses were applied at 14 and 28 DAS, followed by corrective application on the basis of LCC and SPAD meter measurements. Result showed that alternative fertilizer N management strategies based on LCC and SPAD meter in real-time and fixed-time schedules resulted in optimal DDSR yield and high N-use efficiency compared with that obtained with blanket recommendation. Bhat *et al.* (2015) an experiment was carried out with 2 rice varieties 'Jhelum' and 'SR 2' and 8 rates of N application [control (No N), recommended practice (120 kg N ha⁻¹), LCC = 3 (4 splits of 20 kg N ha⁻¹ each -N80 and 3 splits of 30 kg N ha⁻¹ each -N90), LCC = 4 (5 splits of 20 kg N ha⁻¹ each -N100 and 4 splits of 30 kg N ha⁻¹ each -N120) and LCC = 5 (6 splits of 20 kg N ha⁻¹ each -N 120 and 5 splits of 30 kg N ha⁻¹ each -N150)]. The study revealed that variety 'SR 2' recorded significantly higher grain yield (7.3 t ha⁻¹) than 'Jhelum' (6.6 t ha⁻¹). Total N uptake and agronomic efficiency were significantly higher in 'SR 2' than 'Jhelum'. LCC =5 (150 kg N ha⁻¹ applied in 5 splits) recorded significantly higher grain yields (8.2 t ha⁻¹) than recommended dose of 120 N ha⁻¹ (7.1 t ha⁻¹) and LCC = 3 (80 and 90 kg N ha⁻¹), but remained at par with 120 kg N ha⁻¹ applied in 6 splits through LCC = 5 @ 20 kg N ha⁻¹ (7.9 t ha⁻¹). The LCC = 3 (80 and 90 kg N ha⁻¹ applied in 4 and 3 splits respectively) was statistically at par with recommended dose of 120 kg

N ha⁻¹ with respect to yield. The total N uptake and nitrogen-use efficiency were significantly higher with LCC-based N management than the recommended N management. Bhat *et al* (2015) in an experiments included 2 rice genotypes (Jhelum and SR-2) and 8 rates of N application (control, recommended practice and LCC = 3, 4 and 5 levels @ 20 and 30 kg N ha⁻¹). In recommended practice, 120 kg N ha⁻¹ N was applied in 3 equal splits at transplanting (basal), mid-tillering and panicle initiation stages. Result revealed that Genotype 'SR-2' gave significantly more yield than 'Jhelum' whereas LCC = 5 @ 30 kg N ha⁻¹ i.e. 150 kg N ha⁻¹ applied in 5 splits gave significantly higher grain yield but was at par with 120 kg N ha⁻¹ applied in 6 splits [LCC = 5 @ 20 kg N ha⁻¹] as compared to the recommended dose of 120 kg N ha⁻¹. Chlorophyll content increased significantly with increase in N through LCC. The mean chlorophyll content varied from 0.22 to 0.39 and 0.22 to 0.40 g m⁻² during 2012 and 2013, respectively. The correlation coefficient between SPAD and LCC, and SPAD and N were positively correlated at all growth stages of rice. Use of LCC also saved 10 to 40 kg N ha⁻¹ over fixed-time N applications. The application of N through LCC = 5 @ 30 kg N ha⁻¹ gave higher gross returns, net returns and benefit cost ratio in both the rice genotypes. Das and Sahu (2015) study a comparative performance of Farmers' Practice (45-80 kg ha⁻¹ nitrogen, 15-30 kg ha⁻¹ phosphorus and 35-40 kg ha⁻¹ of potassium), Soil test Based NPK application [N:P:K ::60:40:40 (as per soil test values, N was found to be in the medium range, P₂O₅ and K₂O in the low range of nutrient status), and N application through LCC (50-65 kg N ha⁻¹ at 1st and 2nd top dressing which is 22±2 and 42±2 days after sowing respectively) and soil test based P and K (40:40) application. The study showed that 9.5 to 13 per cent yield increase over the farmers' practice was obtained through LCC based nitrogen application coupled with soil test based P and K application over the couple of years of experiment. Rice yield in soil test based fertilizer application was found to be at par with that of LCC based application. However, LCC based nitrogen application saves farmers from unnecessary use of nitrogenous fertilizers and fetches an additional income of Rs.7500/- per ha compared to farmers' practice. Singh *et al*. (2015) conducted an experiment with four fertilizer N levels (60, 120, 180 and 240 kg N ha⁻¹) were applied to rice either whole at transplanting or in two split doses—half at transplanting and remaining half at 21 days after transplanting (DAT). A no-N control plot was also maintained in each experiment. The highest N dose was twice the blanket recommendation for the region (120 kg N ha⁻¹) and it was assumed that at 240 kg N ha⁻¹, N would not be limiting throughout the rice growing season. In all the treatments, measurements with a Green Seeker optical

sensor were made at 42 (PI stage), 49 and 56 DAT stages of rice. This study revealed that high yields coupled with high NUE in transplanted rice can be achieved by replacing blanket fertilizer recommendation by an optical sensor-based N management strategy consisting of applying a moderate amount of fertilizer N at transplanting and enough fertilizer N to meet the high N demand during the period between active tillering and PI before applying a sensor guided fertilizer N dose at PI stage of rice. Joshi *et al* (2013) suggested fixed time and real time N management options as per need of plant using LCC in direct seeded rice. In the fixed time option, N is applied at a preset timing of active tillering and panicle initiation and the dose can be adjusted upward or downward based on leaf colour. Mnguu (2010) reported LCC 3 as threshold leaf greenness in direct seeded rice. Jayanthi *et al* (2007) carried out an experiment to study the effect of N management using LCC as a tool to decide the rate and time of N application in D-DSR. The results revealed that application of recommended dose of N in more number of split doses @ 20 kg N ha⁻¹ at critical value of LCC-3 was more beneficial in enhancing the growth and yield parameters. The yield and yield components of rice were significantly and favorably influenced when N was supplied up to reproductive phase 13 (panicle initiation to ten per cent flowering) under LCC guided N management than the recommended dose of N. Singh *et al* (2007) revealed need-based N management in on-farm experiments at 350 locations in the Indian-Punjab during 2002-05. Following six-panel IRRILCC-based N management, 9.4-54.2 kg N ha⁻¹ less fertilizer was applied (about 25% less fertilizer N was used), without any reduction in yield as compared to the practice of farmers of applying blanket N at fixed time intervals. They reported that application of fertilizer N when color of the first fully expanded leaf was less than LCC-4 increased N-use efficiency from 48 to 65 kg grain kg⁻¹ N. Singh *et al* (2007) conducted field experiments to evaluate need-based fertilizer N management in transplanted rice by using LCC in Punjab, India for three years (2000 to 2002). Application of N with LCC using a critical value of 4 produced rice grain yields, which were on par with recommended N applied in three equal split doses in the three years. There was no effect of applying 20 kg N ha⁻¹ compared with no fertilizer N applied at the time of transplanting on grain yield and N uptake of rice. On average, application of fertilizer N to rice using LCC-4 resulted in a saving of 26 per cent fertilizer N as compared with the recommended practice of applying 120 kg N ha⁻¹. Agronomic efficiency compared and recovery efficiency of fertilizer N were higher when N was applied using LCC-4 as compared to the recommended practice of applying 120 kg N ha⁻¹ in three equal split doses on all soils. Shukla *et al*. (2006) an

experiment was conducted with Combinations of 3 rice cultivars ('Basmati 370' followed by 'PBW 343', 'Saket 4') were grown in main plot and 6 N management practices under a split-plot design with 3 replications. Leaf colour chart threshold values of 3 for 'Basmati 370', 4 for 'Saket 4' and 5 for 'Hybrid 61 111 PHB-71' gave higher grain yield (14.7, 15.6 and 12.4 % respectively) with greater N use efficiencies (AE_n, 3554% and RE_n, 22- 38%) than recommended N use, i.e. 120 kg N ha⁻¹ in 3 splits. The net returns in leaf color chart-based N management were 16-338 higher than recommended N application. Alam *et al* (2005) conducted an experiment to study about the best LCC value for rice crop and found that LCC as a useful tool for deciding time and rate of fertilizer N use in farmer's fields in southwestern Bangladesh. Use of the LCC for N management consistently increased grain yield by 0.1 to 0.7 Mg ha⁻¹ across villages and seasons in comparison with the farmers' practice across the three wet and three dry seasons. Premalatha and Angadi (2005) observed higher N use efficiency using LCC 3 as threshold greenness in DSR in Karnataka, India. Maiti *et al* (2004) found that LCC-4 as the critical value for transplanted rice and found that the use of LCC could save 20 to 42.5 kg N ha⁻¹, which increased the N-use efficiency significantly when compared with the generally recommended fixed-time split N application. Shukla *et al* (2004), Gupta *et al* (2006), Gopal *et al* (2010), reported that in the real-time option, farmers monitor the colour of rice leaves at regular intervals of 7-10 days from early tillering (20 DAS) and N is applied whenever the colour is below a critical threshold value. The results revealed that for high-yielding inbreds and hybrids, N application should be based on a critical LCC value of 4, whereas for basmati types, N should be applied at a critical value 3. Balasubramanian *et al* (2003) also reported LCC 3 as the critical shade for guiding fertilizer N applications to DSR in the Philippines. Budhar and Tamilselvan (2003) compared fertilizer N management following threshold LCC score 3, 4 and 5 (IRRI-LCC, six panel) with the recommended N rate [120 kg N ha⁻¹, applied in three split doses (50% basal, 25% at active tillering and 25% at panicle initiation)] in short duration W-DSR in South India. The blanket recommendation recorded a lower yield than the need based N application of 30, 45 and 30 kg ha⁻¹ at the early, rapid and late growth stages using LCC-4. Application of 135 kg N ha⁻¹ in four split doses at seeding (30 kg ha⁻¹), active tillering (45 kg ha⁻¹), panicle initiation (30 kg ha⁻¹) and flowering based (30 kg ha⁻¹) based on the LCC-4 recorded the highest grain yield which was equivalent to the yield obtained with 165 kg N ha⁻¹ using threshold LCC-5. The highest net income, benefit: cost ratio and agronomic efficiency were observed with LCC-4 based N management. Angadi *et al* (2002) reported that different

LCC threshold scores suitable for different D-DSR cultivars. Rice cultivar Abhilash responded significantly up to higher IRRI-LCC-3.5. The differential responses of cultivars to N application were mainly due to the variation in their susceptibility to lodging. Abhilash did not lodge even at the highest LCC-5, but Intan showed severe lodging beyond a LCC-3.5. Bijay Singh *et al* (2002) revealed that need-based N management in transplanted rice using LCC helped in reducing fertilizer N use by 25% and thus minimized N losses and lessened the risk of NO₃ pollution of ground water. The use of LCC optimized grain yield with improved N use efficiency in DSR.

Conclusions

Site specific nutrient management (SSNM) is a new concept. This concept is fundamental to precision nutrient applications in different crops. SSNM provides an approach for need-based feeding of crops with nutrients while recognizing the inherent spatial variability.

This makes the efficient utilization of nutrients by crop plants and avoids the wastages of fertilizers. The environmental footprints of chemical fertilizers are also reduced. Crop yields increase by over 15%, while amount of nutrients applied mostly decrease. Farm profitability and NUE increase convincingly by using this novel concept.

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Biochemical Changes During Natural and Artificial Ageing of Berseem (*Trifolium alexandrinum* L.) Seed

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Abstract

Berseem serves as an important source of green fodder for milch animals in many parts of world and demand for berseem seed among cattle farmers is increasing owing to superior nutritional quality of this crop. In present study, we have tried to discuss one of the major problems in berseem seed production that is seed deterioration during storage. The study was conducted in differentially aged seeds of berseem var. Wardan to deduce the biological changes contributing towards seed deterioration. Differentially aged seeds collected from successive growing seasons were categorized into different lots based on color of seed coat (dark, red and light yellow) and subjected for various biochemical tests. Original lot (mix colored) of both seasons were also incorporated in the study. The best quality seeds represented by light yellow seed coat were subjected for artificial ageing for four days. Thus, total seven lots of berseem seeds were subjected for biochemical characterization. Result indicated membrane damage through electrolyte leakage and lipid peroxidation as major factors for deterioration and were more pronounced in the seed lot with dark seed coat. Light colored seeds exhibited better activities of antioxidant enzymes like catalase and peroxidase. The result unequivocally indicated that antioxidative enzymes coupled with reduced protein solubilisation and membrane stability are important factors contributing toward healthy seed vigour and seed lots with difference in appearance of seed coat colour may be a useful evaluator of its quality.

Key words : Berseem, seed deterioration, seed lot, catalase, peroxidase, biochemical characterization.

Introduction

Egyptian clover popularly known as Berseem (*Trifolium alexandrinum* L.) is one of the most important winter forage legumes in India, Pakistan, Turkey, Egypt and countries of Mediterranean region. In India, it occupies two million hectares. It is an annual leguminous fodder crop suitable for areas below 1700 m altitude with irrigation facilities. The merit of the crop lies in its multicut nature (4-6 cuts), long duration of green fodder availability (November to April), high green fodder yield (85 t/ha), good forage quality (20% crude protein), and digestibility (up to 65%) and high palatability. Of the two Egyptian biotypes of Berseem 'Mescavi and Fahli' introduced in India during 1903, the former proved to be highly adaptable and productive as fodder crops for large scale cultivation.

Most of the present day cultivars are derivatives of Mescavi. The phenomenal success of berseem in India is also due to its high nitrogen fixing ability resulting in substantial improvement in soil fertility. Important varieties of Berseem developed in India are Mescavi, Wardan, BL-1, BL-10, BL-22, JB-2, BL-2, UPB-110, Bundel Berseem -2 (JHB 146), Bundel Berseem-3 (JHTB 96-4), HFB 478etc.

Fodder based cheaper feeding strategies are required to reduce the cost of quality livestock products as the feed alone constitutes 70% of the milk production cost. There is tremendous pressure of livestock on available total feed and fodder, as land available for fodder production has been decreasing. At present, the country faces a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% feeds (IGFRI, 2011).

To meet the current level of livestock production and its annual population growth, the deficit in all components of fodder, dry crop residues and feed has to be met either from increasing fodder productivity, utilizing untapped feed resources, increasing land area or through import. Although the opportunity for area expansion under fodder crops is not feasible and yields of forage crops are reaching a plateau, still a great scope exists to increase forage availability through strengthening fodder research.

There is an urgent need to revisit the underlying biochemical and physiological processes that control post-harvest quality of forage seeds in India. Very little study has been carried in Berseem seed to understand ageing and deterioration process. The process of seed deterioration starts during seed development phase and after maturity the catabolic reactions continue leading to

reduced seed germination and vigour with increasing age. The rate of seed deterioration is dependent on factors like Genetics, Quality of seed lot at harvest, seed moisture content and temperature of storage environment (Gupta, 1976). Many studies suggest that decrease in the activity of enzymes such as superoxide dismutase, catalase, peroxidase and glutathione reductase during ageing leads to production of free radicals which causes molecular disarrangement (Lehner *et al.*, 2008; McDonald, 2004; Salama and Pearce, 1993). It has also been reported in many crop species that biochemical processes of lipid peroxidation are the major cause of seed deterioration during storage (Popoviciu *et al.*, 2006). Therefore, present study aims to decipher the biochemical changes associated with deterioration in differentially aged berseem seeds.

Materials and Methods

Investigations were conducted on Berseem (*Trifolium alexandrinum* L.) var. Wardan. All experiments were conducted in the laboratory of the Division of Seed Technology. The detailed methodology employed to study the morpho-physiological and biochemical changes during seed deterioration of Berseem is detailed below.

Seeds of berseem var. *Wardan* harvested during Rabi 2011-2012 and 2013-2014 were obtained from the Division of Seed Technology, IGFR, Jhansi. Both the lots contained seeds of different colour (Fig 1), hence, dark coloured seed and light coloured seed were manually separated and thus total six lots were prepared on the basis of year of harvest and seed colour. Further, the light coloured seeds of the 2013-2014 harvest were subjected to artificial ageing for 4 days. Thus overall seven lots of seed were studied for its quality and different physio-chemical changes.

Details of Berseem seed lots under study.

Lot No.	Coding particulars	Seed type	Production Year
01	MS	Mixed Seed	2013-2014
02	DS 12	Dark Seed	2013-2014
03	LS 12	Light Seed	2013-2014
04	LS 14	Light seed	2011-2012
05	DS 12	Dark seed	2011-2012
06	MS-12	Mixed Seed	2011-2012
07	AA Artificially aged		2013-2014

The Accelerated ageing was conducted to induce ageing as per the methodology of Delouche and Baskin (1973). About 50 gm of seeds were stored in Muslin cloth bags at 100 % RH and 40°C in sealed desiccators maintained in an incubator. The desiccators were equilibrated to the given RH and temperature for 2 hours

before keeping the sample. After 4 days the viability of accelerated aged seeds was checked using the standard germination test as mentioned below.

Seed germination was tested in three replications of 100 seeds each by top of paper method at 20°C temperature and 80% RH in the germinator under continuous light condition. The germination percentage represented by number of normal seedlings out of total number of seeds kept for germination.

The seed vigor index 1 & 2 were calculated based on germination percentage and seedling length (cm) and dry weight (g) using the following formulae, (Abdul- Baki and Anderson, 1973) (Perry, 1978).

Seed vigor index-1 = germination percentage × seedling length (cm)

Seed vigor index-2 = germination percentage × seedling dry weight (g)

The total soluble protein was estimated as per Bradford, 1976. The total soluble sugar was estimated by the Anthrone method (Hedge and Hofreiter, 1962; Sadashivam and Manicham, 1992).

Enzyme Estimation

Catalase (CAT) : All the steps of extraction were carried out at 0-4°C. Known weight (300-500 mg) of seedling from control and treated plants were excised and macerated in a chilled pestle and mortar in presence of 3.5 ml of cold extraction buffer (0.1 mM potassium phosphate containing PVP, pH was adjusted to 7.5). The homogenate was centrifuged at 10,000 rpm for 15 min at 4°C. The supernatant was carefully decanted and used as the crude enzyme extract. The activity of catalase was estimated according to the procedure described by Aebi (1984). The reaction mixture in the final volume of 3 ml, contained 1.5 ml, 0.1M phosphate buffer (pH 7.0), 1ml water, 400 μ L H₂O₂ and 100 μ L of cell free extract. Reaction was initiated with the addition of H₂O₂ and enzyme activity was determined by following the degradation of H₂O₂ at 240 nm for 2 min. The specific activity/mg protein of peroxidase enzyme was calculated based on extinction coefficient 43.6 mM⁻¹ cm⁻¹.

Peroxidase (POX) : Enzyme extracts were prepared as per estimation of catalase. Supernatant was pooled out in a pooling tube and was used for further estimation of peroxidase activity. 0.1N phosphate buffer, 2% H₂O₂ in buffer and 0.5% Guaiacol (2- Methoxyphenol) solution in buffer, was made just before the analysis. For peroxidase estimation 1.5ml buffer, 0.1ml H₂O₂, 0.1ml Guaiacol solution, 0.01ml sample aliquot and 1.290ml distilled water was taken in a cuvette separately for each treatment in 3 replicates. Absorbance was recorded at 240nm. The

specific activity/mg protein of peroxidase the enzyme was calculated based on the extinction coefficient $26.6 \text{ mM}^{-1} \text{ cm}^{-1}$.

Electrical Conductivity Test : 25 seeds were weighted and taken in each replication and soaked in 15 ml distilled water in a beaker. The beakers were placed in an incubator at 30°C for 4 h in dark. Later, the seeds were removed with the help of sieve and the seed leachate was collected in a separate beaker. By using an EC meter, the electrical conductivity of water was measured first and later the EC of seed leachate was measured. Subsequently the mean was used for further analysis.

Lipid peroxidation : The level of lipid peroxidation in seed tissue was quantified by determination of MDA, a breakdown product of lipid peroxidation (Heath and Packer, 1968). 200 mg of tissue was homogenized in 5 ml of 0.1% (w/v) trichloroacetic acid. The homogenate was spun at 14000 rpm for 15 minutes. To a 1ml aliquot of the supernatant, 3 ml of 5% (w/v) trichloroacetic acid containing 0.5% (w/v) thiobarbituric acid was added. The mixture was heated at 95°C for 30 minutes and cooled immediately and then centrifuged at 14000 rpm for 10 min. The absorption of the supernatant was read at 532 nm. The value was corrected for non-specific absorption at 600 nm. The concentration of MDA was calculated using the extinction coefficient of $155 \text{ mM}^{-1} \text{ L}^{-1} \text{ cm}^{-1}$.

Statistical Analysis : The data was analyzed as per standard method of Analysis for Variance (ANOVA) using either single or multi factor Completely Randomized Block Design for laboratory experiments as per Gomez and Gomez (1983). The analysis was performed using statistical software SAS 9.2. Further, multiple comparisons of means were done based on Duncan's Multiple Range Test (DMRT).

Results and Discussion

Significant differences were observed among all the lots of seed (Table-1). The highest mean germination was observed in LS-14 (91%) and lowest in DS-12 (16%). Seeds which were subjected for artificial ageing recorded only 32.33% germination. Seeds differentiated into dark and light coloured also recorded different mean germination. While LS-14 recorded 91% germination, LS-12 has only 49.67% germinated seeds, thus showing a 45.41% reduction in the same year seed lot due to colour difference. Similarly, seeds of DS-14 lot showed 23.67% germination and DS-12 had still lower germination i.e. 16%. Original lot of both the season i.e. Ms-14 and MS-12 had 70.67 and 28% germination respectively. Therefore, the total seed lot did not deteriorate at the same rate. The different colour groups within the same seed lot arise due to differential deterioration. It is obvious from these data

that berseem seeds lose their germination capability significantly during the natural ageing process (Table-1).

Seed vigour, a complex trait measured as a product of germination and seedling length, was recorded in all seven lots of seeds, highest vigour index I was observed in light coloured seeds followed by dark coloured and artificially aged seed. Significant difference was observed among different coloured seeds of the same seasons and difference was also significant among the seeds of different seasons (Table 1). Maximum vigour index-I was observed in LS-14 (585.9) and lowest in DS-12 (62.0). Mixed lots of both the seasons showed different vigour i.e. MS-14 (391.4) and MS-12 (122.6).

Seed vigour index II : Since seed vigour is a complex trait it is better to study using different indices. The seed vigour index II which is based on germination and seedling dry weight was studied for all the seed lots. Significant (p) differences were observed between mixed lots of both the seasons and light coloured seeds showed maximum vigor index II (Table 1). While LS-14 has vigour index II value as 3.2, the same was 2.4 for LS-12. Artificially aged seeds showed vigour index II as 1.8.

Biochemical parameter : Relatively more aged dark coloured seed i.e. DS-12 showed maximum Electrical conductivity of leachate (EC) (1.04) followed by AA (1.02). Lowest EC of leachate was observed in LS-14 (0.58) which was significantly lower than LS-12 (0.63) and mixed lot of both season seeds i.e. Ms-14 (0.94) and MS-12 (0.89). The difference was significant for differentially aged seeds and also for different lots of the same season. The lipid peroxidation was measured in terms of malondialdehyde (MDA) content. It gives a fair idea about the extent of membrane damage occurred during seed deterioration. The maximum MDA content was recorded in AA (47.7) while lowest in LS-14 (14.19) (Table 2). The MDA content was significantly higher in DS-14 (19.36) than LS-14. The maximum soluble protein was recorded in DS-14 (17.11) and lowest in MS-12 (5.63). Dark colored seeds reveal more soluble protein than light coloured seeds or mixed lot. All the differences were statistically significant.

Antioxidative enzymes : Catalases are known to metabolize H_2O_2 in the living systems. The CAT activity was assayed in germinating seedling at different stages i.e. 2, 4 and 6 days after germination. The catalase activity was very low in all the seeds and difference among seed lots were insignificant (Table 3). However, as the seedling age advances, the CAT activity was increased in seeds and maximum activity was observed in six days old seedlings of LS-14 (2.77). The more aged seeds (DS-12 and DS-14) record very less initial CAT activities. As the germination prolongs, significant increase in CAT activity

Table-1 : Germination percent, Calculated vigour index-I and II and moisture content in different lots of Berseem seed.

Seed lot	Germination (%)		Vigour Index-I		Vigour Index-II		Moisture content (%)	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
MS-14	70.67 (57.23)	1.16	391.4	18.2	3.57	0.07	9.11	0.04
LS-14	91.00 (72.56)	0.58	585.9	3.3	3.20	0.06	9.06	0.05
DS-14	23.67 (29.07)	1.38	116.1	15.3	0.77	0.18	8.82	0.02
MS-12	28.00 (31.94)	0.64	122.6	3.1	2.53	0.69	8.98	0.08
LS-12	49.67 (44.81)	0.38	277.2	4.2	2.40	0.06	8.86	0.01
DS-12	16.00 (23.52)	1.36	62.0	8.6	1.20	0.32	8.96	0.02
AA	32.33 (34.64)	0.89	119.1	7.5	1.80	0.12	8.90	0.02
C.D.	3.01		31.4		0.92		0.12	
SE (m)	0.98		10.2		0.30		0.04	
SE (d)	1.39		14.5		0.43		0.06	
C.V.	4.06		7.4		23.58		0.78	

Table-2 : Biochemical parameter of different lots of Berseem seed.

Seed lot	Electrical conductivity (mS/g)		Lipid peroxidation content (M/g. seed)		Soluble protein content (M/g. seed)		Sugar content (M/g. seed)	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
MS-14	0.94	0.10	14.69	2.33	13.98	1.23	143.79	2.08
LS-14	0.58	0.05	14.19	0.38	10.05	0.85	158.47	45.64
DS-14	0.90	0.09	19.36	0.25	17.11	1.53	98.12	20.24
MS-12	0.89	0.02	16.55	1.19	5.63	0.77	153.96	9.99
LS-12	0.63	0.03	19.92	0.17	13.14	0.50	151.79	20.72
DS-12	1.04	0.08	19.36	0.25	10.33	0.05	157.25	21.13
AA	1.02	0.04	47.71	1.11	11.61	0.72	72.41	15.47
C.D.	0.20		3.35		2.83		N/A	
SE (m)	0.07		1.09		0.92		23.03	
SE (d)	0.09		1.55		1.31		32.56	
C.V.	13.10		8.73		13.67		29.83	

was observed (Table-3). The interaction effect of seed ageing duration and seedling age was non- significant. There are different types of peroxidase viz, guaiacol peroxidase, ascorbate peroxidase, cytochrome peroxidase, glutathione peroxidase, etc. Assay of guaiacol peroxidase was carried out in this study and results are tabulated in Table 2. The basal activity of POX was more than CAT and its activity was also increased as the germination prolongs. The maximum POX activity during the initial stage of germination was recorded in MS-12 (129) and lowest in DS-12 (11.6). However, maximum POX activity at the advanced stage of germination was recorded in LS-14 (483.8) and lowest in DS-14 (145.9). The maximum increase in POX activity from 2nd day to 6th day of germination was observed in LS-14. The difference in POX activity for seedling age and different seed lot was significant but same was insignificant for interaction effect.

The biochemical parameters were correlated to know the influence of each parameter on germination and others. There was a negative significant correlation between germination and EC of leachate (Table-4). Significant negative correlation was also observed for EC and antioxidative enzyme activities; between lipid peroxidation and sugar content, lipid peroxidation and POX activity. Significant positive correlation was also observed between CAT and POX activity.

Correlation studies : The Biochemical parameters were correlated to know the influence of each parameter (Table-4) on others. Significant positive correlation was observed between Germination; Electrical conductivity of leachate; Lipid peroxidation; Protein; Sugar content; Catalase activity; Peroxidase activity.

Biochemical changes contributing towards seed deterioration : The biochemical parameters viz., protein,

Table-3 : Antioxidative enzymes activity (Specific activity/mg protein) during seed germination of different seed lots of Berseem.

Seed lot	Catalase (CAT) at seedling age (days)				Peroxidase (POX) at seedling age (days)			
	2 Days	4 Days	6 Days	Mean	2 Days	4 Days	6 Days	Mean
MS-14	0.63	0.25	2.45	1.11	69.5	94.7	277.8	147.3
LS-14	1.28	0.15	2.77	1.40	92.4	88.1	483.8	221.4
DS-14	0.41	0.21	1.51	0.71	61.8	59.0	145.9	88.9
MS-12	1.33	0.97	2.76	1.69	129.0	97.3	201.9	142.7
LS-12	1.56	0.67	3.60	1.94	76.3	100.9	411.1	196.1
DS-12	0.57	1.20	2.99	1.59	11.6	70.9	177.8	86.8
AA	0.36	1.66	1.68	1.23	19.5	182.8	179.9	127.4
Mean	0.88	0.73	2.54	1.38	65.7	99.1	268.3	144.4
	Seedling age(A)	Seed lot (B)	AxB		Seedling age(A)	Seed lot (B)	AxB	
C.D.	0.58	N/A	N/A		26.5	40.4	70.0	
SE (m)	0.29	0.44	0.76		13.1	20.0	34.6	
SE (d)	0.20	0.31	0.54		9.2	14.1	24.4	

Table-4 : Correlation matrix of different biochemical parameters of differentially aged Berseem seed.

	G	EC	L-P	P	S	CAT
G	1.00					
EC	-0.612**	1.00				
L-P	-0.341NS	0.393NS	1.00			
P	0.047NS	-0.055NS	0.032NS	1.00		
S	0.237NS	-0.263NS	-0.567**	-0.387NS	1.00	
CAT	0.286NS	-0.579**	-0.332NS	-0.271NS	0.078NS	1.00
POX	0.375NS	-0.485*	-0.568**	-0.372NS	0.321NS	0.522*

G: Germination; EC: Electrical conductivity of leachate; L-P: Lipid peroxidation; P: Protein.

sugar content, lipid peroxidation (in terms of MDA content) measured and antioxidant enzyme activities along with electrical conductivity of seeds leachate were studied in differentially aged seeds. Biochemical changes bear direct effect on physiological activities of live materials. The seed deterioration during ageing leads to certain changes in biochemical indices. Among all, membrane damage and change in antioxidants are most significant. Several comprehensive reviews have identified free radical-mediated lipid peroxidation, enzyme inactivation or protein degradation, disruption of cellular membranes, and damage to genetic (nucleic acids) integrity as major causes of seed ageing (Priestley, 1986; Smith and Berjak, 1995; Walters, 1998; McDonald, 1999). Biochemical deterioration during seed ageing has been studied mostly under accelerated ageing conditions using high temperature and high seed water content (McDonald, 1999). Under such storage conditions, seeds typically lose their viability within a few days or weeks. While these studies allowed important progress towards the understanding of seed ageing mechanisms, a major question has been raised whether the mechanisms of

seed ageing are the same under such accelerated ageing conditions and under the cool dry conditions where seeds age over many years.

The primary physiological change caused by aging of seeds is believed to be damage to cellular membrane (McDonald, 1999). Our study also reveals membrane damage as estimated by electrolyte leakage and lipid peroxidation in dark coloured seeds. It is known that as seed deteriorates, the membrane damage occurs and hence, the leachate shows more electrical conductivity.

Similar changes were also noticed for protein content. Proteins are an integral part of the living cell and are also responsible for most of the catalytic properties. Soluble proteins are an important indicator of seed deterioration especially in leguminous crops. It has been known for a long time that a progressive change in soluble protein occurs during seed ageing (Cheah and Osborne, 1978; Osborne *et al.*, 1981) and our study also proves this fact.

ROS have been widely cited as being the main factor causing seed ageing during prolonged storage (Priestley,

1986). In sunflower seeds, loss of viability during ageing has been shown to be associated with an accumulation of hydrogen peroxide (H_2O_2) and lipid peroxidation and with a decrease in the activity of antioxidant enzymes (Bailly *et al.*, 1996; Kibinza *et al.*, 2006). A lot of reactive oxygen species (ROS) are produced during seed ageing and they interact with lipids, proteins and other biochemical compounds in cells leading to change in their ultrastructure. These changes alter or destroy their chemical properties. Antioxidative enzymes like CAT and POX are known to regulate the H_2O_2 concentration, an important reactive species. Protection against free-radical damage is the major means of preventing oxidative stress. Protective mechanisms directed against active oxygen species during seed storage are predominantly enzymatic.

The POX activity of dark coloured seeds was lower than other lots. The results of this study agree with the earlier observations of Sung and Jeng (1994) and Goel *et al.* (2003). Similar results have been reported by many researchers. The POX activity of peanut seed decreased during aging (Sung and Jeng 1994). Cotton (*Gossypium hirsutum* L.) seed deterioration during accelerated aging was closely related to a decrease in POX activity (Goel *et al.* 2003). Furthermore, these workers noted a good correlation between seed vigor and POX activity. CAT is also an important active free-radical scavenging enzyme (Bailly *et al.* 1996; Goel *et al.* 2003) during seed deterioration. Plants are known to compensate for loss in activity of one enzyme by increase in activity in other related enzymes. Similar results were obtained in this study where increased activity of POX compensated for lower CAT activity.

Conclusions

The present study was carried out in berseem var. Wardan with an intent to deduce biochemical basis of seed deterioration during natural and artificial ageing. Different biochemical parameters were studied and their role in the seed deterioration process were analyzed. Thus this study reveals that seeds in given lot age differentially which is marked by the change in their biochemical attributes. The dark coloured seeds reveal very poor germination and vigour compared to light coloured seeds. Membrane damage was more obvious in dark coloured seeds as understood by electrolyte leakage and lipid peroxidation measured in terms of MDA content. Enzymatic assay reveals differential activity of catalase and peroxidase. The basal activity of POX was more than CAT and its activity was also increased as the germination prolongs. Membrane damage in aged seeds were negatively correlated with the antioxidative enzyme (CAT and POX) activities. Soluble protein was increased during

storage suggesting degradation or dissociation of integral proteins. Thus biochemical markers like enzyme activities and membrane damage may be useful in assessing the germinability and vigour of berseem seed.

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Net Surfing Behavior Among Agriculture Graduates in Haryana

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Abstract

Internet is a versatile tool used by the students for multiple purposes. A study was carried out to find the net surfing behavior among the students of CCS Haryana Agricultural University, Hisar during 2019-2020. The data were collected from 195 respondents using structured interview schedule, as personal interview schedule reduces the bias of respondents and help in collection of credible data. The result illustrated that majority of the students (70.25%) around two third were having medium level of net surfing behavior. Choice of surfing point, larger number of students (85.12%) do net surfing in their own mobile phones, frequency of surfing internet data indicated that all the 195 students (100%) do net surfing on daily basis, hence it is clear that, major proportion (61.53%) of the agri-graduates spent 1-3 hours daily on net surfing, larger number of students (35.89%) had 4-5 years net surfing experience, mostly respondents use internet purpose of "attending online classes" (rank 1st and 2.89 WMS) and most of the respondents were use as a search tool of "Google".

Key words : Agriculture graduates, internet, surfing behavior.

Recovering of agricultural infrastructure should be given furthestmost priority including input delivery, financing, reducing post-harvest losses, cold storage chains, marketing and agricultural education. Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs) play critical role in creating manpower for serving millions of farmers across the country (Ponnusamy and Pachaiyappan 2018). The Internet, which is the foundation of Information and Communication Technology (ICT), addresses some of the most difficult issues in the educational system, including access, equity, and quality. The internet is an information resource that provides users with access to a diverse selection of resources from across the world. The availability of numerous online information resources from computer files, library catalogues, databases, organizations, newsgroups, industrial, and commercial sources, as well as from individuals, makes the internet an indispensable tool for academia and research (Buabeng *et al.* 2016). The importance of the internet in promoting the use of ICT in higher education cannot be overstated. ICT expands the flexibility of educational delivery, allowing students to access information at any time and from any location (Moges 2014). It has the potential to influence how students are taught and learn because the processes are now learner-driven rather than teacher-driven. As a result, educational systems have a vast scope of guiding the way toward increased knowledge and information use in the future through the internet.

Keeping in view the above facts and importance, the study was conducted with the objective to assess the net

surfing behavior among agriculture graduates of CCS Haryana Agricultural University, Hisar.

Materials and Methods

In this research, the present study was conducted in Chaudhary Charan Singh Haryana Agricultural University, Hisar. The university has six colleges, imparting various degrees to students. The College of Agriculture, Hisar and Kaul were selected purposively as both these colleges have B.Sc. (Hons.) agriculture final year students. From both selected colleges, all the B.Sc. (Hons.) Agriculture final year students i.e. 195 registered during the session 2019-20 were selected for study. The data were collected from all the final year students by personal interview technique, with the help of a well-structured interview schedule. Empirical data were tabulated and analyzed with the help of appropriate statistical tools using Statistical Package for Social Sciences (SPSS). The responses of students' were obtained on three-point continuum scale in case of usage behavior (often, occasionally and never used) and scores were given as 3, 2 and 1, respectively. After that frequency was multiplied with the score (3, 2 or 1) and total weighted score was obtained and total weighted score was divided by total respondents (195) for obtaining weighted mean score (WMS) and rank order were assigned accordingly.

Results and Discussion

Results of the study are presented and discussed under broad headings as frequency and extent of students choice of surfing points, frequency of surfing, time spent on surfing per day, net surfing experience, purpose of net surfing and use of various search tools.

Over all net surfing behavior : The result revealed that out of the total 195 students, 12.30 per cent were in low category, 70.25 per cent in medium and 17.43 per cent in high category respectively (Fig.-1). This indicated that majority of the students (around two third) were having medium level of net surfing behavior.

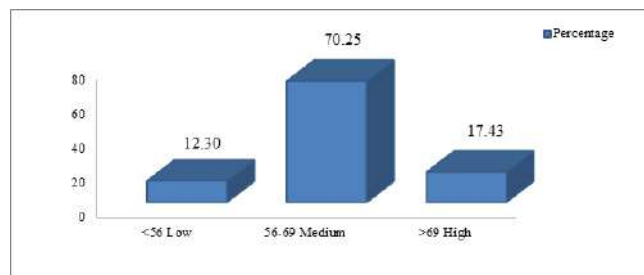


Fig.-1 : Net surfing behavior-wise distribution of the respondents.

Choice of surfing points : The data on choice of surfing point was presented in Table-1. Larger number of students (85.12%) do net surfing in their own mobile phones. While, internet café is the least preferred (only 0.50%) net surfing source. Only, 5.12 per cent of agri-graduates do net surfing at home, 3.58 per cent at university. Moreover, 3.07 per cent agri-graduates used their own modem, and 2.56 per cent used hostel Wi-Fi for net surfing. Similar, observation also recorded by Malik *et al.* (2018) who observed that most of the students used internet at 'hostel' followed by at 'institute', 'home', 'cybercafé' and 'other places'.

Table-1 : Distribution of agriculture graduates according to their choice of surfing behaviour. N=195

S. No.	Choice of surfing points	Frequency	Percentage
1.	University	07	3.58
2.	Home	10	5.12
3.	Internet café	01	0.51
4.	Using own modem	06	3.07
5.	Mobile phone	166	85.12
6.	Hostel Wi-Fi	05	2.56

Frequency of surfing internet : Frequency of surfing internet data indicated that all the 195 students (100%) do net surfing on daily basis (Table-2). Therefore, all the students were distributed in single category i.e. every day net surfing whereas none of agri-graduates was belonged to net surfing 2-3 days in a week and occasionally net surfing categories. Similar, observation also recorded by Malik *et al.* (2018) who revealed that more than two-third of the total respondents used the internet 'daily' for various purposes, followed by '3-4 days in a week', '1-2 days in a week'.

Table-2 : Distribution of agriculture graduates according to their frequency of surfing internet. N=195

S. No.	Frequency of surfing internet	Frequency	Percentage
1.	Everyday	195	100
2.	2 -3 days a week	00	00
3.	Occasionally	00	00

Time spent on surfing per day : The data presented in Table-3 shown that 7.17 per cent of the students spent <1 hour, 61.53 per cent students devoted 1-3 hours, 24.61 per cent agri-graduate dedicated 4-6 hours while 6.66 per cent spent > 6 hours per day on net surfing. Hence it is clear that, major proportion (61.53%) of the agri-graduates spent 1-3 hours daily on net surfing. Similar, observation also recorded by Malik *et al.* (2018) who observed regarding extent of time spent, majority of the respondents (71.42%) spent 'more than 2 h per day' on internet, followed by 'more than 1-2 h per day etc'.

Table-3 : Distribution of agriculture graduates according to their time spent on surfing per day. N=195

S. No.	Time spent on surfing per day	Frequency	Percentage
1.	Less than 1 hour	14	7.17
2.	1 – 3 hours	120	61.53
3.	4 – 6 hours	48	24.61
4.	More than 6 hours	13	6.66

Net surfing experience : The data regarding net surfing experience of the agri-graduates are given in Table-4. The view of the data revealed that larger number of students (35.89%) had 4-5 years net surfing experience. Furthermore, 30.25 per cent agri-graduates possessed 2-3 years of net surfing experience and 29.74 per cent had more than 5 years experience in net surfing. The students with least net surfing experience (up to one year) were only 8 (4.10 %). Similar, observation also recorded by Gautam *et al.* (2018) who revealed that the majority of the respondents (76.66%) were using the internet for above three years, followed by up to two-three year and last one year only.

Table-4 : Distribution of agriculture graduates according to their net surfing experience. N=195

S. No.	Net surfing experience	Frequency	Percentage
1.	Up to one year	08	4.10
2.	2-3 years	59	30.25
3.	4-5 years	70	35.89

Purpose of net surfing : The data on purpose of net surfing revealed that agri-graduates mostly use internet for "attending online classes" (rank 1st and 2.89 WMS) (Table-5). "Communications" was ranked 2nd with WMS (2.84) while, "entertainment" was ranked 3rd accompanied

Table-5 : Ranking of purpose of net surfing based on WMS.**N=195**

S. No.	Purpose of net surfing	Often (3)	Occasionally (2)	Never (1)	TWS	WMS	Rank
1.	Preparing course assignments	95 (48.71)	98 (50.25)	02 (1.02)	483	2.47	VIII
2.	Entertainment	160 (82.05)	34 (17.43)	01 (0.51)	549	2.81	III
3.	Downloading software	71 (36.41)	97 (49.74)	27 (13.84)	434	2.22	XI
4.	Communications	166 (85.12)	28 (14.35)	01 (0.51)	555	2.84	II
5.	Accessing news and current affairs	130 (66.66)	64 (32.82)	01 (0.51)	519	2.66	IV
6.	Knowledge gain regarding different agri-preneurship enterprises	95 (48.71)	94 (48.20)	06 (3.07)	479	2.45	IX
7.	Preparing presentation	99 (50.76)	95 (48.71)	01 (0.51)	488	2.50	VI
8.	Listening/reading agricultural information	108 (55.38)	85 (43.58)	02 (1.02)	496	2.54	V
9.	Spiritual/Religious Text	54 (27.69)	115 (58.97)	26 (13.33)	418	2.14	XII
10.	Library catalogues	56 (28.71)	126 (64.61)	13 (6.66)	433	2.22	XI
11.	Attending online classes	174 (89.23)	21 (10.76)	0 (0.00)	564	2.89	I
12.	Attending webinar	83 (42.56)	109 (55.89)	03 (1.53)	470	2.41	X
13.	Attending online meetings	97 (49.74)	96 (49.23)	02 (1.02)	485	2.48	VII

*Figures in parentheses indicate percentage, TWS = Total Weighted Score, WMS = Weighted Mean Score

Table-6 : Ranking to use of various search tools based on WMS.**N=195**

S. No.	Search engines	Often (3)	Occasionally (2)	Never used (1)	TWS	WMS	Rank
1.	Google	184 (94.35)	11 (5.64)	0 (0.00)	574	2.94	I
2.	Yahoo	42 (21.53)	88 (45.12)	65 (33.33)	367	1.88	IV
3.	Google Scholar	25 (12.82)	51 (26.15)	119 (61.02)	296	1.51	VIII
4.	Research Gate	34 (17.43)	59 (30.25)	102 (52.30)	322	1.65	VII
5.	My Author	12 (6.15)	40 (20.51)	143 (73.33)	2.59	1.32	X
6.	Krishi kosh	33 (16.92)	87 (44.61)	75 (38.46)	348	1.78	VI
7.	Sodhganga	13 (6.66)	50 (25.64)	132 (67.69)	271	1.38	IX
8.	Microsoft	57 (29.23)	53 (27.17)	85 (43.58)	362	1.85	V
9.	Chrome	173 (88.71)	22 (11.28)	0 (0.00)	563	2.88	II
10.	Bing	74 (37.94)	45 (23.07)	76 (38.97)	388	1.98	III

*Figures in parentheses indicate percentage, TWS = Total Weighted Score, WMS = Weighted Mean Score

by 2.81 WMS. The next rank was assigned to “accessing news and current affairs” (4th), followed by “listening/reading agricultural information” (5th), “preparing presentation” (6th), “attending online meetings” (7th), “preparing course assignments” (8th), “knowledge gain regarding different agri-preneurship enterprises” (9th), “attending webinar” (10th), “downloading software” and “library catalogue” (11th). Whereas, the “spiritual text” stood at last rank (12th) with lowest weighted mean score (2.14). Similar, observation also recorded by Malik *et al.* (2018) who observed that majority of the students used internet for entertainment purpose followed by Google maps, research purpose, job search, e-mail, agricultural information, academic purpose etc.

Uses various search tool : The data revealed that “Google” WMS 2.94 with 1st rank (Table-6) was identified as most used search tool followed by “Chrome” (WMS 2.88 with 2nd rank), “Bing” (WMS 1.98 with 3rd rank), “Yahoo” (WMS 1.88 with 4th rank), “Microsoft” (WMS 1.85 with 5th rank), “Krishi kosh” (WMS 1.78 with 6th rank), “research gate” (WMS 1.65 with 7th rank), “Google scholar” (WMS 1.51 with 8th rank), “Sodhganga” (WMS 1.38 with 9th rank) and “My author” (WMS 1.32 with 10th rank). That means, Google, Chrome and Bing were top three most popular search engines among the respondents. While, Google scholar, Sodhganga and My author were least utilized search engine by the agri-graduates. Similar, observation also recorded by Malik *et al.* (2018) who

revealed that a great majority of the respondents used Google for searching information followed by Face book etc.

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Nutrient Uptake and Soil Properties as Influenced by Fertility Levels and Enriched Compost in Soybean (*Glycine max*)

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Abstract

A field experiment was conducted during *kharif* season of 2018 at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan) to study the nutrient uptake and soil properties as influenced by fertility Levels and enriched compost in soybean (*Glycine max* L.) in *Typic Haplustepts* soil of sub-humid southern plain of Rajasthan. The experiment was laid out in randomized factorial block design and treatments were replicated thrice. The experiment included twelve treatment combinations, having three fertility levels viz. Control (F₁), 50% RDF (F₂) and 100% RDF (F₃) as factor I and four enriched compost treatments viz. Control (C₁), 2.0 t ha⁻¹ (C₂), 4.0 t ha⁻¹ (C₃) and 6.0 t ha⁻¹ (C₄) as factor II. Results showed that 100% RDF produced significantly higher N and P content and uptake of N, P and K in grain and stover due to strong correlation with yield. Organic C, available N, available P, bacteria, fungi and actinomycetes population along with dehydrogenase and alkaline phosphatase were also reported significantly higher under 100 % RDF. Application of 6.0 t ha⁻¹ enriched compost recorded significantly higher nutrient content and nutrient uptake by the crop along with higher soil chemical and biological properties but the results were closely followed by application of 4.0 t ha⁻¹ enriched compost. Thus, it can be concluded from the results that combined application of 100% recommended dose of fertilizer with 4 t ha⁻¹ enriched compost was more responsive in terms of productivity and soil quality.

Key words : Fertility, enriched compost, nutrient, uptake, soybean, soil properties.

Introduction

Soybean, also known as a 'miracle crop' is one of the important oilseed and legume crop of India. In India, the total area under soybean cultivation is 11.13 million ha with the production of 13.27 million tons which makes India the fifth largest producer of soybean in the world after USA, Brazil, China and Argentina. In India Madhya Pradesh is leading producer and Rajasthan also covers 8.37 % of area and 8.81 % of production of all India (Agricultural Statistics at a Glance, 2020). Soybean grain contains about 38 to 40 percent high quality lysine rich protein and 20 percent oil. Soybean is also an excellent source of saponins, isoflavones, unsaturated fatty acids, vitamin B complex, fibre, iron, calcium, zinc and other bioactive compounds (Rizzo and Baroni, 2018). In addition it increases soil fertility by atmospheric nitrogen fixation upto the extent of 450 kg ha⁻¹ through the process of symbiosis in root nodules (Hungria and Mendes, 2015). Application of nutrients as basal dose is required in legumes to encourage early plant growth and for root nodule development (Mondal *et al.*, 2020). Imbalanced application of fertilizers and poor management of resources has deteriorated soil health and excessive removal of nutrients by crop is leading to nutrient mining.

To reduce the pace of nutrient mining integrated approach for management of soil nutrients is required (Das *et al.*, 2015). Thus, use of high quality organic manures like enriched compost with fertilizers in an integrated manner not only provide essential plant nutrients but also build up organic carbon and improve soil biological and physical conditions (Abhishek *et al.*, 2021). Preparation of phospho enriched compost (PEC) by value-addition through cheap minerals like rock phosphate improves the soil fertility and also enriches the soil with indigenous micro flora and fauna (Meena *et al.*, 2021). This balanced fertilization reduces the fixation and loss of nutrients from soil and thus increase the availability of nutrient to the crop. Further, optimum fertilization helps to obtain high yield and nutrient uptake by the crop (Singh, 2018). In light of the above facts a field experiment was conducted to find out the response of fertility levels and enriched compost in soybean (*Glycine max* L.) on nutrient uptake and soil properties.

Materials and Methods

Experimental site and soil : The field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during *kharif* 2018 situated at South-Eastern part of Rajasthan at an altitude of 582.5

meter above mean sea level with 24°35' N latitude and 73° 42' E longitude. The region falls under agro-climatic zone IV a (Sub- Humid Southern Plain and Arawali Hills) of Rajasthan. The soil of the experimental field was clay loam in texture with 36.41% sand, 28.70% silt and 34.36% clay. The soil was slightly alkaline (pH 8.18) having medium organic carbon (0.57%), available nitrogen (270.84 kg ha⁻¹) and phosphorus (18.52 kg ha⁻¹) while high in available potassium (390.14 kg ha⁻¹) and was having sufficient available manganese (3.42 mg kg⁻¹) and copper (2.44 mg kg⁻¹) but deficient in available iron (3.64 mg kg⁻¹) and zinc (0.90 mg kg⁻¹).

Enriched compost : Four mineral and organic sources viz. low grade rock phosphate, maize stover, FYM and phosphors solubilising bacteria were used for preparation of enriched compost using standard procedure (Abhishek *et al.*, 2021). C: N ratio of enriched compost was 23:20 and nutrient content was 0.65% N, 1.21% P and 0.66% K.

Experimental design and treatments : The experiment was conducted in randomized factorial block design in three replications with twelve treatment combinations, having three fertility levels viz. Control (F₁), 50% RDF (F₂) and 100% RDF (F₃) as factor I and four enriched compost treatments viz. Control (C₁), 2.0 t ha⁻¹ (C₂), 4.0 t ha⁻¹ (C₃) and 6.0 t ha⁻¹ (C₄) as factor II. JS- 9560 variety of soybean with seed rate of 80kg ha⁻¹ was sown at spacing of 30 cm x 10 cm (R x P). Urea and DAP fertilizers were used to supply RDF (20 N and 40 kg P₂O₅ ha⁻¹) as basal dose and enriched compost was applied 15 Days before sowing of crop. Other agronomic practices were followed as per the standard package of practices to raise the soybean crop.

Plant and soil sampling, processing and analysis : For estimation of N, P and K content, grain and stover samples were collected at harvest from each experiment plot and oven dried at 65 °C to a constant weight and grounded into powder in laboratory mill. After sieving the samples were used for determining nitrogen (Jackson, 1967), phosphorus (Olsen and Sommers, 1982) and potassium (Richards, 1954). Nutrient uptake by seed and stover was calculated by following formula

Nutrient content in seed or Stover (%) x Seed or Stover yield (kg ha⁻¹)

Nutrient uptake (kg ha⁻¹)

$$= \frac{\text{Nutrient content in seed or Stover (\%)} \times \text{Seed or Stover yield (kg ha}^{-1}\text{)}}{100}$$

The surface (0-15 cm depth) soil samples were collected at harvest of crop from three randomly selected spots in each replication and composite samples were prepared. Soil was ground and well mixed. Soil samples

were sieved through 2 mm mesh and stored at 4 °C for biological analysis. In these fresh soil samples, soil microbial populations were determined by standard serial dilution and plate-count method (Vance *et al.*, 1987). Dehydrogenase enzyme activity was analyzed by anthrone extraction method (Cassida *et al.*, 1964) and alkaline phosphatase activity was determined by P-nitro phenol estimation method (Tabatabai and Bremner, 1969). Chemical analysis of oven dried (at 105 °C till constant weight) and sieved soil samples was done by standard methods. Organic Carbon by Walkley and Black, 1934 method, Nitrogen by alkaline permanganate method (Subbiah and Asija, 1956), phosphorous by using sodium bicarbonate (Olsen *et al.*, 1954), potassium by ammonium acetate method (Stanford and English 1949) and available micronutrients (Fe, Zn, Cu and Mn) were analysed by DTPA extraction (Lindsay and Norvell, 1978) method.

Statistical analysis : Recorded experimental data for different parameters were analyzed with the help of analysis of variance (ANOVA) technique for factorial randomized block design to determine the significance of difference between treatment means. The results are presented at 5% level of significance (P=0.05).

Results and Discussion

Nutrient Content and uptake by plant

Effect of fertility levels : It is apparent from the data presented in table 1 that nutrient content in grain and stover of soybean increased with increasing levels of fertility. Significantly higher nitrogen and phosphorus content in grain (6.043 %, 5.545%) and stover (1.543 %, 0.273 %) were recorded with application of 100% RDF (F₃) in comparison 50% RDF (F₂) and control (F₁) respectively. However potassium content in grain and stover was not influenced significantly by different fertility levels. Higher uptake of nutrients by soybean grain and stover was reported with increasing fertility levels. 100% RDF recorded significantly higher N, P and K uptake in grain (105.75, 9.58 and 10.83 kg ha⁻¹) and stover (40.65, 7.21 and 31.52 kg ha⁻¹) over 50% RDF and control, respectively. The nutrient uptake is a function of nutrient content and yield of the crop and is depicted by positive correlation between yield and nutrient uptake by soybean crop (Figure 1). Such findings might be due to improved nutritional environment in the rhizosphere as well as in the plant system with increasing levels of nutrient application which lead to improvement in the translocation of nitrogen, phosphorus and potassium in plant parts and thus yield. Similar results were reported by Jaga and Sharma (2015) and Rana *et al.* (2014) in soybean.

Effect of enriched compost : The nutrient content in

Table-1 : Effect of fertility levels and enriched compost on nutrient content and uptake by soybean.

Treatment	Nutrient content (%)						Nutrient uptake (kg ha ⁻¹)					
	Grain			Stover			Grain			Stover		
	N	P	K	N	P	K	N	P	K	N	P	K
Fertility levels (kg ha⁻¹)												
F1 : Control	5.12	0.43	0.61	1.24	0.22	1.15	50.65	4.27	6.03	22.77	3.98	21.26
F2 : 50% RDF	5.60	0.48	0.62	1.33	0.25	1.15	80.62	6.87	8.86	29.75	5.52	26.21
F3 : 100% RDF	6.04	0.54	0.62	1.54	0.27	1.17	105.75	9.58	10.83	40.65	7.21	31.52
SEm±	0.06	0.01	0.01	0.01	0.00	0.01	2.45	0.20	0.23	1.25	0.21	1.02
CD (P=0.05)	0.17	0.02	NS	0.04	0.01	NS	7.17	0.58	0.67	3.67	0.62	2.98
Enriched Compost levels (t ha⁻¹)												
C1 : Control	5.24	0.43	0.57	1.30	0.21	0.89	49.73	4.13	5.32	24.04	3.97	16.36
C2 : 2 t ha ⁻¹	5.48	0.46	0.61	1.35	0.23	1.07	69.81	5.97	7.63	29.00	5.03	22.61
C3 : 4 t ha ⁻¹	5.76	0.51	0.63	1.40	0.26	1.30	94.18	8.47	10.29	33.52	6.30	30.69
C4 : 6 t ha ⁻¹	5.87	0.52	0.64	1.43	0.27	1.37	102.31	9.06	11.05	37.67	6.98	35.66
SEm±	0.07	0.02	0.02	0.01	0.00	0.01	2.82	0.23	0.26	1.45	0.24	1.17
CD (P=0.05)	0.20	0.02	0.02	0.04	0.01	0.03	8.28	0.67	0.77	4.24	0.71	3.44

Table-2 : Effect of fertility levels and enriched compost on soil chemical properties under soybean cultivation.

Treatment	OC (%)	Available nitrogen	Available phosphorus (kg ha ⁻¹)	Available potassium	Zn	Fe	Mn	Cu
(mg kg ⁻¹)								
Fertility levels (kg ha ⁻¹)								
F1 : Control	0.64	266.55	18.41	379.96	0.91	3.65	3.39	2.40
F2 : 50% RDF	0.68	275.10	20.50	378.98	0.92	3.66	3.41	2.42
F3 : 100% RDF	0.71	286.65	21.94	380.94	0.93	3.68	3.42	2.44
SEm±	0.004	1.67	0.19	1.66	0.01	0.02	0.04	0.01
CD(P=0.05)	0.01	4.90	0.56	NS	NS	NS	NS	NS
Enriched Compost levels (t ha ⁻¹)								
C1 : Control	0.63	267.12	18.09	371.63	0.81	3.46	3.23	2.33
C2 : 2 t ha ⁻¹	0.66	273.19	19.63	377.56	0.88	3.59	3.36	2.39
C3 : 4 t ha ⁻¹	0.69	279.10	21.18	383.57	0.98	3.74	3.48	2.46
C4 : 6 t ha ⁻¹	0.73	285.00	22.23	387.08	1.01	3.86	3.56	2.51
SEm±	0.01	1.93	0.22	1.92	0.01	0.03	0.04	0.02
CD (P=0.05)	0.01	5.66	0.65	5.64	0.03	0.07	0.12	0.04

grain and stover of soybean depicted an increasing trend with increasing levels of enriched compost. 6 t ha⁻¹ enriched compost reported significantly higher N, P and K content in grain (5.867 %, 0.520% and 0.643%) and stover (1.428%, 0.266% and 1.367%) over 2 t ha⁻¹ enriched compost and control, respectively but the results were at par with 4 t ha⁻¹ enriched compost except for stover K content. With higher application rate of enriched compost nutrients were also uptaken in higher amount by soybean crop. Significantly higher N, P and K uptake by grain (102.31, 9.06 and 11.05 kg ha⁻¹) and stover (37.67, 6.98 and 35.66 kg ha⁻¹) were recorded with application of 6 t ha⁻¹ enriched compost over 2 t ha⁻¹ enriched compost and control. However the results were at par with 4 t ha⁻¹

enriched compost except for potassium uptake by stover. Application of enriched compost might have helped the crop in greater root development and nodulation which in turn resulted in higher nitrogen fixation in the soil by root nodules. Thus, increased availability of nitrogen and phosphorus might have resulted in greater uptake of nitrogen, phosphorus and other nutrients by plant for proper development and ultimately enhance their content and uptake by grain and stover. Also the balanced use of various plant nutrient sources results in proper absorption, translocation and assimilation of those nutrients by the crop. These results are in agreement with the findings of Chaturvedi *et al.* (2010), Meena and Biswas (2013) and Yadav *et al.* (2014).

Table-3 : Interaction effect of fertility levels and enriched compost.

Treatments	C ₁	C ₂	C ₃	C ₄
Available Phosphorus (kg ha ⁻¹)				
F ₁	17.15	18.02	18.79	19.69
F ₂	17.96	19.83	21.50	22.73
F ₃	19.17	21.04	23.27	24.27
SEm ±		0.38		
CD(P=0.05)		1.13		
Alkaline phosphates activity (ig PNP g ⁻¹ soil ha ⁻¹)				
F ₁	9.11	10.02	11.04	12.61
F ₂	10.28	11.35	12.75	15.56
F ₃	11.17	13.95	15.58	16.43
SEm ±		0.33		
CD(P=0.05)		0.98		

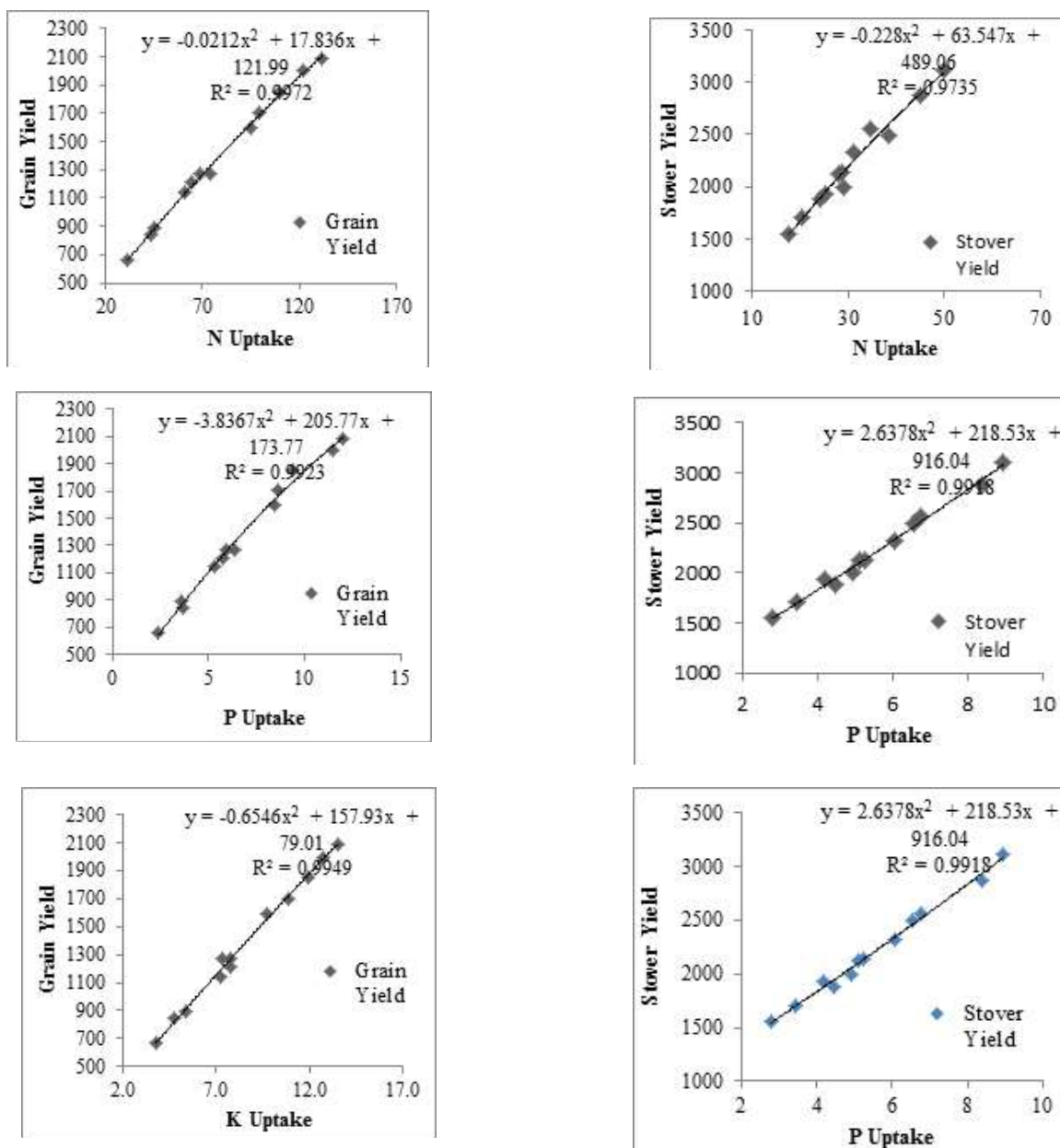


Fig-1 : Relationship between nutrient uptake and yield of soybean crop.

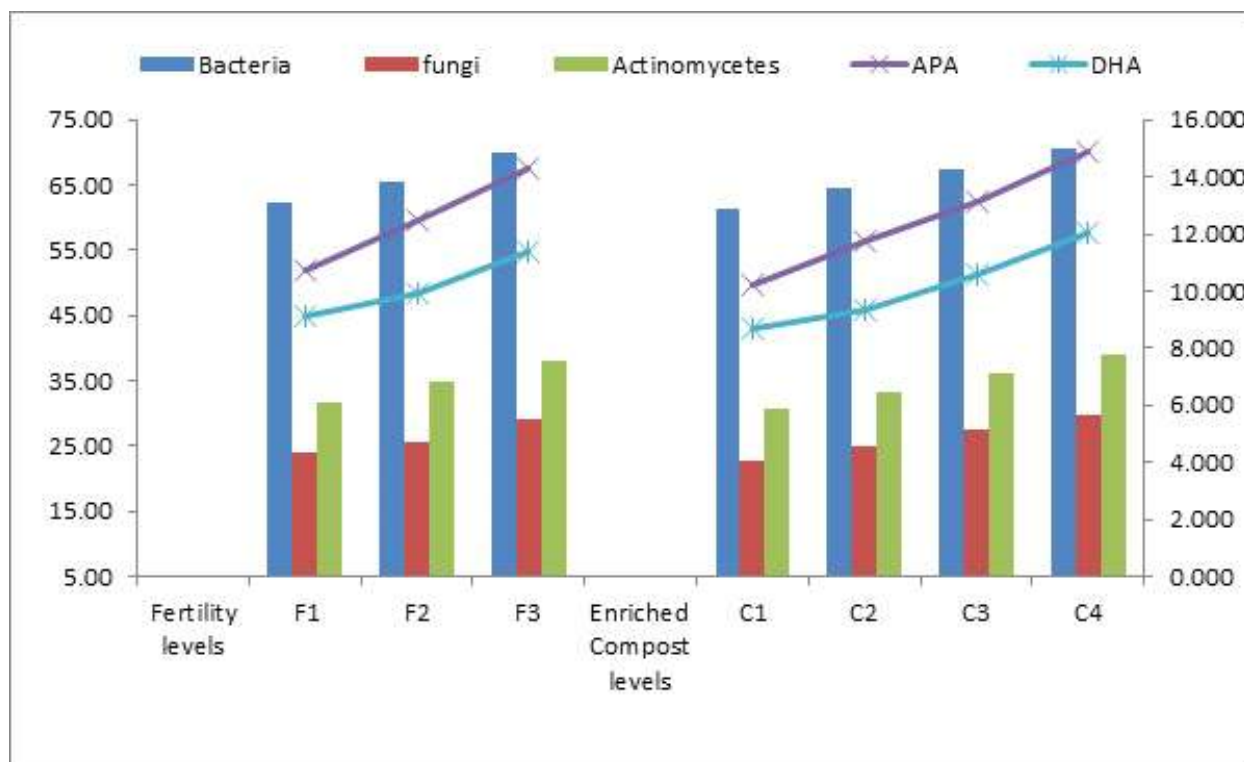


Fig.-2 : Effect of fertility levels and enriched compost on soil microbiological population and enzyme activities (Bacteria $\times 10^6$ cfu g⁻¹ soil, Fungi $\times 10^4$ cfu g⁻¹ soil, Actinomycetes $\times 10^5$ cfu g⁻¹ soil, alkaline phosphatase activity g PNP g⁻¹ h⁻¹ and dehydrogenase activities g TPF g⁻¹ h⁻¹) after harvest of crop.

Soil Properties

Chemical properties

Fertility levels : Data (Table-2) indicates that maximum organic carbon (0.71 %) was recorded in 100% RDF (F₃) which was significantly superior over 50% RDF (F₂) and control. When compared with the control (F₁), the extent of increase in organic carbon with the fertility levels with 50% RDF and 100% RDF was in the order of 6.25 and 10.94 per cent, respectively. Data presented in table 2 indicates that available nitrogen and available phosphorus content was significantly affected by fertility levels and thus 100 % RDF recorded significantly higher available N and available P in comparison to 50 % RDF and control. On the other hand available K and micronutrients viz., Fe, Mn, Cu and Zn content was not affected significantly by different fertility levels. These findings might be due to the reason that variable rate of potassium and micronutrients fertilizer were not applied to the experimental plots and thus they were not affected much whereas with increasing fertility levels dose of N and P increased and thus their content in soil too increased. Similar results were reported by Parewa *et al.* (2014).

Enriched compost levels : Data (Table-2) indicates that application of 2, 4 and 6 t ha⁻¹ enriched compost has significant effect on organic carbon and thus recorded 4.76, 9.52 and 15.87 per cent higher organic carbon

content in soil, respectively over control. Available macronutrients as well as micronutrients were also affected significantly by enriched compost levels. Significantly higher content of available N (285 kg ha⁻¹), available P (22.23 kg ha⁻¹), available K (387.08 kg ha⁻¹), Zn (1.01 mg kg⁻¹), Fe (3.86 mg kg⁻¹), Mn (3.56 mg kg⁻¹) and Cu (2.51 mg kg⁻¹) were recorded with application of 6 t/ ha enriched compost over control and 2 t/ ha enriched compost. But the results for available K, Zn and Mn were at par with 4 t/ ha enriched compost application. Further the interaction effect of fertility levels and enriched compost levels was found to be significant on available phosphorus in soil. Maximum available phosphorus (24.96 kg ha⁻¹) was obtained under treatment combination C₄F₃ which was found statistically at par with treatment combination C₃F₂ and C₃F₃ (Table 3). These findings might be due to addition of organic acids, minimization of leaching of ions by enriched compost, etc. which all together increased the mineralization and availability of nutrients in soil. The results are in line with the findings of Dsouza *et al.* (2018) and Meena *et al.* (2021).

Biological properties

Microbial population and enzymatic activities were significantly affected by fertility levels as well as enriched compost levels (Figure-2). When compared with the control, the extent of increase in bacterial fungal and actinomycetes population and alkaline phosphatase and

dehydrogenase enzyme activity with the 50% RDF and 100% RDF fertility levels was in the order of 5.01 and 12.39 per cent, 7.84 and 22.13 per cent, 10.02 and 20.99 per cent, 16.84 and 33.58 per cent, 8.31 and 24.59 per cent, respectively. The maximum bacterial population (70.48×10^6 cfu g⁻¹ soil), fungal population (29.87×10^4 cfu g⁻¹ soil), actinomycetes population (39.08×10^5 cfu g⁻¹ soil), alkaline phosphatase activity (14.86 μ g PNP g⁻¹ h⁻¹) and dehydrogenase activities (12.02 μ g TPF g⁻¹ h⁻¹) in soil after harvest of crop were recorded with the application of 6 t ha⁻¹ enriched compost (C₄) which was followed by 4 t ha⁻¹ enriched compost (C₃), 2 t ha⁻¹ enriched compost (C₂) and control (C₁), respectively. However the interaction effect of fertility levels and enriched compost levels was found to be significant on alkaline phosphatase activity (Table 3). Maximum alkaline phosphatase activity (16.43 μ g PNP g⁻¹ h⁻¹) was obtained under treatment combination C₄F₃ which was found statistically at par with treatment combination C₃F₂ and C₃F₃. These findings might be due to addition of organic carbon in the form of phospho-enriched compost which in turn provides adequate biomass as nutritional source for the microbes and helps in increasing microbial population as well as enzyme activity in soil. Similar results were reported by Doodhwal *et al.* (2021) and Yadav *et al.* (2021).

It can be concluded from the results that combined application of 100% recommended dose of fertilizer with 4 t ha⁻¹ enriched compost along with economical was more responsive in terms of nutrient content and uptake of soybean crop and also increased soil chemical and biological properties under Typic Haplustepts soils of Udaipur region of Rajasthan.

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Heterosis and Combining Ability for Yield and Yield Contributing Characters in Bottle Gourd (*Lagenaria siceraria* (Mol.) Standl.)

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Abstract

The present investigations was carried out in two years with 10 lines and 4 testers of bottle gourd were taken in line x tester analysis for combining ability, heterosis and gene action for eighteen yield and yield components in bottle gourd. Analysis of variance due to treatments, parents and crosses were highly significant for all the traits in both the years. Variances due to parents vs crosses were highly significant for all characters except for node number to first pistillate flower in Y1 and ascorbic acid in Y2. Variances due to line vs testers were highly significant for all the characters except for days to first staminate flower anthesis in Y1, vine length in Y2 and fruit circumference and number of fruits per plant in both the years. Partitioning of variances into lines revealed highly significant differences for all characters whereas, variances due to testers were also highly significant for all characters in both the years. Combining ability analysis elucidated higher magnitude of variance due to sca (σ^2_s) than variance due to gca (σ^2_g) indicating preponderance of non-additive gene action for all the characters. The values of dominance genetic variance (σ^2_D) was larger than additive genetic variance (σ^2_A) and average degree of dominance were more than unity (>1) for all the characters under study except for days to first staminate flower anthesis, number of fruits per plant, fruit yield per plant and dry matter content in fruit in both the years and days to first pistillate flower anthesis in Y2 which indicated existence of over dominance and controlled by a preponderance of non-additive gene effects suggesting thereby scope of F1's hybrid and or selections of the recombinants within the parents and segregating populations, respectively.

Key words : Bottle gourd, combining ability, heterosis.

Introduction

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl] is one of the important cucurbits commonly grown in both rainy and summer season in various parts of India. The chromosome number of bottle gourd is $2n = 22$ ($X = 11$). This delicious vegetable is also known by names of bottle squash, calabash gourd, white flowered gourd, doodhi and lowki. Due to high remunerative prices in domestic as well as external market, commercial cultivation of bottle gourd has increased in India. Hybrid varieties play a vital role in increasing vegetable production due to their high yield potential, earliness, quality and resistance attributes. It is highly cross-pollinated crop due to its monoecious and andromonoecious nature (Swiander *et al.*, 1994).

Although, heterosis for yield and yield contributing characters has been reported in bottlegourd by early workers (Sirohi *et al.*, 1987, Jankiram and Sirohi, 1992), it has not been exploited sufficiently by plant breeder for improvement. It was therefore, felt necessary to initiate steps in this direction with a view to evolve high yielding quality F1 hybrids through heterosis breeding. There is a great scope for the improvement of this crop through hybridization. Therefore, the present study was undertaken to develop high yielding F1 varieties suitable

for winter as well as summer rainy season cultivation and to study the heterosis in bottle gourd.

Materials and Methods

The experiment was conducted at Horticulture Research Farm, Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.) India during Zaid 2017-18 and 2018-19 with involving 10 lines (NDBG-504, NDBG-509, NDBG-517, NDBG-522, NDBG-601, NDBG-603, NDBG-749-2, NDBG-11, NDBG-10, Narendra Rashmi), 4 testers (Pusa Naveen, NDBG-624, NDBG-S-5, NDBG-104) of bottle gourd and their 40 F1 hybrids produced in $L \times T$ fashion. The experiments were laid out in RBD with three replications having each experimental unit of single row with spacing of 3.0 m $\times$ 0.5 m.

The observations were recorded on parents and F1's for eighteen quantitative traits viz., days to first staminate flower anthesis, days to first pistillate flower anthesis, node number to first staminate flower, node number to first pistillate flower, days to first fruit harvest, vine length at last picking stage (m), number of primary branches per plant, fruit length (cm), fruit circumference (cm), fruit weight (kg), number of fruits per plant, fruit yield per plant (kg), total soluble solids ($^{\circ}B$), ascorbic acid (mg), reducing sugars (%), non-reducing sugars (%), total

Table-1 : Analysis of variance for combining ability following line × tester mating design for 18 characters in bottle gourd (Y₁=2017-18 and Y₂=2018-19).

Sources of variation	Years	df	Days to first staminate flower anthesis	Days to first pistillate flower anthesis	Node number to first staminate flower	Node number to first pistillate flower	Days to first fruit harvest	Vine length at last picking stage (m)	Number of primary branches per plant	Fruit length (cm)	Fruit circumference (cm)
Replications	Y ₁	2	2.286*	1.053	0.196	0.161	0.897	0.353**	1.868**	1.352	0.095
	Y ₂	2	0.533	0.224	0.038	0.324*	0.165	0.488*	0.496*	0.077	0.300
Lines	Y ₁	9	23.786*	4.023	2.509	1.591	15.501	2.570	32.464	111.427**	30.630**
	Y ₂	9	20.511**	5.021	1.896	1.270	20.761**	1.546	21.847	105.617**	31.788**
Testers	Y ₁	3	65.262**	23.575**	10.702*	7.853	7.202	6.295	41.257	7.919	17.870
	Y ₂	3	85.395**	29.158**	8.804*	4.606	27.067**	5.470	43.853	8.861	12.450
Lines × Testers	Y ₁	27	9.586**	5.661**	3.232**	3.267**	8.515**	3.713**	26.339**	35.063**	8.278**
	Y ₂	27	6.440**	4.691**	2.387**	2.125**	8.383**	2.848**	23.238**	33.237**	7.154**
Error	Y ₁	78	0.536	0.437	0.075	0.100	0.808	0.065	0.321	1.247	0.380
	Y ₂	78	0.254	0.258	0.083	0.082	0.261	0.150	0.114	0.123	0.098

Table-1 : Contd....

Sources of variation	Years	df	Fruit weight (kg)	Number of fruits per plant	Fruit yield per plant (kg)	Total soluble solids (°B)	Ascorbic acid (mg/100 g fresh fruit)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Dry matter content in fruit (%)
Replications	Y ₁	2	0.011	0.352	0.855*	0.002	0.008	0.000	0.001	0.002	0.002
	Y ₂	2	0.004	0.085	0.082	0.000	0.000	0.001	0.000	0.001	0.002**
Lines	Y ₁	9	0.158	1.945	7.826	0.732	1.333	0.121	0.030	0.037	2.163*
	Y ₂	9	0.147	2.640	7.545	0.734	1.380	0.124	0.028	0.042	2.192*
Testers	Y ₁	3	0.383*	23.731**	32.214**	0.858	2.567	0.314	0.072	0.087*	4.952**
	Y ₂	3	0.397**	26.583**	31.070**	0.803	2.632	0.340	0.086	0.085	5.066**
Lines × Testers	Y ₁	27	0.091**	2.868**	4.457**	0.386**	0.877**	0.121**	0.043**	0.027**	0.793**
	Y ₂	27	0.081**	3.089**	4.406**	0.388**	0.889**	0.122**	0.040**	0.033**	0.793**
Error	Y ₁	78	0.014	0.182	0.187	0.002	0.003	0.000	0.000	0.001	0.009
	Y ₂	78	0.003	0.123	0.108	0.000	0.000	0.000	0.000	0.001	0.000

*, ** Significant at 5% and 1% probability levels, respectively.

sugars (%) and dry matter content in fruit (%). The observations were also recorded for some qualitative traits as well. Observations on metric traits were recorded on single plant basis on five random selected competitive plants in each genotype from each plot for all the traits. Statistical analysis of data was done to estimate per se values and degree of significance of various traits (Panse & Sukhatme, 1978).

Results and Discussion

The analysis of variance for combining ability in Y₁ and Y₂ for eighteen characters had been presented in table-1.1. In the present study, analysis of variances for combining ability revealed that the partitioning of variances due to lines × testers showed highly significant differences for all the eighteen characters in both the years (Y₁ and Y₂). Variances due to lines were significant for fruit length, fruit circumference, days to first staminate flower anthesis and

dry matter content in fruit in both the years (Y₁ and Y₂) and days to first fruit harvest in only Y₂. The variances due to testers were also highly significant for days to first staminate flower anthesis, days to first pistillate flower anthesis, node number to first staminate flower, fruit weight, number of fruits per plant, fruit yield per plant and dry matter content in fruit in both the years and total sugars in only Y₁ and days to first fruit harvest in only Y₂. Similar finding was also reported by Shaikh *et al.* (2012).

For illustrating genetic worth of parents for hybridization programme, the general combining ability (gca) effects of 14 parents (10 lines and 4 testers) for eighteen characters in Y₁ and Y₂ had been presented in table- 1.2. Significant gca values indicated the importance of additive and additive × additive gene effect as earlier reported by Griffing (1956).

In view of this, these parents offered the best possibilities for the development of improved lines of

Table-2 : Summary of general combining ability effects of parents for 18 characters in bottle gourd ($Y_1=2017-18$ and $Y_2=2018-19$).

S. No.	Lines	Years	Fruit yield per plant (kg)	Days to first staminate flower anthesis	Days to first pistillate flower anthesis	Node number to first staminate flower	Node number to first pistillate flower	Days to first fruit harvest	Vine length at last picking stage (m)	No. of primary branches per plant	Fruit length (cm)	Fruit circumference (cm)
1.	NDBG-504	Y ₁	-0.23	A	G	P	P	G	G	G	G	P
		Y ₂	-0.63**	A	G	P	P	G	A	G	G	P
2.	NDBG-509	Y ₁	-0.37**	P	A	G	G	G	P	G	G	G
		Y ₂	-0.47**	P	G	G	A	G	P	G	G	G
3.	NDBG-517	Y ₁	0.60**	P	P	P	P	A	G	G	A	P
		Y ₂	0.61**	P	P	P	P	A	G	A	G	P
4.	NDBG-522	Y ₁	-0.13	G	P	A	G	A	P	P	G	P
		Y ₂	-0.19*	G	P	A	G	P	P	P	G	P
5.	NDBG-601	Y ₁	-1.20**	P	P	A	A	P	P	P	P	P
		Y ₂	-1.02**	P	P	A	A	P	P	P	P	P
6.	NDBG-603	Y ₁	-0.67**	G	G	A	P	A	G	P	P	G
		Y ₂	-0.57**	G	G	P	P	G	G	P	P	G
7.	NDBG-749-2	Y ₁	1.41**	G	P	G	G	A	A	G	P	G
		Y ₂	1.25**	G	P	G	G	A	A	G	P	G
8.	NDBG-11	Y ₁	-0.74**	G	G	P	G	A	P	P	A	P
		Y ₂	-0.60**	G	G	A	G	P	A	A	A	P
9.	NDBG-10	Y ₁	0.69**	G	G	A	G	A	P	P	A	A
		Y ₂	0.86**	G	A	A	G	P	P	P	A	A
10.	Narendra Rashmi	Y ₁	0.64**	G	A	G	P	P	G	G	P	P
		Y ₂	0.76**	G	A	A	P	P	G	G	P	P
Testers												
1.	Pusa Naveen	Y ₁	0.61**	G	G	G	G	G	P	P	P	G
		Y ₂	0.52**	G	G	G	G	G	P	P	P	G
2.	NDBG-624	Y ₁	-0.44**	P	A	P	A	A	G	G	A	P
		Y ₂	-0.41**	P	A	P	A	A	G	G	P	P
3.	NDBG-S-5	Y ₁	1.06**	G	G	P	P	A	G	G	G	G
		Y ₂	1.10**	G	G	P	P	P	G	G	G	G
4.	NDBG-104	Y ₁	-1.23**	P	P	A	G	P	G	P	A	P
		Y ₂	-1.21**	P	P	A	G	P	A	P	A	P

G=Good combiner, P=Poor combiner and A=Average combiner.

Table-2 : Contd....

S. No.	Lines	Years	Fruit yield per plant (kg)	Fruit weight (kg)	Number of fruits per plant	Total soluble solids (°B)	Ascorbic acid (mg/100 g fresh fruit)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Dry matter content in fruit (%)
1.	NDBG-504	Y ₁	-0.23	G	P	P	G	P	G	P	G
		Y ₂	-0.63**	G	P	P	A	P	G	P	G
2.	NDBG-509	Y ₁	-0.37**	A	A	P	P	G	P	G	G
		Y ₂	-0.47**	P	A	P	P	G	P	G	G
3.	NDBG-517	Y ₁	0.60**	A	G	G	G	P	G	P	P
		Y ₂	0.61**	A	G	G	G	P	G	P	P
4.	NDBG-522	Y ₁	-0.13	A	A	P	G	P	G	G	G
		Y ₂	-0.19*	A	A	P	G	P	G	G	G
5.	NDBG-601	Y ₁	-1.20**	P	A	P	P	G	P	G	G
		Y ₂	-1.02**	P	A	P	P	G	P	G	G
6.	NDBG-603	Y ₁	-0.67**	G	P	A	P	G	P	G	P
		Y ₂	-0.57**	G	P	G	P	G	P	G	P
7.	NDBG-749-2	Y ₁	1.41**	G	G	P	G	A	G	G	P
		Y ₂	1.25**	G	G	P	G	A	G	G	P
8.	NDBG-11	Y ₁	-0.74**	A	P	P	G	P	G	P	P
		Y ₂	-0.60**	P	P	P	G	P	G	P	P
9.	NDBG-10	Y ₁	0.69**	A	G	G	G	P	G	P	G
		Y ₂	0.86**	G	G	G	G	P	G	P	G
10.	Narendra Rashmi	Y ₁	0.64**	A	G	G	P	G	P	G	G
		Y ₂	0.76**	A	G	G	P	G	P	G	G
Testers											
1.	Pusa Naveen	Y ₁	0.61**	P	G	P	P	G	P	G	P
		Y ₂	0.52**	P	G	P	A	G	P	G	P
2.	NDBG-624	Y ₁	-0.44**	G	P	G	P	G	P	G	P
		Y ₂	-0.41**	G	P	G	P	G	P	G	P
3.	NDBG-S-5	Y ₁	1.06**	P	G	G	A	G	A	G	P
		Y ₂	1.10**	P	G	G	A	G	A	G	P
4.	NDBG-104	Y ₁	-1.23**	P	P	G	G	P	G	P	G
		Y ₂	-1.21**	P	P	G	G	P	G	P	G

bottle gourd through hybridization programme. It is, therefore, recommended that to improve yield one should breed for superior combining ability for the component traits with an ultimate objective to improve the pace of its genetic improvement. On the basis of mean performance and gca effects it had been found that there is perfect relationship between per se performance and gca effect of the parents. The above six parents (NDBG-749-2, NDBG-10, Narendra Rashmi and NDBG-517 among lines and NDBG-S-5 and Pusa Naveen among testers) in both the years showed positive and significant gca effects for fruit yield per plant and other important traits as mentioned in above paragraphs may serve as valuable parents for hybridization programme or multiple crossing programme for obtaining high yielding variety or transgressive segregants for developing varieties of bottle gourd.

The specific combining ability effects of the twenty eight crosses for seventeen traits in both the years have been presented in table-1.3. Perusal of table-1.3 revealed that significant positive and negative sca effects were

observed for all the characters. However, none of the crosses showed significant sca effect for all the traits. Further, sca effects were found to vary in nature and magnitude for all the characters with the change of seasons. This varying magnitude of sca effects over seasons may be due to environmental effects and genotypes, respectively. Maurya (1994) also reported similar results.

In present study, the estimates of heterosis over better-parent and standard variety (Pusa Naveen) over two years were calculated for 40 F₁'s to assess their genetic potential as breeding material and presented and summarized in table-1.4. In case of fruit yield per plant, in Y₁ the heterobeltiosis ranged from -32.77 to 71.42 per cent and standard heterosis from -42.15 to 89.32 per cent and in Y₂, over better parent from -27.42 to 79.16 per cent and standard parent from -33.69 to 96.90 per cent. Out of 40 crosses, nineteen F₁'s showed significant and positive heterosis over better and standard parent in Y₁ and in Y₂, twenty F₁'s over better parent and twenty one F₁'s over standard parent showed significant and positive

Table-3 : Summary of specific combining ability (sca) effects of crosses with desirable significant sca effects for fruit yield per plant for 17 characters in bottle gourd ($Y_1=2017-18$ and $Y_2=2018-19$).

S. No.	Crosses	Years	Fruit yield per plant (kg)	Days to first staminate flower anthesis	Days to first pistillate flower anthesis	Node number to first staminate flower	Node number to first pistillate flower	Days to first fruit harvest	Vine length at last picking stage (m)	Number of primary branches per plant	Fruit length (cm)	Fruit circumference (cm)
1.	NDBG-504 × NDBG-104	Y_1	1.30**	A	A	G	A	A	A	P	P	G
		Y_2	0.98**	A	A	A	A	G	A	P	P	G
2.	NDBG-509 × NDBG-104	Y_1	0.92**	G	G	G	A	G	G	P	P	G
		Y_2	1.28**	A	G	G	A	A	A	P	P	G
3.	NDBG-517×Pusa Naveen	Y_1	1.87**	A	G	G	P	G	P	P	P	G
		Y_2	2.15**	P	G	G	P	G	P	P	P	G
4.	NDBG-517 × NDBG-S-5	Y_1	1.11**	G	P	P	A	P	G	A	G	P
		Y_2	0.82**	G	P	A	A	P	G	G	G	P
5.	NDBG-522 × NDBG-624	Y_1	1.16**	A	G	G	G	A	A	P	A	A
		Y_2	1.32**	A	A	G	G	A	A	P	G	A
6.	NDBG-601 × Pusa Naveen	Y_1	0.73**	A	A	A	G	G	G	G	G	A
		Y_2	0.80**	A	A	A	G	G	G	G	G	A
7.	NDBG-601 × NDBG-104	Y_1	1.16**	G	G	P	A	A	G	A	P	A
		Y_2	1.10**	G	G	P	P	A	A	G	P	A
8.	NDBG-603 × NDBG-624	Y_1	0.77**	A	A	A	G	A	G	G	A	A
		Y_2	0.76**	A	A	A	G	A	G	G	A	G
9.	NDBG-749-2 × NDBG-S-5	Y_1	1.56**	P	A	G	A	A	P	A	G	P
		Y_2	1.86**	P	A	G	A	A	P	A	G	P
10.	NDBG-749-2 × NDBG-104	Y_1	0.87**	A	G	P	G	A	P	P	G	A
		Y_2	0.66**	G	G	P	G	P	P	P	G	A
11.	NDBG-11 × NDBG-S-5	Y_1	1.78**	A	A	A	A	A	G	G	A	A
		Y_2	1.82**	A	G	P	A	A	G	G	G	G
12.	NDBG-10 × Pusa Naveen	Y_1	1.02**	P	A	A	G	P	P	P	G	G
		Y_2	1.13**	P	A	A	G	P	P	P	G	G
13.	Narendra Rashmi × Pusa Naveen	Y_1	1.03**	G	A	A	P	A	G	G	A	P
		Y_2	0.68**	G	P	A	P	A	G	G	G	P

G=Good combiner, P=Poor combiner and A=Average combiner.

Table-3 : Contd....

S. No.	Crosses	Years	Fruit yield per plant (kg)	Fruit weight (kg)	Number of fruits per plant	Total soluble solids (°B)	Ascorbic acid (mg/100 g fresh fruit)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Dry matter content in fruit (%)
1.	NDBG-504 × NDBG-104	Y_1	1.30**	A	G	G	P	G	P	G	G
		Y_2	0.98**	P	G	G	P	G	P	G	G
2.	NDBG-509 × NDBG-104	Y_1	0.92**	A	G	A	P	G	P	G	G
		Y_2	1.28**	G	G	P	P	G	P	G	G
3.	NDBG-517 × Pusa Naveen	Y_1	1.87**	A	G	G	G	P	G	P	G
		Y_2	2.15**	A	G	G	A	P	G	P	G
4.	NDBG-517 × NDBG-S-5	Y_1	1.11**	G	A	P	P	G	P	G	P
		Y_2	0.82**	G	A	P	P	G	P	G	P
5.	NDBG-522 × NDBG-624	Y_1	1.16**	A	G	G	P	A	P	A	P
		Y_2	1.32**	A	G	G	P	A	A	P	P
6.	NDBG-601 × Pusa Naveen	Y_1	0.73**	A	G	G	P	P	G	P	P
		Y_2	0.80**	A	G	G	A	P	G	P	P
7.	NDBG-601 × NDBG-104	Y_1	1.16**	G	A	G	G	P	G	P	A
		Y_2	1.10**	G	A	G	A	P	G	P	A
8.	NDBG-603 × NDBG-624	Y_1	0.77**	G	A	A	G	P	G	A	G
		Y_2	0.76**	G	A	P	G	P	G	A	G
9.	NDBG-749-2 × NDBG-S-5	Y_1	1.56**	P	G	P	G	P	G	P	P
		Y_2	1.86**	P	G	P	G	P	G	P	P
10.	NDBG-749-2 × NDBG-104	Y_1	0.87**	A	G	P	P	G	P	G	G
		Y_2	0.66**	P	G	P	P	G	P	G	G
11.	NDBG-11 × NDBG-S-5	Y_1	1.78**	A	G	G	P	G	P	G	P
		Y_2	1.82**	A	G	G	P	G	P	G	P
12.	NDBG-10 × Pusa Naveen	Y_1	1.02**	A	A	P	P	G	P	G	G
		Y_2	1.13**	G	A	P	P	G	P	G	G
13.	Narendra Rashmi × Pusa Naveen	Y_1	1.03**	A	G	G	G	A	A	P	G
		Y_2	0.68**	A	G	G	G	A	A	P	G

G=Good combiner, P=Poor combiner and A=Average combiner.

Table-4 : Lists of crosses with desirable and significant heterosis for 18 characters in bottle gourd ($Y_1=2017-18$ and $Y_2=2018-19$).

S. No.	Characters	Y_1		Y_2	
		BP	SV	BP	SV
1.	Days to first staminate flower anthesis	NDBG-10 × NDBG-S-5 (-6.60), NDBG-603 × Pusa Naveen (-4.54), NDBG-522 × Pusa Naveen (-4.40)	NDBG-10 × NDBG-S-5 (-5.61), NDBG-603 × Pusa Naveen (-4.54), NDBG-522 × Pusa Naveen (-4.40)	NDBG-10 × NDBG-S-5 (-5.87), NDBG-522 × Pusa Naveen (-3.63), NDBG-603 × Pusa Naveen (-3.41),	NDBG-522 × Pusa Naveen (-3.63), NDBG-603 × Pusa Naveen (-3.41), NDBG-10 × NDBG-S-5 (-2.25)
2.	Days to first pistillate flower anthesis	-	NDBG-504 × NDBG-S-5 (-3.00), NDBG-10 × NDBG-S-5 (-2.66), Narendra Rashmi × NDBG-S-5 (-2.53), NDBG-11 × NDBG-S-5 (-2.46)	NDBG-522 × Pusa Naveen (-2.16)	NDBG-522 × Pusa Naveen (-2.16)
3.	Node number to first staminate flower	NDBG-749-2 × NDBG-S-5 (-10.49), NDBG-601 × NDBG-S-5 (-4.87)	-	NDBG-749-2 × NDBG-624 (-8.76), NDBG-749-2 × NDBG-S-5 (-8.46),	-
4.	Node number to first pistillate flower	NDBG-522 × NDBG-624 (-10.49), NDBG-10 × NDBG-S-5 (-7.84), NDBG-749-2 × NDBG-S-5 (-6.51)	-	NDBG-522 × NDBG-624 (-12.87), NDBG-10 × NDBG-S-5 (-11.08)	-
5.	Days to first fruit harvest	NDBG-522 × Pusa Naveen (-3.85)	NDBG-509 × NDBG-S-5 (-4.98), NDBG-517 × NDBG-624 (-4.88), NDBG-522 × Pusa Naveen (-3.85), NDBG-504 × NDBG-S-5 (-3.58), NDBG-509 × NDBG-104 (-3.41)	NDBG-749-2 × Pusa Naveen (-3.47), NDBG-522 × Pusa Naveen (-3.03), NDBG-504 × NDBG-104 (-2.72), NDBG-517 × NDBG-624 (-2.56), NDBG-504 × Pusa Naveen (-2.26)	NDBG-509 × NDBG-S-5 (-4.36), NDBG-517 × NDBG-624 (-3.53), NDBG-749-2 × Pusa Naveen (-3.47), NDBG-504 × NDBG-S-5 (-3.25), NDBG-522 × Pusa Naveen (-3.03)
6.	Vine length at last picking stage (m)	NDBG-10 × NDBG-S-5 (16.38), Narendra Rashmi × Pusa Naveen (12.46), NDBG-11 × NDBG-104 (11.96), NDBG-11 × NDBG-S-5 (10.91), NDBG-749-2 × Pusa Naveen (10.32)	NDBG-603 × NDBG-624 (46.51), Narendra Rashmi × NDBG-624 (37.92), NDBG-517 × NDBG-624 (37.66), NDBG-517 × NDBG-S-5 (35.86), NDBG-11 × NDBG-104 (34.53)	NDBG-10 × NDBG-S-5 (17.73), NDBG-11 × NDBG-S-5 (13.97)	NDBG-603 × NDBG-624 (43.61), NDBG-11 × NDBG-S-5 (34.98), NDBG-603 × NDBG-104 (34.59), Narendra Rashmi × NDBG-624 (33.42), NDBG-517 × NDBG-S-5 (32.51)
7.	Number of primary branches per plant	NDBG-504 × Pusa Naveen (12.19), NDBG-11 × NDBG-104 (10.13)	NDBG-504 × Pusa Naveen (12.19), NDBG-749-2 × NDBG-624 (12.19), NDBG-509 × NDBG-624 (5.30)	NDBG-11 × NDBG-104 (23.01), NDBG-504 × Pusa Naveen (8.54)	NDBG-504 × Pusa Naveen (8.54), NDBG-749-2 × NDBG-624 (6.97), NDBG-11 × NDBG-104 (5.23)
8.	Fruit length (cm)	NDBG-601 × Pusa Naveen (27.04), NDBG-10 × Pusa Naveen (15.87), NDBG-504 × NDBG-S-5 (15.81), NDBG-504 × NDBG-624 (12.86), Narendra Rashmi × Pusa Naveen (12.64)	NDBG-509 × NDBG-624 (53.59), NDBG-522 × NDBG-104 (50.30), NDBG-522 × NDBG-624 (44.42), NDBG-509 × Pusa Naveen (44.22), NDBG-522 × Pusa Naveen (44.02)	NDBG-601 × Pusa Naveen (26.03), NDBG-504 × NDBG-S-5 (18.05), Narendra Rashmi × Pusa Naveen (14.37), NDBG-10 × Pusa Naveen (14.10), NDBG-504 × NDBG-S-5 (13.13)	NDBG-509 × NDBG-624 (54.64), NDBG-522 × NDBG-104 (51.11), NDBG-522 × NDBG-624 (45.46), NDBG-522 × Pusa Naveen (44.76), NDBG-509 × Pusa Naveen (44.35)
9.	Fruit circumference (cm)	NDBG-749-2 × Pusa Naveen (27.83), NDBG-10 × Pusa Naveen (11.13), NDBG-749-2 × NDBG-S-5 (10.55), NDBG-749-2 × NDBG-104 (10.29), NDBG-10 × NDBG-624 (6.03)	NDBG-749-2 × Pusa Naveen (31.68), NDBG-749-2 × NDBG-S-5 (13.87), NDBG-749-2 × NDBG-104 (13.61), NDBG-509 × NDBG-S-5 (12.30), NDBG-10 × Pusa Naveen (11.13)	NDBG-749-2 × Pusa Naveen (30.28), NDBG-749-2 × NDBG-S-5 (13.58), NDBG-749-2 × NDBG-104 (12.21), NDBG-10 × Pusa Naveen (10.88), NDBG-11 × Pusa Naveen (6.76)	NDBG-749-2 × Pusa Naveen (31.83), NDBG-749-2 × NDBG-S-5 (16.45), NDBG-749-2 × NDBG-104 (14.59), NDBG-509 × NDBG-S-5 (12.33), NDBG-509 × NDBG-104 (10.88)
10.	Fruit weight (kg)	NDBG-504 × Pusa Naveen (62.03), NDBG-509 × Pusa Naveen (37.29), Narendra Rashmi × Pusa Naveen (34.92), NDBG-10 × NDBG-104 (16.37)	NDBG-749-2 × NDBG-624 (111.53), NDBG-603 × NDBG-624 (84.75), NDBG-517 × NDBG-624 (77.29), Narendra Rashmi × NDBG-624 (67.12), NDBG-504 × NDBG-624 (66.10)	NDBG-504 × Pusa Naveen (47.70), Narendra Rashmi × Pusa Naveen (24.34), NDBG-509 × Pusa Naveen (22.04), NDBG-10 × NDBG-104 (15.42), NDBG-10 × Pusa Naveen (9.77)	NDBG-749-2 × NDBG-624 (99.67), NDBG-603 × NDBG-624 (73.03), NDBG-517 × NDBG-624 (67.76), Narendra Rashmi × NDBG-624 (56.25), NDBG-504 × NDBG-624 (55.92).

Table-4 : Contd....

11.	Number of fruits per plant	NDBG-517 × Pusa Naveen (34.61), NDBG-749-2 × NDBG-S-5 (33.00), Narendra Rashmi × Pusa Naveen (15.98), NDBG-11 × NDBG-S-5 (14.25)	NDBG-749-2 × NDBG-S-5 (62.84), NDBG-749-2 × NDBG-104 (46.08), NDBG-11 × NDBG-S-5 (39.88), NDBG-601 × NDBG-624 (35.01), NDBG-517 × Pusa Naveen (34.61)	NDBG-517 × Pusa Naveen (52.95), NDBG-749-2 × NDBG-S-5 (45.19), Narendra Rashmi × Pusa Naveen (23.97), Narendra Rashmi × NDBG-S-5 (19.42), NDBG-10 × Pusa Naveen (17.24)	NDBG-749-2 × NDBG-S-5 (63.07), NDBG-517 × Pusa Naveen (52.95), NDBG-11 × NDBG-S-5 (47.59), NDBG-10 × NDBG-624 (33.36)
12.	Fruit yield per plant (kg)	NDBG-517 × Pusa Naveen (71.42), NDBG-749-2 × NDBG-S-5 (58.80), NDBG-10 × Pusa Naveen (57.29), Narendra Rashmi × Pusa Naveen (43.82), NDBG-517 × NDBG-S-5 (38.88)	NDBG-749-2 × NDBG-S-5 (89.32), NDBG-517 × Pusa Naveen (71.42), NDBG-517 × NDBG-S-5 (65.58), NDBG-10 × Pusa Naveen (57.29), Narendra Rashmi × Pusa Naveen (56.47)	NDBG-517 × Pusa Naveen (79.16), NDBG-10 × Pusa Naveen (64.47), NDBG-749-2 × NDBG-S-5 (63.29), Narendra Rashmi × Pusa Naveen (42.92), NDBG-517 × NDBG-S-5 (36.76)	NDBG-749-2 × NDBG-S-5 (96.90), NDBG-517 × Pusa Naveen (79.16), NDBG-517 × NDBG-S-5 (64.91), NDBG-10 × Pusa Naveen (64.47), Narendra Rashmi × Pusa Naveen (54.15).
13.	Total soluble solids (°B)	NDBG-603 × NDBG-104 (12.19), Narendra Rashmi × NDBG-104 (23.73), Narendra Rashmi × Pusa Naveen (11.68)	Narendra Rashmi × NDBG-104 (12.19), Narendra Rashmi × Pusa Naveen (11.68), NDBG-10 × NDBG-S-5 (10.14)	NDBG-603 × NDBG-104 (27.26), Narendra Rashmi × NDBG-104 (23.75), NDBG-10 × NDBG-S-5 (18.42), Narendra Rashmi × Pusa Naveen (12.35)	Narendra Rashmi × Pusa Naveen (12.35), Narendra Rashmi × NDBG-104 (12.04), NDBG-10 × NDBG-S-5 (11.11)
14.	Ascorbic acid (mg/100 g fresh fruit)	NDBG-517 × NDBG-104 (8.34), NDBG-749-2 × Pusa Naveen (7.30), NDBG-603 × NDBG-104 (4.94), NDBG-504 × Pusa Naveen (2.44), NDBG-11 × Pusa Naveen (2.30).	NDBG-517 × NDBG-104 (18.73), NDBG-603 × NDBG-104 (14.97), NDBG-749-2 × NDBG-S-5 (14.33), NDBG-10 × NDBG-S-5 (14.22), NDBG-522 × NDBG-S-5 (13.73)	NDBG-603 × NDBG-104 (9.40), NDBG-749-2 × Pusa Naveen (8.76), NDBG-517 × NDBG-104 (8.70), NDBG-601 × NDBG-104 (2.98).	NDBG-517 × NDBG-104 (20.33), NDBG-10 × NDBG-S-5 (15.87), NDBG-522 × NDBG-S-5 (15.34), NDBG-522 × Pusa Naveen (13.63), NDBG-11 × Pusa Naveen (13.63)
15.	Reducing sugars (%)	NDBG-601 × NDBG-S-5 (32.60), NDBG-11 × NDBG-624 (20.64), NDBG-603 × Pusa Naveen (12.81), NDBG-10 × NDBG-624 (6.17), NDBG-504 × NDBG-624 (4.94)	NDBG-603 × Pusa Naveen (12.81), NDBG-601 × NDBG-S-5 (10.32), Narendra Rashmi × NDBG-624 (6.32), NDBG-509 × Pusa Naveen (5.49), NDBG-749-2 × NDBG-624 (1.16)	NDBG-601 × NDBG-S-5 (35.15), NDBG-11 × NDBG-624 (20.49), NDBG-603 × Pusa Naveen (13.28), NDBG-10 × NDBG-624 (4.90)	NDBG-603 × Pusa Naveen (13.28), NDBG-601 × NDBG-S-5 (12.44), Narendra Rashmi × NDBG-624 (8.40), NDBG-11 × NDBG-S-5 (7.73), NDBG-509 × Pusa Naveen (7.23)
16.	Non-reducing sugars (%)	NDBG-504 × Pusa Naveen (16.80), NDBG-749-2 × Pusa Naveen (16.33), NDBG-509 × NDBG-624 (10.53), NDBG-517 × Pusa Naveen (9.92), NDBG-749-2 × NDBG-S-5 (8.79)	NDBG-749-2 × NDBG-S-5 (51.53), NDBG-504 × Pusa Naveen (45.41), NDBG-10 × NDBG-624 (45.41), NDBG-10 × NDBG-104 (43.37), NDBG-504 × NDBG-S-5 (37.24)	NDBG-504 × Pusa Naveen (12.85), NDBG-749-2 × Pusa Naveen (11.50), NDBG-517 × Pusa Naveen (10.55), Narendra Rashmi × Pusa Naveen (8.00), NDBG-509 × NDBG-624 (6.03)	NDBG-749-2 × NDBG-S-5 (45.50), NDBG-10 × NDBG-S-5 (44.00), NDBG-504 × Pusa Naveen (40.50), NDBG-603 × NDBG-104 (40.00), NDBG-11 × NDBG-624 (38.50)
17.	Total sugars (%)	NDBG-601 × NDBG-S-5 (6.60), NDBG-603 × Pusa Naveen (3.76), NDBG-11 × NDBG-S-5 (2.76).	Narendra Rashmi × NDBG-624 (4.89), NDBG-603 × Pusa Naveen (3.76), Narendra Rashmi × NDBG-S-5 (3.64), NDBG-749-2 × NDBG-624 (3.51), NDBG-509 × Pusa Naveen (3.39).	NDBG-601 × NDBG-S-5 (8.02), NDBG-603 × Pusa Naveen (3.27), NDBG-749-2 × NDBG-624 (2.58), NDBG-11 × NDBG-S-5 (2.60).	Narendra Rashmi × NDBG-624 (5.53), NDBG-601 × NDBG-S-5 (5.03), NDBG-749-2 × NDBG-624 (5.03), NDBG-509 × Pusa Naveen (4.78), NDBG-11 × NDBG-S-5 (4.40).
18.	Dry matter content in fruit (%)	NDBG-603 × NDBG-S-5 (20.52), NDBG-601 × NDBG-624 (8.61)	NDBG-509 × NDBG-104 (13.68), NDBG-522 × NDBG-104 (12.74), NDBG-601 × NDBG-104 (7.75), NDBG-10 × NDBG-104 (6.54), NDBG-504 × NDBG-104 (5.85)	NDBG-603 × NDBG-S-5 (19.43), NDBG-601 × NDBG-624 (7.54)	NDBG-509 × NDBG-104 (14.38), NDBG-522 × NDBG-104 (12.40), NDBG-601 × NDBG-104 (8.18), NDBG-10 × NDBG-104 (6.98), NDBG-749-2 × NDBG-104 (6.55)

heterosis. The best five F1's common over both the years for heterobeltiosis and standard heterosis were NDBG-517 × Pusa Naveen, NDBG-749-2 × BG-S-5, NDBG-10 × Pusa Naveen, Narendra Rashmi × Pusa Naveen and NDBG-517 × NDBG-S-5. The best five F1's common over standard variety were NDBG-749-2 × NDBG-S-5, NDBG-517 × Pusa Naveen, NDBG-517 × NDBG-S-5, NDBG-10 × Pusa Naveen and NDBG-11 × NDBG-S-5. A perusal of revealed that crosses exhibiting significant and positive estimates of heterosis for one or both types of heterosis for fruit yield also exhibited significant heterosis for some other important yield and

yield attributing traits. In contrast, none of the crosses showed significant and desirable heterosis for all the traits. The above results are in conformity with the findings of Sirohi *et al.* (1985), Kumar *et al.* (1998) and Dubey and Maurya (2003).

Based on the above findings it may be concluded that crosses NDBG-749-2 × NDBG-S-5, NDBG-517 × Pusa Naveen, NDBG-517 × NDBG-S-5, NDBG-10 × Pusa Naveen and NDBG-11 × NDBG-S-5 which showed top heterosis over seasons, parents (better and standard) and also possessed attractive fruit shape as per market

demand may be exploited as commercial hybrid in future. Parents NDBG-749-2, NDBG-10, Narendra Rashmi, NDBG-517, NDBG-S-5 and Pusa Naveen may be used in future crossing programme.

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Study on Physico-Chemical Changes During Different Stages of Vermi Composting

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Abstract

This study implemented to evaluate the potential of epigeic earthworms *Eisenia foetida* to transform FYM compost into a more useful product in 65 days i.e., vermicompost. Vermicomposting caused reduction in many factors such as, pH; carbon/nitrogen ratio determines the quality and rate of vermicompost. Whereas N, P, K, No. of earthworm, body weight of worms, Cocoon Production are gradually increasing with stage 0, 30, 65 days respectively. Vermi composting is a cost effective and ecofriendly method which generates employment and income for the farmers.

Key words : Physicochemical changes, earthworms, vermicomposting, B:C ratio.

Introduction

It has become a serious problem to discard and utilize this huge organic waste for better purpose. The organic waste has immense potential to produce four million tonnes of plant nutrients besides biogas and alcohol [Dash & Senapati, 1985]. The earthworms play an important role in recycling these organic wastes. It works as physical aerator, crusher, mixer and chemical degrader and biological stimulator in decomposing the waste. Vermicomposting is the method of using earthworms to transform organic waste into nutrient rich compost. Soil earthworms play an important role in agriculture, it decomposes dead organic litter by consuming them and release as castings. The earthworms accelerate decomposition of plant litter and organic matter and improve soil fertility by releasing mineral elements in the forms that are easily uptake by plants [Curry, 1987]. Microbial composting of organic wastes through earthworm activity is called Vermicomposting [Mitchell M.J.1978]. Vermicompost contains most nutrients in plant available form such as nitrates, phosphates, exchangeable calcium and soluble potassium [Edwards, 1998; Orozco, 1996]. The behavioural activity of earthworms that is feeding, burrowing and casting, modify the physical, chemical and biological properties of organic matter and soil for plant growth and nutrient acquisition. Due to large surface area, vermicompost offers several micro sites for nutrient retention and exchange and microbial activity (Shi-wei and Fu-Zhen, 1991). Vermicompost is usually rich in microbial populations and diversity particularly fungi, bacteria and actinomycetes [Edwards, 1998; Tomati *et al.*, 1987]. Considering the above factors, the present experiment has been

undertaken to evaluate the FYM on Physico-Chemical Parameters on different stages of Vermi composting.

Materials and Methods

The experiment was carried out in the Vermi-tech Unit, RVSKVV-KVK, Khargone Madhya Pradesh India. Fifteen farmers were selected and trained; technical knowledge and some financial support were also provided. The data were collected on 0, 30, 65, days respectively. The earthworm species *Eisenia foetida* were collected from the local area, due to its easy availability and handling, more cocoon formation and easy maintenance. Cow dung and farm yard manure used for Vermicomposting, all physiochemical parameters were measured at the Soil testing laboratory. The economic study also performed. To popularize the vermicomposting technique for improving of soil health, income generation.

Results and Discussion

It is depicted from Table No 1 the results of Physico-chemical parameters on different stages of Vermi composting N, P, K, is gradually increasing with stage 0, 30, 65 days respectively Our findings are in agreement with the results obtained by Warma and AngLopez (2002). Elvira *et al.* (1998) have reported high increase in total nitrogen concentrations due to the mineralization of organic matter. Vermicomposting caused significant reduction in many factors such as, pH; carbon/nitrogen ratio determines the quality and rate with stage 0, 30, 65 days respectively. According to Senesi (1989), a decline in C: N ratio to less than 20 indicates an advanced degree of organic matter stabilization and reflects a satisfactory degree of maturity of organic wastes. It is depicted from

Table-1 : Physico-chemical parameters on different stages of Vermi composting.

Stage	pH	N%	P %	K %	C:N ratio
0 Day	7.8	0.13	0.72	0.085	30.6
30 Days	7.5	0.25	0.90	0.135	16.18
65 Days	7.2	0.38	1.2	0.4	5.56

Table-2 : Earth worm number, body weight and cocoon production at different stages of Vermi composting.

Stage	Earthworms number	Body weight (g)	Cocoon Production
0 Day	28	34	-
30 Days	32	38.5	20
65 Days	45	56.3	50

Table-3 : Gross margin and net profit analysis of vermicompost production.

Commodity	Yield sold @ 500 (q)	Yield Earthworms sold @ 700/kg	Gross Cost (Rs)	Gross returns (Rs.)	Net returns (Rs.)	B:C ratio
Vermicompost	35	15	28000	14000	14000	2.0:1

**Trainees preparing Vermi-beds****Vermicompost units.**

Table No 2 the results of Earth worm number, Body weight (g) and cocoon production at different stages of Vermi composting. Numbers of earthworm, Cocoon Production are gradually increasing with stage 0, 30, 65 days respectively. Further it may be concluded that gross return, net return and B: C ratio were 28000, 14000 and 2.0 respectively.

Conclusions

Vermicompost obtained in this study was rich in the micro and macronutrients which are essential elements for plant growth had good physical properties, low pH and C: N ratio. It improves overall physico chemical condition of soil. These characteristics make vermicomposting useful and effective in sustainable agriculture. Vermi composting is a cost effective and ecofriendly method which generates employment and income for the farmers.

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Effect of Organic Liquid Formulations on Pods Characters, Quality, Yield and the Microbial Population of Soil After Final Harvest of Pea (*Pisum sativum* L.) var. Kashi Mukti

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Abstract

A field experiment was conducted during the *rabi* season of 2020-21 at Horticulture farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. Field trials were designed in Randomized Block Design (RBD) with four replications and eight treatments. The crop's recommended nitrogen dose (RDN) was NPK @ 25:40:50 kg/ha. Results showed that among organic liquid manures practices application of T₈: T₁ was recorded with significantly highest soil organic carbon, (0.68% at harvest), available nitrogen (298.15 kg/ha at harvest), available phosphorus (23.55 kg/ha at harvest), available potassium (292.45 kg/ha at harvest) respectively. The maximum soil bacteria, fungi, and actinomycetes population was recorded under T₈ treatment (*i.e.*, Jeevamruth @ 500 liters/ha at the time of sowing and 30 DAS + Panchagavya @ 4% sprays at 30 and 45 DAS + Vermiwash @ 10% sprays at 35 and 50 DAS).

Key words : Manures, panchagavya, jeevamrut, vermiwash, *Pisum sativum*.

Introduction

India is the second largest producer of pea in the world. Pea occupies about 433.00 thousand hectares area which gives a total production of 39.61 lakh tonnes with 9.14t/ha productivity (Anonymous, 2018). In India, Pea (*Pisum sativum* L.) is grown as a herbaceous winter annual in the plains of North India and as a summer vegetable in the hills. Pea belongs to the family Leguminosae and it is considered to be native to South West Asia. It is a self-pollinated crop that thrives best in a cool climate with a cardinal temperature range between 10°C to 30°C. Garden peas can be grown on a wide range of soils, however, they thrive best on well-drained, loose, and friable loamy soils. Silt loam and clay loam soils having a pH range of 5.5 to 6.5 are best for growing pea. Generally, a pea is sown from the beginning of October to mid-November in the plains of northern India. The crops sown earlier or later suffer from wilt and mildew attacks respectively.

"Kashi Mukti" is an early maturing and powdery mildew resistant variety developed by IVRI, Varanasi through pedigree selection from the cross No.7 x PM-5. Plant height is 50-53 cm and 50% plants bear flowers at 35-36 days after sowing. Pods are 8.5-9 cm long, attractive filled with 8-9 bold soft textured seeds, selling percentage 48-49 and yield 110-120 q/ha.

In modern farming liquid manure play a crucial role in

significant yield increase as well as reduce the fertilizer dose. The Panchagavya, Jeevamrut, Sanjivak are ecofriendly liquid organic preparation made from cow products *i.e.*, cow dung, urine, milk, curd, ghee, legume flour and jaggary etc. results in higher growth, yield & quality of crops. Panchagavya has played a significant role in providing resistance to pests and diseases, resulting in increased overall yields (Tharmaraj *et al.*, 2011). Vermiwash is nutrient rich liquid manure, extracted from vermicomposts rich with more number of earthworms feeding on organic waste material and plant residues. It is non-toxic and eco-friendly, which arrests bacterial growth and forms as a protective layer for their survival and growth. Vermiwash contains N, P, K, Ca & hormones such as auxin, cytokinin, some other secretions and many useful microbes like heterotrophic bacteria, fungi etc. Vermicompost may be utilized as an organic input in vegetable cultivation to ensure safe food production and soil health. The soil state increased as a result of the use of vermicompost, which is rich in humus, various minerals, vitamins, and growth chemicals that encourage great plant growth and production.

Jeevamruth is a low-cost improvised preparation that enriches the soil with indigenous microorganisms needed for soil mineralization. They contain macronutrients, essential micronutrients, many vitamins and necessary amino acids, as well as growth factors such as IAA, GA, and beneficial micro-organisms.

Table-1 : Physico-chemical parameters on different stages of Vermi composting.

Stage	pH	N%	P %	K %	C:N ratio
0 Day	7.8	0.13	0.72	0.085	30.6
30 Days	7.5	0.25	0.90	0.135	16.18
65 Days	7.2	0.38	1.2	0.4	5.56

Table-2 : Earth worm number, body weight and cocoon production at different stages of Vermi composting.

Stage	Earthworms number	Body weight (g)	Cocoon Production
0 Day	28	34	-
30 Days	32	38.5	20
65 Days	45	56.3	50

Table-3 : Gross margin and net profit analysis of vermicompost production.

Commodity	Yield sold @ 500 (q)	Yield Earthworms sold @ 700/kg	Gross Cost (Rs)	Gross returns (Rs.)	Net returns (Rs.)	B:C ratio
Vermicompost	35	15	28000	14000	14000	2.0:1

(Sreenivasa *et al.*, 2010). Jeevamruth promotes immense biological activity in soil and provides the nutrients for the crop stand. Mixing cow urine, cow dung, pulse flour and jaggery (gur), it is prepared and allowed to ferment for a week. The filtered extract is used for soil application, and numerous beneficial microorganisms are believed to microbiologically enrich soil. Jeevamruth is reported to have a very large population of nitrogen fixers, phosphate solubilizers and siderophore producers (Pathak and Ram, 2013).

Heavy use of chemicals in agriculture has damaged the ecological foundation, resulting in soil deterioration, water resource depletion, and food quality degradation. At this stage, there is a growing awareness of the use of “organic farming” as a remedy. Organic farming is low-cost and uses chemical-free fertilizer. It is important to create a powerful, practical, and suitable nutritional management solution.

Vegetable cultivation with organic manures and biological components is the only method of preserving soil and soil resources while also ensuring environmental and human health security. Organic manures not only boost production but also enhance soil's physical, chemical, and biological qualities, which have a direct influence on moisture retention, nutrient conservation, and soil fertility, productivity, and water holding capacity.

Materials and Methods

Description of the study area : The experiment was carried out at the Horticulture Farm, Rajasthan College of Agriculture, MPUAT, Udaipur. Geographically, Udaipur is located at 24°35' N latitude, 73°42' E longitude, and an altitude of 582.17 meters above sea level in the south-eastern part of Rajasthan. The region falls under Rajasthan's Agro-climatic zone IV.a. (Sub-Humid Southern Plain and Aravalli Hills). Mean weekly maximum and minimum relative humidity ranged between 90.6%

and 22.7%, respectively, and the total rainfall received during the crop period is 12.6 mm. The soil analysis confirmed that soil of experimental field was clay loam belongs to Typic Haplustepts, which was slightly alkaline in reaction, low in available nitrogen, medium in available phosphorus, and high in available potassium.

Experimental design and procedure : The field experiment was laid out in Randomized Block Design with four replications eight treatments as per recommended dose of fertilizer (NPK @ 25:40:50 kg/ha) involving levels of Panchgavya, Jeevamruth, and Vermiwash spray at different growth stages of the crop. Water spray were applied as per the: T₁, Panchagavya @4% spray at 30 and 45 days after sowing; T₂, Vermi-wash @10% spray at 30 and 45 days after sowing; T₃, Jeevamruth @500 liters/ha at the time of sowing and 30 DAS; T₄, Panchagavya @ 4% sprays at 30 and 45 days + vermiwash @ 10 spray at 35 and 50 days; T₅, Jeevamruth @ 500 liters /ha at the time of sowing and 30 DAS+ Panchagavya @ 4% spray at 30 and 45 DAS; T₆, Jeevamruth @ 500 liters/ ha at the time of sowing and 30 DAS+ Vermiwash @ 10% spray at 30 and 45 DAS; T₇, Jeevamruth @ 500 liters/ha at the time of sowing and 30 DAS+ Panchagavya @ 4% spray at 30 and 45 DAS+ Vermiwash @ 10% spray at 35 and 50 DAS or spray both at 30 and 45 DAS were accommodated in the field.

Yield parameters

Number of seeds per pod : Several seeds in five tagged plants of each plot were recorded, and an average number of seeds per pod for each plot was calculated.

Pod yield per plant (g) : At each picking, the fresh pods harvested from each plot, including five tagged plants, were weighed at each harvesting, and the total weight of each plant's harvesting was expressed in grams.

Pod yield per plot (kg) : The fresh pods harvested from each plot, including five tagged plants, were weighed at

each harvesting, and the total weight of all the harvesting of each plot was calculated in kilograms.

Pod yield per hectare (t/ha) : The fresh yield obtained from each plot, including selected plants in each harvest, was sum up, which gave the total pod yield per plot and thereafter, with the use of multiplication factor, this yield was converted into per hectare for each treatment.

Quality Parameters

Total soluble solid (°Brix) : TSS of seeds of five pods were taken, and an average TSS of each plot was calculated. The TSS was calculated by refractometer, 3 to 4 seeds from one selected pod were crushed with the help of mortar and pastel, and then the few drops of the crushed seeds were poured on the plate of the refractometer. The plate was closed, and the refractometer was held up to a natural light source. Then the reading was noted down. The plate was cleaned and wiped after each sample to avoid alteration in reading.

Reducing sugar (%) : The method suggested by Ranganna (1986) was used for determining the reducing sugar in pea by using Dinitrosalicylic acid. Sugar was extracted with hot 80% ethanol from a 100 mg sample. The extract was concentrated by keeping it on a water bath at 80°C. The extract (3 ml) was mixed with 3 ml of DNS reagent and boiled for 15 min. After cooling, absorbance was measured using a spectrophotometer (Double beam SL 210 UV Visible Spectrophotometer, Ellico, Hyderabad, India) at 510 nm. The value was plotted against a standard curve prepared from glucose, and figures were expressed on a percentage basis.

Total sugar (%) : Total sugars were as determined using anthrone reagent following the method described by Ranganna (1986). One ml of diluted sample (100 times) was mixed with 4 ml of anthrone reagent and heated for 15 minutes on a water bath. It was then cooled to ambient temperature, and absorbance was measured at 630 nm using a spectrophotometer (Double beam SL 210 UV Visible Spectrophotometer, Ellico, Hyderabad, India). The amount of sugars present in the sample was plotted against standard curve prepared from glucose. The value was expressed in terms of percentage.

Chlorophyll content in pod (mg/g) : Chlorophyll content was determined of the pod. One gram of the fresh sample was ground with 40 ml of 80% acetone to a fine pulp. The resulting green liquid was then transferred to a flask through Whatman No. 1 filter paper. The grinding of the pulp was repeated several times with a fresh 30 ml aliquot of 80% acetone. The extract was centrifuged, and the green supernatant was obtained. Using small quantities of acetone, the extract was centrifuged repeatedly till the lechate became colourless. The supernatant was taken

together and was made up to 10ml with 80% acetone. The extract was kept away from direct sunlight. The optical density of the extract was read at 645 and 663 wavelengths using a spectrophotometer (UV spectrophotometer, Shimadzu Corp. 01477, Model 10800 ENG. 240V). The samples were analyzed in duplicates. From the optical densities, the chlorophyll content was calculated using the formula :

$$\text{Chlorophyll a (mg/g)} = 12.7 (\text{OD } 663) - 2.69 (\text{OD } 645) \times \frac{V}{1000} \times W$$

$$\text{Chlorophyll b (mg/g)} = 22.9 (\text{OD } 645) - 4.68 (\text{OD } 663) \times \frac{V}{1000} \times W$$

$$\text{Total Chlorophyll (mg/g)} = 20.2 (\text{OD } 645) + 8.02 (\text{OD } 663) \times \frac{V}{1000} \times W$$

Where OD = Optical density

V = Final volume of 80% acetone (10 ml)

W = Wt. of sample taken (0.025 g)

Microbial count of soil before treatment application and after final harvest (cfu per g) bacteria, fungus and actinomycetes) : Microbial population was detected by using serial dilution plate method as described by Aneja (1996). The experimental field surveyed and soil sample collected from each treatment plots (eighteen treatments). The soil (0-30 cm depth) was collected in polythene bag and placed at 4°C after preparation of soil sample for microbial population. The initial microbial population was counted by adopting serial dilution pour plate technique on yeast extract mannitol agar (YEMA).

Result and Discussion

Response of liquid organic manures on yield parameters of pea : The yield parameters of pea were significantly affected by liquid organic manures application. Significantly highest number of pods per plant (*i.e.*, 4.82), pod weight (*i.e.*, 10.24 g), pod length (*i.e.*, 8.85 cm), number of seeds per pod (*i.e.*, 10.95), pod yield per plant (*i.e.*, 49.31 g), pod yield per plot (*i.e.*, 7.396 kg) and pod yield per hectare (*i.e.*, 109.46 t/ha) was observed under T₈ treatment (*i.e.*, Jeevamruth @ 500 liters/ha at the time of sowing and 30 DAS + Panchagavya @ 4% sprays at 30 and 45 DAS + Vermiwash @ 10% sprays at 35 and 50 DAS) however, lowest number of pods per plant (*i.e.*, 2.99), pod weight (*i.e.*, 8.19 g), pod length (*i.e.*, 7.42 cm), number of seeds per pod (*i.e.*, 5.99), pod yield per plant (*i.e.*, 49.31 g), pod yield per plot (*i.e.*, 3.667 kg) and pod yield per hectare (*i.e.*, 109.46 t/ha) was noted in T₁ treatment (*i.e.*, control). This might be due to the growth hormones present in these liquid organic manures which helps in root development, mineral absorptions, photosynthesis and ultimately crop yield and easy assimilation of nutrients supplied through liquid organics

Table-1 : Methods followed for soil analysis.

S. No.	Properties	Procedure	Reference
1.	Organic carbon (%)	Rapid titration method	Walkley and Black (1947)
2.	Available nitrogen (kg/ha)	By alkaline permanganate method	Subbiah and Asija (1956)
3.	Available Phosphorus (kg/ha)	Extraction of soil with 0.5 M NaHCO ₃ at pH 8.5 and development of blue colour with SnCl ₂ and measurement through colorimetrically	Olsen <i>et al.</i> (1954)
4.	Available potassium (kg/ha)	Extraction with 1 N neutral ammonium acetate at pH 7.0 and determined by flame photometer	Flame photometer (Jackson, 1967)

Table-2 : Effect of liquid organic manures on pod yield per plant (g), pod yield per plot (kg) and pod yield per hectare (t/ha) of pea.

Treatments	Pod yield per plant (g)	Pod yield per plot (kg)	Pod yield per hectare (t)
T ₁	24.45	3.667	5.43
T ₂	26.85	4.027	5.96
T ₃	30.77	4.616	6.83
T ₄	37.49	5.624	8.32
T ₅	34.07	5.110	7.56
T ₆	40.97	6.146	9.10
T ₇	44.62	6.693	9.91
T ₈	49.31	7.396	10.95
SEm±	0.302	0.045	0.067
CD at 5%	0.889	0.133	0.197

Table-3 : Effect of liquid organic manures on TSS, reducing sugar, total sugar and chlorophyll content.

Treatments	TSS (°Brix)	Reducing sugar (%)	Total sugar (%)	Chlorophyll content (mg/g)
T ₁	13.97	4.07	10.59	1.635
T ₂	14.01	4.30	11.01	1.738
T ₃	14.36	4.52	11.44	1.843
T ₄	15.52	5.01	12.31	2.088
T ₅	14.87	4.77	11.87	1.973
T ₆	16.21	5.26	12.72	2.218
T ₇	16.77	5.50	13.14	2.340
T ₈	17.33	5.74	13.56	2.455
SEm±	0.091	0.031	0.026	0.015
CD at 5%	0.267	0.091	0.077	0.043

to the crop. The result of present study is in close agreement with Devakumar *et al.* (2011), who reported that both jeevamruth and panchgavya have enhanced the growth of nitrogen fixers in locally available substrates such as FYM, pressmud, compost and digested biogas slurry. Similar findings were also reported by Kumar *et al.* (2011) in groundnut, Kumar *et al.* (2012) in blackgram and Choudhary *et al.* (2013) in groundnut.

Response of liquid organic manures on quality parameters of pea : The effect of organic nutrients management practices on quality parameters of pea was also found significant during the course of experimentation. The highest total soluble solid (*i.e.*, 17.33 °Brix), chlorophyll content (*i.e.*, 2.455 mg/g), reducing sugar (*i.e.*, 5.74 %) and total sugar (*i.e.*, 13.56 %) was observed in T₈ treatment (*i.e.*, Jeevamruth @ 500 liters/ha at the time of sowing and 30 DAS + Panchagavya @ 4% sprays at 30 and 45 DAS + Vermiwash @ 10%

sprays at 35 and 50 DAS) whereas, lowest total soluble solid (*i.e.*, 13.97 °Brix), chlorophyll content (*i.e.*, 1.635 mg/g), reducing sugar (*i.e.*, 4.07%) and total sugar (*i.e.*, 10.59%) was recorded in T₁ treatment (*i.e.*, control). It ought to be the fact that fermented liquid organic manure contains macro and micro-nutrients, many vitamins, essential amino acids, numerable microorganism and growth promoting substances like IAA, GA etc., which help in improving plant growth, metabolic activity and resistance to pest and diseases, (Palekar, 2006; Natarajan, 2007 and Sreenivasa *et al.*, 2010), Similar results were also obtained by Gore and Sreenivasa (2011) and Satashiya *et al.* (2012) in fenugreek.

Response of liquid organic manures on soil properties after harvest of pea : Significantly, highest soil organic carbon and available nitrogen, phosphorus and potassium (*i.e.*, 0.68 %, 298.15 kg/ha, 23.55 kg/ha and 292.45 kg/ha, respectively) was reported with T₈

Table-4 : Effect of liquid organic manures on soil properties after final harvest of pea.

Treatments	Organic carbon (%)	Available N (kg /ha)	Available P (kg /ha)	Available K (kg /ha)
T ₁	0.435	239.04	16.58	233.35
T ₂	0.458	247.48	17.58	241.78
T ₃	0.490	255.93	18.57	250.20
T ₄	0.557	272.85	20.56	267.05
T ₅	0.529	264.38	19.57	258.62
T ₆	0.603	281.27	21.56	275.54
T ₇	0.638	289.71	22.55	283.96
T ₈	0.680	298.15	23.55	292.45
SEm±	0.007	2.857	0.257	0.749
CD at 5%	0.021	8.403	0.756	2.201

Table-5 : Effect of liquid organic manures on microbial population of soil after final harvest of pea.

Treatments	Bacteria (x106 cfu per g)	Fungi (x104 cfu per g)	Actinomycetes (x104 cfu per g)
T ₁	38.62	18.06	30.86
T ₂	43.77	19.63	32.46
T ₃	48.91	21.20	34.06
T ₄	59.19	24.31	37.31
T ₅	54.06	22.76	35.67
T ₆	64.37	25.86	38.91
T ₇	69.55	27.41	40.51
T ₈	74.73	28.99	42.11
SEm±	0.250	0.145	0.223
CD at 5%	0.730	0.425	0.655

Table-6 : Effect of liquid organic manures on nutrient uptake in pea.

Treatments	Available N (kg /ha)	Available P (kg /ha)	Available K (kg /ha)
T ₁	69.13	13.39	77.17
T ₂	83.21	13.63	81.27
T ₃	99.65	13.88	90.90
T ₄	101.83	14.7	103.13
T ₅	100.57	14.4	94.87
T ₆	102.83	14.57	106.90
T ₇	104.32	14.73	110.10
T ₈	106.74	16.27	118.87
SEm±	0.25	0.16	0.77
CD at 5%	0.73	0.45	2.23

treatment (*i.e.*, Jeevamruth @ 500 liters/ha at the time of sowing and 30 DAS + Panchagavya @ 4% sprays at 30 and 45 DAS + Vermiwash @ 10% sprays at 35 and 50 DAS), whereas the lowest soil organic carbon and available nitrogen, phosphorus and potassium (*i.e.*, 0.435%, 239.04 kg/ha, 16.58 kg/ha and 233.35 kg/ha, respectively) was recorded under T₁ treatment (*i.e.*, control). This might be due to the fact that the use of organic manure not only helps to sustain crop yield but also plays a key role by showing both direct as well as indirect influence on the nutrient availability in soil by improving the physical, chemical, and biological properties of soil and also improve the use efficiency of applied fertilizers (Das *et al.*, 2015). Further, Jeevamruth is reported to have a very large population of nitrogen fixers, phosphate solubilizers and siderophore producers (Pathak and Ram, 2013).

Response of liquid organic manures on microbial population in soil at final harvest of pea : Significantly, the maximum soil bacteria, fungi and actinomycetes (*i.e.*, 74.73 x 10⁶, 28.99 x10⁴ and 34.25 x 10⁴ cfu per g, respectively) was noted under T₈ treatment (*i.e.*, Jeevamruth @ 500 liters/ha at the time of sowing and 30 DAS + Panchagavya @ 4% sprays at 30 and 45 DAS + Vermiwash @ 10% sprays at 35 and 50 DAS) while, the minimum soil bacteria, fungi and actinomycetes population (*i.e.*, 62.69 x 10⁶, 21.79 x 10⁴ and 32.51 x 10⁴ cfu per g, respectively) was noted under T₁ treatment (*i.e.*, control). It is ought to be, the reason that FYM helps in the conservation of soil moisture, which is helpful to microbial growth and development. Enriched compost is responsible for enhancing microbial population in soil which are helped in conversion of soluble phosphorus in



soil and neem cakes controls harmful organisms like nematodes and pathogens and also reduces the alkaline content in the soil. This response is backed up by Anisa *et al.* (2016) and Devanda (2020), where they also found similar trend of improvement in the population of microorganisms by use of organic manure in okra.

Response of liquid organic manures on nutrient uptake in pea : The effect of organic nutrients management practices on nutrient uptake was observed significant with the highest uptake nitrogen (*i.e.*, 106.74 kg/ha), phosphorus (*i.e.*, 16.27 kg/ha) and potassium (*i.e.*, 77.17 kg/ha) was reported under T₈ treatment (*i.e.*, Jeevamruth @ 500 liters/ha at the time of sowing and 30 DAS + Panchagavya @ 4% sprays at 30 and 45 DAS + Vermiwash @ 10% sprays at 35 and 50 DAS) While, the lowest uptake nitrogen (*i.e.*, 69.13 kg/ha), phosphorus (*i.e.*, 13.39 kg/ha), and potassium (*i.e.*, 77.17 kg/ha) was observed in T₁ treatment (*i.e.*, Control). Pea crop could accrue high quantity of biomass and partitioned a higher fraction of assimilates to the sink thus resulting in better yield as displayed by improvement in overall yield attributes and improvement in quality parameters. Higher N, P, K, S, Zn and Fe uptake by blackgram crop might be ascribed to higher N, P, K, S, Zn and Fe content in seed and straw, which resulted higher seed and straw yield with application of panchagavya. The regulation of stomata was favorably influenced by the bioactive substances produced by beneficial microorganisms present in panchagavya, which also enhanced the uptake of nutrients of the pea. Similar findings were also reported by Shwetha *et al.* (2009), Shivakumar and Ponnusami (2011) and by Rao *et al.* (2010) in blackgram.

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Scientific Dairy Farming Practices in Bhilwara District of Rajasthan

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Abstract

The present study was undertaken to find out scientific dairy farming practices in Bhilwara district of Rajasthan. The size of sample of 60 households. In India dairy farming is a supplementary and complementary enterprise to crop farming which lead to increase in income and provide employment. Dairy play an important role to improve the economy of small milk producer's households in different regions of India. India has highest milk production of 176.35 million tonnes in world. The result revealed that adequate knowledge and awareness about scientific dairy farming practices to milk producers is important for facilitating higher and efficient milk production system. Productivity is a major factor that directly related to profitability of dairy farming and it highly driven by use of certain scientific dairy farming practices at individual farm level.

Introduction

Indian agriculture has been the main stay of Indian economy as more than 50 per cent of the population depends on it (Indian Economic Survey, 2018). At present agriculture and allied sector contribute nearly 17.95 per cent of GVA in 2016-17. Livestock plays a crucial role in the farm and food production is concerned, though their role in absorbing the huge quantities of crop residues, cereals by-product, coarse grains and farm left over and returning valuable dung for fuel and farm yard manure. The share of livestock sector in total GVA was 4.6 per cent in 2016-17. Dairy farming in India is a supplementary and complementary enterprise to crop farming which not only in increases income, provide employment but also improves nutritional requirement for the rural as well as urban people and highly integrated with the crop production sector. India is the leading country in milk in world with production of 176.35 million tonnes in 2017-18. Total livestock of India was 512 million in 2012. Uttar Pradesh was highest milk producer state in India with 29,052 thousand tonnes followed by Rajasthan (22,427 thousand tonnes) in 2017-2018. The present share of India in milk production of world production is 17 per cent. The most significant contribution of the co-operatives dairying is to bridge gap between the rural producers with the urban consumers, through the national milk grid.

Dairy cooperatives have played an important role to improve the economy of small milk producers' households in different regions of India. Rajasthan is one amongst them, which is predominantly an agricultural state with an excellent potential for milk production. The adequate knowledge and awareness about livestock interventions or scientific dairying practices to milk producers is important for facilitating higher and efficient milk

production system. Productivity is a major factor that directly related to profitability of dairying farming and it highly driven by use of certain scientific dairying practices at individual farm level. Therefore, it is important to study the scientific dairying practices adopted by farmers - producers in the study area.

Materials and Methods

The Bhilwara district of Rajasthan has been selected for the present study. Two milk producing tehsils viz., Asind and Shahpura were selected from Bhilwara district. Two villages from each tehsil was selected randomly. Total 4 villages viz., Padli, Aamesar, Buchhkhera and Devriya were selected from two tehsils of district for present study. The milk producers were classified into three categories viz., small medium and large based on the number of adult milch animals using cumulative frequency square root method. 15 households were randomly selected from each village. Thus, a total sample of 60 households was selected to study scientific dairying practices. The selected households were interviewed personally to get the primary information regarding family size and its composition, education level of head, different scientific dairy farming practices adopted by milk producer, milk production, pattern of selling output, feed trough, chaff cutter, iron chains, number of milk animals etc. were collected. For the study preliminary information was collected from each households for the year 2018-19.

Results and Discussion

Awareness about adoption of scientific dairy farming practices : The adoption of scientific dairying practices influences livestock production to a great extent. The remarkable research work on the various aspects of scientific/improved dairy husbandry practices has been

done earlier by the different researchers such as Singh *et al.* (2010), Kumar *et al.* (2012), Singh *et al.* (2012), Meena *et al.* (2012), Maheshwari and Patil (2015), Chakravarthi *et al.* (2017), Meena *et al.* (2017), Singh *et al.* (2017) etc. in different parts of the country. But adoption as well as awareness level of scientific dairying practices differs from region to region and district to district. The adequate knowledge and awareness about scientific dairy farming practices to milk producers is important for facilitating higher and efficient milk production system. Productivity is a major factor that directly related to profitability of dairy farming and it highly driven by use of certain scientific dairy farming practices at individual farm level. Therefore, keeping this in view, an attempt has been made to study the extent of adoption of scientific dairying practice by dairy households and depicted in Table 4.12.

1. Fodder Cultivation : It is clear that all the households (100%) follow the practices of fodder cultivation. They were grown sorghum, maize, berseem, bajra, lucerne and green grasses as green fodder and wheat straw, sorghum straw and bajra straw as dry fodder. It was observed that green fodder more available in rainy and winter season compared to summer season.

2. Fodder Conservation : Fodder conservation is an important practice to households. It has important feed attribute such as protein, dry matter percentage, and digestible energy. Fodder is usually conserved as hay and silage form. Fodder conserved during periods of feed shortage in dry season to livestock. It caused by limited pasture growth and inadequate pasture conditions. It was found that out of 60 households, 61.67 per cent households were conserved fodders as hay forms. Fodder conservation in silage form was not adopted by any household due to inadequate knowledge about fodder conservation as silage form.

3. Concentrate feeding : It was found that all the sample households (100%) adopted the practice of feeding concentrates. It is important sources to feed supply to milch animals. Feed concentrate is given to animals based on body weights of animals. The main aim of concentrates is to increase milk production. Feeding concentrates is not given in recommended ratio due to lack of knowledge about concentrates feeding. Homemade concentrates and compounded cattle feed were fed to milch animals. Among compounded cattle feeds, saras cattle feed is popular brand name. Different ingredients were used among the different seasons in different proportions. Homemade concentrates mixture such as cottonseeds mustard seed and cake, wheat flour and maize flour in which mustard cake is most common.

4. Feed troughs : It was observed that majority of household (100%) followed the practices of feed trough.

Improved feed trough is help to household to reduced feed wastage during feeding period. It was found that out of 60 households, 70 per cent households have puccha and 30 per cent households have kaccha feed troughs.

5. Chaff cutters : Out of 60 households, on an average 56.67 per cent household have manual and power operated chaff cutter. It is a mechanical device used for cutting straw in small pieces before mixed. Chaff cutter is reduced the time in chopping the fodder.

6. Grazing : It is method of feeding in which feed on grasses and herbaceous plant that reduce requirement of fodder at home. Out of 60 households, 15 per cent households followed the practice of grazing. It was followed mainly in rainy season in the study area. The households leaving their animal for grazing for period of 6-8 hours in a day on roadside, own land and pasture land. The main reason for grazing to animal is easy availability of green grasses in the study area during this season. This practice generally followed in case of dry animals.

7. Animal feed supplement : Feeding plays a crucial role in growth development and productivity of dairy animals. Animal feed supplement is important to improve milk production, improve growth of the animal, keeps cattle healthy and improve palatability and feed intake by animals. Out of 60 households, on an average, 73.33 per cent households followed the animal feed supplement practices. They were used salt, mineral mixture, calcium tablets and mustard oils as animal feed supplement in a concentrate feed. Majority of households were used salt and mustard oil in the feeding of animals.

8. Artificial Insemination (A.I.) : It is commonly used in many species of animal to increase production efficiency. It can reduce many risk involved in breeding. It was found that majority of household followed the practice of artificial insemination. Approximately 36.67 per cent, 71.67 per cent and 21.67 per cent households followed the practice of artificial insemination in case of buffalo, crossbred cows and local cows. It was observed that adoption of artificial insemination is comparatively low due to inadequate knowledge about artificial insemination services; poor conception rate of A.I., lack of A.I. centers and high service charges for A.I. In case of crossbred cows, a natural service was not used by households and natural service was used in case of buffalo and local cow.

9. Superior breeds of animals : It was found that Murrah buffalo, Gir, Jersey and Holstein Friesian crossbred cows were popular superior breeds of animals in the study area which increased milk production. Approximately 41.67 per cent and 71.67 per cent households kept and reared buffalo and crossbred cows, respectively in the study area.

Table-1 : Response of milk producers towards scientific dairy farming practices.

Practices	Frequency	Per cent
1. Fodder cultivation		
a. Green fodder	33	55.00
b. Dry fodder	60	100.00
2. Fodder conservation	37	61.67
3. Concentrate feeding	60	100.00
4. Feed troughs	60	100.00
a. Kaccha	42	70.00
b. Pucca	18	30.00
5. Chaff cutters	34	56.67
6. Grazing	9	15.00
7. Animal feed supplement	44	73.33
8. Artificial insemination		
a. Buffalo	22	36.67
b. Crossbred cow	43	71.67
c. Local cow	13	21.67
9. Superior breeds of animals		
a. Murrah	25	41.67
b. Crossbred cows	43	71.67
10. Method of milking		
a. Full hand method	20	33.33
b. Stepping	13	21.67
c. Knipping	43	71.67
11. Animal healthcare and management practices		
a. Regular cleaning	60	100.00
b. Vaccination	43	71.67
c. Deworming of calves	31	51.67
d. Feed colostrums to newly born calves	60	100.00
e. Cattle insurance practices	0	0.00
f. Treatment of specific disease	53	88.33
g. Feeding the milk to calves	60	100.00
12. Milk management practices		
a. Washing of milking pail and hands before milking	60	100.00
b. Keeping the milk production record	0	00.00
c. Regularity in milking hours	60	100.00
13. Housing management practices		
a. Construction of pucca paved floor	42	70.00
b. Loose housing with seasonal modification	27	45.00
c. Pucca manager	23	38.33
d. Proper drainage and slope in floor	55	91.67
e. Adequate floor space in the shed	57	95.00
14. Feeding management practices		
a. Chaffing of green fodder	20	33.33
b. Feeding concentrate mixture to milch animal on the basis of body weight	33	55.00
c. Regular feeding of recommended quantity of green fodder to animals	31	51.67
d. Feeding extra concentrate to pregnant animals	28	46.67

10. Method of milking : Method of milking influence the quality and quantity of milk produced at the dairy farm. Full hand method is scientific method of milking but not adopted by milk producer due to lack of knowledge. Knipping method of milking is commonly adopted by milk producers. Out of 60 households, 71.67 per cent, 33.67 percent and 21.67 per cent households followed the

Knipping, full hand and stepping methods of milking in study area, respectively.

11. Animal healthcare and management practices : It is clear that all the households were follow practice of regular cleaning, feed colostrums to newly born calves and calf feeding. Out of 60 households on average 71.67 per cent households adopt vaccination against contagious

disease and only 51.67 per cent adopted de-worming of calves. The majority of households don't know the significance of timely feeding of colostrums. It was found that the practice of cattle insurance was not adopted by any households. The practices of regular cleaning, grooming of animals, feeding of colostrums were followed by all households due to low cost.

12. Milk management practices : It is clear that all the households (100%) followed the practices of milk management which includes washing of milking pail and hands before milking and regularity in milking hours. It was found that the practice of keeping the milk production record was not adopted by any milk producers.

13. Housing management practices : It was found that majority of households adopted the practices of adequate floor space in the sheds (95%) followed by proper drainage and slope in floor (91.67%). The practices of construction of pucca paved floor (70%) followed by loose housing with seasonal modification (45%) and pucca manager (38.33%).

14. Feeding management practices : It was found that majority of households followed the practice of regular feeding of recommended green fodder to animal (55%) followed by practice of feeding concentrate mixture to animal (51.67%) on the basis of body weight of animals. Approximately 46.67 per cent households followed the practice of feeding extra concentrates to pregnant animals.

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Production, Consumption and Marketable Surplus of Milk in Bhilwara District of Rajasthan

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Abstract

The present study was undertaken to find out production, consumption and marketable surplus of milk in Bhilwara district of Rajasthan with a sample of 60 households. In India dairy farming is a supplementary and complementary enterprise to crop farming which lead to increase in income and provide employment. Dairy play an important role to improve the economy of small milk producer's households in different regions of India. India has highest milk production of 176.35 million tonnes in world. Larger milk production does not mean more marketed surplus. The results of study revealed that overall daily minimum nutritional requirement, marketable surplus and marketed surplus of milk were 1.52 litres, 10.60 litres and 7.93 litres, respectively. The minimum nutritional requirement of milk per day per household was 1.36 litres, 1.52 litres and 1.68 litres on small, medium and large herd size category of households, respectively. Marketable surplus and marketed surplus of milk per day household for different category of household were 6.46& 4.53 litres, 10.20& 7.91litres and 15.16& 11.36 litres on small, medium and large herd size category of households, respectively. The results of study revealed that the absolute quantity of average production, consumption and marketed surplus of milk was increased with increase in herd size category.

Introduction

Indian agriculture has been the main stay of Indian economy as more than 50 per cent of the population depends on it (Indian Economic Survey, 2018). At present agriculture and allied sector contribute nearly 17.95 per cent of GVA in 2016-17. Livestock plays a crucial role in the farm and food production is concerned, though their role in absorbing the huge quantities of crop residues, cereals by-product, coarse grains and farm left over and returning valuable dung for fuel and farm yard manure. The livestock provides food and non-food items to the people. The share of livestock sector in total GVA was 4.6 per cent in 2016-17. Dairying accounts for more than two-third of the livestock output and is largely responsible for the increasing importance of the livestock sector in the country. Dairy farming in India is a supplementary and complementary enterprise to crop farming which not only in increases income, provide employment but also improves nutritional requirement for the rural as well as urban people and highly integrated with the crop production sector. India is the leading country in milk in world with production of 176.35 million tonnes in 2017-18. Total livestock of India was 512 million in 2012. Uttar Pradesh was highest milk producer state in India with 29,052 thousand tonnes followed by Rajasthan (22,427 thousand tonnes) in 2017-2018. The present share of India in milk production of world production is 17 per cent. The most significant contribution of the co-operatives dairying is to bridge gap between the rural producers with the urban consumers, through the national milk grid.

Dairy cooperatives have played an important role to improve the economy of small milk producers' households in different regions of India. Rajasthan is one amongst them, which is predominantly an agricultural state with an excellent potential for milk production. Larger milk production always does not necessarily mean more marketed surplus. Moreover, rise in milk production would be beneficial from consumer's point of view, if it is followed by proportionate rise in the marketed surplus of milk. The assessment of this parameter is important to the milk producers, consumers, dairy cooperatives, and food processing industries. Furthermore, in order to provide milk to millions of non-producers, the marketed surplus of milk has to be increased considerably to meet the demand for milk. Such knowledge helps in formulating a realistic policy for increasing milk production. Therefore, in present study, an attempt has been made to assess production, consumption and marketable surplus of milk.

Materials and Methods

The Bhilwara district of Rajasthan has been selected for the present study. Two milk producing tehsils viz., Asind and Shahpura were selected from Bhilwara district. Two villages from each tehsil was selected randomly. Total 4 villages viz., Padli, Aamesar, Buchhkhhera and Devriya were selected from two tehsils of district for present study. The milk producers were classified into three categories viz., small medium and large based on the number of adult milch animals using cumulative frequency square root method. 15 households were randomly selected from

each village. Thus, a total sample of 60 households was selected to study production, consumption and marketable surplus of milk. The selected households were interviewed personally to get the primary information regarding family size and its composition, education level of head, different scientific dairy farming practices adopted by milk producer, milk production, pattern of selling output, feed trough, chaff cutter, iron chains, number of milk animals etc. were collected. For the study preliminary information was collected from each households for the year 2018-19. Marketable surplus was calculated by subtracting the total milk requirement of the households from total milk production. Distress sale is the excess of marketed surplus over the marketable surplus i.e. marketed surplus > marketable surplus. It was calculated by using the following formula :

Distress sale = Marketed surplus - Marketable surplus

$$(P - AC) - (P - MNR)$$

$$= MNR - AC$$

P = Production

MNR = Minimum nutritional requirement (As per ICMR recommendations)

AC = Actual consumption

Results and Discussion

Production, consumption and marketable surplus of milk : Total milk production of household depends on the ratio of animals in milk, instead type of milch animals. However, higher milk production does not necessarily mean higher marketable surplus of milk. If milk production increases which are more beneficial from the consumer point of view. It is followed by balanced increase in the marketed surplus of milk. An attempt in the present study was made to work out production, consumption, marketed surplus, marketable surplus, per capita availability and consumption of different herd size categories.

Milk production, consumption and marketed surplus :

The average production, consumption and marketed surplus of milk per day per household are presented in Table-1. The perusal of table revealed that overall daily milk production per household was 12.12 litre, out of which 34.57 per cent milk consumed and rest of milk (65.43 per cent) was sold to different marketing agencies and consumers. The production of milk per day per household was 7.82 litres, 11.72 litres and 16.84 litres for small, medium and large herd size category of households, respectively. The consumption of milk per day per household was 3.29 litres, 3.81 litres and 5.48 litres for small, medium and large herd size category of households, respectively. The marketed surplus of milk per day per household was 4.53 litres, 7.91 litres and

11.36 litres for small, medium and large herd size category of households, respectively. The results of study revealed that the absolute quantity of average production, consumption and marketed surplus of milk was increased with increase in herd size category.

Consumption pattern of milk : The quantity of milk consumed as liquid and converted into milk products at household's level was estimated and depicted in Table-2. It can be observed from the table that overall daily milk retained per household for family consumption was found to be 4.19 litres, out of which 12.89 per cent consumed as liquid milk and 87.11 per cent converted into milk products. The percentage of milk consumed as liquid and converted into milk products across the different herd size category was 14.59 & 85.41, 13.91 & 86.09 and 11.13 & 88.87 on small, medium and large category, respectively. It can be concluded from the analysis that percentage of milk consumed as liquid milk was increased with the increase in the herd size categories while reverse trend was true for milk converted into milk products.

Per capita availability and consumption of milk : The per day per capita availability and consumption of milk helps in knowing the nutritional position of the rural households, Therefore, per capita availability per day and consumption of milk was calculated and are depicted in Table 3. It was observed that the overall average per capita per day availability and consumption of milk were observed 1685 and 586 grams, respectively. Overall average per capita consumption per day of milk was more than the minimum nutritional requirement of milk as recommended by Indian Council of Medical Research (250 grams per capita per day). The study revealed that per capita availability and consumption of milk was found to increase with increase in herd size category.

Marketable surplus and marketed surplus of milk :

The actual quantity of milk sold by milk producers was considered as marketed surplus in market. The quantity of milk retained at home after fulfilling consumption requirements was reckoned marketable surplus. The marketable surplus of total milk production was measured by taking into consideration of minimum nutritional requirement as recommended by Indian Council of Medical Research (ICMR). The production, marketable surplus and marketed surplus of milk per day household were estimated for different category of household and are presented in Table 4. It was found that overall daily minimum nutritional requirement, marketable surplus and marketed surplus of milk were 1.52 litres, 10.60 litres and 7.93 litres, respectively. The minimum nutritional requirement of milk per day per household was 1.36 litres, 1.52 litres and 1.68 litres on small, medium and large herd size category of households, respectively. Marketable

Table-1 : Average milk production, consumption and marketed surplus in various herd size (Litre/day/household).

Category	Production	Consumption at household level	Marketed surplus
Small	7.82 (100.00)	3.29 (42.07)	4.53 (57.93)
Medium	11.72 (100.00)	3.81 (32.51)	7.91 (67.49)
Large	16.84 (100.00)	5.48 (32.54)	11.36 (67.46)
Overall	12.12 (100.00)	4.19 (34.57)	7.93 (65.43)

Figures in parenthesis are percentage to total production

Table-2 : Consumption pattern of milk in various herd size (Litre/day/household)

Herd size category	Average milk retained	Milk consumed as liquid	Converted into milk products
Small	3.29 (100.00)	0.48 (14.59)	2.81 (85.41)
Medium	3.81 (100.00)	0.53 (13.91)	3.28 (86.09)
Large	5.48 (100.00)	0.61 (11.13)	4.87 (88.87)
Overall	4.19 (100.00)	0.54 (12.89)	3.65 (87.11)

Figures in parenthesis are percentage to total average milk retained.

Table-3 : Per capita availability and consumption of milk in various herd size (grams/day).

Category	Per capita availability	Per capita consumption
Small	1238	520
Medium	1661	539
Large	2158	701
Overall	1685	586

Table-4 : Marketable surplus and marketed surplus of milk in various herd size (Litre/day/household).

Category	Production	Minimum quantity of milk required	Marketable surplus	Marketed surplus
Small	7.82	1.36 (17.39)	6.46 (82.61)	4.53 (57.93)
Medium	11.72	1.52 (12.97)	10.20 (87.03)	7.91 (67.49)
Large	16.84	1.68 (9.98)	15.16 (90.02)	11.36 (67.46)
Overall	12.12	1.52 (12.54)	10.60 (87.46)	7.93 (65.43)

surplus and marketed surplus of milk per day household for different category of household were 6.46& 4.53 litres, 10.20& 7.91litres and 15.16& 11.36 litres on small, medium and large herd size category of households, respectively. The results of study indicated that quantity of minimum nutritional requirement, marketable surplus and marketed surplus of milk was increased with increase in herd size category. The marketed surplus of milk was less than marketable surplus of milk. Hence, no distress sale was observed in the study area.

The results of above analysis revealed that the absolute quantity of average production, consumption and marketed surplus of milk was increased with increase in herd size category.

Conclusions

Larger milk production does not mean always more marketed surplus. Moreover, increase in milk production would be beneficial from consumer's point of view, if it is followed by proportionate rise in the marketed surplus of milk. The assessment of this parameter is important to the milk producers, consumers, dairy cooperatives, and food processing industries. Furthermore, in order to provide milk to millions of non-producers, the marketed surplus of

milk has to be increased considerably to meet the demand for milk. Such knowledge helps in formulating a realistic policy for increasing milk production. The absolute quantity of average production, consumption and marketed surplus of milk was increased with increase in herd size category. The quantity of minimum nutritional requirement, marketable surplus and marketed surplus of milk was also increased with increase in herd size category. The marketed surplus of milk was less than marketable surplus of milk. Hence, no distress sale was observed in the study area.

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Effect of Soil and Foliar Applications of Micronutrients on Nodulation, Yield and Quality of Greengram (*Vigna radiata* L.) under Dryland Condition of Rajasthan

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Abstract

A field experiment entitled “Effect of soil and foliar application of micronutrients on nodulation, yield and quality of Greengram (*Vigna Radiata* L.)” was conducted at Agronomy farm, S.K.N College of Agriculture, Jobner during Rabi, 2013-14. The experiment included 16 treatment combinations comprising 4 levels of soil application (control, ferrous sulphate @ 50 kg/ha, zinc sulphate @ 25 kg/ha and borex @ 1.5 kg/ha) and four level of foliar spray (control, ferrous sulphate @ 0.5%, zinc sulphate @ 0.5 % and borex @ 0.2%). These were evaluated under Randomized Block Design with three replications. The result indicate that among the treatments applied as soil, application of zinc sulphate @ 25 kg/ha being at par with ferrous sulphate @ 50 kg/ha recorded significantly higher total nodules per plant, effective nodules per plant, number of pods per plant, number of seed per pod, seed, straw, test weight of Greengram over control. The significantly maximum protein content in seed were recorded with application of zinc sulphate @ 25 kg/ha. Significantly highest net returns Rs.61731 and B: C ratio 4.18 were also recorded with soil application of zinc sulphate @ 25 kg/ha. Significantly maximum increase in total nodules per plant, effective nodules per plant, number of pods per plant, number of seed per pod, grain, straw, test weight were recorded with foliar spray of zinc sulphate @ 0.5 % over control. The significantly maximum protein content in seed were recorded with application of zinc sulphate @ 0.5%. The highest net returns Rs.60372 and B: C ratio 4.06 was recorded with foliar spray of zinc sulphate @ 0.5 %.

Key words : Micronutrients, nodulation, greengram yield, quality and economics.

Introduction

Greengram [*Vigna radiata* (L.) Wilczek] is an important pulse crop of India (Divyashree *et al.*, 2018). It is also known as “Golden Bean” because of its have a great nutritional value as 24.5% protein, 1.3% fat and 59.9% carbohydrate and also contains 75 mg calcium, 8.5 mg iron, and 49 mg α -carotene per 100g of split dal. Greengram being a short duration crop, its well grown in many intensive crop rotations so that prevents soil erosion, fixes atmospheric nitrogen through Rhizobial symbiosis and helps in improving soil fertility and fix the nitrogen approximately 30 kg ha⁻¹ per year also suitable for increasing the soil fertility (Afzal *et al.*, 2004, Bansal, 2009 and Mondal *et al.*, 2011). Among all pulses growing crops in India, Greengram ranks third after chickpea and pigeon pea (Anonymous, 2012). In India Greengram is grown on an area of about 3.29 million ha with the production of 2.01 million tons and productivity of 472 kg/ha (Jyoti and Kushwaha, 2020). Improper nutrient management under limited moisture is considered as major limiting factors for achieving higher productivity of Greengram in semi-arid regions. The nutrient management thus assumes

importance to sustain productivity. Due to poor socio-economic conditions of farmers coupled with low and erratic rainfall distribution, the intensive use of chemical fertilizers is a risky proposition in these regions. Among the various reasons, deficiency of micro-nutrient, especially the zinc is the major factor for the low productivity of several crops now a days in general and Greengram particular in Rajasthan (Takkar, and Randhawa, 1980). Micronutrients also have played vital roles in the improvement of growth, yield and quality of legume crops through foliar and soil application due to their effect on the plant itself, nitrogen fixing symbiotic process and effective use of major and secondary nutrients (Singh *et al.*, 2017). Foliar application of micronutrients was better than soil application for increasing yield (Mondal *et al.*, 2011). Among the application of micronutrient zinc, iron and boron significantly affect the growth and yield of greengram and their application methods also impact so that keeping in view above facts, the present investigation in this research the effect of soil and foliar applications of micronutrients on nodulation growth, yield and quality of mungbean.

Materials and Methods

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner-Jaipur. Geographically, Jobner is situated at $75^{\circ} 28'$ East longitude and $26^{\circ} 08'$ North latitude and 427 m above mean sea level. This area falls under Agro-climatic zone – IIIa (Semi-Arid Eastern Plain) of Rajasthan. The experiment included 16 treatment combinations comprising four levels of soil application (control, ferrous sulphate @ 50 kg/ha, zinc sulphate @ 25 kg/ha and borex @ 1.5 kg/ha) and four level of foliar spray (control, ferrous sulphate @ 0.5%, zinc sulphate @ 0.5 % and borex @ 0.2%). These were evaluated under Randomized Block Design with three replications. The soil of experimental field was loamy sand in texture having soil pH 8.2, low in available nitrogen (143 kg/ha) available phosphorous (18.841.3 kg/ha) and in organic carbon (16.0 g kg⁻¹) medium available potassium (168.5 kg/ha).

Mungbean crop (RMG-268) was sown on July 13, 2014 in furrows at a row spacing of 30 cm apart. Seed @ 20 kg/ha was treated with carbandazin @ 3.0g/kg seed. Crop was fertilized uniform basal dose of 25 kg N ha⁻¹ was applied through DAP and urea to the soil phosphorus through 40 kg P₂O₅ ha⁻¹ and the quantity of NPK was applied as basal in furrow below the seed uniformly in all treatments. Zinc (25 kg ZnSO₄ / ha), boron (1.5 kg borex / ha) and iron (50 kg FeSO₄ / ha), were applied prior to sowing through broadcasting and mixed thoroughly in the soil and foliar application of iron sulphate (0.5 % FeSO₄.7H₂O) , zinc sulphate (0.5 % ZnSO₄.7H₂O) and boron (0.2 % Borex) was done at flower initiation and pod initiation separately and both the stages with water, respectively. Plant spacing of 10 cm was maintained by thinning operation. Crop was raised under rainfed condition, which was received 400 to 500 mm rainfall during cropping period out of an annual rainfall condition of 660 mm. The observation recorded as total no. of nodules per plant, effective no. of nodules per plant, number of pods per plant, number of seed per pod, seed, straw, test weight of Greengram at harvest the crop and economics net returns and B: C ratio calculated. Protein content in seed was calculated by multiplying per cent nitrogen in seed with a constant factor 6.25 (A.O.A.C. 1960). The data gathered in each observation were statistically analyzed using analysis of variance technique and significant differences among treatments mean were tested using least significant difference (LSD) test at 5% probability (Panse and Sukhatme 1985).

Results and Discussion

Nodulation : Greengram crop nodulation was significantly affect with soil application and

non-significantly affected with foliar application but nodulation was increased with soil and foliar application as compare to control. The maximum total and effective no. of nodules per plant (33.91 and 25.08) was recorded with the soil application of 25 kg Iron sulphate per ha and which was increased 19.96% and 25.84% over control, respectively. The soil application of iron and zinc was remained at par each other. So that indicated the iron impart the major role in nodulation and symbiotic nitrogen fixation, however many researcher reported poor nodulation in absence of iron (Balachander *et al.*, 2003 and Thapu *et al.*, 2003), so that the direct relation the initiation of nodules and development the iron and other micronutrient, and the Brear *et al.*, 2013 reported that the deficiency of iron was reduction the nodule development. Iron is a key part of several key proteins like nitrogenase, leghaemoglobin and ferredoxin (Pingoliya *et al.*, 2014). Due to micronutrient application the nodulation fixes atmospheric nitrogen through Rhizobial symbiosis and helps in improving soil fertility and fix the nitrogen also suitable for increasing the crop nodulation inGreengramand other legumes and also increasing the bacterial activity of nodule (Afzal *et al.*, 2004, Bansal, 2009, Mondal *et al.*, 2011, Paliya *et al.*, 2014, Jamal *et al.*, 2018, Khan, Muhammad Tariq, 2018 and Monika *et al.*, 2019). Amara (1998) and Ahmad *et al.*, (2013) concluded that micronutrients (Zn, B, Fe, Mo) increased the microbial activities in the rhizosphere and thus increased nodulation and yield attributes and yield of mungbean.

Yield attributes and quality : Yield attributes viz. no. of pods per plant and no. of seeds per pod, seed and straw yield, test weight and protein content were significantly improved due to soil and foliar application of micronutrients (Fe, Zn and B) over control. Significantly higher yield attributes and protein content were found with 25 kg FeSO₄.7H₂O ha⁻¹ soil application and foliar application of iron (0.5% FeSO₄). Application of iron sulphate up to 50 kg/ha (T₁) produced significantly higher grain and straw yield over control followed by soil application of zinc sulphate @ 25 kg/ha (T₁) and registered an increase of 25.79 and 24.34 per cent higher over control, respectively. However, the soil and foliar application of iron and Zinc was at par with each other. This shows that the use of zinc iron and boron in all the doses and stages of application enhanced metabolic process of plant which resulted better yield attributes and quality of mungbean. It exhibited beneficial effect of zinc, iron and boron in varying degree as plant metabolism, chlorophyll and photo synthesis, and assimilates transportation to sink resulted to enhanced seed yield of mungbean. The foliar application of micronutrients, which might have also responsible for efficient translocation of photosynthate from source to sink, this cause higher

Table-1 : Effect of soil and foliar applications of micronutrients on nodulation, yield and quality of mungbean.

Treatments	Total no. of nodules per plant at flowering	Effective no. of nodules per plant at flowering	No. of Pods per plant	No. of Seeds per pod	Seed (kg ha ⁻¹)	Straw (kg ha ⁻¹)	Test weight (g)	Net returns (Rs/ha)	B : C ratio	Protein content (%)
Soil application										
T ₀ -control	28.33	19.93	22.69	8.05	981	2481	26.48	45864	3.24	20.81
T ₁ -50 kg FeSO ₄ .7H ₂ O	33.91	25.08	29.88	9.53	1255	3129	32.12	61731	4.18	22.69
T ₂ -25 kg ZnSO ₄ .7H ₂ O	33.74	24.93	28.91	9.45	1234	3085	31.48	58626	3.52	22.63
T ₃ -1.5 kg Borex	31.12	22.55	26.53	8.85	1144	2861	29.38	55417	3.85	21.44
SEm+	0.81	0.83	0.74	0.21	24.05	68.39	0.69	1077	0.09	0.48
CD (P=0.05)	2.35	2.40	2.14	0.61	69.44	197.49	1.98	3110	0.26	1.38
Foliar application										
F ₀ -water spray	30.74	22.49	19.77	7.95	1016	2626	27.03	47868	3.28	19.67
F ₁ -0.5% FeSO ₄ .7H ₂ O	32.69	23.62	31.97	9.78	1240	3035	31.63	60372	4.06	23.01
F ₂ -0.5% ZnSO ₄ .7H ₂ O	31.36	23.41	30.26	9.44	1219	3011	31.41	58965	3.89	22.88
F ₃ -0.2% Borex	32.30	22.97	26.01	8.70	1139	2884	29.39	54433	3.56	22.00
SEm+	0.81	0.83	0.74	0.21	24.05	68.39	0.69	1077	0.09	0.48
CD (P=0.05)	NS	NS	2.14	0.61	69.44	197.49	1.98	3110	0.26	1.38

number of pod formation and higher dry matter accumulation of plant. Similar results were also obtained by Jain (2007), Sharma and Abraham (2010), Quddus *et al.*, (2011) Dubey *et al.* (2013), Jat *et al.* (2015). Divyashree *et al.*, 2018 was recorded higher yield with application of micronutrients along with RDF might be due to increased availability of nutrients in balanced proportion. Similar increase in the productivity of pulses with the foliar spray of Zn, Fe, B, Mn and Mo was reported by Savithri (2001). Application of these micronutrients might to enhance the activity of nitrogenase, in turn supplied more nitrogen by fixation for better growth and yield attributes. Similar results were also reported by Singh *et al* (2010) and Choudhary *et al* (2011). An enhancement in seed yield is attributed to cumulative effect of number of pods/plant, pod length, number of grain/pod and seed weight. This result is also in close conformity with the findings of Singh *et al* (2010), Tiwari *et al* (2011), Choudhary *et al* (2011) and Meena *et al* (2016).

Economics : Significantly higher net returns (Rs.61731 & 60372) and B: C ratio (4.11 & 4.06) was recorded with soil application of iron sulphate @ 50 kg/ha and foliar spray of iron sulphate @ 0.5 %, which was increased 34.6 % and 26.1 % over control, respectively. The significant increment in net return and B:C might be due to significant increase in yield with increased supply of available iron zinc in the soil and correction the deficiency of zinc and ferrous in plants or better nutrition of the crop with foliar application of these micronutrients. This increase was due to significantly higher value of grain and stover yield as compared to cost of cultivation of concerning treatment. The results were supported by Sharma *et al.* (2018) and Sajid *et al.* (2016). This could be associated because of

high value of gross returns as compared to cost of cultivation. Result confirmed by the finding of Atul *et al.* (2017), Shivay *et al.* (2014) and Jat *et al.* (2015).

Conclusions

Experimental finding was concluded that the soil application of iron sulphate @ 50 kg/ha and foliar spray of iron sulphate @ 0.5% can be recommended for Greengram in the Entisols as these gave nodulation, yield attributes and yield, net returns and B:C ratio due to the supply of balancing nutrition, increase the microbial activities and fixation of atmospheric nitrogen in to soil due to application of micronutrient.

Acknowledgement

Dr. Rajhans Verma and shyopal Jat conducted a field experiment to study the effect of soil and foliar application of micronutrient on Mungbean. The nodulation, yield attributes, yield and quality characteristics of Greengram studies the under supervision of myself. The data analysis, tabulation and manuscript was written by Shyopal Jat, Madhuri Meena, Anita Meena and subsequently, manuscript was revised jointly by Dr. Rajhans Verma.

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Use of Drip Irrigation System to Observe its Implications on Nitrogen Levels for Rabi Drill Fennel (*Foeniculum vulgare* Mill) on Growth, Yield and Quality Parameters

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Abstract

A field experiment was carried out on medium black calcareous soil at Junagadh (Gujarat) during *rabi* seasons of 2012-13 and 2013-14 to evaluate effect of drip irrigation and nitrogen levels on *rabi* fennel. There were sixteen treatment combinations comprising of three drip irrigation regimes (0.6, 0.8 and 1.0 PEF) and surface methods (1.0 IW/CPE ratio) as main plot treatments along with four levels of nitrogen as sub plot treatments viz., Control, 60, 90 and 120 kg N ha⁻¹. The results showed that the drip irrigation ratio at 1.0 PEF recorded the maximum plant height (92.01, 113.68, 127.86 and 140.58 cm), number of umbels plant⁻¹ (22.58), number of umbellate umbel⁻¹ (26.31), number of seeds umbellate⁻¹ (28.27) 1000 seed weight (7.23 g), seed yield (1833 kg ha⁻¹) as well as stover yield (2867 kg ha⁻¹) was recorded in drip irrigation level at 1.0 PEF over surface method of irrigation at 1.0 IW/CPE, respectively. However, the application of 120 kg N ha⁻¹ significantly increased plant height (85.71, 109.81, 125.35 and 135.79 cm), number of umbels plant⁻¹ (19.24), number of umbellates umbel⁻¹ (25.23), number of seeds umbellate⁻¹ (29.34) and 1000-seed weight (7.13g) with higher harvest index (39.0%) and protein content (9%) over surface method of irrigation at 1.0 IW/CPE. Fennel seed yield increased with increase in nitrogen levels. Application of 120 kg N ha⁻¹ recorded significantly the highest seed yield (1777 kg ha⁻¹) and stalk yield (2741 kg ha⁻¹) over control. The results showed that the treatment combination of drip irrigation at 1.0 PEF along with 120 kg N ha⁻¹ gave the maximum gross realization (Rs. 140143 ha⁻¹) as well as net realization of (Rs. 101789 ha⁻¹) drilled *rabi* fennel.

Key words : Drip irrigation, nitrogen, PEF, fennel, seed and stover yield.

Introduction

India is known over the world as 'The Home of Spices', thus Spices and condiments need no introduction. The climate of the country is ideal for the growth of almost all spices. Spices mark an important place under the group of agricultural goods, which are virtually paramount in the culinary art. They also play a significant role in our national and international economy in terms of several spice producing, exporting and importing countries. India is reported to contribute for about 45% of the global spice exports. In India, spices are important commercial crops in support of the domestic consumption and export.

Gujarat and Rajasthan together known as 'seed spices bowl' of India contributing about more than 80% of the total seed spices production in the country. Among the many popular seed spices, fennel (*Foeniculum vulgare* Mill) is one of the most important condiments of these two states commonly known as *Saunf* or *Badi saunf* in Hindi and *Variari* in Gujarati. India, being the land of spices is the largest producer, consumer and exporter of spices in the world. The seed spices acquire total area about 36% and 17% of total production of spices in the country (Aishwath *et al.*, 2010).

Gujarat stands for the second leading producer of spices after Andhra Pradesh in the country. DOA, 2011 report exhibits that, during 2010-11 Gujarat occupied 26300 ha in area with production of 35800 tonnes and productivity of 1.36 t ha⁻¹. DOA, 2011 also reported that Mehsana district ranks first in area of (8200 ha), production (11600 tonnes) and productivity of (1410 kg ha⁻¹) of fennel in Gujarat.

Spice crops play an important role in Indian economy. Demand of spices increase at 10-12 per cent annually in the world market due to change in food habit and use of ayurvedic medicines. Arid to semi-arid regions of Gujarat are well known in India and abroad for their quality spice seed production. Soils of these regions are poor in fertility and water retentive capacity. Adoption of micro-irrigation is only alternative for economic use of water, which reduced consumption of costly and scarce inputs to increased crop yields (Patel *et al.*, 2012).

Water, being considered as precious natural and scare resource is vital for daily life and to develop sustainable agriculture. Intensive agriculture and our growing population are depleting the water very speedy (Shinde *et al.*, 2002). Globally out of the total fresh water,

69% is used in agricultural sector, 8% in domestic and 23% in industrial and other sectors. In India, about 82% water is used in agriculture sector which covers around 80 mha area under irrigation. Currently about 38% of cultivable area is irrigated and more efforts are needed to cover additional area to enhance water productivity. Irrigation and fertilizers together are costly and treated as scarce inputs for crop production. Availability of irrigation water is limited and therefore, it should be utilized most efficiently by adopting latest irrigation technologies (Kumar *et al.*, 2020; Patel *et al.*, 2000 and Zala *et al.*, 2011).

Drip irrigation is a regulated and slow application of irrigation water through emitters at frequent intervals near the plant root zone over a long period of time. Drip irrigation if implemented will lead to reduction ground water exploitation which partly occurs because of inefficient use of water under surface methods of irrigation (Choudhary *et al.*, 2022). It aids in saving irrigation water, increases water / fertilizer use efficiencies, decrease tillage requirement and increased crop yields with higher quality produce. It is particularly suitable for irrigation with poor quality water such as saline water and daily irrigation pushes the salt to the periphery of the moist zone (Rathore and Gaur, 2010).

Besides water, fertilizer is another key input which played a key role in increasing crop productivity. At least 40-50% increase in agricultural production in recent decades achieved by management of water and fertilizer alone. Among the essential macro nutrients, nitrogen is often supplied in bulk in a few split in order to obtain optimum crop production. Nitrogen constitutes about 40-50% of the dry matter in plants and is one of the essential elements for proper plant growth and development (Kumar *et al.*, 2022).

Materials and Methods

During *rabi* seasons of 2012-13 and 2013-14, the present experiment was conducted at instructional farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh with an objective of studying the effect of different levels of drip irrigation along with various nitrogen levels in *rabi* drill fennel (*Foeniculum vulgare* Mill.). The soil was medium clayey in texture and slightly alkaline in reaction with pH (8.01) and EC (0.31 dSm⁻¹), low in available N (241.2 kg ha⁻¹), medium in available P (22.44 kg ha⁻¹) and available K (242.2 kg ha⁻¹). The experiment comprising of three levels of drip irrigation and surface method (0.6, 0.8 and 1.0 PEF and 1.0 IW/CPE) and four levels of nitrogen (0, 60, 90 and 120 kg ha⁻¹) were laid out in split plot design with three replications. The fennel variety 'Gujarat Fennel-11' was sown at 45-15 cm paired rows. The crop

was fertilized with 90-30-0 kg N-P₂O₅-K₂O/ha. The crop was raised following the recommended package of practices. Under drip system, laterals were laid out at 90 cm spacing (in between each paired row) and drippers (4 lit. hr⁻¹ capacity) at 60 cm spacing. Drip irrigation was operated on alternate day at 1.2 kg ha⁻¹cm² pressure on the basis of pan evaporation fraction (PEF) of 0.6, 0.8 and 1.0. Flood irrigation maintained at 5 cm depth each was scheduled based on IW/CPE ratio of 1.0.

Results and Discussion

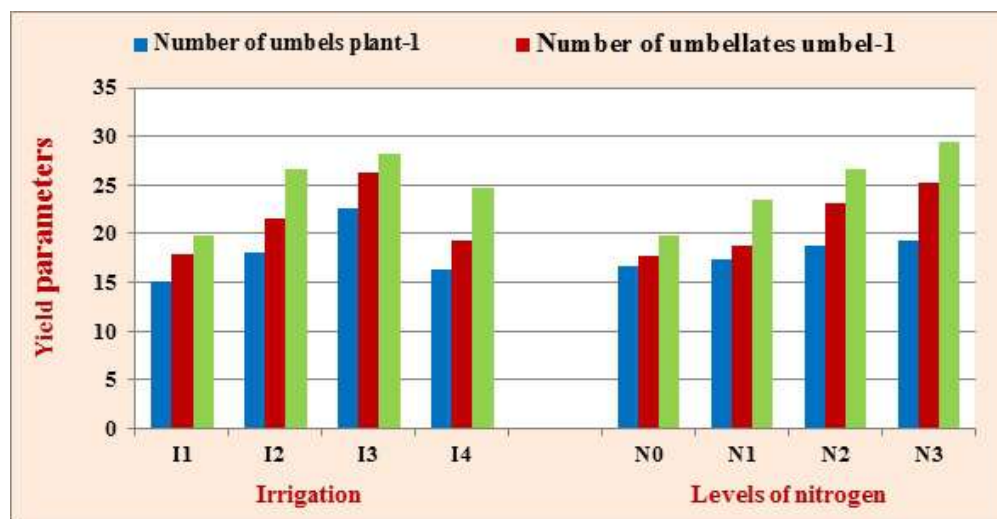
Effect of irrigation on yield and yield attributes : Data presented in Table-1 indicated that different methods of irrigation significantly influenced yield attributes and yield of fennel. Significantly the highest plant height at 60, 90, 120 DAS and at harvest (140.58 cm), number of umbels plant⁻¹ (22.58), umbellates umbel⁻¹ (26.31) were recorded with drip irrigation at 1.0 PEF over drip irrigation at 0.6 PEF. The quantum of water application through high pressure drip irrigation as well as low pressure drip system was same but it is the rate of flow of water that plays an important role for water movement in horizontal and vertically downward directions. In the low pressure drip system the discharge rate is slow that facilitate more downward movement of water through percolation hence horizontal spread is less. Similar results have also been reported by Lal *et al.* (2013) in fenugreek. Bhunia *et al.* (2005) also reported increased plant height, primary and secondary branches plant⁻¹ with increasing levels of irrigation in fennel.

Drip irrigation at 1.0 PEF (I₃) recorded significantly the highest number of seeds umbellate⁻¹ (28.27), 1000 seed weight (7.23 g), it remained at par with drip irrigation at 0.8 PEF (I₂), respectively (Table-1). Conversely, drip irrigation at 0.6 PEF registered significantly the lowest values of these yield contributing parameters. In drip irrigation system, water is applied at a low rate for a longer period at frequent intervals near the plant root zone through lower pressure delivery system, which increase the availability of nutrient near the root zone with a reduction in leaching losses (Paul *et al.*, 2013). More nutrient availability, especially near the root zone might have increased the translocation of photosynthates to storage organ of capsicum resulting in an increased weight of capsicum (Kumar *et al.*, 2019 and Sankar *et al.*, 2008).

Seed and stover yield of fennel was significantly influenced by different methods of irrigation during the course of investigation (Table-2). Irrigating the fennel crop by drip irrigation at 1.0 PEF (I₃) recorded significantly the maximum seed yield (1833 kg ha⁻¹) and stalk yield (2867 kg ha⁻¹) but it was remained at par with drip irrigation at 0.8 PEF, respectively. Obviously, drip irrigation at 0.6 PEF

Table-1 : Yield attributing parameters of fennel as influenced by different methods of irrigation and nitrogen levels. (Two years data)

Treatments	Plant height (cm)				Number of umbels plant ⁻¹	Umbellates umbel ⁻¹	Number of seeds umbellate ⁻¹	1000 seed weight (g)
	60 DAS	90 DAS	120 DAS	At harvest				
Irrigation levels (I)								
I ₁ -0.6 PEF	67.43	92.22	108.82	121.42	15.18	17.82	19.74	5.61
I ₂ -0.8 PEF	78.79	104.04	117.18	129.96	18.03	21.49	26.67	6.63
I ₃ -1.0 PEF	92.01	113.68	127.86	140.58	22.58	26.31	28.27	7.23
I ₄ -1.0 IW/CPE	72.38	97.96	113.86	122.79	16.30	19.28	24.65	6.28
S.Em.±	1.68	1.58	1.76	2.84	0.35	0.47	0.56	0.15
C.D. at 5%	5.16	4.88	5.65	8.75	1.07	1.44	1.74	0.46
C.V. %	10.57	7.60	7.68	10.81	9.47	10.80	11.14	11.37
Nitrogen levels (N)								
N ₀ -Control	68.82	95.35	108.05	121.58	16.64	17.74	19.83	5.78
N ₁ -60 kg N ha ⁻¹	75.55	99.18	114.08	126.40	17.44	18.86	23.48	6.13
N ₂ -90 kg N ha ⁻¹	80.51	103.56	120.24	130.98	18.75	23.06	26.68	6.70
N ₃ -120 kg N ha ⁻¹	85.71	109.81	125.35	135.79	19.24	25.23	29.34	7.13
S.Em.±	1.35	1.37	1.35	2.50	0.33	0.38	0.45	0.11
C.D. at 5%	3.83	3.90	3.83	7.10	0.93	1.09	1.28	0.32
C.V. %	8.50	6.59	5.65	9.51	8.87	8.81	8.88	8.51
Interaction I x N								
S.Em.±	2.69	2.74	2.70	5.00	0.65	0.76	0.90	0.22
C.D. at 5%	7.66	7.80	7.67	14.21	1.85	NS	2.56	NS

**Fig.-1 : Number of umbels plant⁻¹, umbellate umbel⁻¹ and number of seeds umbellate⁻¹ as influenced by irrigation and nitrogen levels**

produced significantly the lowest seed and stalk yields. In fact seed yield is the function of several yield components, which are depended on complementary interaction between vegetative and reproductive growth of crop. Results of present study are closely related with the findings of Patel *et al.* (2000), Bhunia *et al.* (2005) in fennel and Rao *et al.* (2010) also observed similar findings in cumin. Maheria *et al.* (2012) and Lal *et al.* (2013) cited that moisture status and soil nutrient availability can be taken into consideration as the yield attributing parameter

factor which set the superiority of drip and micro sprinkler irrigation. The soil remains moist and soft due to frequent irrigation to fill the demand of crop evapo-transpiration under drip and micro sprinkler treatments.

Effect of nitrogen levels on yield and yield attributes :

Data presented in Table-1 indicated that application of recommended dose of nitrogen 120 kg N ha⁻¹ (N₃) produced significantly enhanced plant height at 60, 90, 120 DAS and at harvest (85.71, 109.81, 125.35 and 135.79 cm), number of umbels plant⁻¹ (19.24), which was

Table-2 : Yield and quality parameters of fennel as influenced by different methods of irrigation and nitrogen levels. (Two years data).

Treatments	Seed yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)	Harvest index (%)	Protein content in seed (%)
Irrigation levels (I)				
I ₁ -0.6 PEF	1129	2167	34.31	7.52
I ₂ -0.8 PEF	1472	2500	37.03	8.15
I ₃ -1.0 PEF	1833	2867	39.00	9.00
I ₄ -1.0 IW/CPE	1222	2250	35.14	8.03
S.Em. ±	32.62	49.26	0.95	0.15
C.D. at 5%	100.50	151.77	2.91	0.45
C.V. %	11.30	9.87	12.74	8.80
Nitrogen levels (N)				
N ₀ -Control	968	2168	32.65	7.20
N ₁ -60 kg N ha ⁻¹	1339	2340	35.82	8.06
N ₂ -90 kg N ha ⁻¹	1574	2535	38.15	8.46
N ₃ -120 kg N ha ⁻¹	1777	2741	38.85	8.99
S.Em. ±	20.00	28.66	0.70	0.08
C.D. at 5%	56.86	81.51	1.99	0.24
C.V. %	6.93	5.74	9.44	5.00
Interaction I x N				
S.Em. ±	39.99	57.33	1.40	0.17
C.D. at 5%	113.71	163.01	3.98	0.47

**Fig-2 : Protein content as influenced by irrigation and nitrogen levels.**

found statistically at par with N₂ (90 kg N ha⁻¹). Application of 120 kg N ha⁻¹ recorded significantly the highest umbellates umbel⁻¹ (25.23), number of seeds umbellate⁻¹ (29.34), 1000 seed weight (7.13 g) over control. The yield of the crop is basic function of various yield components which are dependent on complementary interaction between vegetative and reproductive growth of the crop. As these growth and yield attributes evidently resulted in higher yields under higher nitrogen levels. The present findings are in agreement with the results shown by Patel *et al.* (2000) and Ehsanipour *et al.* (2012). The increasing levels of N through drip restricted fertilizers to the wetted zone of soil where the active roots are concentrated thus,

leads to better utilization of nutrients, their uptake and enhanced vegetative growth. The similar results were also obtained by El- Mekawy *et al.* (2012) and Ram Pratap *et al.* (2010).

Fennel seed yield increased with increase in nitrogen levels Table 2. Application of 120 kg N ha⁻¹ (N₃) recorded significantly the highest seed yield (1777 kg ha⁻¹) and stalk yield (2741 kg ha⁻¹) over control. Significantly increase in seed and straw yield under these nitrogen levels appears to be on account of their influence on dry matter production and indirectly via increase in plant height, number of branches plant⁻¹ and perhaps a

result of higher uptake of nutrients. The present findings are in closely linked with the results obtained by Patel et al. (2000).

Effect of irrigation on quality parameters : A perusal of data furnished in Table-2 revealed that quality parameters like oil content of seed was not influenced significantly due to drip irrigation treatments (Table 2). Protein content increased with increase in drip irrigation levels was found up to 1.0 PEF. Higher nitrogen in seed is directly responsible for higher protein because of increased N content in seed which might be the result of increased availability of nitrogen to plants. Another reason for higher nitrogen content might be due to increased activity of nitrate reductase enzyme. Higher nitrogen in seed is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. Bhunia et al. (2005) also observed similar findings.

Effect of nitrogen levels on quality parameters : Data presented in Table-2 indicated that oil content in seed was not influenced significantly by nitrogen levels (Table-2). Application of 120 kg N ha⁻¹ recorded significantly the highest protein content in seed and it was found at par with application of 90 kg N ha⁻¹. Significantly the lowest protein content in seed was observed in control. The significant improvement in nutrient status of plant parts (seed and straw) might have resulted in greater synthesis of amino acid, proteins and growth promoting substances, which seems to have accelerated the meristematic activity and increased cell division and their elongation. These findings were also aligned with Patel et al. (2000) and Tuncurk (2011).

Conclusions

The pooled results of two-year experimentation brought to the conclusion that higher yield and protein content in seed production of drip irrigation at 1.0 PEF along with 120 kg N ha⁻¹ was contributing factor for optimum results which was recorded in terms of higher values of growth and yield attributes, producing maximum seed yield of fennel in *rabi* season under water scarce conditions.

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Bio-Efficacy of Different Insecticides against Whitefly, *Bemisia tabaci* on Bt Cotton

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Abstract

A study was carried out during Kharif, 2018 at instructional farm, College of Agriculture, Bikaner to determine the bio-efficacy of nine insecticides viz., Imidacloprid (0.01%), pyreproxifen (0.008 %), acetamiprid (0.012%), afidopyropen (0.18%), thiamethoxam (0.03%), difenthiuron (0.125 %), triazophos (0.03 %), dimethoate (0.05 %) and fipronil (0.062 %) against whitefly, *Bemisia tabaci* (Genn.) on Bt cotton. Among the above nine insecticides the treatment of pyreproxifen (0.008 %) proved most effective in reducing the pest population followed by afidopyropen (0.18%) and acetamiprid (0.012%). The treatment of Imidacloprid (0.01%), thiamethoxam (0.03%) and fipronil (0.062 %) found as middle order of their efficacy. Treatment of dimethoate (0.05 %) proved least effective followed by the treatment of difenthiuron (0.125 %) and triazophos (0.03 %).

Key words : Bt cotton, Bio-efficacy, *B. tabaci* and whitefly

Introduction

Cotton is one of the major fiber and cash crops of all around world. It is grown under tropical and subtropical regions of more than 80 countries of world occupying an area nearly 33 m ha with an annual production of 19 to 20 million tonnes of bales. China, U.S.A., India, Pakistan, Uzbekistan, Australia, Brazil, Greece, Argentina and Egypt are main cotton producing countries. An approximately 85% of the overall cotton production contribute by these countries. Release of Bt cotton for mercantile cultivation in India during 2002 has come as a blessing to the cotton farmers who have harvested improved yields with maximum returns. Bt cotton distinctly came to have been playing a key role in production and productivity. Although introduction of Bt cotton could reduce the bollworm incidence, number of other pests viz., whitefly, leafhopper, mirid bugs, aphids and thrips are becoming potential threats (Kranthi *et al.*, 2011) and these sucking pests were responsible for the loss of 50 per cent of young cotton plants (Sakimura, 1963). Among them whitefly is most destructive sucking pest of cotton. Whitefly is widely distributed polyphagous pest in tropical and subtropical regions of India. However, in spite of these, newer insecticides have come in our modern farming, which may not be dispensed off due to their efficacy and economics. In order to avoid adverse consequences of use of persistence insecticides it becomes necessary to evaluate the new molecules against insect pests for their host specificity and safety to natural enemies.

Materials and Methods

Present investigation on bio-efficacy of different insecticides against whitefly, *B. tabaci* on Bt cotton were recorded at the Research farm College of Agriculture, Swami Keshwanand Rajasthan Agricultural University Bikaner, (Rajasthan). The experiment was conducted in simple randomized block design. There were 10 treatments including control and each replicated three times. The seeds of Bt cotton variety NCS-855 BG II were sown on 22nd May in 2018 in plots size 6.0 x 4.5 m, keeping row to row and plant to plant distance of 67.5 cm and 67.5 cm, respectively. The recommended package of practices was followed to raise the crop. The spraying was done by using pre-calibrated knapsack sprayer. The first spray of all insecticides taken in experiment was done in 1st September during 2018 after examining the economic threshold level. The second spray was given again when ETL was observed. The quantity of water at the rate of 400 lit per hectare was used in each spray. The observations on whitefly populations were recorded regularly one day before and 3, 7, 10 and 15 days after each spray application. The population was counted by holding the base of leaves gently until the entire underside of leaf was clearly visible. Population was estimated with least disturbance at early hours of the day. From this, the average population per leaf was worked out. Seed cotton yield per plot per kg was recorded at the end of season and converted into quintal per hectare and then statistically analyzed. The data obtained one day before and 3, 7, 10 and 15 days after the spray was taken into consideration to find out the reduction percentage in the

Table-1 : Bio-efficacy of different insecticides against whitefly, *B. Tabaci* on Bt cotton during Kharif, 2018. (First spray)

S. No.	Treatments	Formulation	Conc. (%)	Mean per cent reduction in adult population				Mean
				3 DAS	7 DAS	10 DAS	15 DAS	
1.	Imidacloprid	17.8 SL	0.01	60.31 (51.00)*	65.71 (54.22)	61.21 (51.52)	43.87 (41.47)	57.78
2.	Pyriproxifen	10 EC	0.008	77.64 (61.97)	83.39 (66.38)	78.89 (62.93)	60.81 (51.28)	75.18
3.	Acetamiprid	20 SP	0.012	74.37 (59.65)	80.28 (63.79)	75.78 (60.62)	56.57 (48.78)	71.75
4.	Fipronil	25 WP	0.062	57.17 (49.15)	62.18 (52.10)	57.68 (49.45)	39.74 (39.07)	54.19
5.	Dimethoate	30 EC	0.05	39.03 (38.64)	43.35 (41.17)	39.87 (39.15)	21.87 (27.80)	36.03
6.	Thiamethoxam	25 WG	0.03	58.18 (49.74)	63.26 (52.75)	59.24 (50.35)	41.41 (40.03)	55.52
7.	Triazophos	40 EC	0.03	42.75 (40.80)	47.58 (43.60)	43.46 (41.22)	25.65 (30.36)	39.86
8.	Afidopyropen	50 EC	0.18	75.41 (60.42)	81.38 (64.69)	76.88 (61.43)	58.88 (50.15)	73.14
9.	Diafenthiuron	50 WP	0.125	40.96 (39.75)	45.17 (42.19)	41.52 (40.07)	23.56 (28.99)	37.80
10.	Control			0.00	0.00	0.00	0.00	
	S.Em.±			2.28	2.59	2.35	1.61	
	C.D.at 5 %			6.76	7.69	6.99	4.78	

*Figures in parenthesis are angular transformed values.

Table-2 : Bio-efficacy of different insecticides against whitefly, *B. Tabaci* on Bt cotton during Kharif, 2018. (Second spray).

S. No.	Treatments	Formulation	Conc. (%)	Mean per cent reduction in adult population				Mean
				3 DAS	7 DAS	10 DAS	15 DAS	
1.	Imidacloprid	17.8 SL	0.01	58.78 (50.10)*	63.90 (53.15)	59.55 (50.55)	40.45 (39.49)	55.67
2.	Pyriproxifen	10 EC	0.008	76.35 (60.95)	81.47 (64.58)	77.12 (61.48)	58.02 (49.63)	73.24
3.	Acetamiprid	20 SP	0.012	72.84 (58.65)	77.96 (62.08)	73.61 (59.15)	54.51 (47.60)	69.73
4.	Fipronil	25 WP	0.062	55.64 (48.26)	60.76 (51.26)	56.41 (48.71)	36.41 (37.07)	52.30
5.	Dimethoate	30 EC	0.05	37.50 (37.74)	42.62 (40.74)	38.27 (38.19)	19.16 (25.90)	34.39
6.	Thiamethoxam	25 WG	0.03	56.65 (48.85)	61.77 (51.85)	57.42 (49.29)	38.23 (38.18)	53.52
7.	Triazophos	40 EC	0.03	41.22 (39.91)	46.34 (42.89)	42.22 (40.49)	22.99 (28.63)	38.19
8.	Afidopyropen	50 EC	0.18	73.88 (59.39)	79.00 (62.92)	75.13 (60.26)	56.36 (48.66)	71.10
9.	Diafenthiuron	50 WP	0.125	39.43 (38.84)	44.55 (41.85)	40.20 (39.30)	21.10 (27.08)	36.32
10.	Control			0.00	0.00	0.00	0.00	0.00
	S.Em.±			2.15	2.21	2.24	1.60	
	C.D.at 5 %			6.40	6.57	6.64	4.75	

*Figures in parenthesis are angular transformed values

Table-3 : Effect of insecticides on yield of Bt cotton during, *kharif* 2018.

S. No.	Treatments	Formulation	Conc. (%)	Mean Yield q ha ⁻¹
1.	Imidacloprid	17.8 SL	0.01	23.50
2.	Pyriproxifen	10 EC	0.008	26.60
3.	Acetamiprid	20 SP	0.012	25.60
4.	Fipronil	5 SC	0.062	22.40
5.	Dimethoate	30 EC	0.05	18.40
6.	Thiamethoxam	25 WG	0.03	22.90
7.	Triazophos	40 EC	0.03	20.20
8.	Afidopyropen	50 EC	0.18	26.10
9.	Diafenthiuron	50 WP	0.125	19.30
10.	Untreated			16.00
	S.Em.±			0.69
	C.D.at 5 %			2.05

population which was calculated by applying a correction factor given by Henderson and Tilton (1955) referring it to be a modification of Abbot's (1925) formula. The analysis carried out by transforming the percentage mortality data into angular transformation values Gomez and Gomez, 1976).

Results and Discussion

The reduction in whitefly, *B. tabaci* population as a result of first and second application of insecticides after three days of first and second application of insecticides the reduction in whitefly, *B. tabaci* population ranged from 39.03 to 77.64 and 37.50 to 76.35 per cent, respectively in different treatments (Table 1 & 2). All the treatments were found significantly superior over untreated control. The minimum reduction was obtained from the treatment of dimethoate, difenthiuron and triazophos which were found at par to each other, whereas, the maximum reduction was recorded in the pyroproxifen treated plots followed by afidopyropen and acetamiprid however, these treatments formed a non-significant group. These results are similar to that of Vijay *et al.* (2014) who found that the lowest population of whitefly, *B. tabaci* adults was recorded in pyroproxifen 10 EC spray which was significantly better than other treatments. The treatment of pyroproxifen was reported significantly superior over rest of the treatments in reducing whitefly, *B. tabaci* followed by afidopyropen and acetamiprid. The treatments imidacloprid, thiamethoxam and fipronil resulted in the middle order in exhibiting the whitefly, *B. tabaci* reduction. The decreasing trend of efficacy of the tested treatments was found to be in the order of pyroproxifen, afidopyropen, acetamiprid, imidacloprid, thiamethoxam, fipronil, triazophos, difenthiuron and dimethoate.

After seven days of first spray, the maximum reduction was recorded in pyroproxifen (83.39 %) treated plots followed by afidopyropen (81.38 %) and acetamiprid (80.28 %) which were found significantly superior over rest of the treatments. The minimum reduction in whitefly,

B. tabaci population was recorded in dimethoate treated plots followed by difenthiuron and triazophos however, these treatments were found at par to each other. The similar studies were conducted by Muhammed *et al.* (2014) who found that difenthiuron was most effective treatment against whitefly, *B. tabaci*, Saner *et al.* (2013) revealed that the triazophos 40 EC was promising insecticide against whitefly, *B. tabaci* in Bt cotton. The other treatments imidacloprid, thiamethoxam and fipronil were in the middle order of efficacy. Asiet *et al.* (2008) reported that the treatment of imidacloprid caused significantly reduction in the population of whitefly, *B. tabaci*. Panduranga *et al.* (2011) noticed that the treatment of thiamethoxam was found most effective and recorded lowest population of whitefly, *B. tabaci*. Patilet *et al.* (2009) noticed that the treatment of fipronil was most effective against whitefly, *B. tabaci*. After ten days of first and second spray, pyroproxifen, afidopyropen, and acetamiprid recorded highest reduction in whitefly, *B. tabaci* population and these treatments were statistically at par to each other. The efficacy and superiority of acetamiprid observed during the present study is in similar line with the results obtained by Ghelani *et al.* (2014) who reported that that acetamiprid had recorded higher efficacy on adults of whitefly, *B. tabaci*. Lowest reduction of whitefly, *B. tabaci* population was shown by the treatments of dimethoate, difenthiuron and triazophos these were statistically at par to each other. Rest of the treatments was found in the middle order with respect to reduction in whitefly, *B. tabaci* population these treatments were imidacloprid, thiamethoxam and fipronil.

These results are agreement to that of Kadam *et al.* (2014) who observed imidacloprid and thiamethoxam was the most effective treatment for the controlling whitefly, *B. tabaci*. The decreasing order of whitefly, *B. tabaci* reduction was observed in the treatments are pyroproxifen, afidopyropen, acetamiprid, imidacloprid, thiamethoxam, fipronil, triazophos, difenthiuron and dimethoate.

After 15 days of first and second spray, the treatment of pyroproxifen give maximum per cent reduction in whitefly, *B. tabaci* population followed by afidopyropen, and acetamiprid which were found statistically at par to each other. The minimum per cent reduction in population of whitefly, *B. tabaci* was recorded in dimethoate, difenthiuron and triazophos treated plots which were found to be at par to each other. These results are in agreement with the finding of Afzal *et al.* (2014) who mentioned that spray of difenthiuron for the control of whitefly, *B. tabaci* in field condition were highly effective, and could be a good alternative to other insecticides.

Effect of different insecticides on yield of Bt cotton :

All the treatments were found significantly increased yield over untreated control. The maximum seed cotton yield 26.60 q ha⁻¹ (Table-3) was obtained from the pyroproxifen treated plots followed by afidopyropen, and acetamiprid. However, these treatments were at par to each other. The results are similar with that of Patil *et al* (2007) who reported that acetamiprid treated plots were produce considerable yield among all the insecticides. The treatments of imidacloprid, thiamethoxam and fipronil formed next group in terms of Bt cotton yield. These results are in agreement to that of Bharpoda *et al.* (2014) who reported that highest seed cotton yield was harvested from crop treated with imidacloprid followed by clothianidin, difenthiuron, thiamethoxam and acetamiprid. The minimum seed cotton yield was noticed in the treatment of dimethoate followed by difenthiuron, and triazophos treated plots.

Conclusion

The overall efficacy of nine newer insecticides were evaluated against whitefly, *B. tabaci* found that the treatment of pyroproxifen (0.008 %) proved most effective in reducing the pest population followed by afidopyropen (0.18%) and acetamiprid (0.012%). Treatment of dimethoate (0.05 %) proved least effective followed by the treatment of difenthiuron (0.125 %) and triazophos (0.03 %). All these insecticides increased the marketable yield of seed cotton significantly over the control. The maximum seed cotton yield was observed in the treatment of pyroproxifen.

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Analysis of Socio-personal, Socio-Economic and Communication Pattern Characteristic of Beneficiary and Non-beneficiary Wheat Growers towards Pradhan Mantri Fasal Bima Yojana

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Abstract

This study was carried out during 2018 in Jaipur region of Rajasthan on registered farmers under Pradhan Mantri Fasal Bima Yojana (PMFBY). A semi-structured interview schedule was used to collect the data from the respondents. The results of the study revealed that majority (63.89) of respondents belonged to middle age group, belonged to Other Backward Class category and 60.00 per cent belonged to agriculture sector. Nearly fifty per cent of respondents belonged to marginal (below 1 Ha.) land holding and had ground water irrigation as main source of irrigation. Its further revealed that majority of respondents i.e. 57.22 per cent had medium level of mass media exposure and 67.78 per cent of respondents had medium level of extension agency contact. The information seeking behaviour of respondents was also medium with 68.33 per cent of total number and nearly seventy per cent of the respondents had medium level of information sharing behaviour.

Key words : PMFBY, age, education, land holding and Information sharing behavior.

Introduction

Crop insurance is a method by which farmers can stabilize farm income and investment and guard against disastrous effect of losses due to natural hazards or low market prices. Crop insurance not only stabilizes the farm income but also helps the farmers to initiate production activity after a bad agricultural year. It cushions the shock of crop losses by providing farmers with a minimum amount of protection. The Pradhan Mantri Fasal Bima Yojana (Prime Minister's Crop Insurance Scheme) was launched by Hon'ble Prime Minister of India Mr. Narendra Modi Ji on 18 February 2016. This new Crop Insurance Scheme is in line with One Nation-One Scheme theme. The highlights of the scheme are as follows: There will be a uniform premium of only 2 per cent to be paid by farmers for all Kharif crops and 1.5 per cent for all Rabi crops. In case of annual commercial and horticultural crops, the premium to be paid by farmers will be only 5 per cent. The premium rates to be paid by farmers are very low and balance premium will be paid by the Government to provide full insured amount to the farmers against crop loss on account of natural calamities. The present study was undertaken with the objective to socio-personal, socio-economic and communication pattern characteristic of beneficiary and non-beneficiary wheat growers towards Pradhan Mantri Fasal Bima Yojana.

Research Methodology

The Jaipur district of Rajasthan state was selected purposely for the present investigation on the basis of highest number of registered farmers under Pradhan Mantri Fasal Bima Yojana among all the districts of the state. Three tehsils namely Chomu, Kotputli, and Kisangarh-renwal were selected purposely for the present investigation on the basis of highest registered farmers under Pradhan Mantri Fasal Bima Yojana. Further, two villages from each tehsil namely Nangal Bharda and Astikalan from Chomu; Nangal Panditpura and Rai Karanpura from Kotputli, Badhal and Itawa from Kisangarh renwal were also selected purposely on the basis of highest number of registered farmers under PMFBY for the present investigation. The proportionate random sampling method was used to select the user respondents and they were called as beneficiary of PMFBY because they have benefitted under PMFBY. Further, equal number of non-beneficiary respondents from the same villages were also selected randomly who have not benefitted under Pradhan Mantri Fasal Bima Yojana and they were called as non-beneficiary respondents. Thus, total 180 respondents i.e. 90 beneficiary and 90 non-beneficiary respondents were selected from selected villages for the present investigation. Thus, the total sample size from the

selected six villages was 180 respondents. Wheat crop has been purposely selected for the present investigation because wheat crop has first position in both area and production in Jaipur district of Rajasthan during Rabi season 2016-17 among the other Rabi crops. The data were collected with the help of pretested semi-structured interview schedule. The pre-testing of the interview schedule was carried out with 25 non-sampled respondents who were not included in the study. The personal interview technique was adopted for the collection of data. Analysis of the data was done with the help of different statistical tools like mean, standard deviation, frequency and percentage.

Results and Discussion

In this section the data regarding the socio-personal, socio-economic and communication pattern characteristics of farmers viz. age, caste, education, social participation, occupation, annual income, land holding, source of irrigation, extension agency contact, mass media exposure, information seeking behaviour and information sharing behaviour were studied using appropriate measurement and have been presented under following heads :

Socio-personal Characteristics

Age : The data in Table-1 reveals that maximum number of the beneficiary (65.56%) and non-beneficiary (62.22%) respondents were found in the age group of 33 to 59 years. While 13.33 per cent beneficiary and 22.22 per cent non-beneficiary farmers were belonged to the old age category. There were 21.11 per cent beneficiaries as well as 15.56 per cent of non-beneficiary farmers found in the category of less-than 33 years.

Table-1 also indicates that the majority of respondents belonged to middle age group i.e. between 33 to 59 years of age. This age group constituted 63.89 per cent of total sample followed by 18.33 per cent and 17.78 per cent farmers from young and old age group respectively. The findings are in line with the findings of Nayak (2016) and Jambuvant (2017) who reported that majority of the respondents of crop insurance scheme belonged to middle age category.

Caste : A close look of the Table-2 explicates that majority of beneficiary (72.23%) and non-beneficiary (71.12%) respondents belonged to Other Backward Class category. On the other hand only 03.33 per cent beneficiary farmers and 10.00 per cent non-beneficiary farmers belonged to scheduled caste category. Further, 12.22 per cent beneficiary and 07.77 per cent non-beneficiary respondents belonged to General Caste category. While, 12.22 per cent beneficiary respondents and 11.11 per cent non-beneficiary respondents belonged to Scheduled

Tribe category. If we see the data irrespective of beneficiary and non-beneficiary respondents, data in the Table 2 reveals that the majority of PMFBY respondents belonged to Other Backward Class category. This caste group alone constituted 71.67 per cent of the total Sample. This was followed by Scheduled Tribe (11.66%), General Caste (10.00%) and Scheduled Caste (06.67%) respectively.

The results of the present study are in conformity with the findings of Patel (2007) who concluded that majority of respondents belonged to Other Backward Class category.

Education : The data incorporated in Table-3 reveals that out of total respondents, 33.33 per cent of beneficiary farmers and only 02.22 per cent of non-beneficiary farmers were educated graduate and above, twenty per cent of beneficiary and 17.78 per cent of non-beneficiary farmers were educated up to secondary level, 16.67 per cent of beneficiary and 12.22 per cent of non-beneficiary farmers were educated up to middle level, 13.34 per cent of beneficiary and ten per cent of non-beneficiary farmers were educated up to senior secondary level, 12.22 per cent of beneficiary and 16.67 per cent of non-beneficiary farmers were educated up to primary level. Only 04.44 per cent of beneficiary farmers and 41.11 per cent of non-beneficiary farmers were found illiterate.

Further, 18.89 per cent of overall respondents were educated up to secondary level followed by graduate and above 17.78 per cent, middle 14.44 per cent and equal number of respondents were educated up to primary level, while 11.67 per cent of overall respondents were educated up to senior secondary level. Among all the overall respondents 22.78 per cent of the respondents were illiterate. The findings are in line with the findings of Kotwal (2009), Kale & Kadam (2012), Sundar & Ramakrishanan (2013) and Jambuvant (2017) who reported that more than one third of the beneficiaries belonged to secondary school category followed by primary school.

Social Participation : It is obvious from the data presented in Table-4 that majority of the beneficiary farmers (82.22%) and non-beneficiary farmers (94.44%) were not holding any position in social organization.

It was also noted that 17.78 per cent beneficiary respondents and only 05.56 per cent non-beneficiary farmers were member of social organization.

Further, data in Table 4 also reveals that majority of the overall respondents i.e. 88.33 per cent in the study area were not holding any position in social organization, whereas, 11.67 per cent of farmers were the member of social organization. The findings were contradictory with

Table-1 : Distribution of Wheat Growers on the basis of Age.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Young (<33.09 years)	19	21.11	14	15.56	33	18.33
2.	Middle (33.09 to 58.91 years)	59	65.56	56	62.22	115	63.89
3.	Old (>58.91 years)	12	13.33	20	22.22	32	17.78

Mean : 46 S.D. : 12.91

Table-2 : Distribution of Respondents on the basis of Caste.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Scheduled Caste	03	03.33	09	10.00	12	06.67
2.	Scheduled Tribes	11	12.22	10	11.11	21	11.66
3.	Other Backward Class	65	72.23	64	71.12	129	71.67
4.	General Caste	11	12.22	07	07.77	18	10.00

Table-3 : Distribution of Respondents on the basis of Education.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Illiterate	04	04.44	37	41.11	41	22.78
2.	Primary	11	12.22	15	16.67	26	14.44
3.	Middle	15	16.67	11	12.22	26	14.44
4.	Secondary	18	20.00	16	17.78	34	18.89
5.	Senior Secondary	12	13.34	09	10.00	21	11.67
6.	Graduate and Above	30	33.33	02	02.22	32	17.78

Table-4 : Distribution of Respondents on the basis of Social Participation.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Not holding any position in social organization	74	82.22	85	94.44	159	88.33
2.	Member of social organization	16	17.78	05	05.56	21	11.67

Table-5 : Distribution of Respondents on the basis of Occupation.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Leased Land/ Contractual Farming	09	10.00	04	04.44	13	07.22
2.	Agriculture	53	58.89	55	61.12	108	60.00
3.	Business	15	16.67	21	23.33	36	20.00
4.	Service	13	14.44	10	11.11	23	12.78

the findings of Vidyadhara (2015) who found that majority of respondents had membership in Milk Producer's Cooperative Society and SHGs.

Socio-economic Characteristics

Occupation : The data presented in Table-5 depicts that more-than half of the beneficiary respondents i.e. 58.89 per cent and 61.12 per cent of non-beneficiary respondents belonged to agricultural background. Beside

Table-6 : Distribution of Respondents on the basis of Annual Income (Lacs Rupess).

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Low (<0.66 Lacs)	02	02.22	17	18.89	19	10.55
2.	Medium (0.66 to 2.84 Lacs)	64	71.11	65	72.22	129	71.67
3.	High (>2.84 Lacs)	24	26.67	08	08.89	32	17.78

Mean : 1.75 Lac S.D. 1.09

Table-7 : Distribution of Respondents on the basis of Land Holding.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Marginal (below 1 ha.)	40	44.44	46	51.11	86	47.78
2.	Small (1-2 ha.)	33	36.66	29	32.22	62	34.44
3.	Medium (2-4 ha.)	09	10.00	12	13.34	21	11.67
4.	Large (above 4 ha.)	08	08.90	03	03.33	11	06.11

Table-8 : Distribution of Respondents on the basis of Source of Irrigation.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Ground Water Irrigated	73	81.11	65	72.22	138	76.66
2.	Water Hiring	17	18.89	25	27.78	42	23.34

Table-9 : Distribution of Respondents on the basis of Mass Media Exposure.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Low (<03.34 Score)	07	07.78	36	40.00	43	23.89
2.	Medium (03.34 to 11.20 Score)	54	60.00	49	54.45	103	57.22
3.	High (>11.20 Score)	29	32.22	05	05.55	34	18.89

Mean : 7.27 S.D. : 3.93

Table-10 : Distribution of Respondents on the basis of Extension Agency Contact.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Low (<17.20 Score)	06	06.67	27	30.00	33	18.33
2.	Medium (17.20 to 22.00 Score)	62	68.89	60	66.67	122	67.78
3.	High (>22.00 Score)	22	24.44	03	03.33	25	13.89

Mean : 19.60 S.D. : 2.40

this 16.67 per cent of beneficiary respondents and 23.33 per cent of non-beneficiary respondents were engaged in business. Remaining 14.44 per cent, 10.00 per cent of beneficiary and 11.11 per cent, 04.44 per cent of non-beneficiary respondents were engaged in service and leased land/contractual farming respectively.

Further, It is clear from the data in Table-5 that

majority of the farmers in the study area i.e. 60.00 per cent belonged to agriculture sector and remaining i.e. 20.00 per cent, 12.78 per cent and 07.22 per cent belonged to other occupation such as business, service and leased land/contractual farming respectively. Thus, it may be concluded from the above findings that agriculture was main occupation of rural families. The findings are in conformity with the findings of Gaikwad (2016) who

Table-11 : Distribution of Respondents on the Basis of Information Seeking Behaviour.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Low (<03.87 Score)	04	04.44	19	21.11	23	12.78
2.	Medium (03.87 to 10.93 Score)	58	64.44	65	72.22	123	68.33
3.	High (>10.93 Score)	28	31.12	06	06.67	34	18.89

Mean : 7.40 S.D. : 3.53

Table-12 : Distribution of Respondents on the basis of Information Sharing Behaviour.

S. No.	Categories	Respondents					
		Beneficiary Respondents (n=90)		Non-beneficiary Respondents (n=90)		Overall Respondents (n=180)	
		F	%	F	%	F	%
1.	Low (<14.71 Score)	07	07.78	26	28.89	33	18.33
2.	Medium (14.71 to 18.09 Score)	65	72.22	59	65.56	124	68.89
3.	High (>18.09 Score)	18	20.00	05	05.55	23	12.78

Mean : 16.40 S.D. : 1.69

observed that majority of the farmers were having agriculture as their main occupation.

Annual Income : Annual income is the total income in rupees earned by the respondent family in a year from different sources. The data in Table-6 depicts that 71.11 per cent of the beneficiary respondents belonged to medium level of income category (₹ 0.66 to ₹ 2.84 lacs) followed by 26.67 per cent in high income category i.e. > ₹ 2.84 lacs and remaining 02.22 per cent in low income group i.e. < ₹ 0.66 lacs, respectively. In case of non-beneficiary respondents, 72.22 per cent belonged to medium level of income category followed by 18.89 per cent in low level of income category and 08.89 per cent in high income group, respectively. From the above findings, it may be concluded that more than seventy per cent of the respondents (both beneficiary and non-beneficiary) were from medium level income category. The findings are supported by the findings of Surve (2002), Deshmukh *et al.* (2007) and Jambuvant (2017) who reported that majority of the respondents had medium level of annual income whereas, very few respondents had high and low income level, respectively.

Land Holding : A perusal of the data presented in the Table-7 indicates that majority of the beneficiary (44.44%) and non-beneficiary (51.11%) respondents possessed land below one hectare and belonged to marginal category followed by 36.66 per cent of beneficiary respondents and 32.22 per cent of non-beneficiary respondents in small category who possessed 1-2 hectares of land. Further, only ten per cent of beneficiary respondents and 13.34 per cent of non-beneficiary respondents were having land holding of 2-4 hectare, comes under medium category. Only 08.90 per cent of the

beneficiary respondent and very-few i.e. 03.33 per cent of the non-beneficiary respondents possessed land above 4 hectares and belonged to large category.

Table-7 further reveals that majority of the wheat growers (47.78%) under PMFBY belonged to marginal land holding category. This category alone constituted nearly half of the total wheat growers under PMFBY and remaining half of them were in small, medium and large category respectively. The findings are in accordance with the findings of Jambuvant (2017) who found that majority of the beneficiaries come under small land holding category, followed semi medium and medium size of land holding.

Source of Irrigation : The data in Table-8 depicts that more than eighty per cent of the beneficiary respondents and 72.22 per cent of non-beneficiary respondents were under the purview of ground water irrigated followed by 18.89 per cent of beneficiary respondents and 27.78 per cent of non-beneficiary respondents were in water hiring category.

Further, data in Table-8 also reveals that the majority of the overall respondents i.e. 76.66 percent had ground water irrigation as main source of irrigation followed by 23.34 per cent had water hiring as a source of irrigation, respectively. The findings of the present investigation are in conformity with the findings of Patel (2007) who found that wells are the main source of irrigation for ground water, which provided irrigation facilities in area of 30.48 per cent of the net irrigated area in the Kasrawad block as well as Khargone district with 50.62 per cent net irrigated area.

Communication Pattern

Mass Media Exposure : The exposure of mass media varied amongst the respondents as data shows in the Table-9 that most of the beneficiary (60.00%) and non-beneficiary (54.45%) respondents had medium level of mass media exposure. On the other hand, 32.22 per cent of beneficiary and 05.55 of non-beneficiary respondents had high level of mass media exposure. Further, only 07.78 percent of beneficiary and 40.00 per cent non-beneficiary respondents had low level of mass media exposure.

Table-9 also shows that the majority of respondents i.e. 57.22 per cent had medium level of mass media exposure. The remaining respondents had low (23.89%) and high (18.89%) level of mass media exposure, respectively. The findings are in conformity with the findings of Vidyadhara (2015) who reported that more than half of the respondents had medium level of mass media exposure followed by high and low respectively.

Extension Agency Contact : The data in Table-10 reveals that majority of beneficiary (68.89%) and non-beneficiary (66.67%) respondents had medium level of extension agency contact. On the other hand 06.67 per cent of beneficiary and thirty per cent of non-beneficiary respondents had low level of extension agency contact and only 03.33 per cent of non-beneficiary and 24.44 per cent of beneficiary respondents had high level of extension agency contact.

The data presented in Table-10 also indicates that majority of the respondents i.e. 67.78 per cent had medium level of extension agency contact followed by 18.33 per cent low and 13.89 per cent of high level of extension agency contact, respectively. The findings are in line with the findings of Vidyadhara, (2015) who found that more than half of the farmers had medium level of contact with the extension agents followed by low and high respectively.

Information Seeking Behaviour : The data in Table-11 indicates that majority of the respondents i.e. 64.44 per cent beneficiary and 72.22 per cent non beneficiary respondents had medium level of information seeking behaviour.

On the other hand 04.44 per cent of beneficiary and 21.11 per cent of non-beneficiary respondents had low level of information seeking behaviour. Further, 31.12 per cent of beneficiary and 06.67 per cent of non-beneficiary respondents had high level of information seeking behaviour. The data in Table-11 also reveals that majority of the overall respondents i.e. 68.33 per cent had medium level of information seeking behaviour followed by high (18.89%) and low (12.78%), respectively. The findings are

in line with the findings of Suresh (2004), Chouhan (2013) and Alawa (2014) who reported that majority of the respondents had medium level of information seeking behaviour.

Information Sharing Behaviour : Table-12 depicts that majority of beneficiary (72.22%) and non-beneficiary (65.56%) respondents had medium level of information sharing behaviour.

Only 07.78 per cent of beneficiary and 28.89 per cent of non-beneficiary respondents had low level of information sharing behaviour. On the other hand twenty per cent of beneficiary and only 05.55 per cent of non-beneficiary respondents had high level of information sharing behaviour. The data in Table 12 also shows that the nearly seventy per cent of the overall respondents had medium level of information sharing behaviour followed by low (18.33%) and high (12.78%) level of information sharing behaviour respectively. The findings are in accordance with the findings of Parmar (2014) who found that most of the respondents had high information seeking behaviour followed by medium and low information seeking behaviour.

Conclusions

On the basis of this study, it is concluded that the majority (63.89) of respondents belonged to middle age group i.e. between 33 to 59 years of age, 71.67 per cent respondents belonged to Other Backward Class category. 18.89 per cent of overall respondents were educated up to secondary level followed by graduate and above 17.78 per cent, middle 14.44 per cent and equal number of respondents were educated up to primary level and 88.33 per cent of respondents in the study area were not holding any position in social organization. Majority of the farmers in the study area i.e. 60.00 per cent belonged to agriculture sector and more than seventy per cent of the respondents (both beneficiary and non-beneficiary) were from medium (0.66 to 2.84 Lacs Rupees) level income category. 47.78 per cent wheat growers under PMFBY belonged to marginal (below 1 Ha.) land holding category and 76.66 percent respondents had ground water irrigation as main source of irrigation. Its further revealed that majority of respondents i.e. 57.22 per cent had medium level of mass media exposure and 67.78 per cent of respondents had medium level of extension agency contact. The information seeking behaviour of respondents was also medium with 68.33 per cent of total number and nearly seventy per cent of the respondents had medium level of information sharing behaviour.

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Survey of Purple Blotch Disease of Onion Caused by *Alternaria porri*

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Abstract

Investigation was carried out on roving survey for recording the severity of purple blotch disease of onion during Rabi 2016 in four districts of Rajasthan viz Jaipur, Alwar, Sikar and Nagaur. The intensity of disease was noted by counting at least 100 plants in each field. Observation on purple blotch intensity was recorded; the symptoms expressed as initial small, water-soaked lesions later turned to light yellow to brown coloured. The per cent disease severity was calculated by using 0-5 point disease rating scale. On the basis of survey purple blotch of onion incited by *Alternaria porri* and found that Sikar district has maximum disease severity 41.28 in Rabi 2016, respectively and minimum disease severity was observed in Nagaur 29.41%, respectively.

Key words : Onion, purple blotch, survey, surveillance, disease severity.

Introduction

Allium, a large genus containing five hundred or more species, belongs to the family *Alliaceae*. There are five important species of the genus *Allium* of which the onion is the most important crop (Messiaen, 1994). Onion is ranked as one of the five most important fresh market vegetable crops world-wide (Cramer, 2000). Onion are used both as food and also for seasoning, the immature and mature bulbs are eaten raw or they may be cooked and eaten as a vegetable (Messiaen, 1994). Among vegetables, onion (*Allium cepa* L.) often called as “Queen of Kitchen” is one of the oldest known and an important vegetable crop grown in India. Onion contains the lachrymatory agent, a strong antibiotic, with fungicidal, bacterial and nematocidal properties (Purseglove, 1972). Onion a bulbous, biennial herb is one of the most important vegetable crops grown throughout world and in India. As a vegetable and spice, it is used both as tender and mature bulb. In bulb group of vegetables, onion is the most important crop. The bulb is composed of concentric, fleshy, enlarged leaf bases or scales. It is consumed throughout the year by almost all classes of people on account of its medicinal and dietary value. Due to use of onion blood pressure, diabetes and blood fat are controlled. The young green onions are used as salad, while the mature bulbs are used as food for cooking vegetables (Smith 2003). In onion there is report of high levels of photochemical especially flavonols, which provide colour, texture and taste in onions.

India stand second in area and third in production with a 23 million tonnes production in 12 lakh hectare area with productivity of 18.10 t/ha (Anonymous, 2018). Indian

onions are marketed in Bangladesh, Malaysia, Sri Lanka, U.A.E, Pakistan and Nepal. In Rajasthan, it is cultivated in 0.10 lakh hectares with productivity of 15.40 mt/ha a total production of 6.47 lakh tons (Anonymous, 2018). Onion is cultivated in all season throughout the country. The major onion producing states are Maharashtra, Karnataka, Gujarat, Bihar, Madhya Pradesh, Andhra Pradesh, Rajasthan and Haryana (Anonymous, 2018).

Onion is highly susceptible to many foliar, bulb and root pathogens, which reduce yield and quality (Cramer, 2000). Among the diseases, purple leaf blotch (PLB) and Stemphylium leaf blight (SLB) are the major diseases of onion worldwide (Awad *et al* 1978, Everts and Lacy 1990 (a, b), Brar *et al* 1990, Aveling *et al* 1993, 1994, Chaput 1995, Cramer, 2000). The PLB and SLB have been reported on many species of *Allium* family including onion (*A. cepa*), Egyptian onion (*A. proliferum*), Welsh onion (*A. fistulosum*) and leek (*A. ampeloprasum* var. *porrum*) world-wide (Sherf and McNab 1986). Among the various foliar diseases of onion, purple blotch caused by *Alternaria porri* is one of the most destructive diseases, due to this disease yield loss ranging from 2.5 to 87.8 per cent during *Kharif* season (Shrivastava *et al.*, 1994). Considering the above, the present study was undertaken to survey of *Alternaria porri* causing purple blotch of onion to standardize innovative onion purple blotch complex management approaches.

Materials and Methods

Two villages, from each selected district were surveyed for the purpose were examined randomly and scored for disease severity by following 0-5 scale as given by Pathak *et al.*, (1986).

Disease rating	PDI Range	Reaction
0.	0 to 5%	Immune
1.	5 to 10%	Resistant
2.	11 to 20%	Moderately Resistant
3.	21 to 40%	Moderately Susceptible
4.	41 to 60%	Susceptible
5.	More than 61%	Highly Susceptible

Per cent disease intensity (PDI) was calculated by using the following formula (Wheeler, 1969);

$$\text{PDI} = \frac{\text{Sum of all individual diseases rating}}{\text{Total number of plants assessed} \times \text{Maximum rating}} \times 100$$

Collection of diseased plant material : The disease samples were collected from severely infected plants of onion from farmer's field in Rabi season 2016 from the farmer's field of the Sikar district of Rajasthan.. The infected leaves were thoroughly washed with running tap water and then immediately examined under a compound microscope for preliminary identification of the pathogen. Later on, the fungus was brought into pure culture on potato dextrose agar medium using following method:

Cleaning and sterilization : All the glassware was cleaned with potassium dichromate or sulphuric acid solution and washed with sterilized water and sterilized in hot air oven at 160°C for 2 hours. Culture medium (Potato Dextrose Agar) was sterilized by autoclaving at 1.045 kg / cm² pressure for 20 minutes. Soil used in the present study was sterilized at 1.045kg /cm² pressure for one and half hour on two consecutive days. The earthen pots were sterilized by dipping then in 10 per cent formaldehyde solution for 5 minutes.

Isolation, purification and maintenance of *Alternaria porri* : Isolation of the fungus was made by tissue isolation technique. Typical diseased spots on leaves were selected and cut into small bits with the help of a sterilized blade. These bits of diseased tissues were washed with sterilized distilled water and disinfected with 0.1 per cent mercuric chloride (HgCl₂) solution for 30 to 60 seconds. These disinfected bits were immediately washed thrice with sterilized distilled water to remove excess mercuric chloride. These bits were placed on the surface of Petri plates containing potato dextrose agar (PDA) and incubated at 28±2 for 10 days. The resulting fungus culture was purified by hyphal tip technique in PDA slant. The pure culture was maintained on PDA by storing it under refrigeration at 5°C and making periodical transfers at every fortnight.

Single spore isolation : Ten ml of clear, sterilized water agar of 2 per cent strength was poured into Petri plates and was allowed to solidify. Dilute spore suspension was prepared using sterilized distilled water from 12 days old culture. One ml of such suspension was spread uniformly

on 2 per cent water agar plates. The plates were incubated at 28±1°C for 8 hours. Then, such plates were examined under microscope to locate germinated conidia. Single isolated and germinated conidia were then marked under the microscopic field on the surface of the plate. These marked agar areas were cut and transferred to PDA slants with the help of cork borer under aseptic conditions and incubated at a temperature of 28±2°C. The growth of fungus in slants was used to study the morphological characters. As single spore isolates were identical and multiplied further. Pure culture derived from such slants was used for further studies.

Maintenance of the culture : The pathogen was sub cultured on PDA slants and allowed to grow at 28±2°C for ten days and such slants were preserved in a refrigerator at 5°C and renewed once in 30 days.

Proving the pathogenicity : Onion seedlings (cv. RO-252) were raised in earthen pots, size 6" X 5", filled with sterilized soil. Plants were thoroughly cleaned with sterilized distilled water using moist cotton. Later, the plants were sprayed with distilled water. They were covered with polythene bags for 24 hrs. Onion seedlings (injured with brush) were inoculated with mycelial suspension prepared from 10 days old culture, suitable controls were maintained. Plants were injured with brush in control and maintained by spraying water only instead of mycelial suspension of the causal fungus. The seedlings were covered with polyethylene bags and were incubated for 120 hrs to ensure successful penetration of the pathogen into the host tissue. The polythene bags removed after five days and seedlings were kept under greenhouse conditions. Observations were made regularly for the appearance and development of symptoms. After appearance of disease symptoms, reisolation was made from the diseased tissues of artificially infected plants. The isolate obtained was compared with the original culture for confirmation of fungus under study.

Results and Discussion

A roving survey was conducted during rabi 2016 in four onion growing districts of Rajasthan viz Jaipur, Alwar, Sikar and Nagaur Survey was carried out in two villages from one tehsil of each district. During the survey, discussions were held with the farmers concerned, regarding occurrence and severity of the disease. The results presented in (table-1) depicts that purple blotch disease intensity was more severe in onion growing districts of Rajasthan. The disease intensity of purple blotch of onion was recorded from 28.70 to 42.39 per cent in all surveyed areas of Rajasthan. The highest disease intensity was recorded from Rashidpura and dotasara village of sikar district with 42.39 per cent and 40.27 per

Table-1 : Per cent disease severity of purple blotch of onion caused by *A. porri* in onion growing area.

S.No.	Isolate No.	District	Tehsil	Village	Disease intensity (%)
1.	AltJp1	Jaipur	Amer	Biharipura	34.32
2.	AltJp2	Jaipur	Amer	Jahota	36.43
				Mean	35.37
3.	AltAw1	Alwar	Kishangarh Bas	Bambora	38.29
4.	AltAw2	Alwar	Kishangarh Bas	Nangal Dungar	37.36
				Mean	37.82
5.	AltSk1	Sikar	Luxmangarh	Dotasara	40.27
6.	AltSk2	Sikar	Luxmangarh	Rashidpura	42.39
				Mean	41.28
7.	AltNg1	Nagaur	Nawa	Rajliya	28.70
8.	AltNg2	Nagaur	Nawa	Muwana	30.12
				Mean	29.41
				Overall mean	35.97

cent respectively. Lowest disease intensity was observed from Rajliya village (28.70%) of Jaipur district. Highest mean disease intensity 41.28 per cent was observed in Luxmangarh tehsil of sikar distict followed by Kishangarh Bas (37.82%) tehsil of Alwar district. The lowest mean disease intensity was recorded in Nawa tehsil of nagaur district with 29.41 per cent.

The district wise observations were given in Table-1. The data indicated that the disease appeared in severe form during the crop seasons (*Rabi* 2016).

This might have helped in the rapid development of the disease in *Rabi* when favourable environmental conditions prevailed. Working on survey of *Alternaria* leaf blight disease of onion, Patil and Patil (1991) concluded that it is the most predominant and severe disease in the onion growing centers of Maharashtra.

Conclusions

The per cent disease severity was calculated by using 0-5 point disease rating scale. On the basis of survey and surveillance of purple blotch of onion incited by *Alternaria porri* and found that Sikar district has maximum disease severity and minimum disease severity was observed in Nagaur district.

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Variability of Seed Spices in Rajasthan

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Abstract

For analyzing the variability of seed spices in Rajasthan, the current study was conducted from 1998-99 to 2017-18. The entire period was divided into three sub-periods viz. Period I (1998-99 to 2007-08), Period II (2008-09 to 2017-18), and Overall Period (1998-99 to 2017-18). Four major seed spices mainly coriander, cumin, fennel, and fenugreek were considered for the analysis. The necessary data on the area, production, and productivity were gathered from various annual publications of Govt. of Rajasthan. The study was done by analyzing the instability. For this, analytical tools such as Coefficient of Variation, Detrended Instability were used. Most of the seed spices showed high instability in area, production, and productivity during the study period. Aberrant weather conditions, cultivation of crops on the marginal lands, and high occurrence of the diseases could be the cause of variation.

Key Words : *Coriander, cumin, fennel, fenugreek, coefficient of variation, detrended instability*

Introduction

Around the globe, India is identified as the land of spices. Indian spices are admired for their flavour in both domestic and international markets. Since primeval times, India is known for producing superior quality spices. Indian spices savour foodstuffs in almost 135 countries around the world and their essential qualities makes them unmistakably exceptional in flavour, colour, and aroma. India produces nearly all the known spices in the world. Spices are among the most economical and marketable agronomic crops. Spices possess therapeutic values. Due to varied agro-climatic conditions, India cultivates an extensive array of spices. Among the total spices cultivated in India, 20 are categorized as seed spices. Seed spices are types of crops whose chief economical portion is a seed. These are generally utilized whole or in a blended form to provide distinctive taste, smell to the food. Among the seed spices, the largest area is under cumin next is coriander succeeded by fennel then fenugreek, carom seeds, celery, nigella, dill seeds, and anise, etc. Seed spices are generally cultivated in the *rabi* season. Being seasonal plants, seed spices are cultivated predominantly in sequence with food crops. These are also cultivated as inter/mixed crops in rainfed/irrigated environment.

India is the biggest cultivator, end user, and exporter of seed spices. During 2017-18, area under seed spices was 1793.95 thousand hectares and production was 1860.55 thousand MT. Share of seed spices is about 46.26 per cent of the entire region and 22.90 per cent of whole output amongst total spices in nation. In 2017-18, India earned ₹3136.17 crores through export of 2.49 lakh tonnes seed spices (Annual report, NRCSS, Ajmer, 2018-19). Rajasthan and Gujarat which comes under dry

and partially dry regions of our nation are identified as 'Seed Spices Bowl' as they produce greater than 80 per cent of whole seed spices. Rajasthan cultivated 1144.37 thousand MT spices in 918.86 thousand hectares' area during the year 2017-18 (Horticultural statistics at a glance, 2017-18).

Objective : To analyze the instability in area, production, productivity of major seed spices in Rajasthan.

Materials and Methods

Selection of major crops and study area : Four major seed spices based on the highest area were selected from the state of Rajasthan also the production of these seed spices was highest during the year 2017-18. The four seed spices viz. coriander, cumin, fennel, and fenugreek were selected.

Databases : The research work was based on secondary data. Twenty years' data i.e. 1998-99 to 2017-18 was considered for the analysis of instability in area, production, productivity, the data were collected from various authentic sources as follows :

Vital Agriculture Statistics (Directorate of Agriculture, Pant Krishi Bhawan, Jaipur, Rajasthan)

Rajasthan Agricultural Statistics at a Glance (Commissionerate of Agriculture, Jaipur, Rajasthan)

Fertilizer and Agriculture Statistics Northern Region (The Fertilizer Association of India, Northern Region, New Delhi)

Analytical Tools : In the present study, the instability index was calculated using the Coefficient of Variation and Detrended Instability.

Measure of Instability in Area, Production, Productivity of Coriander in Rajasthan (In Per cent)

Crops	First Period (1999-2008)		Second Period (2009-2018)		Third Period (1999-2018)	
	I ₁	I ₂	I ₁	I ₂	I ₁	I ₂
Area	26.91	26.88	24.95	21.90	27.24	26.52
Production	30.32	30.30	28.01	22.75	30.88	30.26
Productivity	12.95	12.98	22.89	22.73	18.58	18.08

Measure of Instability in Area, Production, Productivity of Cumin in Rajasthan. (In Per cent)

Crops	First Period (1999-2008)		Second Period (2009-2018)		Third Period (1999-2018)	
	I ₁	I ₂	I ₁	I ₂	I ₁	I ₂
Area	40.27	39.64	32.98	19.73	49.51	38.33
Production	51.20	50.09	55.81	22.26	74.05	73.26
Productivity	31.94	32.07	32.43	21.17	33.03	29.78

Measure of Instability in Area, Production, Productivity of Fennel in Rajasthan. (In Per cent)

Crops	First Period (1999-2008)		Second Period (2009-2018)		Third Period (1999-2018)	
	I ₁	I ₂	I ₁	I ₂	I ₁	I ₂
Area	54.47	41.39	68.18	70.60	95.47	137.33
Production	59.42	42.52	91.74	97.14	131.05	154.57
Productivity	24.57	16.41	22.11	21.31	30.07	18.87

Measure of Instability in Area, Production, Productivity of Fenugreek in Rajasthan (In Per cent)

Crops	First Period (1999-2008)		Second Period (2009-2018)		Third Period (1999-2018)	
	I ₁	I ₂	I ₁	I ₂	I ₁	I ₂
Area	50.55	50.70	39.49	29.71	52.08	44.75
Production	51.95	51.31	44.46	31.63	56.47	47.72
Productivity	13.76	13.09	10.52	9.25	11.95	11.90

Estimation of Instability Index : The instability in Area, Production, Productivity of the major seed spices for 20 years were worked out with the help of the following measure:

$$(1) \text{ Instability Index } (I_1) = \frac{\bar{x}}{\bar{x}} \times 100$$

Where, $\bar{x}$ = Standard deviation, $\bar{x}$ = Arithmetic mean

$$(2) \text{ Instability Index } (I_2) = \frac{\bar{x}}{\bar{x}} \times 100$$

Where, $\bar{x}$ = Standard deviation of detrend Area / Production / Productivity

$\bar{x}$ = Arithmetic mean of detrend Area / Production / Productivity

Results and Discussion

Instability in the Area, Production, Productivity of Seed Spices in Rajasthan

Instability in the coriander crop : During the first period i.e. 1999-2008, the coriander area showed instability of

26.91 per cent in terms of coefficient of variation while detrended instability was 26.88 percent. Coriander showed highest coefficient of variation in terms of area during the overall period (1999-2018) which was 27.24 per cent.

In terms of production, the coriander showed highest coefficient of variation during the overall period i.e. 30.88 percent. While, the highest detrended instability in terms of production was observed during first period which was 30.30 percent. The instability in the production of the coriander might be due to aberrant weather conditions and dominant effect of the instability in the area.

In terms of productivity, the highest instability was observed during the second period. The coefficient of variation was 22.89 percent and the detrended instability was 22.73 percent while other periods revealed lower instability. The instability in productivity of coriander was more and less similar during all the periods. This might be due to the fact that coriander has reached its potential yield capacity in Rajasthan.

Instability in the cumin crop : The instability in cumin in terms of the area was highest during the overall period

(1998-99 to 2017-18). While, the detrended instability was highest during the first period which was 39.64 per cent.

The instability in the production of cumin was relatively high as compared to coriander. The instability in production was highest during the overall period. The coefficient of variation in terms of production was 74.05 percent while detrended instability was 73.26 percent during this period.

The instability in the productivity of cumin was less as compared to production. During 1997-98 to 2017-18, the coefficient of variation in productivity of cumin was 33.3 percent which was highest while the instability measured in terms of detrended productivity was highest during the first period i.e. 32.07 per cent.

Instability in the fennel crop : The fennel crop showed high variability in the area during each period. But, the highest variability was observed during the overall period. The coefficient of variation was 95.47 per cent and detrended instability was 137.33 per cent during this period. Higher instability in the fennel during all periods was mainly due to expansion of the area under fennel.

The fennel crop showed a high variation in production similar to area. During the overall period (1998-99 to 2017-18), the variation in the production of fennel was highest. The coefficient of variation in production was 131.05 per cent and the detrended instability in production was 154.57 per cent.

The fennel crop showed low variation in productivity during every period. During the third and overall period (1998-99 to 2017-18), the coefficient of variation was 30.07 per cent, the detrend variation was low i.e. 18.87 per cent.

Instability in the fenugreek crop : The fenugreek crop showed high variation during each period in terms of area. But, the coefficient of variation in area of fenugreek was highest during the overall period (1999-2018) i.e. 52.08 percent. The detrended instability in terms of area was highest during first period during which area variation was 50.70 percent.

In the initial study period (1998-99 to 2007-08), the instability in the production of fenugreek was high. The deviation taken from the trend revealed the variation of 51.31 per cent which was highest compared to other periods. Whereas, the coefficient of variation in production period was highest during the overall period i.e. 56.47 per cent. The instability in the production was mainly due to increased variation in the area and higher production due to improved technology.

The instability in the productivity of fenugreek showed some steadiness during all the periods. The first

period (1998-99 to 2007-08) showed highest instability with coefficient of variation measuring 13.76 per cent and detrended instability was 13.09 per cent.

Conclusion

The coriander crop was found to be the most stable crop during all the periods. The fennel was found to be the most unstable crop as it showed high instability in all the periods. The highest coefficient of variation was observed in the production of fennel in Rajasthan during the overall period (131.05 per cent). Most of the seed spices showed high instability in area, production, and productivity during the study period. The reason might be that mostly seed spices cultivation is dependent upon the domestic prices of crop which was lower in the initial investigation period. Also, aberrant weather conditions, cultivation of crops on the marginal lands, and high occurrence of the diseases in the first period (1999 to 2008) whereas tremendous growth due to better quality seeds and production technology in the second period (2009 to 2018) could be the cause of variation. The farmers must be acquainted with the latest varieties and improved package of practices of seed spices from Agricultural Research Stations of the State Agricultural Universities and NRCSS, Ajmer to improve the productivity of seed spices.

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Response of NPK, Biofertilizers and Plant Spacing on Economics of African Marigold

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Abstract

A field experiment was conducted during winter season of 2014-15 to study the response of NPK, biofertilizers and plant spacings on growth and yield of African marigold. The economics of maximum B: C ratio (6.00) was recorded with combined application of 100 % RDF of NPK + *Azotobacter* + PSB + 60 x 45 spacing cm and maximum net returns (₹ 283267 ha⁻¹) was recorded with same combination of treatments. This treatment was significantly superior over other treatment combinations except 100% RDF of NPK + 60 x 45 cm (₹ 262726 ha⁻¹) which was found at par.

Key words : *Azotobacter*, PSB, African marigold, net Return, B:C Ratio.

African marigold (*Tagetes erecta* L.) is a popular and commercial flowering annual that is grown in almost all of India's states. It is in high demand for garland, cut flowers, and decorative reasons during various festivals. It can be used as a potted plant, as well as for bedding, edging, garland making, veni, religious offerings, and other things. To achieve a high decorative value of plant while lowering production costs, sustainable flower production requires effective fertiliser management (Vedavathi *et al.*, 5; Zhang *et al.*, 6). Nutrient status of the plants can be a pointer to the response of plant to the fertilization and internal content of the nutrients determine the fertilizer requirements. Kumar and Singh (2) are of the opinion that closer spacing provides more number of plants but deteriorates the quality of flower and reduce yield per plant, whereas, wider spacing gives good quality flowers but lower yield. So, optimum spacing is required to provide better quality flowers as well as higher yield.

Present study was carried out at the experimental farm of Department of Horticulture, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) during rabi season, 2014-15. The climate of this region is typically semi-arid characterized by aridity of the atmosphere, scarcity of water with extremity of temperature both during summer and Winter. The maximum temperature touches around 45.5°C during May and June, while in December and January it falls below 1°C. The average rainfall varies between 400-500 mm. The fertilizer recommendation of 100 % RDF of (NPK- 120:80:60 kg / ha) and seedling treated with biofertilizer (*Azotobacter* and PSB). The treatments consisted seven combination of fertilizer *i.e.* F₀ (Control), F₁ (50% RDF of NPK), F₂ (50 % RDF of NPK + *Azotobacter* + PSB), F₃ (75 % RDF of NPK), F₄ (75 % RDF of

NPK + *Azotobacter* + PSB), F₅ (100% RDF of NPK), F₆ (100% RDF of NPK + *Azotobacter* + PSB), and three combination of plant spacings *viz.* D₁ (45 x 45 cm), D₂ (60 x 45 cm), D₃ (60 x 60 cm) which were replicated three times in randomized block design with factorial approach. One month-old seedlings were transplanted at different spacings. Randomization of treatments was done with the help of random number table (Fisher, 1).

ECONOMICS

1. **Gross Income (₹)** = Total crop production x Value of the product (both main and by product)

2. **Total cost** = Common cost + Treatment cost

3. **Net return (₹/ha)**

Net return (₹/ha) of individual treatment was calculated by deduction of cost of cultivation from the gross return of particular treatment.

Net return = Gross Return – Total Cost of Cultivation

1. **Benefit : Cost ratio** : In order to find out net benefit : cost ratio, the net return from individual treatments was divided by their respective cost of cultivation, which included cost of treatment also.

B : C Ratio = Net return/ Total Cost of Cultivation

In order to evaluate the effect of different treatments on vegetative growth and yield characters, the data were statistically analyzed as per Panse and Sukhatme (3).

Net Returns : Interactive effect between NPK, bio fertilizers and different plant spacing was found to be significant with respect to net returns (Table 2). The maximum net returns (₹

Table-1 : General cost of cultivation for African marigold.

S. No.	Particulars	Unit (ha ⁻¹)	Rate (Unit ⁻¹)	Cost ha ⁻¹ (Rs.)
A.	Land preparation	10 hrs (by tractor)	800	8000
	Sub total	-	-	8000
B.	Labour charges			
1.	Layout of field	15 man days	160	2400
2.				
3.	Raising of seedlings	6 man days	160	960
4.	Transplanting	13 man days	160	2080
5.	Weeding and hoeing	15 man days	160	2400
6.	Irrigation	30 man days	160	4800
7.	Drenching of fungicides	6 man days	160	960
8.	Harvesting and selling	20	160	3200
9.	Electricity	20	300	6000
10.	Miscellaneous	-	-	3240
Total				34040

Table-2 : Economics of different treatments of African marigold cultivation.

Treatments	Common cost (₹ ha ⁻¹)	Treatments cost (₹ ha ⁻¹)	Total cost (₹ ha ⁻¹)	Yield (q ha ⁻¹)	Gross return (₹ ha ⁻¹)	Net returns (₹ ha ⁻¹)	B:C ratio
F ₀ D ₁	34040	8888.5	42928.5	54.19	81279	38351	0.89
F ₀ D ₂	34040	6666.5	40706.5	77.21	115810	75103	1.84
F ₀ D ₃	34040	5000.0	39040	62.21	93310	54270	1.39
F ₁ D ₁	34040	12001.2	46041.2	74.17	111254	65213	1.42
F ₁ D ₂	34040	9779.2	43819.2	105.68	158520	114701	2.62
F ₁ D ₃	34040	8112.7	42152.7	85.15	127723	85570	2.03
F ₂ D ₁	34040	12241.2	46281.21	94.66	141985	95704	2.07
F ₂ D ₂	34040	10019.2	44059.2	134.87	202306	158247	3.59
F ₂ D ₃	34040	8352.7	42392.7	108.67	163002	120609	2.85
F ₃ D ₁	34040	13557.6	47597.6	117.21	175818	128221	2.69
F ₃ D ₂	34040	11335.6	45375.6	167.01	250514	205138	4.52
F ₃ D ₃	34040	9669.1	43709.1	134.56	201844	158135	3.62
F ₄ D ₁	34040	13797.6	47837.6	133.00	199499	151662	3.17
F ₄ D ₂	34040	11575.6	45615.6	189.50	284255	238640	5.23
F ₄ D ₃	34040	9909.1	43949.1	152.69	229030	185081	4.21
F ₅ D ₁	34040	15114.0	49154	144.89	217328	168174	3.42
F ₅ D ₂	34040	12892.0	46932	206.44	309658	262726	5.60
F ₅ D ₃	34040	11225.5	45265.5	166.33	249497	204232	4.51
F ₆ D ₁	34040	15354.0	49394	154.61	231913	182519	3.70
F ₆ D ₂	34040	13132.0	47172	220.29	330439	283267	6.00
F ₆ D ₃	34040	11465.5	45505.5	177.49	266241	220736	4.85

Sale price of African marigold yield = ₹ 15/kg,
 Urea = 5.8 kg⁻¹, SSP = 7 kg⁻¹, MOP = 16.5 kg⁻¹, PSB 120 kg⁻¹, Azotobacter/PSB = 120 kg⁻¹

283267 ha⁻¹) was recorded with combined application of 100 % RDF of NPK + *Azotobacter* + PSB + 60 x 45 cm spacng. This treatment was significantly superior over other treatment combinations except 100% RDF of NPK + 60 x 45 cm (₹ 262726 ha⁻¹) which was found at par. Treatments 100% RDF of NPK + *Azotobacter* + PSB + 60 x 45 cm plant spacing and 100% RDF of NPK + 60 x 45 cm plant spacing registered

an increase in net returns to order of 277.17 and 249.82 per cent, respectively over control. Maximum net return realization of ₹ 171862 in cabbage at plant spacing of 30 x 30 cm had also been reported by Prakash *et al.* (4).

B : C Ratio : Interactive effect between NPK, bio fertilizers and different plant spacing had significant effect on B: C ratio (Table 2.). The maximum B: C ratio (6.00) was recorded with

combined application of 100 % RDF of NPK + *Azotobacter* + PSB + 60 x 45 cm spacing. This treatment was significantly higher over other treatment combinations. However, application of 45 x 45 cm with control gave minimum B: C ratio (0.89). Treatments 100 % RDF of NPK + *Azotobacter* + PSB + 60 x 45 cm plant spacing and 100% RDF of NPK + 60 x 45 cm plant spacing registered increased B:C ratio to the tune of 226.08 and 204.34 per cent, respectively.

On the basis of the experiment as well as economic point of views, an application of bio fertilizers in combination with chemical fertilizers produced its significant impact on net returns and cost of benefits ratio. The treatments (F₆ D₂) were found economical, profitable and proved highly remunerative under the Jobner (Rajasthan, India) conditions for growing the marigold cv. 'Pusa Narangi Gaiinda', which also improved the soil health.

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Influence of Plant Growth Regulators on Quality Parameter of Guava (*Psidium guajava* L.) cv. Allahabad Safeda

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Abstract

A field experiment was conducted during the year 2017-18 and 2018-19 at Horticulture Research Farm-I, Department Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow (U.P.), India on 18-year-old guava plants, "Studies on the effect of plant growth regulators on quality parameter of guava (*Psidium guajava* L.) cv. Allahabad Safeda", revealed that T.S.S ($^{\circ}$ Brix), acidity (%), ascorbic acid (mg/100g), reducing sugar (%), non-reducing sugar (%) and total sugars (%) were maximized when foliar spray was done with CCC 1000 ppm, NAA 200 ppm, GA₃ 150 ppm.

Key words : Guava, GA₃, NAA, CCC and quality parameters

Introduction

Guava (*Psidium guajava* L.) is one of the most popular fruits grown in tropical, sub-tropical and some parts of arid regions of India. Guava belongs to the family Myrtaceae. It has been in cultivation in India since 17th century and has originated in tropical America perhaps from Mexico to Peru and introduced in India by Portuguese. It can withstand drought up to some extent but only few degrees of frost. The importance of guava is due to the fact that it is a hardy fruit and which can be grown in poor alkaline soil or poorly drained soils and pH 8.5, it can withstand to the maximum temperature at 46 $^{\circ}$ C and annual rainfall of less than 25 mm. Guava fruits are also used for preparation of jam, jelly, RTS, nectar etc. The guava bears flowers and fruits on current season growing twinges and highly cross-pollinated crop and pollination occurs through honey bees and andirona insect, fruit of guava developed from inferior ovary on exhibited double sigmoid growth curve, fruit with many seed berry, the fruit take nearly 4-5 month from dark green to yellowish green. The common guava is a diploid 2n=22, but natural and artificial triploid (2n=33) and aneuploid exist triploid generally produce seedless fruit. In northern India guava plant bears flower twice or sometimes thrice in a year. The spring flowering is called "Ambe-bahar" June or monsoon flowering is called "Mrig-Bahar" and third flowering which comes in October is called "Hast-bahar" Ambe-bahar fruit ripen from July to September and Mrig-bahar fruit ripen in from November to February, however, Hast-Bahar fruit ripen in spring season, which also known as summer season crop.

Materials and Methods

18-year-old uniform guava plants of Allahabad Safeda

cultivar planted at 6x6 m a part growing in Horticulture Research Farm-I of Babasaheb Bhimrao Ambedkar University Lucknow 226025 were taken for the investigation. T₂ GA₃ 50 ppm, T₃ GA₃ 100 ppm, T₄ GA₃ 150 ppm, T₅ GA₃ 200 ppm, T₆ NAA 50 ppm, T₇ NAA 100 ppm, T₈ NAA 150 ppm, T₉ NAA 200 ppm, T₁₀ CCC 250 ppm, T₁₁ CCC 500 ppm, T₁₂ CCC 750 ppm, T₁₃ CCC 1000 ppm along with T₁ Control (water spray). First spraying of plant growth regulators were done before flowering (first week of August) and second after fruit set (second week of September) during 2017 and 2018, respectively. The experiment was laid out in R.B.D. with three replications. The experiment was laid out in R.B.D. with three replications. Observations recorded to be T.S.S ($^{\circ}$ Brix), acidity (%), ascorbic acid (mg/100g), reducing sugar (%), non-reducing sugar (%) and total sugars (%). The data so obtained were analysed statistically.

Results and Discussion

A perusal of data presented in Table-1 shows that significant response in the maximum TSS content was observed due to treatment CCC 1000 ppm (T₁₃) followed by (8.81 $^{\circ}$ Brix) CCC 750 ppm and GA₃ 50 ppm (8.82) (T₂). while minimum TSS content was recorded in control (water spray) T₁. The TSS contents of guava fruits varied from 7.59 to 7.62 in control.

The maximum reducing sugar content (3.31 to 3.32) was obtained with foliar application GA₃ 50 (T₂) ppm, NAA 50 ppm (3.20 to 3.21) (T₆), followed by (CCC 1000 ppm (T₁₃). The minimum value (3.07 to 3.08) was found in control (T₁).

The reducing sugar contents of guava fruits varied from 2.88 to 3.91 in control. The highest non-reducing

Table-1

Treatments	TSS (%)		Acidity (%)		Ascorbic acid (mg/100g)		Reducing sugar (%)		Non-reducing sugar (%)		Total sugars (%)	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T ₁ Control (water spray)	7.59	7.62	0.510	0.514	148.60	149.30	3.07	3.08	3.01	3.02	6.08	6.10
T ₂ GA ₃ 50 ppm	8.82	8.85	0.410	0.413	156.20	156.95	3.31	3.32	3.15	3.16	6.46	6.48
T ₃ GA ₃ 100 ppm	8.25	8.26	0.430	0.433	157.50	158.20	3.21	3.22	3.04	3.06	6.25	6.28
T ₄ GA ₃ 150 ppm	8.10	8.12	0.435	0.440	158.40	159.20	3.17	3.18	3.01	3.02	6.18	6.20
T ₅ GA ₃ 200 ppm	8.00	8.02	0.440	0.443	158.60	159.40	3.15	3.17	3.00	3.01	6.15	6.18
T ₆ NAA 50 ppm	8.35	8.37	0.460	0.463	154.00	154.75	3.20	3.21	3.03	3.04	6.23	6.25
T ₇ NAA 100 ppm	8.10	8.12	0.470	0.475	156.60	157.35	3.14	3.15	2.98	3.00	6.12	6.15
T ₈ NAA 150 ppm	8.00	8.03	0.478	0.481	157.20	157.95	3.12	3.13	2.96	2.97	6.08	6.10
T ₉ NAA 200 ppm	7.96	7.96	0.480	0.484	159.80	160.60	3.10	3.11	2.94	2.95	6.04	6.06
T ₁₀ CCC 250 ppm	8.90	8.92	0.446	0.450	157.20	157.95	3.33	3.34	3.16	3.18	6.49	6.52
T ₁₁ CCC 500 ppm	8.85	8.87	0.470	0.470	159.80	160.55	3.23	3.24	3.07	3.08	6.30	6.32
T ₁₂ CCC 750 ppm	8.81	8.83	0.475	0.480	160.10	161.20	3.18	3.20	3.04	3.04	6.22	6.24
T ₁₃ CCC 1000 ppm	8.75	8.77	0.485	0.490	160.40	161.20	3.14	3.16	3.03	3.03	6.17	6.19
S.Em. ±	0.103	0.095	0.005	0.005	1.598	1.774	0.037	0.056	0.131	0.150	0.065	0.071
C.D. at 5%	0.301	0.279	0.015	0.015	4.664	5.179	0.107	0.382	0.382	0.437	0.188	0.207

sugar content (3.15 to 3.16 %) was measured with the foliar application of GA₃ 50 ppm (T₂), and CCC 250 ppm followed by NAA 50 ppm (T₆). The minimum value (3.01 to 3.02%) was found in control (T₁). The results, further, advocated that higher concentration of all treatments proved effective as compared to the lower concentrations.

The maximum total sugars content of fruit (6.49 to 6.52 %) was recorded with foliar application of CCC 230 ppm, GA₃ 50 ppm (T₂), followed by (7.08%) NAA 50 ppm (T₆). The minimum value (6.08 to 6.10 %) was found in control (T₁).

The highest ascorbic acid (160.40 to 161.40 mg/100g fruit pulp) was recorded with higher concentration of CCC 1000 ppm (T₁₃), and NAA 200 ppm (159.80 to 160.60) followed by GA₃ 200 ppm (158.60 to 159.40 mg/100g fruit pulp) ppm (T₅). The lowest (148.60 to 149.30 to 149.30 mg/100g) fruit pulp) under control (T₁).

The minimum acidity was recorded with the application GA₃ 50 ppm (0.410 to 0.413) (T₂), followed by NAA 50 ppm (T₆) and CCC 1000 ppm. However, produced significantly less acidic fruits when compared with rest of the treatments. The fruits under control gave significantly maximum control (water spray) T₁.

Conclusions

In conclusion, the quality parameters of fruit with respect T.S.S (⁰Brix), Reducing sugar, non-reducing sugar, Total sugar, Ascorbic acid and Acidity were obtained maximum

with the foliar spray of GA₃ 50 ppm (T₂), NAA 50 ppm. Therefore, separate spray NAA 50 ppm (T₆) and CCC 1000 ppm can be advocated to guava growers for serving higher yield and better of quality of fruits.

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Evaluation of Physicochemical Parameters and Cost of Natural Preservatives Containing Table Spread

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Abstract

The fat content in the diet is major source of energy and provides 9 calorie energy per gram of fat. Due to the high cost and poor spreadability of butter at low temperature, the demand for fat spreads is increasing. In this study, for the preservation of omega-3 and carotenoid- rich table spread, optimized level of natural preservatives, namely bacteriocin or MicroGARD™ were employed. The physicochemical parameters of developed table spread were analyzed during the storage. It was observed that all the parameters, i.e. colour value, aw and acidity of control table spread (CPS) and developed table spreads (SPT) decreased during the storage study. The cost for CPS and SPT were 225.60 Rs and 226.88 Rs per 200 grams, respectively.

Key words : Table spread, essential oil, MicroGARD™, potassium sorbate.

Introduction

The dietary pattern of consumers has changed and demand of foods having improved health benefits has shown an increase. Besides this, the demand of consumers is also increasing towards the healthy convenience foods containing natural ingredients. In most of the food products, fat impart creamy texture and mouth feel as well as nutty pleasant flavour. The fat-based product such as butter, cream, margarine and fat spread are the valuable product due to their unique characteristic like aroma, flavour, taste and nutritional value (Ronholt et al., 2013). The consumption of bread (75% of all household) has increased as a regular diet. With this, demand of suitable spread also increased (Deshpande and Thompkinson, 2000). Table spreads or fat spreads are the products containing fat as major source of energy that are plastic in nature, therefore, are able to spread into a thin layer over the food product such as a bread slice. The various types of spreads are available in market like butter spread, cheese spread and fruit spreads, etc. Butter is one of the most popular spreads in India and abroad among the various dairy products. However, the consumption of butter has declined in last decade due to its high cost, higher saturated fatty acids, high cholesterol, and poor spreadability at refrigerated temperatures.

Table spreads can be defined as oil-in-water type emulsion having fat content less than 15% or water-in-oil type of emulsion having fat higher than 15% (Moran, 1994). 'Dairy spreads', as the name indicates contain generally butterfat, whereas 'non-dairy spreads' contain vegetable fat. Mortensen (2009) defined the spread of milk fat as a commodity that is comparatively rich in fat and is found in the form of spreadable emulsion, mainly

the emulsion of o/w type and remains solid at 20°C. The global fat spread market is expected to grow at a CAGR of 3.5 % during 2019 to 2024 and its value is expected to reach USD 28.9 billion by 2024. During the forecast period, it is expected to grow by \$ 7.60 billion, representing a CAGR of 4.53 percent (Marketresearch, 2022). The market is predicted to grow at a rate of 5.20 percent per year (CAGR 2022-2027). In India, the growth of spread market will be US\$1,926.00 million in 2022. The market is predicted to grow annually by 6.28% (CAGR 2022-2027) (Statista, 2022). In 2021, the market of spreads sold in India was USD 446 million (Statista, 2022). Dr. Oetker India Pvt. Ltd., Cremica Food Industries Ltd., Agro Tech Foods Limited (Sundrop), Gujarat Cooperative Milk Marketing Federation Ltd., Parag Milk Foods Limited (Go), Britannia Dairy Private Limited are predominant players operating in India's spread marketplace.

These days food industries are actively involved in new product development to fulfil the requirement of consumers and to maintain their position in the market (Verma and Garg, 2002). Since fat spreads possess mild flavor and are economical, therefore their demands are increasing. Various researchers developed the dairy and non-dairy type fat spread as per the market requirement by using butter, cream (Devdhara et al., 1991), paneer and channa (Tiwari and Sachdeva, 1991), chakka and chhana (Reddy et al., 2000), skim milk powder and cheese (Prajapati, 1988), cheese and chakka (Dholu et al., 1994), Ultrafiltration retentate (Deshpande and Thompkinson, 2001), safflower oil- milk blended with buffalo milk (Deshmukh et al., 2003) and various types of vegetable oil. Further, the cost estimation is becoming important for commercialization of product. The most

important aspect considered during cost estimation of the final product included the land and building cost; plant and machinery cost; utility cost; manpower cost; expenses and raw material cost; packaging material cost; and transportation and marketing cost; etc. In the market, most of the customers prefer to buy a product having low cost and high quality. It is important to develop a product which is economical to all. For the estimation of the cost, project evaluation, price of ingredient, design and size of plant, process optimization and other techno-economic studies are the important aspects. Based on the process design principle, material and energy balance is used for determination of raw material and utility cost while the equipment cost is estimated based on equipment size and processing time. The labour cost is predicted through the study of the equipment flow sheet and type of equipments used (Marouli and Maroulis, 2005; Roy et al., 2018). The objective of this study was to analyse the physicochemical parameters and cost of the omega-3 rich and carotenoids containing table spread previously optimized in our laboratory containing natural preservatives.

Materials and Methods

Physico-chemical Analysis

Estimation of Colour value : A Tristimulus spectrophotometer Hunter Lab model Colour Flex® (Mini Scan XE plus, Hunter Associates Laboratory Inc. Reston, Virginia, U.S.A.) along with the software (version 4.10) was used to measure the colour of table spread and the results were expressed in terms of CIE LAB system (L^* , a^* , and b^*).

Estimation of Water Activity : The water activity of table spread was determined by AQUA Lab, Decagon Devices, WA, USA. Firstly, the instrument was calibrated by placing dry charcoal into the sample tray to absorb the internal moisture of the chamber. The table spread was filled into the sample tray to prevent moisture gain. The tray was placed in the instrument and the chamber was sealed for measurement. The reading displayed on the display of the instrument was recorded after measurement.

Estimation of pH : Ten grams of table spread was mixed with 10 mL of distilled water and a slurry was prepared thereof. The pH of slurry was determined at 25°C using microprocessor-controlled pH analyzer with combined glass electrode. The pH meter was first calibrated at pH 9.20 and 4.0 and standardized at pH 7.0 using buffer solutions.

Estimation of titratable acidity : About 10 g of the table spread was accurately weighed in a 250 mL conical flask. It was followed by addition of 30 mL warm distilled water and 1 mL of phenolphthalein indicator (0.5 g phenolphthalein was dissolved in 100 mL of 50% ethyl alcohol).

The contents were properly mixed and titrated against standard 0.1N NaOH solution. A blank was run with taking all chemicals except sample in another conical flask for comparison of colour.

Calculation

$$\text{Titratable acidity (\% lactic acid)} = \frac{9VN}{W}$$

Where,

V - Volume of standard NaOH required for titration

N - Normality of Standard NaOH solution

W - Weight of sample taken for test

Cost estimation : The cost estimation for commercialization of table spread is highly reliant on the evaluation of techno-economic feasibilities. The manufacturing cost of table spread was estimated as per the method and procedure suggested by Prajapati et al. (1991). The cost of different components used in the manufacture of table spread was taken during the research work from August 2019 to June 2020.

Statistical analysis : All the experiments were carried out in triplicate during storage study. Results are expressed as mean $\pm$ standard deviation (SD). The data obtained during storage were analyzed statistically using one-way ANOVA and two-way ANOVA method in IBM SPSS Statistics 25 software as function of multiple comparison Tukey Test ($p < 0.05$).

Result and Discussion

Evaluation of physicochemical properties of developed table spread (SPT) and control table spread (CPS) during storage : Physicochemical characteristics of the product are essential to be determined as they signify the changes in the physical and chemical characteristic of product. The consumer's acceptability is strongly affected by the changes in the physical characteristic of the product.

Colour value

L^* value : L^* value is a measure of lightness and darkness of a product and its range vary from 0 to 100, where L^* value of 100 indicates the completely white body and 0 value indicates completely black body.

It can be deduced from Table 1 that a significant difference ($p < 0.05$) was obtained between the CPS (which contained potassium sorbate as the preservative) and SPT (which contained optimized combination of thyme essential oil and MicroGARDTM-100 as preservative) during the entire period of storage study. The L^* value of developed table spread (78.96 ± 0.04 for SPT) was significantly ($p < 0.05$) higher than CPS

(78.52±0.08) at 0th month, which indicates darker colour/intensity in the developed table spread (Table 1). This could be due to the presence of essential oil which possess darker colour and MicroGARDTM-1 as preservative in developed table spread. It can be further deduced from Table 1 that L* value decreased during storage of all samples, this decrease was non-significantly ($P>0.05$) different in CPS for 1st and 2nd month and for SPT, it was non-significant ($P>0.05$) during 0th and 1st month of storage. The values as obtained after the 2 months of storage were 78.07±0.07 and 78.19±0.07, for CPS and SPT, respectively which indicate the decreasing lightness of the product during storage study (Table 1). From Table 2, 78.52±0.08 value of L* was obtained at the 0th month and 77.64±0.06 value was obtained at 4th month for CPS. Further, since SPT spoiled after 2 months of storage, while CPS spoiled after 4 months of storage on account of microbial spoilage (results not reported here), therefore all the analysis of CPS were carried out till 4 months of storage, while for SPT, the study was terminated after 2 months of storage. From Table 2, it can be observed that the L* value significantly ($p<0.05$) decreased during storage which indicate the decreasing lightness during the storage of CPS. Gradual decrease of L* value of table spread containing sesame oil was observed by Mijena (2015) over the progression of storage period. Kamble (2019) also obtained the same trend for L* value.

Table-1 : Changes in physicochemical parameters (colour value) of CPS and developed table spread during storage study.

Parameters	Months	CPS	SPT
L*	0	78.52±0.08 ^{bp}	78.96±0.04 ^{ap}
	1	78.09±0.05 ^{bq}	78.54±0.08 ^{ap}
	2	78.07±0.07 ^{bq}	78.19±0.07 ^{aq}
a*	0	4.74±0.16 ^{aq}	4.80±0.16 ^{aq}
	1	4.96±0.16 ^{ap}	5.01±0.17 ^{ap}
	2	5.08±0.18 ^{ap}	5.11±0.17 ^{ap}
b*	0	30.99±1.06 ^{ap}	31.30±1.07 ^{ap}
	1	30.92±1.05 ^{ap}	30.81±1.04 ^{ap}
	2	30.85±1.05 ^{ap}	30.67±1.04 ^{ap}
Water activity	0	0.979±0.002 ^{ap}	0.981±0.002 ^{ap}
	1	0.978±0.002 ^{ap}	0.979±0.002 ^{ap}
	2	0.974±0.002 ^{aq}	0.976±0.002 ^{aq}
pH	0	5.63±0.03 ^{bp}	5.72±0.03 ^{ap}
	1	5.45±0.04 ^{aq}	5.39±0.03 ^{bq}
	2	5.12±0.04 ^{ar}	4.91±0.04 ^{br}
Acidity	0	0.46±0.02 ^{ar}	0.44±0.01 ^{ar}
	1	0.48±0.02 ^{aq}	0.49±0.02 ^{aq}
	2	0.51±0.02 ^{ap}	0.53±0.02 ^{ap}

CD (P = .05) L*: 0.06; a*: 0.12; aw: 0.002; pH: 0.02; Acidity: 0.01

a-b Mean value with different superscripts are significantly different with each other in a row ($p<0.05$) for a particular parameter. p-r Mean value with different superscripts are significantly different with each other in a column ($p<0.05$) for a particular parameter.

a* Value : The a* value indicates redness and greenness in product and its value ranges from +60 to -60. The positive value represents redness of the sample, while a negative value represents greenness of product. It is evident from Table 1 that non-significant difference ($p>0.05$) was obtained between the CPS and developed table spread throughout the storage study. The a* value of developed table spread (4.80±0.16 for SPT, respectively) was non-significantly ($p>0.05$) higher than that of CPS (4.74±0.16) at 0th month, which indicates that the developed table spread has higher redness ting than CPS (Table 1). From Table 1, it can be observed that a* value increased significantly ($P<0.05$) during storage for all the samples. The value of a* obtained after the 2 months of storage for CPS and SPT were 5.08±0.18 and 5.11±0.17, respectively (Table 1). From Table 2, 4.74±0.16 a* value was obtained at the 0th month and 5.64±0.19 value was obtained after 4th month for CPS. From Table 2, it can be observed that a* value significantly increased during storage which indicate the increasing reddish tinge during the storage of CPS. Chen (1995) stated that the degradation of carotenoids increases a* values of products during storage. Kamble (2019) also obtained the same trend for a* value.

b* value : The b* value describes the yellowness and blueness of the product and it falls in the range of -60 to +60. The positive value represents yellowness of the sample, while a negative value represents blueness of the product. From Table 1, the non-significant difference ($p>0.05$) was obtained between CPS and SPT throughout the storage study. The b* value of developed table spread (31.30±1.07 for SPT) was non-significantly ($p>0.05$) higher than that of CPS (30.99±1.06) at 0th month, which indicates that developed product has higher yellowness than developed table spread. From Table 1, it can be revealed that the b* value non-significantly ($p>0.05$) decreased during entire period of storage for all the samples. The b* value obtained after 2 months of storage for CPS and SPT was 30.85±1.05 and 30.67±1.04, respectively (Table 1). From Table 2, for CPS, 30.99±1.06 b* value was obtained at the 0th month and 30.14±1.02 value was obtained at 4th month of storage. From Table 2, it can be observed that the b* value significantly decreased during storage which indicate increasing yellowness in CPS during the storage. The findings of present study support hypothesis of Munsch and Simard, (1983), who stated that degradation of carotenoid during processing of foods and storage decreases the b* values of foods.

Water activity (aw) : It is important to study aw of table spread kind of product during the storage period as it is related to microbial contamination, chemical and

Table-2 : Physico-chemicals attributes of CPS during storage

Months	Colours vale			Water activity	pH	Acidity
	L*	a*	b*			
0	78.52±0.08 ^p	4.74±0.16 ^t	30.99±1.06 ^p	0.979±0.002 ^p	5.63±0.03 ^p	0.46±0.02 ^s
1	78.09±0.05 ^q	4.96±0.16 ^s	30.92±1.05 ^p	0.878±0.108 ^q	5.45±0.04 ^q	0.48±0.02 ^s
2	78.07±0.07 ^q	5.08±0.18 ^r	30.85±1.05 ^p	0.974±0.002 ^r	5.12±0.04 ^r	0.51±0.02 ^r
3	77.88±0.05 ^r	5.31±0.19 ^q	30.31±1.03 ^p	0.969±0.002 ^r	4.95±0.04 ^s	0.55±0.02 ^q
4	77.64±0.06 ^s	5.64±0.19 ^p	30.14±1.02 ^p	0.965±0.002 ^r	4.81±0.03 ^t	0.58±0.02 ^p

CD (P = .05) L*: 0.18; a*:0.21; Water activity:0.057; pH: 0.04, acidity: 0.02 NS: b*

Table-3 : Requirement and Cost of Raw Materials for CPS.

Sr. No.	Item	Requirement (kg)		Rate (Rs/kg)	Annual cost (Rs.)
		Daily	Annual		
1.	Pectinase	2.25	821.25	387998	318643357.5
2.	Cellulase	1.58	576.7	248086	143071196.2
3.	Pomace	450	164250	3	492750
4.	Butter	875	319375	350	111781250
5.	Flaxseed oil	450	164250	332	54531000
6.	Salt	20	7300	15	109500
7.	Tri sodium citrate	6	2190	130	284700
8.	Seasoning	2.1	766.5	1750	1341375
9.	WPC	100	36500	400	14600000
10.	Citric acid	2.4	876	90	78840
11.	Sugar	15	5475	42	229950
12.	Guar gum	6	2190	730	1598700
13.	Glycerol monostearate	6	2190	150	328500
14.	Potassium sorbate#	2	730	450	328500
15.	MicroGARDTM*	15	5475	100	547500
16.	Essential oil*	10	3650	1000	3650000
Total (CPS)					647419618.7
Total (SPT)					651288618.7

Added only in CPS

* Added only in SPT

Table-4 : Operating Labour and Supervision Cost.

Sr. No.	Staff	Nos.	Monthly salary	Monthly cost (Total Rs.)	Annual cost (Rs)
1.	Labors	5	7000	35000	420000
2.	Skilled workers	4	9000	36000	432000
3.	Mechanics/electrician	1	9000	9000	108000
4.	Boiler attendants	2	11000	22000	264000
5.	Lab analysts	2	18000	36000	432000
6.	Lab attendants	1	7000	7000	84000
7.	Section incharges	2	15000	30000	360000
8.	Shift supervisors	3	11000	33000	396000
Total					2496000

enzymatic spoilage (Mossel, 2012). Ayrest (1969) reported the growth of *Aspergillus* spp. at 0.85 aw at 5°. It can be observed from Table 1 that the non-significant difference ($P>0.05$) was obtained between CPS and SPT throughout the storage study. The aw of developed table spread (0.981 ± 0.002 for SPT) was non-significantly

($p>0.05$) higher than that of CPS (0.979 ± 0.002) at 0th month (Table 1). Further, it was observed that aw was non-significantly ($p>0.05$) decreased till 1st month of storage for CPS and SPT. Also, the decrease was significant ($p<0.05$) from 1st to 2nd month of storage for all the samples. The value of aw obtained after the 2 months

Table-5 : Charges on Power and Utilities.

Sr. No.	Item	Quantity required		Rate (Rs.)	Annual cost (Rs.)
		Daily	Annual		
1.	Steam	1800 kg	657000	300/1000 kg	197100
2.	Refrigeration	2000500 kJ	730182500	15/100000 kJ	109527.375
3.	Electricity	550 unit	200750	5/unit	1003750
4.	Water	30000 lit	10950000	2/1000 lit	21900
				Total	1332277.375

Table-6 : Initial Costs and Depreciation (by straight line, method) on plant, Equipment and Machinery.

Sr. No.	Item	Nos.	Rate (Rs.)	Initial value (Rs.)	Scrap value (Rs.)	Life (yrs)	Annual depreciation
1.	Storage tank	2	350000	700000	70000	17	37058.82
2.	High speed mixture	2	400000	800000	80000	10	72000
3.	Batch pasteurizer	2	300000	600000	60000	15	36000
4.	Packaging unit	1	300000	600000	60000	15	36000
5.	Weighing balance	1	25000	25000	2500	20	1125
6.	Insulated van	1	500000	500000	50000	10	45000
7.	Boiler and steam system	1	150000	150000	15000	30	4500
8.	Cold storage and refrigeration System	1	500000	500000	50000	17	26470.59
9.	Sanitary pump	4	16000	32000	3200	12	2400
10.	Homogenizer	2	300000	600000	60000	15	36000
11.	High shear mixture	1	450000	450000	45000	10	40500
12.	Pasteurized water tank	1	150000	150000	15000	15	9000
13.	Weighing balance	1	20000	20000	2000	17	1058.824
14.	Miscellaneous		500000	500000	50000	15	30000
Total				5627000			347113.2353

Table-7 : Administrative Expenses.

Sr. No.	Staff	Nos.	Monthly salary	Monthly cost (Total Rs.)	Annual cost (Rs)
1.	Store Keepers	1	9000	9000	108000
2.	Accountant	1	9000	9000	108000
3.	Drivers	1	9000	9000	108000
Total					324000

of storage for CPS and SPT were 0.974 ± 0.002 and 0.976 ± 0.002 , respectively (Table 1). From Table 2, 0.979 ± 0.002 value of water activity was obtained at the 0th month and 0.965 ± 0.002 value was obtained at 4th month for CPS. Thus, it can be inferred that the a_w of CPS and SPT individually decreased during entire period of storage for all the samples. The obtained decrease in water activity could be due to oozing of some oil from the table spreads during storage.

pH : Kosikowski, (1982) reported that the growth of microorganism is inhibited below pH of 5.2. Velez and Leal, (1973) reported that the unsalted or salted margarine gave good stability in the pH range of 4-5 and 5-6, respectively. From Table 1, it can be observed that the significant difference ($p < 0.05$) was obtained between CPS and developed table spread i.e. SPT during the entire period of storage study. The pH of developed table

spread (5.72 ± 0.03 for SPT) was significantly ($p < 0.05$) higher than CPS (5.63 ± 0.03) at 0th month. It can be seen from Table 1 that the pH of all samples decreased significantly ($P < 0.05$) during entire period of storage. The value of pH as obtained after the 2 months of storage for CPS and SPT was 5.12 ± 0.04 and 4.91 ± 0.04 , respectively (Table 1). From Table 2, 5.63 ± 0.03 pH was obtained at the 0th month and 4.81 ± 0.03 value was obtained at 4th month for CPS. From Fig 2, it can be observed that the pH was significantly decreased during storage. These observations are in accordance with the findings of Sethi (2017) who used thyme oil as natural preservative, and Sharma (2007) who used MicroGARDTM as natural preservative and both reported that the pH value of spread constantly decreased during the storage period. Kamble, (2019) (used potassium sorbate as preservative) stated that the pH of product decreased during storage. Kharb (2007) and Kumar (2011) observed the continuous steady

Table-8 : Detailed Break-up Cost of CPS (Capacity 2 tonnes/day).

Sr. No.	Cost component	Rates	Rs. Per annum
A	MANUFACTURING COST		
A	Direct product cost		
I.	Raw material	Table 3	647419618.70
II.	Packaging cost (200g jar) 10000 jar/day 8 Rs/ jar		29200000
III.	Operating labour and operation supervisor	Table 5	2496000
IV.	Power and utilities	Table 6	1332277.38
V.	Maintenance and repairs	5% of the fixed Capital	363451.25
VI.	Operating supplies	15 % of maintenance and repairs	54517.69
VII.	Laboratory charges	0.2% of cost of raw Materials	1294839.24
VIII.	Cleaning and sanitizing material	0.1% of cost of raw Materials	647419.62
	Subtotal (a)		682808123.90
B	Fixed charges		
I.	Depreciation on capital Investment	Table 7	347113.24
II.	Insurance and taxes	2% of the capital Investment	145380.50
III.	Plant overheads	60% of operating Labor and supervision maintenance and Repairs	1715670.75
	Subtotal (b)		2208164.48
	Manufacturing cost (a + b)		685016288.40
B	GENERAL EXPENSES		
I.	Administrative expenses	Table 8	324000
II.	Interest on capital	12% of the fixed Capital	872283
	Sub total		1196283
	Product cost (A + B)		686212571.40
C	MARKETING AND DISTRIBUTION		
	20% product cost		137242514.30
	TOTAL COST (A+B+C)		823455085.70
	Total cost per 200 g		225.60

Table-9 : Detailed Break-up Coast of SPT (Capacity 2 tonnes/day)

Sr. No.	Cost component	Rates	Rs. Per annum
A	MANUFACTURING COST		
A	Direct product cost		
I.	Raw material	Table 4	651288618.70
II.	Packaging cost (200g jar) 10000 jar/day 8 Rs/ jar		29200000
III.	Operating labour and operation supervisor	Table 5	2496000
IV.	Power and utilities	Table 6	1332277.38
V.	Maintenance and repairs	5% of the fixed Capital	363451.25
VI.	Operating supplies	15 % of maintenance and repairs	54517.69
VII.	Laboratory charges	0.2% of cost of raw Materials	1302577.24
VIII.	Cleaning and sanitizing material	0.1% of cost of raw Materials	651288.62
	Subtotal (a)		686688730.90
B	Fixed charges		
I.	Depreciation on capital investment	Table 7	347113.24
II.	Insurance and taxes	2% of the capital Investment	145380.50
III.	Plant overheads	60% of operating Labor and supervision maintenance and Repairs	1715670.75
	Subtotal (b)		2208164.49
	Manufacturing cost (a + b)		688896895.40
B	GENERAL EXPENSES		
I.	Administrative expenses	Table 8	324000
II.	Interest on capital	12% of the fixed Capital	872283
	Sub total		1196283
	Product cost (A + B)		690093178.40
C	MARKETING AND DISTRIBUTION		
	20% product cost		138018635.70
	TOTAL COST (A+B+C)		828111814.10
	Total cost per 200 g		226.88

decrease in pH value of table spread during storage due to increase in bacterial count in table spread.

Acidity : Increase in acidity affect the flavor of fat spread and influences various biochemical changes which further causes the growth of microorganism. As per Chrysam, (1985), the undissociated acids are one of the factors that are responsible for the preservative effect and microbial growth in a product. From Table 1, it can be deduced that the non-significant difference was obtained between the CPS and SPT during the entire period of storage study. The acidity of developed table spread (0.44 ± 0.01 for SPT) was non-significantly ($p > 0.05$) lower than CPS (0.46 ± 0.02) at 0th month (Table 1). From Table 1, it can be seen that acidity of all samples significantly increased during the entire period of storage study. After the 2 months of storage, the value of acidity as obtained for CPS and SPT were 0.51 ± 0.02 and 0.53 ± 0.02 , respectively (Table 1). From Table 2, it is evident that $0.46 \pm 0.02\%$ acidity was obtained at the 0th month and $0.58 \pm 0.02\%$ value was obtained at 4th month for CPS. From Table 2, it is deduced that the acidity of CPS significantly increased during storage. These observations are in accordance with the findings of Sethi (2017) and Sharma (2007) who reported that the acidity of spread increased during the storage period. Kamble (2019) also stated that the acidity of product increased during storage.

Determination of cost of production of control and developed spread : The manufacturing cost of table spread was estimated as per the method suggested by Prajapati et al., (1991). During the estimation of cost, price of ingredient, design and size of plant, process optimization and other equipment and machines are the important aspects. Based on the process design principle, material and energy balance is used for determination of raw material and utility cost, while the equipment cost is estimated based on equipment size and processing time. The labour cost is predicted through the study of the equipment flow sheet and type of equipments used (Marouli and Maroulis, 2005; Roy et al., 2018). In order to get a reasonable realistic production cost of the product, certain assumptions were made.

Basic Assumptions for Cost Estimation : The basic assumption made for cost estimation of table spreads (both control and developed) were :

- (a) Processing plant having manufacturing capacity of 2 tonnes per day
- (b) The plant would run in three shifts and for 365 days a year
- (c) All the ingredients required for production would be purchased from open market.

(d) The cold storage capacity is six tonnes and the product is dispatched for sale every alternate day.

(e) The product would be transported from the plant to the sales booths in insulated vans.

Detailed break-up of Total Product Cost : The break-up of total cost of production is divided into fixed cost, building and equipment's.

Fixed Cost : These consisted of the cost on land, building, plant and machinery

Land : An area of 700 m^2 (10 times the plant area) was estimated to cost Rs. 4,20,000 (assuming Rs. $600/\text{m}^2$).

Building : The construction cost of the plant (200 m^2) was computed to be Rs. 8,00,000 (@ $4000/\text{m}^2$).

Equipment : As indicated in Table 7, the cost of equipment was worked out to be Rs. 56,27,000. The cost of installation @ 7.5 per cent of the equipment cost would be Rs. 4,22,025. Thus, the cost of the installed equipment with total annual depreciation would be Rs. 60,49,025 and Rs. 3,47,113.23, respectively.

Therefore, total fixed costs (Rs.) = $420000 + 800000 + 6049025 = 7269025$

The calculated fixed cost for spread was Rs. 72,69,025/-.

Requirement and Cost of Raw material : Various ingredients were used for preparation of CPS and SPT table spread as shown in Table 3. The requirement of individual ingredient for preparation of CPS and SPT is given in Table 3 as per the daily and annual requirement or the cost on the daily and annually basis.

The annual cost of the raw material was estimated 64,74,19,618.7 Rs and 65,12,88,618.7 Rs for CPS and SPT, respectively.

Operating Labor and Supervision Cost : Skilled labor and worker are required for manufacturing high quality product and for proper functioning of plant with healthy environment and high-quality production. It is essential to have minimum number of staff in each section as per requirement for peaceful and efficient running of the plant. The minimum staff required for running a plant for manufacturing of table spread and their monthly and annually salary is given in Table-4.

Power and Utilities : Steam, refrigeration, electricity and water are essential for running a plant. Electricity is required for running electric machines and equipment's, refrigerant is required for cold storage and for cooling of the water. At the industrial level, steam is used for heating purpose like to heat required for pasteurization, sterilization and heating of water which is used for

processing, CIP and cleaning purpose etc. The rate and annual cost of the essential utilities is provided in Table 5.

Equipment and Machinery : The equipment and machineries are required for production of product which include the weighing balance, storage tank, high speed mixture, pasteurizer, boiler, cold storage, sanitary pump, homogenizer, high shear mixture, pasteurized water tank etc. The list of required machineries and equipment with their price and annual cost are given in Table 6.

Administrative expenses : In the industry, administrative staff is required to maintain all record and for proper running of the plant. The cost of salary per month and annually of the administrative staff is given in Table 7.

Final product cost : The final product cost is the sum of all the expenses and also it is varying from product to product and industry to industry. The final cost of product influenced by many factors which can be divided into two categories such as internal factor and external factor. Internal factor means organizational factor, marketing strategy, cost of the product and objective of firm, etc., while the external factor include demand and supply, elasticity of demand, competition in market, suppliers, economic condition of firm, buyers and government. The final cost/ total cost of the product is the sum of manufacturing cost, general expenses and marketing & distribution cost (20% of the product cost). For calculating final price of the product, the total cost is divided by 365 day for getting the per day cost and the per day cost is divided by total production for getting the per kilogram (kg) price of product. Finally, the price of per unit selling in market or retail pack is calculated by multiplying or dividing the quantity of the product with price of per kg of product, as the case may be. The final price calculation and method is given in Table 8 and Table 9 for CPS and SPT, respectively. The price of 200g spread were obtained 225.60 Rs and 226.88 Rs for CPS and SPT, respectively.

Conclusions

The physicochemical attributes were analyzed during the storage study of the product. A significant difference ($p < 0.05$) was obtained for L^* value and pH, while non-significant difference ($p > 0.05$) obtained for a^* , b^* , water activity and acidity of CPS and SPT during the entire storage study. It can be deduced from the study that all the parameters decreased during the storage study. The study of SPT was terminated after 60 days due to the spoilage of developed product and the study of CPS continued until it was spoiled. The final price of the product depends on various factors such as cost of raw material, utility cost, break down and maintenance cost, labor cost, marketing strategy and market etc. The final price of table

spread was estimated at ₹ 225.60 and ₹ 226.88/- per 200 grams for CPS and SPT, respectively.

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Effect of different dates of sowing on growth and yield attributes of different cultivars of wheat (*Triticum aestivum* L.)

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Abstract

The present study was conducted at the student research farm Nawabganj of C.S. Azad University of agriculture and technology, Kanpur to study the effect of different dates of sowing on growth and yield attributes of different cultivars of Wheat (*Triticum aestivum* L.) During Rabi season 2019-20. The experiment was laid out on 12 treatments in Split Plot Design with three replications. The experiment consists of four dates of sowing $D_1=10^{\text{th}}$ November, $D_2=25^{\text{th}}$ November, $D_3=10^{\text{th}}$ December and $D_4=25^{\text{th}}$ December. The varieties used were $V_1=K-1006$, $V_2=K-607$ & $V_3=K-9423$. Sowing dates and varieties both significantly affected the plant height, number of tillers, Number of spikelets per spike, test weight, straw yield and grain yield. In case of sowing dates significantly maximum grain yield (47.10 q ha^{-1}) was obtained when crop was sown on 25th November (D_2) against the minimum grain yield (43.38 q ha^{-1}) in sowing date i.e. 25th December (D_4). Among of varieties K-1006 (V_1) gave significantly maximum yield (43.38 q ha^{-1}) while minimum yield (42.22 q ha^{-1}) was obtained by K-9423 (V_3).

Key words : Sowing dates, varieties, growth, yield, Kanpur

Introduction

Wheat (*Triticum aestivum* L.) is the world's largest cultivated cereal crop, which belongs to family Poaceae and genus *Triticum*. Because of the acreage it occupies, productivity and its highly adoptability to different agro-climatic and soil conditions it is known as "King of Cereals". Wheat cultivation has also been a symbol of green revolution, self-sufficiency in food and sustained production (Alam *et al.*, 2013). The increase in temperature by $1-3^{\circ}\text{C}$ is likely to advance the optimum sowing time by 5-8 days per degree rise in temperature. However, this advancement is less in relatively cool regions (Kalra *et al.*, 2008) and even this abnormal increase in temperature for a period of one day at grain formation and filling stages can result in large grain losses (Alexander *et al.*, 2010). The total area occupied by wheat in the world is 215.29 million hectares with production of 763.93 million tonnes and productivity is 3390 Kg/ha^{-1} annually. Sowing time governs the Phenological development, yield and effective conversion of biomass into economic yield in wheat. Timely sowing of wheat provides optimum growing period for the crop growth which can accumulate more biomass and finally results in higher grain and biological yield.

Materials and Methods

The field experiment entitled "Studies on the effect of date of sowing and genotypes of wheat (*Triticum aestivum* L.) in relation to environment" was conducted during *rabi* season of 2019-20.

Experimental site and location : The field experiment was conducted on wheat crop during Rabi season 2019-20 at crop research farm Nawabganj, C.S. Azad university of Agriculture and Technology, Kanpur. The farm is situated in the main campus of university which lies between latitude of $25^{\circ} 26'$ to $26^{\circ} 58'$ N and longitude $79^{\circ} 31'$ to $80^{\circ} 34'$ E. Kanpur is situated at an elevation of 126.3 meter from the mean sea level and falls in the Indo - Gangetic plains of Uttar Pradesh. The field selected for experiment was field no 36 it is leveled and has homogenous fertility with irrigation facility of a tube well. The soil of experimental field was sandy loam in texture and neutral in pH. The climate of Kanpur is sub-tropical, semi-arid with hot dry summer and severe cold in winter. Maximum temperature during summer reaches up to 38°C , while during winter it fall up to 4°C . The total rainfall received 177.5 mm during crop growing period. The atmospheric temperature was also observed normal during growth period of the crop. Maximum temperature ranging from 13°C to 38°C attained at complete maturity of crop which favors the early harvesting of crop. The field was cleaned & prepared properly to carry out wheat sowing. Only one pre-sowing irrigation was applied and then the whole field was prepared by two ploughings with harrow followed by cultivator and planking on 10th November (first sowing date). For the rest sowing dates the field was ploughed on 25th November, 10th December and 25th December after application of pre-sowing irrigations, respectively for second, third and fourth sowings varieties as per treatments were sown at the rate of 100 kg seed per hectare. The seed was sown

by using pora method of sowing in rows having 22.5 cm distance from each other irrespective to sowing dates. The wheat crop varieties were sown in rows at 22.5 cm as per treatment scheduled. Gap filling was carried out after 15 days of sowing while thinning operation was carried out to facilitate optimum plant population. Fertilizer (NPK) was applied based on recommended dose. Nitrogen was applied at the rate of 150 kg ha⁻¹ in two splits i.e. ½ at sowing and ½ at first irrigation while full dose of Phosphorus (P₂O₅) and Potassium (K₂O) were applied at the time of sowing at the rate of 60 kg ha⁻¹ each. The crop was harvested manually on April 18, April 20, April 22 and April 25, 2019 for 10th November, 25th November, 10th December and 25th December sowings, respectively. After sun drying bundle weight was taken and threshing was carried out on April 27, 2019. Yield of all the plots was threshed separately with thresher and grain weight of each plot was recorded.

The observations were recorded on five randomly selected competitive plants in each replication for all the characters except for days to 50% flowering and days to maturity, which were recorded on plot basis. The data was recorded for following traits: pre-harvesting observations like emergence, plant height at different growing stages viz, 30, 60, 90 days after sowing (DAS), number of tillers per plant at different stages 40 & 60 days after sowing (DAS). Post-harvest observations like length of spike (cm), effective tillers, number of grains/spike, test weight (gm.), grain yield (q/ha), straw yield (q/ha), harvest index (%) and benefit cost ratio was calculated.

Results and Discussion

Effect of sowing dates and variety : Yield of wheat crop is directly related to number of effective tillers along with other yield attributes. Higher the number of effective tillers more the spike density and more will be the crop yield. In current investigation 25th December sown crop being at par with 25th November resulted in significantly higher number of effective tillers as compared to 10th November and 25th December sowings (Table 1.1). Higher number of effective tillers with 25th November sowing might be due to favourable climatic condition which prolonged vegetative period and resulted in more interception of solar radiation which affected the number of tillers positively, higher the total tillers more the spike density and more will be the effective tillers. Also, it could be due to longer reproductive stage which affected positively the translocation of assimilated photosynthates from source (leaves and stalk) to sink (grain) which caused the plant to produce viable pollen which affected directly grain set up which is in link with elongation and viability of the spike. The results are in line with Kamrozzaman *et al.* (2016). Among the varieties, K-607 recorded maximum effective

tillers which was at par with K-1006 but significantly higher as compared to rest of the varieties which was due to the genetic background of the varieties and the conditions to which the crop is exposed during growth and also it could be due to higher LAI of the variety which provided better source sink relationship. Spike length determines the availability of grains in spike which affects the final yield of the crop. Significantly higher spike length was recorded in 25th November sowing as compared to rest of sowings (Table 1.1). Reduction in spike length with sowings beyond 25th December might be due to prevailing of higher temperature which shorten vegetative and reproductive phases, forced crop to complete its life span earlier which hasten senescence of leaves and flag leaf (responsible for solar radiation interception) resulting in inadequate assimilation absorption and translocation through source for development of reproductive organs. The results are supported by Baloch *et al.* (2010), who reported that early sown crop produced maximum spike length than delayed sown crops. Variety K-9423 produced significantly longer spike than K-1006 and K-607 but being with rest of varieties. Variation in spike length among varieties could be due to genetic makeup and somehow environment related. In case of number of grain per spike, significantly higher number of grains per spike was recorded with 10th December sowing as compared to 25th December and 10th November sowings but it was at par with 25th November sowing (Table 4.19). It might be due to availability of suitable temperature during anthesis stage (fertilization) which resulted in viable pollens and longer grain filling period (translocation of assimilates from source to sink) which ultimately induced production of higher grains per spike. The result was supported by Baloch *et al.* (2012) who reported higher number of grains per spike with earlier sown crop. Maximum number of grains per spike was observed with variety K-9423 which might be due to genetic makeup of the variety, respiratory losses and it could be due to short grain filling period, reduced grain filling rate or combined effect of both which ultimately resulted in reduced grain Test weight determining the yield contribution of individual grain as well as quality appearance of grain. Sowing on 10th December resulted in significantly higher test weight as compared to rest of the sowings (Table 1.1). Reduction in test weight beyond 10th November sowing might be due to prevailing of higher temperature and hot winds during grain filling period which resulted in faster senescence of leaves, poor assimilate synthesis, poor photosynthetic translocation to developing grain and greater size and shriveled grains. The results are attributed to those of Spink *et al.* (2000). Among the varieties, maximum test weight was recorded with K-1006 which was at par with K-9423 but significantly higher than rest of varieties which

Table-1 : Effect of sowing dates and wheat varieties on yield attributes.

Treatments	Effective tillers/m ⁻² (No)	Spike length (cm)	Grains/spike (No)	Test weight (g)
Sowing dates				
10th November	309.88	9.71	48.44	38.11
25th November	399.10	10.05	51.88	39.11
10th December	378.66	9.90	52.44	39.23
25th December	321.88	9.27	48.22	38.54
SEm ±	1.65	0.104	0.48	0.25
CD at 5%	5.72	0.35	1.67	NS
Varieties				
K-1006	359.32	9.52	50.33	39.00
K-607	348.83	9.12	48.66	38.23
K-9423	348.99	10.55	51.75	39.017
SEm ±	1.44	0.14	0.30	0.13
CD at 5%	4.32	0.42	0.91	0.39

Table-2 : Effect of sowing dates and wheat varieties on yields and harvest index.

Treatments	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Harvest index (%)
Sowing dates			
10th November	45.35	65.63	40.74
25th November	47.10	66.71	41.30
10th December	45.99	66.58	40.85
25th December	43.38	65.85	39.77
SEm ±	0.48	0.63	0.32
CD at 5%	1.66	NS	NS
Varieties			
K-1006	48.38	69.27	41.08
K-607	45.76	67.62	40.32
K-9423	42.22	61.68	40.60
SEm ±	0.44	0.60	0.29
CD at 5%	1.32	1.80	NS

might be due to its genetic background. The grain yield is the sum total of various yield contributing factors controlled both genetically and environmentally factors (Shirpurkar *et al.*, 2008). In current investigation 25th November sown crop resulted in higher grain yield as compared to 10th November, 10th December and 25th December sowings (Table 4.23). The higher grain yield with 25th November sowing attributed to suitable temperature during reproductive phase which resulted in viable pollens, prolonged grain filling period, more interception of light and translocation of photosynthates to the sink (grain) due to higher leaf area index, higher test weight and also could be due to higher number of effective tillers. These results are in line with those of Laghari *et al.* (2012), who found that early sown wheat produces higher grain yield as compared to late sowings. Variety HI 1544 being at par with HD 3086 produced higher yield than rest of varieties which might be due to higher leaf area index, higher number of effective tillers, and grater test weight as compared to other varieties. Higher straw yield was recorded with 25th December sowing which was at par with 25th November sown crop but it was significantly higher than rest of sowings (Table 4.23). Higher straw

yield with November sown crops could be attributed with higher in taller plant, higher number of tillers and higher dry matter accumulation. Baloch *et al.* (2010) reported higher straw yield with early sown crop. Variety K-1006 resulted in significantly higher straw yield than K-607 and K-9423 but at par with rest of the varieties which might be due to its genetic makeup and it can be reflected to higher dry matter accumulation in the variety. 25th November sown crop resulted in higher biological yield as compared to 10th November and 25th December sowings (Table 4.23). Higher biological yield with November sowings was attributed to availability of optimum temperature during crop growth span which prolonged growing period of the crop and resulted in maximum accumulation of GDD which ultimately resulted in higher growth and yield attributing parameters viz. plant height, number of tillers, leaf area index, dry matter production, effective tillers, spike length, number of grains per spike and test weight. The finding is similar to that of Khan *et al.* (2015) who reported lesser biological yield with late sown crop. Among the varieties, K-9423 being at par with K-1006 and K-9423 resulted in significantly higher biomass as compared to rest of varieties. This was due to higher

production of dry matter, higher number of tillers, higher test weight. Amrawat *et al.* (2013) reported that varieties differed from each other with respect to biological yield. Harvest index indicates the efficiency in partitioning of dry matter to economic part of the crop. Higher the harvest index better is the economic return from the crop. In present study maximum harvest index was recorded with 25th November sown crop which was significantly higher than 10th November, 10th December and 25th December sowings (Table 32). The lowest harvest index was observed with 25th December sowing which might be due to lowest grain yield production with this sowing date. Singh *et al.* (2017) also reported maximum harvest index with 4th November sowing of wheat crop. Non-significant variation was observed among varieties in respect to harvest index; however, K-1006 recorded higher harvest index than other varieties and it might be due to its high grain yield production ability.

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Calculation of per cent disease index and screening of French bean genotypes against *Sclerotium rolfsii* Sacc. under field condition

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ABSTRACT

French bean (*Phaseolus vulgaris*) is an important leguminous vegetable belonging to the family Fabaceae. French bean suffers heavily from pod rot disease which is incited by *Sclerotium rolfsii* Sacc. The pod rot of French bean was found well distributed in the different localities of Meghalaya. Per cent disease index was found maximum in Mawlai (52.34) under East Khasi Hills, followed by umiam (45.18) under Ri-Bhoi district. Fourteen French bean genotypes were screened for their resistance to *S. rolfsii* Sacc. under field condition during December 2019. Based on the PDI values of genotypes, FB 68, FB 38, FB 61, MZ 44 and RCMFB 75 showed the highest PDI with 35.30, 33.88, 33.33, 30.42 and 28.18 respectively which are categorized into susceptible, Nagaland 32, FB 36, Nagaland 23, Selection 9, MZ 49, M 1, RCMFB 75 and Vaishnavi 264 were categorized into moderately susceptible with PDI 24.70, 22.71, 20.93, 20.92, 14.44, 12.72, 10.39 and 10.13 respectively. However, the lowest PDI was recorded in FB 56 with 7.18 and FB 70 with 8.72 which are categorized into moderately resistant genotypes.

Key words : *Sclerotium rolfsii*, French bean, Per cent disease index, Genotypes.

Introduction

French bean is an important vegetable food crop grown throughout the world and contribute nearly 30% of the total production of food legumes (Vasishtha and Srivastava, 2012). French bean is a rich source of nutrient and minerals. The French bean seeds (Rajma) contains 17.8-28.7% protein, green pods contain 1.4-2.5% protein, 11.7% fat, 70% carbohydrates and 340-450 Kcal energy (Sardana *et al.*, 2000). French bean is an important cool season legume crop grown for its tender pods, shelled green bean and dry beans. The ideal temperature range for proper growth of this crop is 10-27°C. Above 30°C, the flower drop is a serious problem. Similarly, below 5°C, the flowers and developing pods and branches are damaged. French bean crop prone to many diseases such as anthracnose, pod rot, bean rust, white mold and fusarium rot. Among these, pod rot incited by *S. rolfsii* Sacc. causes 40-50% yield loss in India (Dasgupta *et al.*, 2005). *S. rolfsii* Sacc. is a soil borne pathogen with wide host range and difficult to control by chemicals alone, because the fungus produces sclerotia and survives in soil for a longer period of time. Excessive use of fungicides in agriculture has led to deteriorating human health, environmental pollution and development of pathogen resistance to fungicide. Screening of French bean genotypes is most effective to investigate

disease resistance of soil borne pathogen. French bean is an important vegetable food and also an export crop in India. French bean is a rich source of nutrients and

minerals and crude fibre are concentrated in seed while crude protein and energy are stored in cotyledons (Singh *et al.*, 1997).

Materials and Methods

Collection of diseased samples and Calculation of per cent disease index of Pod rot : Infected pod samples of French bean were collected from localities of Umeit, Mawpun kshaid and Bhoirymbong of Ri-Bhoi district and Mawlai, Myllem and Sohryngkham of East Khasi hills of Meghalaya during June to July 2019. The per cent disease index was assessed by collecting pods from randomly selected French bean plants. 100 pods were collected from each localities randomly and calculated the per cent disease index. Per cent disease index was calculated using 0-9 grade disease rating scale (Mayee and Datar, 1986).

Table-1 : Disease rating scale (0-9) for scoring Pod rot.

Rating scale	Per cent infection
0	No symptoms on the pod
1	Up to 1% of pod surface area
3	Up to 10% of pod surface area
5	Up to 25% of pod surface area
7	Up to 50% of pod surface area
9	More than 50% pod surface area

Per cent disease index (PDI) of the disease was calculated using the formula as :

$$PDI = \frac{\text{Summation of all numerical ratings}}{\text{Number of pods examined}} \times \frac{\text{maximum disease grade}}{100}$$

Screening of French bean genotypes against pod rot

French bean genotypes were collected from ICAR-RC for NEH Region, Barapani, Meghalaya. The experiment was laid out in randomized block design (RBD) with three replications. Plot size of French bean 1 x 1 m² and spacing 30 x 10 cm. Fourteen French bean genotypes were selected for screening against pod rot French bean genotypes namely, FB 36, FB 38, FB 56, FB 61, FB 68, FB 70, M 1, MZ 44, MZ 49, Nagaland 23, Nagaland 32, RCMFB 70, RCMFB 75 and Vaishnavi 264.

Ten plants from each plot were selected randomly for disease reaction. The first appearance of pod rot infection were recorded and thereafter the observation were recorded at 10 days interval throughout the cropping season. The observations were recorded on the basis of 1 to 5 scale on the basis of PDI adopted by (Gopal *et al.*, 2006).

Table-2 : Disease rating scale (0-5) for scoring Pod rot.

Rating scale	Per cent infection
0	No symptoms on the pod
1	Up to 5% of pod surface area
2	Up to 10% of pod surface area
3	Up to 25% of pod surface area
4	Up to 50% of pod surface area
5	More than 50% pod surface area

Table-3 : Disease reaction.

PDI	Reaction
0	Highly Resistant (HR)
1-10	Resistant (R)
11-20	Moderately Resistant (MR)
21-50	Susceptible (S)
51 and above	Highly Susceptible (HS)

$$PDI = \frac{\text{Summation of all numerical ratings}}{\text{Number of pods examined} \times \text{maximum disease grade}} \times 100$$

Screening of French bean genotypes against *Sclerotium rolfsii* Sacc. under field condition :

Field experiment was conducted to manage Pod rot of French bean with the total area of 100 m² and each plot was having the size of 1x1 m². The experiment was laid out in randomized block design with three replications using the local cultivar of French bean.

Field preparation : Power tiller was used for making soil of good tilth and field was exposed to bright sunshine and final ploughing was done. Clods and stubbles were also removed from the field to ensure the proper growth of crop and the field was incorporated with well decomposed FYM to maintain its soil fertility.

Results and Discussion

Collection of diseased samples and calculation of per

cent disease index of pod rot : Pod samples were collected randomly from farmer's field in different localities and calculated per cent disease index. The pod rot disease was found well distributed in various localities of Meghalaya. Highest per cent disease index was recorded at Mawlai (51.44%) under East Khasi Hills, followed by umeit (45.18%) under Ri-Bhoi district. In average, per cent disease index was found more in East Khasi Hills (37.51%), than by Ri-Bhoi district (34.41%).

Identification and assessment of *S. rolfsii* Sacc. :

Infected pods showed the characteristic rotting, development of white fungal thread over the affected pod tissue. The white profuse mycelial growth of fungus covers the entire pod. On such infected pod white to brown coloured, round to spherical mustard seed like sclerotia were seen. Infected pods were collected from different localities under the two districts of Meghalaya namely Ri-Bhoi and East Khasi Hills district to know the per cent disease index. The maximum per cent disease index was recorded in Mawlai (51.44%) under East Khasi Hills, followed by Umeit (45.18%). However in East Khasi Hills the least per cent disease index was observed in Myllem (29.37%) and Sohryngkham (31.72%) respectively. In Ri-Bhoi district, least per cent disease index was observed in Mawpun kshaid (24.32%) and Bhoirymbong (33.73%) respectively. In average, disease index was found highest in East Khasi Hills (37.51%), followed by Ri-Bhoi district (34.41%). It was observed that highest per cent disease index was found in East Khasi Hills than Ri-Bhoi district.

Table-4 : Per cent disease index (PDI) of pod rot in various regions of Meghalaya.

District	Locality	Disease index (%)	Mean Disease Index (%)
Ri-Bhoi	Umeit	45.18	34.41
	Mawpun kshaid	24.32	
	Bhoirymbong	33.73	
East Khasi Hills	Mawlai	51.44	37.51
	Myllem	29.37	
	Sohryngkham	31.72	

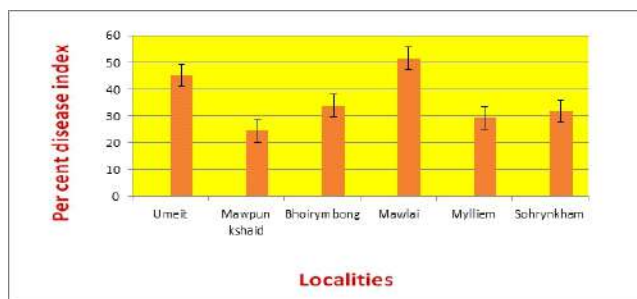


Fig-1 : Bar diagram showing the per cent disease index (PDI) of pod rot in various localities of Meghalaya.

Screening of French bean genotypes against pod rot :

Fourteen French bean genotypes were screened against pod rot under NEH Region, Barapani, Meghalaya. The genotypes were collected from NBPGR & ICAR institutes. The results of study are accessed.

Based on the PDI values of genotypes, they are classified into different classes. It was found that among French bean genotypes, MZ 44, FB 61, RCMFB 75, FB 68 and Nagaland 32 showed the highest PDI with 52.23, 42.80, 38.50, 33.30 and 27.77 respectively which are categorized into susceptible, FB 36, Vaishnavi 264, Nagaland 23, M 1, RCMFB 70, FB 56 and FB 38 are categorized into moderately susceptible with PDI 25.40, 24.60, 17.73, 15.57, 12.27, 11.93 and 11.17 respectively. However, the lowest PDI was recorded in MZ 49 with 5.03 and FB 70 with 6.80 which are categorized into moderately resistant genotypes.

Table-5 : Assessment of PDI of pod rot in French bean genotypes.

T1	FB 61	42.80±0.41(40.80) ^b	S
T2	FB 68	33.60±0.95(35.41) ^c	S
T3	FB 70	6.80±0.49(15.10) ^f	MR
T4	FB 36	25.40±0.45(30.25) ^d	MS
T5	FB 38	11.17±0.48(19.50) ^e	MS
T6	FB 56	11.93±0.27(20.20) ^e	MS
T7	M1	15.57±0.57(23.22) ^e	MS
T8	MZ 44	52.23±1.43(46.26) ^a	S
T9	MZ 49	5.03±0.50(12.94) ^f	MR
T10	Nagaland 23	17.73±0.94(24.89) ^e	MS
T11	Nagaland 32	27.77±1.26(31.78) ^{cd}	S
T12	RCMFB 70	12.27±0.52(20.49) ^e	MS
T13	RCMFB 75	38.50±0.45(38.33) ^{bc}	S
T14	Vaishnavi 26	24.60±2.12(29.70) ^d	MS
Control	Selection 9	30.43±0.41(33.47) ^c	S
SEm±	2.46	2.88	
CD	7.59	7.25	

S- Susceptible, MR-Moderately resistant and MS-Moderately susceptible
(Figures in parentheses indicate arc sine transformed values)

Note : Data followed by different small letters after mean values within each column indicate significant difference among treatments using ANOVA at $p < 0.05$.



Plate-1 : Experimental plot

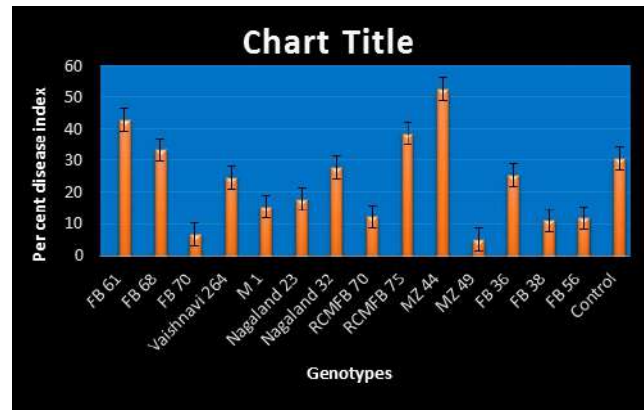


Fig-2 : Bar diagram showing screening of French bean genotypes against *Sclerotium rolfsii* Sacc.

Conclusion

From the present investigation, it may be concluded that pod rot of French bean incited by *S. rolfsii* Sacc. was found predominantly well distributed in different localities of Meghalaya. The pod rot of French bean were found well distributed in the different areas of Meghalaya. Percent Disease index was found maximum in Mawlai (52.34%) under East Khasi Hills, followed by umeit (45.18%) under Ri-Bhoi district.

Future Prospects

Future plant disease management should aim to strengthen food security for a stable society while simultaneously safeguarding the health of associated ecosystems. Sustainable plant disease management should place emphases on rational adaptation of resistance, avoidance, elimination of pathogen. Due to *Sclerotium rolfsii* Sacc. is a soil borne pathogen with wide host ranges and it is difficult to control by chemicals alone, because the fungus produce sclerotia and survives in soil for a longer period of time. Screening of French bean genotypes is more effective to investigate disease resistance of soil borne pathogen.

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Estimates of Genetic Variability, Heritability and Genetic Advance in Rice (*Oryza sativa* L.) Genotypes

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Abstract

The experimental material consisted of 40 rice genotypes, evaluated in a Randomized Block Design (RBD) with three replications and observations were recorded on thirteen characters. The experiment was carried out during *Kharif*, 2020 at Main Rice Research Centre, Navsari Agricultural University, Navsari, Gujarat. The analysis of variance revealed significant mean square values for all the traits in forty genotypes suggesting a sufficient amount of variability present among them. Genotypes exhibited moderate values of GCV and PCV for grain yield per plant and high values for protein content indicating the greater scope of improving these characters. The less difference between estimates of GCV and PCV indicated less influence of environment on the traits and the selection could be effective for those traits. Moderate GCV and PCV values were also observed for number of productive tillers per plant, grains per panicle, 1000 grain weight, kernel length, L/B ratio and straw yield per plant indicating the environmental influence on these traits. Low GCV and PCV values were recorded for the characters viz., days to 50 % flowering, plant height, panicle length, kernel breadth and amylose content indicating the narrow range of variability for these traits and restricting the scope of selection. High heritability coupled with high genetic advance was found for grain yield per plant, productive tillers per plant, straw yield per plant, grain weight, grains per panicle, kernel breadth, amylose content, kernel length, L/B ratio and protein content which is indicating the preponderance of additive gene action and the selection would be more effective for their improvement.

Introduction

Rice has shaped the culture, diets and economic of thousand of millions of peoples, though it was mentioned in the Yajur Veda (1500-800 BC). For more than half of the humanity “Rice is Life” (Anonymous, 2014). Asia is considered as the ‘rice bowl’ of the world. Rice (*Oryza sativa* L.) is a diploid crop having chromosome no.: $2n = 24$. It is the world's second most principal cereal crop belonging to the family *Poaceae*. Rice is a nutritional food which provides instant energy as its most important component is carbohydrate (starch). On the other hand, rice is poor in nitrogenous substances with average composition of these substances being only 8% and fat content or lipids only negligible, i.e., 1% and due to this reason it is considered as a complete food for eating (Anonymous, 2014). Rice flour is rich in starch and is used for making various food preparations. Nutritional value of rice (raw) per 100 grams, it contains 6.8 g protein, 0.5 g fat, 8.2 g carbohydrates, 0.6 g minerals, 10 mg calcium, 0.2 g fiber and 345 K cal energy (Anonymous, 2014).

The variability of nutritional composition and characteristics of rice is really broad and depends on variety and environmental conditions under which the crop is grown. The population in Asia increases rapidly,

up to 1.8% increase per year (Abdullah et al. 2019), and the world's population is expected to reach 9 billion by 2050. Therefore, it demands efforts to increase food production (Collard et al. 2013). In order to achieve the goal of increased production by increasing the yield potential of genotypes, knowledge of variability, inheritance is must required.

Variability means differences among the individuals of a single species or different species. The variability may be due to environment or genotype or resultant effect of interplay between both. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) are useful in determining the amount of variation present in genetic material, which aids in the development of an effective breeding plan. Estimates of heritability are a good indicator for predicting character transmission from parents to offspring. Heritability coupled with genetic advance helps in understanding the mode of inheritance of quantitative traits (Patidar et al., 2018) [15]. Hence, the present study was conducted to investigate genetic variability, heritability and genetic advance in rice genotypes so as to identify superior genotypes for future breeding programs.

Table-1 : Analysis of variance (mean sum of square) of experimental design for different yield and yield contributing characters in rice genotypes.

Source	d.f.	Days to 50 per cent flowering	Plant height (cm)	Number of productive tillers per plant	Panicle length (cm)	Grains per panicle	1000 grain weight (g)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	Grain yield per plant (g)	Straw yield per plant (g)	Amylose content (%)	Protein content (%)
Replication	2	12.85**	204.80	0.29	10.08	100.27	4.52*	0.003	0.007	0.01	15.48	8.99	1.74*	0.03
Genotypes	39	49.95**	221.32**	4.07**	13.06**	2127.62**	26.92**	1.60**	0.14**	0.60**	42.33**	103.32**	17.77**	12.02**
Error	78	2.26	110.31	0.58	7.66	78.21	1.26	0.03	0.004	0.01	7.350	10.41	0.48	0.02
C.D. @ 5%	-	2.45	17.07	1.24	4.50	14.38	1.83	0.32	0.11	0.18	4.41	5.25	1.13	0.26
S.E. (m)	-	0.869	5.99	0.441	1.598	5.106	1.863	0.113	0.040	0.063	0.650	1.565	0.401	0.090

*, ** significant at 5% and 1% levels of significance, respectively

Table-2 : Measures of variability parameters of all thirteen characters in rice.

	Days to 50 per cent flowering	Plant height (cm)	Number of productive tillers per plant	Panicle length (cm)	Grains per panicle	1000 grain weight (g)	Kernel length (mm)	Kernel breadth (mm)	L/B ratio	Grain yield per plant (g)	Straw yield per plant (g)	Amylose content (%)	Protein content (%)
Range	Minimum Maximum	81.67 96.00	87.08 122.30	5.11 10.70	16.17 25.68	155.11 243.38	4.97 7.82	1.98 2.89	1.90 3.74	18.37 32.81	23.30 45.92	19.33 29.27	2.95 9.95
Grand Mean	90.26	100.05	7.23	20.85	198.27	25.81	6.24	2.43	2.60	25.59	34.51	24.69	5.50
Genotypical Variance	15.89	37.00	1.16	1.80	683.13	8.55	0.52	0.04	0.19	11.66	30.96	5.76	3.99
Phenotypical Variance	16.65	73.77	1.35	4.35	709.20	8.97	0.53	0.04	0.20	14.11	34.44	5.92	4.00
Environmental Variance	0.75	36.77	0.19	2.55	26.07	0.42	0.01	0.002	0.004	2.45	3.47	0.16	0.01
GCV (%)	4.41	6.08	14.89	6.43	13.18	11.32	11.57	8.90	17.09	13.34	16.12	9.72	36.35
PCV (%)	4.52	8.58	16.10	10.01	13.43	11.60	11.72	9.05	17.26	14.67	17.00	9.85	36.39
ECV (%)	1.66	10.49	10.57	13.27	4.46	4.36	3.16	2.85	4.21	10.59	9.35	2.81	2.86
Genetic Advance as % of Mean 5%	8.89	8.87	28.39	8.52	26.65	22.78	23.56	18.03	34.85	24.98	31.49	19.75	74.81
Genetic Advance	8.02	8.87	2.05	1.77	52.84	5.88	1.47	0.43	0.90	6.39	10.87	4.87	4.11

Where,

GCV (%) = Genotypic Coefficient of Variation,

PCV (%) = Phenotypic Coefficient of Variation

Materials and Methods

The present experiment was comprised of 40 rice germplasm/genotypes and carried out during *Kharif*, 2020 at the farm of Main Rice Research Centre, Navsari Agricultural University, Navsari. The entire experimental material was divided into three replication and in which each plot consisted 12 rows of 3.0-meter-long row. Each row comprised of 20 plants of single genotype with 20 cm and 15 cm row to row and plant to plant spacing, respectively. The genotypes were randomly assigned to the plots in every replication. Data for all the characters were collected from the arbitrarily selected five plants on an individual plant basis for different characters, except for days to 50 per cent flowering, and their averages were computed and subjected to the statistical analysis. Observation for days to 50 per cent flowering was recorded on plot basis. Analysis of variance was carried out as per standard procedure by (Panse and Sukhatme, 1985). Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) as per (Burton, 1952), heritability as per (Burton and Devane, 1953), genetic advance as per (Johnson *et al.*, 1955) were estimated.

Results and Discussion

The analysis of variance was performed to test the differences among genotypes for all the thirteen characters and presented here in Table 1. The results revealed that the mean sum of squares due to genotypes were highly significant for all the quantitative and qualitative characters *viz.*, days to 50% flowering, plant height, number of productive tillers per plant, panicle length, grains per panicle, 1000 grain weight, kernel length, kernel breadth, L/B ratio, grain yield per plant, straw yield per plant, amylose content, protein content which indicated that considerable amount of variability was present among genotypes for various characters. This show that there is ample scope to generate early, high yielding and lodging resistance materials by applying a judicious selection pressure for specific traits. All thirteen characters under study had shown a wide range of phenotypic variation. Similar results for most of characters were also recorded by Souroush *et al.* (2004), Manickavelu *et al.* (2006), Babu *et al.* (2012), Oladosu *et al.* (2014), Bhinda *et al.* (2017) and Manjunatha *et al.* (2017).

The moderate as well as closer values of genotypic and phenotypic variance were observed for plant height, productive tillers per plant, grains per panicle, 1000 grain weight, kernel length, kernel breadth, L/B ratio, grain yield per plant and straw yield per plant indicating higher contribution of genetic components to the total variation

(Table-2). Therefore, these traits could be considered and easily exploited through selection. The higher and closer values of phenotypic coefficient of variation (PCV) than the respective genotypic coefficient of variation (GCV) for all the thirteen traits under study indicated the inherent connection between genotypes and phenotypic expression of the traits under study (Table-1). In present study, moderate PCV and GCV (10-20%) values were observed for of Productive tillers per plant (16.10, 14.89), grains per panicle (13.43, 13.18), 1000 grain weight (11.60, 11.32), kernel length (11.72, 11.57), L/B ratio (17.26, 17.09), grain yield per plant (14.67, 13.34), straw yield per plant (17.00, 16.12) which indicated that these traits offer a better opportunity for improvement through selection. Whereas, high PCV and GCV (>20%) was observed for protein content (36.35, 36.39). The present result was akin with findings of Madhusudhan (2001), Pratap *et al.* (2012), Kumar and Verma (2016) and Patel *et al.* (2018).

The present study revealed that heritability in broad sense (h^2_{bs}) was moderate (30-60%) for characters *viz.*, plant height (50.2), panicle length (41.4). High heritability (>60%) was recorded for characters like grain yield per plant (82.6), productive tillers per plant (85.6), straw yield per plant (89.9), grain weight (95.3), days to fifty per cent flowering (95.5), grains per panicle (96.3), kernel breadth (96.7), amylose content (97.3), kernel length (97.6), L/B ratio (98.0), protein content (99.8). The investigation of experiment revealed that genetic advance as per cent of mean at 5% as low for plant height (8.87), days to fifty per cent flowering (8.891) and panicle length (8.52) whereas, moderate (10-20%) for characters *viz.*, kernel breadth (18.03), amylose content (19.75). High genetic advance as per cent of mean at 5% (>20%) was observed in characters like grain weight (22.78), kernel length (23.56), grain yield per plant (24.98), grains per panicle (26.65), productive tillers per plant (28.39), straw yield per plant (31.49), L/B ratio (34.85), protein content (74.81). For predicting reliable estimates of additive and non-additive effects, heritability should be considered in conjugation with genetic advance (Burton 1952, Johnson *et al.* 1955). High heritability coupled with high genetic advance was found for grain yield per plant, productive tillers per plant, straw yield per plant, grain weight, grains per panicle, kernel length, L/B ratio, protein content. These results are in accordance with the findings of Bisne *et.al.*, (2009), Lingaiah *et al.*, (2019), Padmaja *et al.*, (2008) and Hasan-Ud-Daula *et al.* (2020).

Conclusions

The analysis of variance revealed the presence of sufficient variability among all the genotypes of rice for different characters under study. The values of phenotypic

coefficient of variation were slightly higher than genotypic coefficient of variation indicating the least/negligible influence of environmental factors for most of the characters under investigation. The highest genotypic coefficient of variation was recorded for protein content. Similarly, it was also recorded moderate for number of productive tillers per plant, grains per panicle, 1000 grain weight, kernel length, L/B ratio, grain yield per plant and straw yield per plant. This result indicated the presence of extensive inherent variation for these characters and its further improvement is possible by applying judicious selection to the individual traits. High heritability coupled with high genetic advance was found for grain yield per plant, productive tillers per plant, straw yield per plant, grain weight, grains per panicle, kernel length, L/B ratio, protein content indicating the preponderance of additive gene action and the selection would be more effective for their improvement.

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Seasonal Incidence of Shoot and Fruit Borer [*E. vittella*] on okra, *Abelmoschus esculentus* (L.) Moench), in Relation to Abiotic Factors

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Abstract

The present experiment was undertaken to study the "Seasonal Incidence of shoot and fruit borer [*E.vittella*] on okra, *Abelmoschus esculentus* (L.) Moench), in relation to abiotic factors during Kharif season 2018 at the vegetable research farm, B.H.U., Varanasi". The shoot infestation by *E.vittella* appeared first one month after sowing i.e. 36th S.W with mean per cent infestation of 3.50 %. Thereafter shoot infestation was gradually raised and attained the peak (18.70) during 42nd S.W i.e. 3rd week of October, after that the population gradually declined and disappear during 44th S.W. The damage on fruit borer started from 36th S.W (4 weeks after sowing) till end of cropping season i.e. 45th S.W (2nd week of November). The peak fruit infestation (25.50 %) was reported during 41st S.W (2nd week of October). Thereafter the fruit infestation gradually declined and attained very less infestation observed at 45th S.W. There was significant positive impact of weather factors on shoot damage except one i.e. rainfall which has negative and significant correlation with shoot infestation. While The relationship between weather parameters and fruit infestation revealed that there was significant positive impact of weather parameters on fruit infestation with morning , evening relative humidity and significant negative impact with rainfall.

Key words : shoot and fruit borer, okra crop, abiotic factors.

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench), commonly known as lady's finger or bhendi belonging to family Malvaceae, is an important warm season vegetable crop cultivated widely in tropical and sub-tropical regions of the world (Alam and Hossain, 2008). Okra is native to Ethiopia . It is an important commercial vegetable crop grown throughout the year in tropical and sub-tropical tropical regions of the world.

Okra requires long and warm growing season. The crop is highly sensitive to frost and the seeds do not germinate below 18°C. It grows well in all types of soil ranging from sand to clay, however best yields are obtained in loose, friable and well manured loamy soils with pH ranging from 6 to 6.8. In India okra is being cultivated around the year in *kharif*, *rabi* and summer season. However, several biotic and abiotic factors are responsible for low yield.

The spotted bollworms are the most dreadful pests causing serious turn down of the produce, in terms of quality as well as of quantity (Suman *et al.* 1984). *Earias* spp. are distinguished from other pests of okra by their marked tendency for stem boring. The larvae enter the terminal bud of vegetable shoot and channel down from the growing point. Severe attack, results in the wilting of top leaves and collapsing of the main stem. The

larvae also bore into the flower buds, flowers and fruits of the crop. Serious decline in production of okra due to the okra shoot and fruit borer has been reported by different workers and the damage varied from 8.4 to 73.2% yield loss (Kumar and Urs, 1988), 32.06 to 40.84% loss in yield (Singh and Brar, 1994).

It is well known that meteorological factors play important role in the seasonal incidence of the pests. Different meteorological factors like temperature, humidity, rainfall and sunshine hours contribute to the increase or decrease of the pest incidence. By studying these parameters in detail and correlating them with incidence, one can predict the increase of the pest incidence in advance, which helps in decision making and forehand planning of the plant protection measures. Hence, it was planned to study the seasonal incidence of the pests and their relation with weather parameters as well as biotic factors like natural enemies. The shoot and fruit borer incidence on fruits started from fourth week of August on 5-week-old plants and continued until fourth week of October on 14-week-old plants. The highest population of *Earias vitellae* was observed in the third week of September. Bright sunshine hours, maximum and minimum temperature showed non-significant positive effect. Whereas, relative humidity and rainfall was showed a negative non-significant and significant influence on *E. vitella*, respectively (Singh *et al.*, 2015).

Chandra and Singh (2012) observed the incidence of *Eariasvitella* in Bundelkhand Agro-climatic condition where they first noticed during 4th standard week. The shoot damage (20.2%) and fruit damage (30.9%) by *Eariasvitella* were noticed maximum at 13th and 16th standard week respectively. According to Nath *et al.* (2011) the maximum fruit damage as 43.52% and 42.31% in 41st S.W during both the years was caused by *Eariasvitella*. The temperature with per cent fruit damage showed significant and negative relationship during 2005 and 2006 and RH showed non-significant and positive relationship with this pest. Azizet *et al.* (2011) reported that, the maximum, minimum and average temperatures showed a positive effect; whereas, the relative humidity and rainfall exerted a negative effect on the fruit infestation, separately as well as on cumulative basis. The shoot infestation of okra was found to be positively correlated with maximum and average temperatures while, negatively correlated with the relative humidity and rainfall on the basis of an average for both the years of studies. Mandal *et al.* (2006) revealed that, the pest activity started to build-up from four-week-old crop and remained intensified critically below a maximum temperature of 35 °C and above a minimum temperature of 22 °C. A significant negative correlation with maximum temperature and positive relationships with minimum temperature, relative humidity, vapour pressure and rainfall were observed. Pareek *et al.* (2001) observed the fruit borer incidence to start in first week of September with maximum fruit infestation in third week of October. The shoot and fruit borer activity was observed when the crop was 3-4 weeks old and remained active until the okra crop was removed. Bright sunshine hours, maximum and mean temperature showed a significant positive effect, whereas mean vapour pressure and relative humidity had a significant negative influence on larval activity on okra (Zala *et al.*, 1999).

Materials and Methods

The experiments on the “Seasonal Incidence of shoot and fruit borer [*E.vittella*] on okra, *Abelmoschus esculentus* (L.) Moench), in relation to abiotic factors” were carried out at Vegetable Research Farm, IAS, BHU, Varanasi. The alluvial soils of this geographical region in general are reported to be flat, well drained and moderately being less in available nitrogen and medium in available phosphorus and potash. The normal pH varies from 7.2 - 8.4. The climate of this region is typically sub-tropical which is characterized by extremes of weather conditions particularly during summer and winter seasons. The average rainfall is reported to be 1100 mm per annum and the methods adopted and materials used during experimentation are briefed below.

An area of 50 m² was raised with okra (VRO-3) to study the population buildup and succession of shoot and fruit borer infestation. Okra seeds of variety VRO-3 were sown at a distance of 60 x 30 cm. The experimental plot was kept unsprayed during the course of investigation and all recommended agronomical practices were adopted to render suitable crop growth. The pest population was recorded in this un-protected plot of okra at 7 days interval from the occurrence or initiation of the pest number and or infestation and was continued up to end of the crop. A total of 25 plants from five random locations in the bulk plot @ 5 plants per each location were selected and tagged for recording the observations on shoot and fruit infestation.

Weather data were collected from the metrological observatory available at Agriculture Research Farm, Institute of Agricultural Sciences, BHU, Varanasi and correlated with the occurrence of the shoot and fruit borer infestation. Among weather parameters, relative humidity, temperature and rainfall were considered for correlating with the occurrence of the insect pests of okra. To work out the relationship between the occurrence of the insect pests of okra and the weather parameters, simple correlation method was adopted.

Methods of observation : Shoot and fruit infestation The per cent shoot and fruit infestation observations were recorder at weekly interval during reproductive stage by counting damaged shoots and fruits per sampling unit and counting total number of shoots and fruits per plot respectively. Number of damaged shoots Per cent.

Per cent shoot infestation

$$= \frac{\text{Number of damaged shoots}}{\text{Total number of shoots}} \times 100$$

Number of damaged fruits Per cent fruit infestation

$$= \frac{\text{Number of fruit}}{\text{Total number of fruit}} \times 100$$

Statistical analysis

The correlation coefficient between the pest population and the abiotic factors of the environment using standard statistical formula.

Results and Discussion

The occurrence of *E. vittella* on okra crop along with meteorological observations has been presented in Table-1. The data showed that the shoot infestation by *E. vittella* appeared first one month after sowing i.e. 36th S.W with mean per cent infestation of 3.50 %. Thereafter shoot infestation was gradually raised and attained the peak (18.70) during 42nd S.W i.e. 3rd week of October, after that the population gradually declined and disappeared

Table-1 : Population succession of Shoot and Fruit borer [*E. vittella*] on okra and impact of abiotic factors on seasonal incidence during kharif 2018.

S. Week	Month and date	Temperature			Relative humidity%			Rainfall (mm)	Average* percent infestation fruit and shoot borer	
		Max.	Min.	Avg.	Morning	Evening	Avg.		Shoot	Fruit
33	Aug. 13-19	30.50	23.00	26.75	90.00	78.00	84.00	125.00	0.00	0.00
34	Aug. 20-26	31.10	24.00	27.55	91.00	81.00	86.00	154.80	0.00	0.00
35	Aug. 27-2	32.00	24.30	28.15	93.00	77.00	85.00	118.40	0.00	0.00
36	Sep. 3-9	30.60	23.60	27.10	91.00	79.00	85.00	94.60	3.50	0.01
37	Sep. 10-16	32.40	23.60	28.00	88.00	68.00	78.00	0.00	6.60	0.30
38	Sep. 17-23	32.50	22.80	27.65	88.00	65.00	76.50	53.40	9.00	6.00
39	Sep. 24-30	33.40	25.90	29.65	88.00	63.00	75.50	0.00	12.60	9.11
40	Oct. 1-7	34.20	20.80	27.0	83.00	51.00	67.00	0.00	13.08	17.87
41	Oct. 8-14	31.00	20.00	25.50	89.00	61.00	75.00	0.00	17.11	25.50
42	Oct. 15-21	33.40	25.90	29.65	84.00	40.00	62.00	0.00	18.70	20.14
43	Oct. 22-28	31.50	14.40	22.95	89.00	41.00	65.00	0.00	12.10	16.00
44	Nov. 29-4	31.10	16.70	23.90	91.00	48.00	69.50	0.00	6.80	12.50
45	Nov. 5-11	28.20	12.20	20.20	87.00	44.00	65.50	0.00	0.00	6.50

Table-2 : Correlation coefficient(r) Fruit and Shoot borer on [*E. vittella*] okra with prevailing weather parameters during kharif 2018.

Insect pest Fruit and shoot borer	Rainfall (mm)		Weather parameter					
			Relative humidity			Temperature		
			Morning	Evening	Average	Maximum	Minimum	Average
	Fruit	-0.702**	0.557*	0.729**	0.740**	0.298	-0.274	0.133
	Shoot	-0.613*	0.662**	0.483*	0.539*	0.611	0.180	0.320

*Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level

after 44th S.W. The corresponding meteorological parameters during peak shoot infestation was observed as maximum temperature 33.40C, minimum temperature 25.90C, morning R.H 84%, evening R.H 40 % and there was no rainfall during this period.

The simple correlation was worked out between weather factors and infestation of shoot presented in Table 2, revealed that there was significant impact of weather factors on shoot damage except one i.e., rainfall is negative and significant correlation with shoot infestation ($r=-0.613$) (Table-2). The shoot infestation was primarily observed during 36th S.W. 7 (weeks after sowing) and reached a peak during 2nd week of October (42nd S.W.) with a mean percent infestation of 18.70%. Thereafter shoot infestation was dropped due to initiation of flowering and fruiting. The shoot infestation prevailed high in the okra field from during 36th S.W. (1st week of September) to 44th S.W. (1st week of November). Mandal *et al.* (2006) and Zala *et al.* (1999) described the activity of shoot borer in the field at four weeks after sowing. The results are found to be in close relationship with results obtained by Shukla *et al.* (1997) who reported that shoot infestation initiation occurred 3 weeks after sowing. These outcomes are more or less similar with earlier findings made by Chandra and Singh (2012) reported that the peak mean shoot infestation was detected as 20.20%.

The shoot infestation exhibited significant and positive correlation with morning R.H and maximum temperature. These results are comparable with the findings of Mandal *et al.* (2006) and Aziz *et al.* (2009) who reported that shoot infestation was significant and positively, correlated with relative humidity and maximum temperature respectively. In the present studies The relationship between shoot infestation and rainfall was non-significant and negative and these results are in close accord with Aziz *et al.* (2011) who reported that shoot infestation indicated a negative correlation with rainfall.

While The incidence of fruit infestation presented in the Table-1 revealed that the damage of fruit borer started from 36th S.W. (4 weeks after sowing) till end of crop season i.e. 45th S.W. (2nd week of November). The peak fruit infestation (25.50 %) was observed during 41st S.W. (2nd week of October). Thereafter the fruit infestation gradually declined and attained very less infestation at 45th S.W. The maximum temperature, minimum temperature, morning R.H, evening R.H during peak fruit infestation was recorded as 31.0C, 20.0C, 89%, 61% respectively. There was no rainfall during peak infestation. The simple correlation was worked out between weather parameters and fruit infestation presented in Table-2 revealed that there was significant impact of weather parameters on fruit infestation

particularly the relative humidity and rainfall than the temperature.

The fruit infestation was started during 37th S.W. (7 weeks after sowing) in the 2nd week of September and persisted up to 2nd week of November (46th S.W.) and the peak infestation was observed during 41st S.W. (fortnight of October) with a mean per cent fruit infestation as 25.50. The present examination is in partial agreement with those of Yadav *et al.* (2007) and Singh *et al.* (2015) who reported that fruit infestation initiated on five weeks old crop Singh *et al.* (2015) also reported that fruit infestation conquer in field up to nine weeks old crop and these results are also nearly alike with the present findings. The present values are also supported with the results of Pareek *et al.* (2001) who reported fruit infestation started in the month of September and peak fruit damage observed in third week of October.

In the present study the weather parameters, except rainfall, showed significant role with fruit infestation. The current results are in close association with Singh *et al.* (2015) and Nath *et al.* (2011) who reported that temperature and related humidity exhibited significant and positive correlation with fruit infestation. Further Kumar and Urs (1988) informed a negative non-significant correlation between rain fall and fruit infestation.

Conclusions

The shoot infestation was significant positive impact of weather factors on shoot damage except one i.e. rainfall which has negative and significant correlation with shoot infestation. In Fruit infestation between weather parameters and fruit infestation revealed that there was significant positive impact of weather parameters on fruit infestation with morning, evening relative humidity and significant negative impact with rainfall.

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Determination of Biochemical Characteristics of Wheat Grain for Resistance/ Susceptibility to *Rhizopertha dominica*

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Abstract

Fifteen varieties of wheat viz., MP-1234, MP-3288, GW-366, Raj -4037, HI-1544, HD-2932, HI-8627, HI-153, HI-1500, Anuradha, Lok-1, HI-1567, KRL-1-4, MPO-1203 and MPO-1215 were screened for resistance/susceptibility against *R. dominica* for biochemical characteristics. None of the variety was found free from infestation of *R. dominica*, however the varieties Raj-4037, HI-153, MP-1234, HI-8627, GW-366 and HI-1500 were found moderately resistant while Anuradha, KRL-1-4, HI-1544, Lok-1, MPO-1203, HD-2932 and MPO-1215 were susceptible and HI-1567 was the highly susceptible. The maximum per cent grain moisture, crude protein, crude fiber, gluten and phenol content in grains was recorded in susceptible varieties while minimum in moderately resistant varieties. Thus, it is clear that the increase in per cent grain moisture, crude protein, crude fiber, crude fat, crude ash, gluten and phenol content increase the infestation of *R. dominica* and vice-versa. The increase the level of carbohydrates, soluble sugars in grains decrease the level of pest infestation and vice-versa.

Introduction

Wheat is attacked by many insect pests in field as well as in storage condition. Although, there are about 200 species of insects and mites found infesting wheat grains, few of which are major or primary pests. Among different stored grain pests, the lesser grain borer, *R. dominica*, is an important internal and primary feeder of various stored wheat grains. *R. dominica*, attacks a wide range of stored cereals such as barley, paddy, wheat, maize and sorghum. It also infests various other commodities including pulses and dried cassava root. With the help of strong jaws, it can also damage any part of wooden structure to tide over unfavorable conditions. The beetle is a strong flier, spreads with grater rapidity and is also found attacking wheat in the field. Both the adult and larvae bore into healthy kernels of grain, reducing them to hollow husk by using of their strong mandible. It not only feeds on food grains but also affects their nutritional and baking quality as well as germination capacity (Patel and Vekaria, 2013). So that an effective management strategy can be developed. These aspects need more intensive investigations, as biochemical properties of wheat grain such as moisture percent, crude protein, crude fat, ash content, crude fiber, crude carbohydrates, gluten percent, total phenol and soluble sugars of stored products play a vital role in pest infestation.

Materials and Methods

The present study entitled "To determine biochemical characteristics of wheat grain for resistance/susceptibility to *R. dominica*" was conducted under *invitro* conditions in

the Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur. Proximate composition of the grains (i.e. determination of moisture content, crude protein, soluble sugar, crude fat, crude fibre, ash content, crude carbohydrates, gluten and phenol) was estimated in accordance with the standard method of Association of Official Analytical Chemists (AOAC, 1990).

Results and Discussion

Chemical properties of wheat grains : The quantitative estimation of biochemical content in different varieties of fresh wheat grain was done and the results are presented in Table-2.

Moisture per cent : Moisture percentage in different varieties of wheat varied from 9.80 to 12.96 (Table-2). The lowest moisture content was found in Raj-4037 (9.80%), which was at par with HI-153 (9.94 %), MP-3288 (10.20 %), MP-1234 (10.40 %), HI-8627 (10.63 %) and GW-366 (10.90 %). The highest moisture content was observed in HI-1567 (12.96%), at par with KRL-1-4 (12.90%), Lok-1 (12.80%), HD-2932 (12.75%), MPO-1203 (12.65%), HI-1544 (12.48%), Anuradha (11.95%), MPO-1215 (11.50%) and HI-1500 (11.23%). Singh *et al.* (1992) observed that the varieties with higher moisture content were most susceptible in comparison to that of lower moisture content in barely. Nemaram and Bhargava (2012) reported variety (Lok-1) to contain higher moisture per cent (12.96 %) and was susceptible.

Crude protein : The data revealed that protein content in different wheat varieties increased due to infestation of *R. dominica*. It is evident from the Table-2 that there was no

Table-1 : Following varieties of wheat tested for their relative susceptibility.

1. MP-1234	6. MP-3288	11. GW-366
2. Raj-4037	7. HI-1544	12. HD-2932
3. HI-8627	8. HI-153	13. HI-1500
4. Anuradha	9. Lok-1	14. HI-1567
5. KRL-1-4	10. MPO-1203	15. MPO-1215

Table-2 : Biochemical parameters of different varieties of wheat grains against *R. dominica*.

Varieties	Grain moisture (%)	Crude Protein (%)	Crude fat (%)	Ash (%)	Crude fiber (%)	Crude Carbohydrate (%)	Gluten (%)	Phenol (mg/100g)	Soluble sugars (%mg)
MP-1234	10.40	12.17	3.32	1.82	2.45	72.29	8.14	77.80	7.17
Raj-4037	9.80	12.01	2.99	1.25	2.37	73.95	7.90	74.39	7.29
HI-8627	10.63	12.14	3.53	1.63	2.45	72.07	8.70	83.09	7.18
Anuradha	11.95	13.18	3.94	2.34	2.65	68.59	10.20	93.07	7.09
KRL-1-4	12.90	13.69	4.54	2.71	2.97	66.16	10.93	104.21	6.90
MP-3288	10.20	12.83	3.09	1.44	2.43	72.44	8.17	81.03	7.22
HI-1544	12.48	13.30	4.21	2.44	2.68	67.57	10.40	93.08	7.07
HI-153	9.94	12.29	3.09	1.31	2.42	73.37	8.03	70.13	7.32
Lok-1	12.80	13.32	4.28	2.67	2.97	66.93	11.33	103.04	6.94
MPO-1203	12.65	13.55	4.18	2.49	2.78	67.13	10.43	97.80	7.03
GW-366	10.90	12.33	3.61	1.96	2.55	71.20	9.10	87.04	7.16
HD-2932	12.75	13.65	4.09	2.63	2.90	66.88	10.78	99.70	6.96
HI-1500	11.23	12.17	3.84	2.20	2.58	70.56	9.33	88.90	7.15
HI-1567	12.96	14.02	4.29	3.07	3.08	65.66	11.02	107.2	6.88
MPO-1215	11.50	12.37	3.88	2.2	2.65	70.05	9.87	91.90	7.14
S.Em.+	0.75	0.76	0.05	0.19	0.20	1.08	0.61	1.28	0.62
C.D.(P=0.05)	2.18	2.21	0.14	0.56	0.57	3.12	1.76	3.72	1.80

significant difference in protein content among different varieties. The protein content of wheat varieties ranged from 12.01-14.02 per cent. Ascending order of protein content in different wheat varieties; Raj-4037 (12.01%), HI-8627 (12.14 %), MP-1234/HI-1500 (12.17 %), HI-153 (12.29 %), GW-366 (12.33 %), MPO-1215 (12.37 %), MP-3288(12.83%), Anuradha (13.18 %), HI-1544 (13.30 %), Lok-1 (13.32 %), MP-1203 (13.55 %), HD-2932 (13.65 %), KRL-1-4 (13.69 %) and HI-1567 (14.02 %). Verma *et al.* (1999) found that low protein content rice varieties were least susceptible and higher protein content varieties was highly susceptible to *R. dominica*. Tiwari and Sharma (2002) reported the values of protein between 10.26-14.03 per cent and Khan *et al.* (2005) recorded 12.64 and 13.33 percent protein in two wheat varieties. Singh *et al.* (2005a) studied the per cent protein content of 30 wheat cultivars in the range of (9.36-13.42) and noted minimum in least susceptible varieties and maximum in highly susceptible varieties for the preference of *R. dominica*, which incorporated with present results of the protein content of wheat varieties ranged from 12.01-14.02 per cent.

Crude fat : The data revealed that crude fat content in different wheat varieties increased due to infestation of *R. dominica*. It is evident from the Table-2 that there was significant difference in fat content among different wheat

varieties. The fat content of wheat varieties ranged from 2.99-4.54 per cent. The highest fat content of 4.54 per cent was observed in KRL-1-4 and lowest, 2.99 per cent in Raj-4037. In the present study out of fifteen different wheat varieties six were having more than 4 per cent crude fat while remaining except Raj-4037 were having between 3 to 4 per cent.

Ash content : The ash content (%) of different wheat varieties was in the range of 1.25-3.07 (Table-2). Variety, HI-1567 had the highest ash content of 3.07 per cent followed by 2.71, 2.67 and 2.63 per cent in KRL-1-4, Lok-1 and HD-2932 respectively, but was statistically at par; whereas, Raj-4037 had the lowest value of 1.25 per cent followed by 1.31, 1.44, 1.63 and 1.82 per cent in HI-153, MP-3288, HI-8627 and MP-1234, respectively but were statistically at par. Tiwari and Sharma (2002) reported that ash value in the range of 1.13-2.13 per cent, which was bit lower than the values obtained in the present study.

Crude fiber : The crude fiber content of the different wheat varieties was in a range between 2.37- 3.08 per cent. No significant differences were observed for the fiber content of wheat grains in different varieties however, HI-1567 had the highest fiber content of 3.08 per cent and Raj-4037 had the lowest value of 2.37 per cent (Table-2).

Crude carbohydrates : During the study significant

difference was observed for the per cent crude carbohydrates in grains of different wheat varieties (Table-2). It was found in the range of 65.66-73.95 %. The dry matter was highest in Raj-4037 (73.95 %) followed by HI -153 (73.37 %), MP- 3288 (72.44 %), MP-1234 (72.29%), HI-8627 (72.07 %) and GW-366 (71.20 %) but were statistically at par and lowest in HI-1567 (65.66 %) followed by KRL-1-4 (66.16 %), HD-2932 (66.88 %), Lok-1 (66.93 %), MP-1203 (67.13 %), HI-1544 (67.57 %) and Anuradha (68.59%) but were statistically at par. Khan *et al* (2005) reported values (69.97 and 84.27 %) of carbohydrates content for the two wheat varieties. Batta *et al*. (2007) reported that lower protein contained varieties found resistant and high carbohydrates varieties were found susceptible against *R. dominica* F which is in agreement present study. Mebarkia *et al*. (2010) also reported similar results (68.12-73.53) of the carbohydrates content for the wheat varieties.

Gluten per cent : During the study significant difference was observed for the per cent gluten content in grains of different wheat varieties. The maximum percentages of gluten content 11.33 were recorded in Lok-1, followed by HI-1567, KRL-1-4, HD-2932, MP-1203, HI-1544, Anuradha and MPO-1215 and were statistically at par. Minimum percentage of gluten content 7.90 was in Raj-4037 followed by 8.03, 8.14, 8.17, 8.70, 9.10 and 9.33 in HI-153, MP-1234, MP-3288, HI-8627, GW-366 and HI-1500, respectively; however, the values were statistically at par (Table-2). Tiwari and Sharma (2002) reported the gluten content ranged from 6.13-7.94 was found in wheat varieties.

Total phenol content : The total phenol content of the different wheat grains was in a range of 70.13- 107.20 mg/100g (Table-2). Variety, HI-1567 had the highest phenol content followed by KRL-1-4 of 104.21mg/100g and was statistically at par; whereas, HI-153 had the lowest value of phenol content followed by Raj-4037 and MP-1234 with 74.39 and 77.80 mg/100g with phenol.

Soluble sugars (%mg) : The soluble sugars content of the different wheat varieties was in a range of 6.88 to 7.32 mg/g. No significant differences were observed for the soluble sugars of wheat grains in different varieties however, HI-1567 had the lowest soluble sugars of 6.88

mg/g and Raj-4037 had the highest value of 7.32 mg/g (Table-2).

Conclusion

Thus, it is clear that the increase in per cent grain moisture, crude protein, crude fiber, crude fat, crude ash, gluten and phenol content increase the infestation of *R. dominica* and vice-versa. The increase the level of carbohydrates, soluble sugars in grains decrease the level of pest infestation and vice-versa.

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Evaluation of Plant Products, Vegetable Oils and Inert Dusts against *Rhizopertha dominica* in Stored Wheat Grain

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Abstract

Efficacy of inert dusts, vegetable oils and plant products increased with increase in the dose level. Adult mortality recorded after 7, 14 and 21 days of exposure period in different treatments showed that highest mortality of adult (100.0 %) was recorded on diatomaceous earth at doses of 3g and 5 g per 100 g grains while minimum mortality (39.63 %) was observed on neem leaf powder at the rate of 1.0 g. Data recorded on grain damage, weight loss and adult emergence after 12 months of infestation of grains showed nil grain damage and weight loss and adult emergence on diatomaceous earth. Neem leaf powder at 1.0 g was found least effective by giving maximum grain damage (25.00 %), maximum weight loss (9.57 %) and maximum adult emergence (27.95 adults). Diatomaceous earth at both higher rates caused cent per cent F_1 adults mortality; whereas, neem leaf powder at the rate of 1.0 g caused 32.74 per cent F_1 adult's mortality. The diatomaceous earth at both their application rates of 3 g and 5 g was more effective and gave 100 per cent inhibition rate; whereas, neem leaf powder at the rate of 1.0 g caused 83.59 per cent inhibition rate in emergence of F_1 , *R. dominica*. No adverse effect of all treatments was found on the germination of wheat grains at any dose level up to 120 days of treatment. Highest germination per cent of wheat grains was recorded on diatomaceous earth at dose of 5.0 g (91.67 %) while minimum (60.33 %) was observed in control.

Introduction

Wheat is attacked by many insect pests in field as well as in storage condition. Although, there are about 200 species of insects and mites found infesting wheat grains, few of which are major or primary pests. Among different stored grain pests, the lesser grain borer, *R. dominica*, is an important internal and primary feeder of various stored wheat grains. *R. dominica*, attacks a wide range of stored cereals such as barley, paddy, wheat, maize and sorghum. The beetle is a strong flier, spreads with greater rapidity and is also found attacking wheat in the field. Both the adult and larvae bore into healthy kernels of grain, reducing them to hollow husk by using of their strong mandible (Patel and Vekaria, 2013). The use of inert dust, plant products and vegetable oils assumed significance as an important component of insect pest's management in stored grain because of their economic viability and eco-friendly nature (Kabir *et al.*, 2013 and Rajasri *et al.*, 2012).

Materials and Methods

The experiments were carried out under laboratory condition in the Department of Entomology. Different plant products, vegetable oils and inert dusts were mixed with 100 g wheat grains to study their efficacy against *R. dominica* at 0, 7, 14 and 21 days after treatment. Treated grains 100g were kept in 250 ml capacity plastic containers and replicated three times under Completely Randomized Design (CRD) and 20 pairs of freshly

emerged adults of test insect were released in to the treatments. The mouth of container was covered with muslin cloth and tightened with rubber band. All released adults were removed after 21 days and the observations were taken on the following parameters.

Corrected mortality (%) : Data of adult mortality was corrected as by Abbott's formula (Abbott, 1925) :

Corrected mortality (%)

$$= \frac{\text{Mortality in treatment (\%)} - \text{Mortality in control (\%)}}{100 - \text{Mortality in control (\%)}} \times 100$$

Per cent inhibition rate (% IR) : Percentage reduction in emergence of F_1 adults or inhibition rate (% IR) was calculated by using the following formula (Tapandjou *et al.*, 2002) :

$$\text{Inhibition rate (\%)} = \frac{(C_n - T_n)}{C_n} \times 100$$

Where C_n is the total number of newly emerged insects in the control and T_n is the total number of emerged insects in the treatment.

Grain damage : After one year, damaged and healthy grains were counted separately and per cent grain damage was calculated by the following formula :

$$\text{Grain damage (\%)} = \frac{\text{Number of damaged grain}}{\text{Total number of grain used}} \times 100$$

Weight loss : The weight loss was calculated by the

method suggested by Adams and Schulten (1978) and express in percentage.

$$\text{Grain weight loss (\%)} = \frac{(W_n - N_d) - (W_d - N_u)}{W_u (N_d + N_u)} \times 100$$

Where;

W_u = Weight of undamaged grains

N_d = Number of damage grains

W_d = Weight of damaged grains

N_u = Number of undamaged grains

Germination percentage : The numbers of germinated seeds were counted and expressed as a percentage. Per cent seed germination was calculated as

$$\text{Seed germination (\%)} = \frac{\text{No. of germinated seed}}{\text{Total no. of seed in sample}} \times 100$$

Statistical analysis : The data obtained on various characters/parameters were subjected to analysis of variance technique applicable for completely randomized design. The level of significance used in "F" test was $P=0.05$ wherever, F calculated was significant, critical difference values were calculated for treatment comparisons. The values obtained in percentage were transformed into angular values and subjected to analysis.

Results and Discussion

Adult mortality : Data recorded for adult mortality after 7 days of exposure on treated wheat grains showed significant higher adult mortality 93.35 per cent was observed in diatomaceous earth @ 5 g per 100 g grains followed by 80.35 and 80.00 per cent in diatomaceous earth @ 3 g and mustard oil @ 1.2 ml per 100 g grains, respectively but were statistically at par. The lowest significant mortality was obtained in neem leaf powder (13.35 %) at lower dose followed by groundnut oil at lower dose which exhibit 20.00 per cent adult mortality. Highest adult mortality (100 %) after 14 days of exposure on treated wheat grains was recorded in the treatment comprises diatomaceous earth @ 5 g per 100 g grains followed by 96.59 per cent in diatomaceous earth @ 3 g and significantly differ from each other. The lowest adult mortality 20.34 per cent was obtained the treatment in neem leaf powder at lower dose and significantly superior over rest of the treatments. Data recorded for adult mortality after 21 days of exposure on wheat grains on different treatments showed cent per cent adult mortality in both the dosage rates of diatomaceous earth i.e. 3 g and 5 g followed by 93.12 and 91.36 per cent in diatomaceous earth 1g and mustard oil 1.2 ml, respectively and were found statistically at par to each other. The lowest adult mortality 39.63 was recorded in neem leaf power @ 1g

followed by 44.80 and 48.27 per cent in groundnut oil when treated with 0.4 ml and 0.8 ml, respectively but were statistically at par (Table 3). Similarly, Arthur (2002) reported that diatomaceous earth (Protect-It) @ 300 ppm exhibited 100 per cent mortality of *Sitophilus oryzae* within one week of exposure in wheat. Waqas *et al.* (2006) reported that diatomaceous earth (Protect-It) @ 500 and 600 ppm per kg grains exhibited 100 per cent mortality of *R. dominica* after three weeks of exposure in wheat. Singh *et al.* (2014) and Carlos *et al.* (2016) reported that diatomaceous earth was found very effective against stored insects. Lal *et al.* (2015) reported fly ash @ 0.5% was found effective treatments with 70.30 per cent adult mortality. Kudachi and Balikai (2009) and Chudasama *et al.* (2015) reported that mixing of custard apple seed powder @ 5 per cent was found most effective. Borad (2013) reported mustard and groundnut oil @ 0.5 per cent exhibited 44.08 and 35.13 per cent mortality of *S. oryzae*, respectively in maize grain up to six month of storage period. Singh and Singh (2005) and Mishra and Pandey (2014) reported neem kernel powder appeared to be the most effective. Arya and Tiwari (2013) and Kakde *et al.* (2014) reported effective results with neem leaf powder against *R. dominica*.

Adult emergence (F_1) : Adult emergence on treated wheat grains exhibit that no adult emergence was recorded in diatomaceous earth 5 g and 3g followed by 0.25 adults in lower rate of diatomaceous earth (Table-4). Maximum adult emergence (170.35 adults) observed in control that was significantly different to all the treatments. The present findings are also in agreements with the findings of Baldassari and Martini (2014) and Lal *et al.* (2015) reported that diatomaceous earth @ 1 and 0.5%, exhibited no progeny emergence. Singh *et al.* (2014) and Carlos *et al.* (2016) reported that diatomaceous earth was found very effective against stored insects.

F_1 adult mortality : Diatomaceous earth at both higher rates caused cent per cent mortality and mustard oil, fly ash, custard apple seed powder, neem seed powder at higher dose rate and diatomaceous earth at lower rate per 100 g grains caused (>80 %) mortality followed by remaining treatment concentrations caused 32.74-71.29 per cent mortality. No progeny mortality was observed in untreated control (Table 4). The present findings are also in agreements with the findings of Baldassari and Martini (2014) and Lal *et al.* (2015) reported that diatomaceous earth @ 1 and 0.5%, exhibited 98 and 97 adult mortality of *R. dominica* and Carlos *et al.* (2016) reported that diatomaceous earth was found very effective against stored insects.

Inhibition rate (%) : Parasual of Table-4 showed that diatomaceous earth at both their application rates (3 g and

Table-1 : List of plant products, vegetables oils and inert dusts used for bioefficacy against *R. dominica*.

S. No.	Common Name	Scientific Name	Dose/100g grains
1.	Neem leaf powder	<i>Azadiracta indica</i> A. Juss	1.0, 3.0 & 5.0 g
2.	Custard apple seed powder	<i>Annona squamosa</i> Linn	1.0, 3.0 & 5.0 g
3.	Neem seed kernel powder	<i>Azadiracta indica</i> A. Juss	1.0, 3.0 & 5.0 g
4.	Groundnut oil	<i>Arachis hypogaea</i> Linn	0.4, 0.8 & 1.2 ml
5.	Mustard oil	<i>Brassica juncea</i>	0.4, 0.8 & 1.2 ml
6.	Fly ash	-	1.0, 3.0 & 5.0 g
7.	Diatomaceous earth	-	1.0, 3.0 & 5.0 g
8.	Control	-	

Table-2 : Correlation coefficients among insect and grain damage variables.

Variables	Parent mortality	F ₁ Progeny emerged	F ₁ Progeny Mortality	Grain damage (%)	Weight loss (%)
Parent mortality	1.000				
F ₁ Progeny emerged	-0.789*	1.000			
F ₁ Progeny mortality	0.987*	-0.753*	1.000		
Grain damage (%)	-0.962*	0.844*	-0.888*	1.000	
Weight loss (%)	-0.956*	0.875*	-0.893*	0.993*	1.000

Correlation coefficient; * significant at 5 per cent.

Table-3 : Efficacy of plant products, vegetable oils and inert dusts on adult mortality of *R. dominica*.

Treatment	Per cent corrected mortality after days			
	Dose g or ml per 100g grains	7 th	14 th	21 st
Neem leaf powder	1	21.43 (13.35)	26.81 (20.34)	39.01 (39.63)
	3	28.90 (23.35)	34.59 (32.23)	45.99 (51.73)
	5	36.27 (35.00)	46.47 (52.57)	48.97 (56.91)
Custard apple seed powder	1	30.00 (25.00)	40.63 (42.40)	49.96 (58.61)
	3	37.26 (36.65)	49.40 (57.65)	61.75 (77.60)
	5	45.95 (51.65)	58.63 (72.90)	68.18 (86.19)
Neem seed kernel powder	1	31.08 (26.65)	39.62 (40.67)	48.97 (56.91)
	3	38.26 (38.35)	48.40 (55.92)	61.75 (77.60)
	5	46.92 (53.35)	57.52 (71.17)	66.80 (84.48)
Ground nut oil	0.4	26.57 (20.00)	34.84 (32.64)	42.02 (44.80)
	0.8	33.21 (30.00)	38.64 (38.99)	44.01 (48.27)
	1.2	35.27 (33.35)	44.52 (49.16)	50.96 (60.32)
Mustard oil	0.4	34.05 (31.35)	52.37 (62.73)	60.56 (75.84)
	0.8	49.81 (58.35)	58.63 (72.90)	66.80 (84.48)
	1.2	63.43 (80.00)	68.31 (86.34)	72.91 (91.36)
Fly ash	1	31.72 (27.65)	51.35 (61.00)	55.09 (67.25)
	3	44.05 (48.35)	56.48 (69.50)	65.47 (82.77)
	5	56.38 (69.35)	64.41 (81.34)	68.18 (86.18)
Diatomaceous	1	43.08 (46.65)	48.40 (55.92)	74.79 (93.12)
	3	63.44 (80.35)	79.36 (96.59)	90.00 (100.00)
	5	75.06 (93.35)	90.00 (100.00)	90.00 (100.00)
Control	-	0.00 (0.00)	7.38 (1.65)	10.55 (3.35)
S.Em. ±		1.56	1.93	2.29
C.D. (P=0.05)		5.21	6.02	6.88

Figures in parentheses are retransformed per cent values.

5 g) was more effective and exhibit 100 per cent inhibition rate in generation emergence F₁ of *R. dominica* followed by 99.85 per cent in diatomaceous earth @ 1 g/100g. All the treatments at higher dose rates exhibit 92.51 to 98.77 per cent whereas; lower rate of all treatments gave 83.59

to 93.92 per cent inhibition rates in emergence of F₁ except diatomaceous earth.

Grain damage (%) and weight loss (%) : No grain damage and weight loss was recorded in diatomaceous earth at both the higher rates followed by 0.47 per cent

Table-4 : Efficacy of plant products, vegetables oils and inert dusts on adult emergence of *R. dominica*.

Treatment	Dose g or ml per 100 g grains	Inhibition rate (%)	F ₁ adult emergence	F ₁ adult mortality (%)
Neem leaf powder	1	66.10 (83.59)	5.33 {27.95}	34.90 (32.74)
	3	71.14 (89.55)	4.28 {17.80}	43.71 (47.75)
	5	74.12 (92.51)	3.64 {12.75}	46.24 (52.16)
Custard apple seed powder	1	71.95 (90.40)	4.10 {16.35}	45.96 (51.68)
	3	75.07 (93.37)	3.44 {11.30}	57.29 (70.80)
	5	79.51 (96.21)	2.48 {5.65}	64.47 (81.42)
Neem seed kernel powder	1	71.47 (89.90)	4.21 {17.20}	45.00 (50.00)
	3	74.51 (92.87)	3.56 {12.15}	57.54 (71.19)
	5	78.78 (96.21)	2.64 {6.45}	63.88 (80.62)
Ground nut oil	0.4	66.65 (84.30)	5.22 {26.75}	35.79 (34.21)
	0.8	71.89 (90.34)	4.12 {16.45}	39.12 (39.82)
	1.2	75.94 (94.10)	3.25 {10.05}	47.43 (54.23)
Mustard oil	0.4	75.73 (93.92)	3.29 {10.35}	51.28 (60.87)
	0.8	80.09 (97.04)	2.36 {5.05}	57.60 (71.29)
	1.2	83.62 (98.77)	1.61 {2.10}	65.91 (83.33)
Fly ash	1	74.28 (92.66)	3.61 {12.50}	50.07 (58.80)
	3	79.00 (96.36)	2.59 {6.20}	56.89 (70.16)
	5	83.47 (98.71)	1.64 {2.20}	64.56 (81.55)
Diatomaceous	1	88.80 (99.85)	0.87 {0.25}	63.43 (80.00)
	3	90.00 (100.00)	0.00 (0.71)	90.00 (100.00)
	5	90.00 (100.00)	0.00 (0.71)	90.00 (100.00)
Control	-	-	13.07 (170.35)	0.00 (0.00)
S.Em. $\pm$		2.14	0.36	1.61
CD (P=0.05)		6.53	1.09	5.37

Figures in parentheses are retransformed per cent values.

Figures in { } are retransformedsquare root $\times \pm 0.5$ values.

Table-5 : Effect of plant products, vegetable oils and inert dusts on wheat grain damage, weight loss caused by *R. dominica* and on germination.

Treatments	Dose g or ml per 100 g grains	Grain damage (%)	Weight loss (%)	Germination (%)
Neem leaf powder	1	30.00 (25.00)	18.02 (9.57)	57.00(70.33)
	3	27.22 (20.92)	15.72 (7.34)	57. 62(71.33)
	5	25.01(17.87)	14.19 (6.01)	58.48(72.67)
Custard apple seed powder	1	21.96(13.98)	12.29 (4.53)	62.25(78.33)
	3	17.47 (9.01)	10.94 (3.60)	64. 65 (81.67)
	5	16.35 (7.92)	8.80 (2.34)	65.90 (83.33)
Neem seed kernel powder	1	21.13 (13.00)	11.88 (4.24)	63.20 (79.67)
	3	17.58 (9.12)	10.06 (3.05)	63.92 (80.67)
	5	14.21(6.03)	8.68 (2.28)	65.40 (82.67)
Ground nut oil	0.4	27.26(20.98)	15.72 (7.34)	61.12 (76.67)
	0.8	24.32(16.96)	13.56 (5.50)	62.26 (78.33)
	1.2	19.38 (11.01)	12.82 (4.92)	62.49 (78.67)
Mustard oil	0.4	12.75(4.87)	7.34 (1.63)	67.76 (85.67)
	0.8	3.57 (10.88)	6.87 (1.43)	68.30 (86.33)
	1.2	7.58(1.74)	4.83 (0.71)	69.44 (87.67)
Fly ash	1	12.92(5.00)	8.15 (2.01)	66.68 (84.33)
	3	10.32(3.21)	7.03 (1.50)	67.48 (85.33)
	5	8.13(2.00)	5.53 (0.93)	68.59 (86.67)
Diatomaceous	1	1.24(0.47)	0.99 (0.03)	71.25(87.67)
	3	0 (0.00)	0 (0.00)	69.44 (89.33)
	5	0 (0.00)	0 (0.00)	73.22 (91.67)
Control		65.88 (83.30)	36.01(34.57)	50.96 (60.33)
S.Em. $\pm$		0.49	0.52	2.26
CD (P=0.05)		1.46	1.49	6.42

Figures in paren theses are retransformed per cent values.

grain damage in lower dose of diatomaceous earth (Table-5). The mustard oil and fly ash at all rates of application gave between 1.74 to 5.00 per cent grain damage 0.71 to 2.01 per cent weight loss. Maximum grain damage (83.30%) and weight loss (34.57%) was recorded in the control. Minimum protection with maximum grain damage, 25.00 per cent was observed in neem leaf powder at 1 g followed by 20.98 and 20.92 per cent in groundnut oil 0.4 ml and neem leaf powder 3 g but was statistically at par. The present findings are also in agreements with the findings of Chudasama *et al.* (2015) and Kumawat (2009) reported that plant products @ 2.5 and 5.0 g/100 g seeds showed no weight loss up to 90 and 270 days of storage. Baldassari and Martini (2014) and Lal *et al.* (2015) reported that diatomaceous earth @ 1 and 0.5%, with less grain damage Singh *et al.* (2014) and Carlos *et al.* (2016) reported that diatomaceous earth was found very effective against stored insects.

Germination (%) : The germination of grains ranged from 60.33 to 91.67 per cent (Table-5). The inert dust and mustard oil at all their application rates gave more than 84.0 per cent germination, whereas plant products and groundnut oil at all application (dosage) rates gave 70.33 to 83.33 per cent germination as compared to control (60.33). Shaheen and Khaliq (2005); Singh and Singh (2005); Biswas and Biswas (2005); Meghwal and Bajpai (2102) and Mishra and Pandey (2014) who reported that inert dusts and plant products were not inhibited the germination up to 3 to 4 months. Lal *et al.* (2015) reported no adverse effect of fly ash and diatomaceous earth on the germination of treated wheat grains upto 120 days of treatment.

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Study of Isolation, Identification, Purification and Pathogenicity Test on Anthracnose of Pomegranate Caused by *Colletotrichum gloeosporioides* (Penz. and Sacc.)

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Abstract

Pomegranate (*Punica granatum* L.) is an old table product of tropical and sub-tropical areas of the world. It belongs to the smallest botanical family *punicaceae*. Pomegranate tree is local from Iran to the Himalayas in northern India and has been developed since antiquated occasions all through the Mediterranean area of Asia, Africa and Europe. The fruits have high food value and rich in carbohydrates, calcium, iron, sulphur and vitamin-c and citric acid. The fungus in the present study produced septate mycelium. Later it produced conidiophores arising singly or closely packed together in rows. Conidiophores were single celled, hyaline and aseptate with one or several conidial scars. The typical major anthracnose symptoms were observed on leaves and fruits.

Key Words : *Colletotrichum gloeosporioides*, isolation, pathogenicity.

Introduction

Pomegranate is regarded as the “Fruit of Paradise”. It is one of the most adaptable subtropical minor fruit crops and its cultivation is increasing very rapidly. In India, it is regarded as a “vital cash crop”, grown in an area of 1.5 lakh ha with a production of 11.0 lakh tons (Jadhav and Sharma, 2009). Madhya Pradesh has forayed into commercial cultivation of pomegranate. Known for its in numerous health-giving properties especially for anemic persons, this juicy fruit is said to have its origin in Iran. In India Maharashtra is the largest pomegranate producing state followed by Gujarat, Haryana, Rajasthan, Karnataka, Tamil Nadu, Uttar Pradesh, Punjab and Haryana. In India, anthracnose disease was first reported by McRae (1924). In Asian nation leaf spot and fruit spot of pomegranate square measure incited by fungi admire fungus genus *Cercospora punicae* O, Henn., *C. granati* Rawla, *C. lytheracearum* Heald and wilt, Sphacelome species. Among the illness the leaf and fruit spots caused by *Colletotrichum gloeosporioides* is economically vital as a result of it causes respectable losses in fruit yield. Studies of cultural, morphological and physiological characters of the pathogen are of immense use in understanding the nature and adaptation of the pathogen in different environmental and nutritional conditions. Isolation, identification and of fungus causing anthracnose of pomegranate is essential for the proper study and diagnosis of the disease, the morphological characters of the fungus such as mycelial and cultural characters, length, breadth and shape of conidia, fruiting body use for the identification of fungus.

Materials and Methods

The studies about anthracnose of pomegranate caused by *Colletotrichum gloeosporioides* and its management were carried out during 2018-19 in the Department of Plant Pathology, College of Agriculture, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur (M.P.). Studies made so far include symptomatology, morphology, nature of the pathogen, Pathogenicity, damage and other related information about the disease and its management.

Isolation : Pomegranate fruits and leaves infected with anthracnose were collected from experimental site and from different locations during survey viz and used for isolation of the fungus *in vitro*. The isolation of the fungus was made by using standard tissue isolation technique. The disease infected leaves and fruits were cut and surface sterilized by using 1 per cent sodium hypochlorite (NaClO) solution for 60 seconds. These cut parts were thoroughly washed in sterile distilled water to remove the traces of sodium hypochlorite (NaClO) if any and then aseptically transferred to sterile potato dextrose agar (PDA) slants inoculated slants were incubated at room temperature (27±1°C).

Purification

Single spore isolation : Ten ml of clear filtered 2 % water agar was poured into the sterile petri-plates and allowed to solidify. Diluted spore suspension was prepared in sterilized distilled water from ten to twelve days old culture. One ml of such suspension was spread uniformly on water agar plate. Plates were incubated at 27

Table-1 : Percent Disease Index of anthracnose.

(a) Spore suspension method			
Observation Days	3rd Days	7th Days	10th Days
Percent Disease Index	8.06	8.20	8.46
(b) Spores dip method			
Observation Days	3rd Days	5th Days	10th Days
Percent Disease Index	6.65	6.98	7.22

$\pm 1^{\circ}\text{C}$ for 12 hrs and watched under compound microscope so as to locate germination of conidia. Single germinated conidium was marked with ink-marker on the lower surface of the plates.

The growing hyphal tip portion was transferred to fresh PDA slants with the help of cork borer under aseptic conditions and incubated at $27 \pm 1^{\circ}\text{C}$, obtained pure culture tubes were used for further studies.

Maintenance of the culture : The fungus was sub cultured on PDA slant, allowed to grow at $27 \pm 1^{\circ}\text{C}$ for 12 days and preserved in refrigerator at 5°C . This pure culture was used for future study.

Identification of the fungus : For identification of pathogen, morphological characters of the fungus such as mycelial and cultural characters, length and breadth of conidia, fruiting body were observed with the help of compound microscope.

Pathogenicity : To test the pathogenicity of *Colletotrichum gloeosporioides* spore suspension and spore dip method was used.

Spore suspension method : The pathogenicity of *Colletotrichum gloeosporioides* proved under field condition through spray suspension method. The healthy leaves and fruits were selected from experimental sites. Spore suspension of *Colletotrichum gloeosporioides* was prepared in amount of 10^6 cfu/ml and sprayed on the healthy leaves and fruits. Inoculated leaves and fruits were covered with transparent polythene and tagged. Observations were taken at 3, 7 and 10th days after inoculation for symptom development.

Spore dip method : Pathogenicity was proved under artificial condition through spore dip method. The healthy young leaves and fruits were collected from experimental site. Then they were washed thoroughly with tap water, swabbed with 1 per cent sodium hypochlorite and washed with distilled sterile water. By using a hypodermic needle, small surface wound was made up of 1-2 mm in size. Spore suspension of fungal culture was prepared in amount of 10^6 cfu/ml and used for inoculating the healthy leaves and fruits by dipping in suspension solution. Further they were placed in humid chamber and incubated at $27 \pm 1^{\circ}\text{C}$. Observations were made at 3, 5, 10th days after dipping for symptoms development.

Results and Discussion

Isolation and purification : During survey infected samples showing typical anthracnose symptoms on leaf and fruits were collected. Upon tissue isolation the pathogen from experimental site was brought into pure culture. Based on, morphological characters the pathogens were identified as *C. gloeosporioides* (Penz.) Penz. and Sacc. in accordance with the description given by Ekbote (1994); Sudhakar (2000); Venkataravanappa (2002) and Prashanth (2007). Zakaria et al. (2009) isolated thirteen *Colletotrichum* isolates from different banana cultivars (*Musa* spp.) with symptoms of anthracnose lesions on the surface of the fruit or from pieces of infected tissues.

Identification : The study on characteristics of *Colletotrichum gloeosporioides* indicated, septate hyphae, conidiomata acervilli and hyaline conidiophore, conidia single celled, hyaline, straight, cylindrical, rounded at both the ends, with one to two oil globules in the conidium. The findings are in agreement with the findings of earlier workers (Simmonds, 1965; Mordue, 1971, Irwin and Camerson, 1978; Holiday, 1980; Jeffries et al., 1990; Ekbote., 1994; Sudhakar 2000; Prasanna 2001; Venkataravanappa 2002 and Prashanth, 2007). Based on the mycelial and spore morphology, asexual fruiting body of the fungus under study was identified as *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc.

Pathogenicity

Spore suspension method : The data in table-1 indicate that after 3rd day of inoculation, minute pin head size brown to black coloured water-soaked spots were seen on leaves with percent diseases index of 8.06 per cent. After seven-day, percent disease index was observed 8.20 per cent. Spot turned slightly brown surrounded by chlorotic halo, while on ten day these spots enlarged and showed dark brown colour surrounded by slight chlorotic halo. After ten days the central portion of spot showed minute dark coloured acervilli, later these spots coalesced and percent disease index was recorded 8.46 per cent. Parey et al. (2013) proved pathogenicity of isolated fungi *C. capsici* causing chilli anthracnose by four different inoculation methods under in vitro conditions, on detached semi-ripe fruits of chilli. The methods included pin-prick,

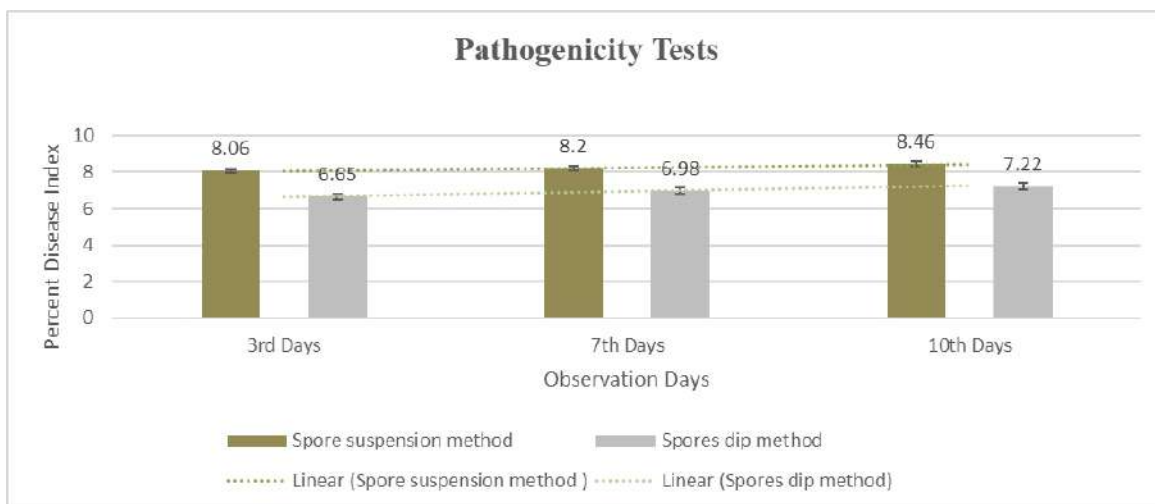


Fig. Pathogenicity test (Percent Disease Index of anthracnose).



Plate 1: Infected leaves and infected



Plate 2: Pure culture plate



Plate 3: Acervulus of *C. gloeosporioides*



Plate 4: Pure culture test tube (12th Day old)



Plate 5: Spore suspension method



Plate 6: Spores dip method

spore suspension spray, spore suspension injection and spore suspension dip.

Spores dip method : The data in table-1 indicate that after three days of inoculation, percent disease index of anthracnose was recorded 6.65 per cent. At fifth days percent disease index was recorded 6.98 per cent while after ten days, it was observed 7.22 per cent. The description given agreed with earlier worker (Jamadar, 2007), Chanderia UK *et al.* (2008) described the test of pathogenicity method the spray suspension and spore dip method.

Conclusion

The pathogen isolated from pomegranate (*Punica granatum*) leaves and fruit having leaf and fruit spot symptom was identified as *Colletotrichum gloeosporioides*. The pathogen *Colletotrichum gloeosporioides* mostly infect mature fruits causing brown to dark brown, circular depressed spots on fruit and violet to black spots on leaf. The pathogenicity of the *Colletotrichum gloeosporioides* was proved by spore suspension method and spore dip method, maximum percent disease index was recorded after ten days of inoculation on leaf.

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Incompatibility Behavior in Fruit Plants

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Introduction

Pollen deposition is frequently restricted in flowering plants due to insufficient or poor-quality pollen (Knight *et al.*, 2005), possibly due to limited pollinator visits, inefficient transmission of pollen, or a lack of suitable partners (Ashman *et al.*, 2004). Sexual incompatibility among flowering plants is a common phenomenon that contributes to inbreeding within populations. By erecting unilateral barriers between self-compatible and self-incompatible populations (U.I.), it appears to contribute to speciation (unilateral incompatibility). Darlington and Mather (1949) estimated that half of angiosperm species had S.I.; the generalization rule of Lewis and Crowe's (1958), that S.I. × S.C. species are cross incompatible would imply that U.I. functions in more than one interspecific pollination out of four on average. Outbreeding is enforced by incompatibility, a physiological process. It can be found in many different blooming plant families.

Incompatibility is the inability of male and female gametes to fertilize together in specific combinations. Pollen pistil interaction is characterized by incompatibility. Incompatibility exists both between species (interspecific) and within species (intraspecific). Some species are incompatible due to pollen not germinating, while others are incompatible because pollen tubes do not penetrate the entire length of the style. The stoppage of pollen-tube growth resulting from style-grafting and temperature experiments may be caused by the reaction of a substance in the pollen tube with a complementary substance in the style. Pollen and style chemicals react differently according on the allele. The reaction is irreversible and prevents some processes required for tube growth.

Types of Incompatibility

Cross Incompatibility : Cross incompatibility refers to any relationship (or lack thereof) between pollen and pistil, preventing the production of hybrid zygotes in crossings between two viable species (de Nettancourt, 2001). The explanation for this behavior has been attributed to a lack of genetic information concerning the structure or

physiology of the other partner in a particular genotypic combination (Hogenboom, 1973), or for pistil identification of pollen from another species (Kermi cleand Evans, 2010). Based on whether CI happens unilaterally or bilaterally, a particular genotypic combination can be incompatible in one or both directions. In CI, pollen tube growth can be halted at several sites in the pistil (stigma; upper, middle, or lower part of the style) or in the ovary, as seen in wild potatoes (Camadro and Peloquin, 1981; Hayes *et al.*, 2005), wild tomatoes (Baek *et al.*, 2015), and peppers (Onus and Pickersgil, 2004). Apple, plums, citrus, cherry, apricot, ber, almond, chestnut and other fruits have cross-incompatibility.

Self-incompatibility : Koelreuter (1761) was the first to record self-incompatibility and term was later given by Stout (1917). It's the incapacity of hermaphrodite flowers functioning male and female gametes to set seeds after self-pollination. Self-discrimination between pollen and pistil limits inbreeding in plants with self-incompatibility systems, a process genetically mediated by one or more highly polymorphic loci. The S-locus has been studied the most because it is found in Rosaceae, Solanaceae, and Gramineae species. Based on whether the S-haplotype expressed by a pollen grain is dictated by the genotype of the pollen parent or by the genotype of the pollen grain, S-locus reactions are classified as sporophytic (SSI) or gametophytic (GSI) (de Nettancourt, 2001).

General features of Self-incompatibility :

Due to crosspollination, it maintains a high degree of heterozygosity.

Between pollination and fertilization, it may operate at any stage.

It reduces selfing and encourages out-breeding, increasing the chances of new gene combination.

Morphological, physiological, genetic, and biochemical, all factors can play a role.

Cross pollination produces normal seed set.

In plants, S.I. is frequently inherited by a single gene (S) with several alleles (e.g. S1, S2, S3, etc.).

S allele activity is reported to be increased or decreased by polygenes (modifying genes).

Self-incompatibility can occur as are suit of following factors :

On the stigmatic surface, pollen grains may not germinate.

Although some germinate but they are unable to penetrate the stigmatic surface.

The pollen tube enters the style, but it grows too slowly to have an impact on fertilization.

Fertilization is affected sometimes, but the embryo degenerates at a very early stage.

Classification of self-incompatibility : Bateman (1952) classified self-incompatibility into complementary and oppositional systems based on the interaction between pollen grains and pistil.

Complementary System of SI (Stimulatory type)	Oppositional System of SI (Inhibitory type)
If pollen growth differs in SI genotype from that of pistil, both the pollen and pistil together produce substances that stimulate pollen germination and growth.	If pollen and pistil produce the same SI reaction, pollen cannot germinate or grow pollen tubes.
The germination and growth of the pollen having similar genotype is not stimulated.	The germination and growth of the pollen differing in SI reaction is not inhibited
Ex-Dendrobium (least common type)	Almost all cases of SI are of this type (most common type)

Complementary system of self-incompatibility : Self-incompatibility of this type is also known as stimulatory self-incompatibility. When pollen from one S.I. group lands on the stigma of another S.I. group, both generate chemicals that promote pollen tube germination and expansion, resulting in fertilization success. However, if they belong to the same S.I. group, no such compounds are created, preventing pollen germination and subsequent growth.

Oppositional system of incompatibility : This type of self-incompatibility is also known as inhibitory self-incompatibility. Pollen and pistil release substances that hinder pollen germination and growth when they belong to the same S.I. No chemicals restrict normal growth in a suitable response. Pollen development will lead to effective fertilization. Lewis (1954) [13] established the traditional classification of self-incompatibility based on floral shape. He divided S.I. into two categories: homomorphic systems and heteromorphic systems. The homomorphic self-incompatibility system is divided into gametophytic and sporophytic systems once more.

Heteromorphic Self Incompatibility : It's due to differences in the flower's morphological characteristics. The same species produces multiple morphological types

of flower in this form of incompatibility. Distyly and tristily are related concepts.

Criteria		Types
Flower morphology (Lewis, 1954)	Heteromorphic self-incompatibility	Distyly
		Tristyly
	Homomorphic self-incompatibility	Sporophytic self-incompatibility
		Gametophytic self-incompatibility

There are two types of stamens and styles in distyly. It is governed by a single gene S, which has two alleles, Ss and ss, which produce thrum and pin flowers, respectively. A plant's genotype affects the pollen incompatibility reactions by determining whether 'S' dominates over 's'. As a result, the incompatibility system represents the heteromorphic sporophytic type. Flowers of the thrum type have a short style and long stamens. Pin type refers to a flower with a long style and short stamen. In addition to stamen and style length, thrum and pin flowers differ in six ways. The only condition that is compatible is Pin x Thrum or vice versa. This trait is controlled by a single S locus with six genes (L1, L2, G, S, A and P). For example, pin types of flowers present in sapota, pomegranate, litchi, and thrum types a represent in almond, carambola.

I1	I2	G	S	A	P	S	Pin
I1	I2	G	S	A	P	P	
L1	L2	G	S	A	P	S	Thrum
I1	I2	G	S	A	P	P	

Styles and stamens in tristily come in three different sizes (small, medium and large). Two genes, S and M, each having two alleles, determine it. The expression of gene M is being masked by the S gene. Short style is derived from the letter S. s and M refer to the medium style, whereas and m refer to the long style. Short styles have SsMm, SsMm, or SsMM genotypes, medium styles have ssMm or ssMM genotypes, and long styles have ssmm genotypes. Pomegranate varieties such as Ganesh and Kandhari, as well as *Prunus* fruit crops, are example s of tristily.

Homomorphic Self Incompatibility : In this case, floral morphological variations aren't a factor in incompatibility. The incompatibility might be caused by the genotypes of the plant on which it's grown (sporophytic control), or by the genotypes of the plant itself (gametophytic control).

Gametophytic Self Incompatibility : As a result of self-incompatibility in gametes, the gametophytic self-incompatibility system arises. East and Mangelsdorf (1925) were the first to discovered this mechanism in *Nicotiana sanderae*. Both alleles express themselves and demonstrate codominance in style. In this form of incompatibility, pollens are binucleate, the pollen behavior is determined by the S allele, and the stigma is wet type .It

means that pollens incompatibility reaction is determined by its genotypes, not the genotype of the plant on which it is formed. In most cases, a single gene with numerous alleles determines incompatibility reaction. Polyploid pollen can sometimes lose incompatibility due to competition between the two S alleles. A mono factorial system is one in which a single gene controls the incompatibility reaction; a bifactorial system is one in which two genes control it. Almond, apple, apricot, ber, cherry, loquat, pear, pineapple, and plum are all important examples of gametophyte self-incompatibility. Pollen parents with the genetic constitution S_1S_2 produce two gametes, S_1 and S_2 , and two alleles are co-dominant in female parents, and both are expressed. Because the reaction in the stigma is co dominance, pollen grains with S_1 or S_2 genetic makeup will not germinate when they fall on a plant with S_1S_2 . When it lands on a female plant's stigma with S_1 and S_3 , then S_2 can germinate and causes partial incompatibility, however when it lands on a female with S_3 and S_4 , it causes total compatibility (Hughes and Babcock, 1950).

Cross	Compatibility
$S_1S_2 \times S_1S_2$	Fully incompatible
$S_1S_2 \times S_1S_3$	Partially compatible
$S_1S_2 \times S_3S_4$	Fully compatible

Apple : The apple (*Malus × domestica* Borkh.) is incompatible with itself and with other apple cultivars. As a consequence, apple production has to rely on at least two genetically different cultivars. Lal *et al.* (1972) discovered 9 apple cultivars that were entirely self-incompatible and 4 that were somewhat self-incompatible. The best pollinators for the Early Shanburry cultivar were Fanny (54.5%), Winter Banana (60.4%), and Rome Beauty (54.25%). Jonathan produced the most fruit in Red Delicious (87.50%). With self-pollination, the cultivars McIntosh, Rymer, Jonathan, and RomeBeauty produce a

fair harvest. Delicious is a self-incompatible and cross-pollinated category of cultivars.

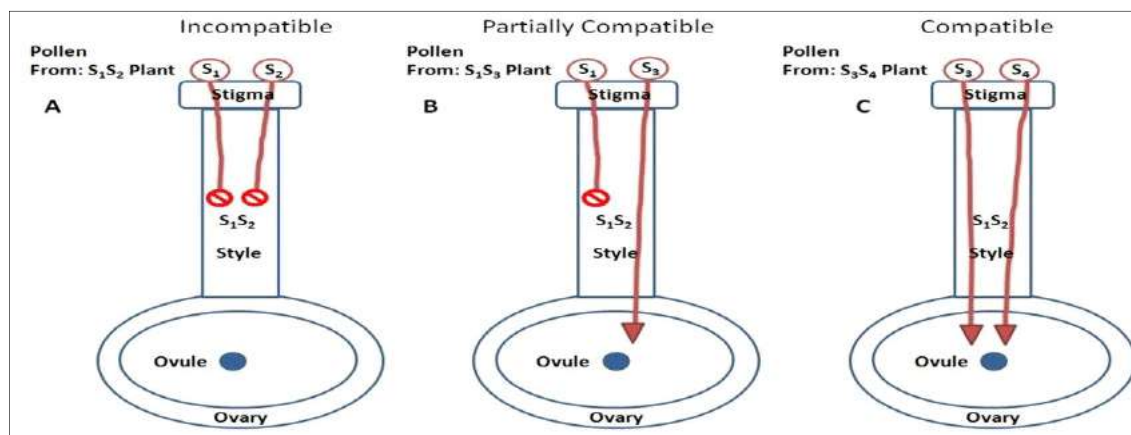
Ber : Banarsi, Karaka, Mundia, Murhara, Reshmi, Sandhura, Narnaul, Safeda, Umrans, Illaichi, Kakrola are varieties that are self-incompatible. Illaichi × Kakrol Gola produces the highest fruit set, and Umrans is the best pollen donor and recipient (Godara,1980).Umrans was shown to be compatible with Sanuar-2 as a female parent, although Sanuar-2 did not bear fruitwhen Umrans pollinated it (Mehrotra and Gupta, 1985). Pollen is mostly transmitted by honey bees since it is sticky. Most flowers do not get pollinated during critical periods of gynoecium receptivity because of the short receptivity time.

Apricot : Apricot (*Prunus armeniaca* L.) has a single locus with numerous allelic variations that controls gametophytic self-incompatibility. Some cultivars, including as Gold Rich and Lambert, have been known to be cross incompatible.

Plums : The majority of Japanese plum cultivars are self-incompatible, requiring cross-pollination with compatible cultivars at blooming time.

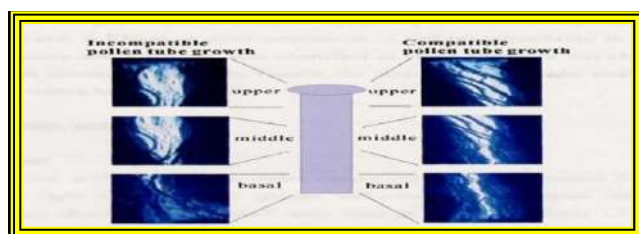
Loquat : Late Yellow, Golden Yellow, Tanaka, and California Advance loquat cultivars have all been reported to have S.I.

Cherry : There are a large number of cherry cultivars that are incompatible with each other. There are multiple cross-incompatible groups, and for optimum fruit set, cross compatible cultivars within each group should be planted in the orchard. When varieties with the same sterility alleles are planted together, they will not set fruit, and at least one additional variety with a distinct sterility allele is required for better fruit set. Stella, Vista, Vic, Seneca, and Vega are universal donor kinds that can be planted with any variety.



Diagrams of the three possible reactions in crossing two apple varieties

Source: <https://www.researchgate.net/publication/317731880> A Grower's Guide to Cross-Compatibility and Self-Compatibility in Apple



Pollen tube growth in sweet cherry (*P. avium*) pistil (Yamane, 2003)

Citrus : Lemon, grapefruit, grapefruit, sweet limes, and mandarins are thought to be incompatible. The lemon variety Kagzi Kalan, Pant Lemon, exhibits self-incompatibility. Hybrids between S.I. cultivars are also S.I., with some being Cl. Cross incompatibility was discovered between Clementine and 'Ariake,' a hybrid of Navel Orange and Clementine (Yamamoto, *et al.*, 2006).

Pineapple : Commercial clones of the pineapple are self-incompatible; thus, their fruits develop parthenocarpically and are seedless.

Sporophytic self-incompatibility : Pollen's incompatibility is determined by the genotype of the plant that produces it, not by its genotype. Pollen grains from a given plant behave similarly due to incompatibility imposed by the maternal genotype. Huges and Babcock (1950) were the first to reported this mechanism in *Crepis foetida*. Pollen germination is inhibited as a result of incompatibility at the stigmatic surface. Mango, aonla, and cocoa pollens are trinucleate, with a dry stigmatic surface. If either of the two alleles exists in the sporophyte parent that produced the pollen, the pollen will not germinate on the stigma. This is true despite the fact that each pollen grain is haploid and only contains one of the alleles. For example, S₂ pollen, produced from an S₁S₂ parent, will not germinate on an S₁S₃ stigma.

Cross	Compatibility
S ₁ S ₂ × S ₁ S ₂	Fully incompatible
S ₁ S ₂ × S ₁ S ₃	Partially compatible
S ₁ S ₂ × S ₃ S ₄	Fully compatible

Pollen donor self-incompatibility (SSI) is more restrictive, as all S-alleles are potentially recognized in the recipient pollen (Heizmann, 1992), but complex dominance effects can occur between S-alleles (Hiscock & McInnis, 2003).

Late-acting self-incompatibility (LSI) : According to Seavey and Bawa (1986), this term is used to describe lack of fruit set following selfing in a species despite growth of self-pollen tubes to the ovary. Other authors have used 'ovarian incompatibility' or 'pistillate sorting' (Sage *et al.*, 1994). It is also termed as ovarian self-incompatibility (OSI). Self pollen germinates and reaches the ovules in this process, but no fruit is

produced. LSI can be pre-zygotic (embryo sac degeneration before the pollen tube entry) or post-zygotic (embryo sac deterioration after pollen tube entry) (malformation of the zygote or embryo).

Cocoa : Knight and Rogers (1953, 1955) looked into the genetics and cytology of this embryo sac suppression. In the style, compatible and incompatible pollen tubes grow at the same rate. Incompatible self-and cross-pollinations, on the other hand, result in non-fusion ovules with 25 %, 50 %, or 100 % male nuclei but no syngamy, and such flowers abscise prematurely. The non-fusion of gametes is a result of the same S allele acting as a dominant (or codominant) in both parents, as shown by the sequence of S alleles S₁ > S₂ = S₃ > S₄ > S₅. The dominance relationships suggest that this reaction is controlled by sporophytic mechanisms (Seavey and Bawa, 1986).

Mango : Singh *et al.* (1962) confirmed mango self-incompatibility in the variety Dashehari. Self incompatibility was discovered in Dashehari, Langra, Chausa, and Bombay Green by Mukherjee *et al.* (1968) and Sharma and Singh (1970). The best pollinizers for Dashehari and Chausa appear to be Bombay Green and Dashehari, respectively (Ram and Sirohi, 1979). Embryological research demonstrated that 15 days after pollination, despite normal fertilization following self-pollination, endosperm degeneration occurred (Mukherjee *et al.*, 1968). The sporophytic kind of self-incompatibility mechanism operates in mango. Self-incompatibility in mangos is post-zygotic, as opposed to conventional sporophytic incompatibility. Certain mango cultivars have been shown to be cross-incompatible, according to Ram *et al.* (1976). Self-compatibility exists between Pusa Arunima and Pusa Surya. Self-incompatibility is used in Mango to create hybrids like Arka Puneet, Arka Neelkiran and Arka Anmol.

Mechanism of Self Incompatibility : It can be divided into three groups based on the many phenomena observed during pollination and fertilization :

Pollen-stigma interaction : Pollen germination is often prevented by this contact, which occurs shortly after pollen grains reach the stigma. Gametophytic stigmas are plumose, have extended receptive cells, and are often referred to as moist stigmas. At a later stage, the incompatibility reaction occurs. There are distinct serological variations between pollen grains of various S genotypes, which have not been reported in the sporophytic system. In the sporophytic system, stigmas are papillate and dry, covered by a hydrated layer of proteins referred to as pellicle. The pellicle appears to play a role in the incompatibility reaction. The stigma antigens differ dramatically depending on the S allele makeup. Within minutes of reaching the stigmatic surface, the

Table-1 : S alleles in some commercial apple varieties.

Variety	Parentage	S alleles	Literature Source
Delicious	Chance Seedling	S ₉ S ₂₈	Hegedus, 2006
Empire	McIntosh × Delicious	S ₁₀ S ₂₈	Broothaerts, 2004
Rome Beauty	Chance Seedling	S ₂₀ S ₂₄	Hegedus, 2006;Broothaerts, 2004
Jonathan	Chance Seedling	S ₇ S ₉	Long, 2010; Hegedus, 2006; Broothaerts, 2004
Granny Smith	Chance Seedling	S ₃ S ₂₃	Dreesen, 2010;Hegedus 2006; Broothaerts, 2004
Golden Delicious	Chance Seedling	S ₂ S ₃	Dreesen, 2010;Hegedus, 2006; Broothaerts, 2004;Long 2010
Fuji	Delicious × RallsJanet	S ₁ S ₉	Dreesen, 2010;Hegedus, 2006; Broothaerts,2004

Table-2 : S-genotypes and incompatibility groups of few parental sweet cherry cultivars.

Cultivar	S genotype	IG	Reference for S-genotype
Bigareau Burlat	S ₃ S ₉	XVI	Schuster (2012)
Bigarreau de Schrecken	S ₁ S ₃	II	Schuster (2012)
Drogans Gelbe	S ₁ S ₅	XIV	Schuster (2012)
Lijana	S ₁ S ₆	XX	Schuster (2012)
Majova Rana	S ₁ S ₄	IX	Maricand Radicevic (2014)
Van	S ₁ S ₃	II	Schuster (2012)

Table-3 : Difference between Gametophytic and Sporophytic Self Incompatibility (Singh B.D., 2014).

Gametophytic Self Incompatibility	Sporophytic Self Incompatibility
Incompatibility reactions are determined by the genotype of pollen.	Pollen incompatibility reactions are determined by a plant's genotype.
The stigma is wet and smooth.	The stigma is papillate (hairy) and has a dry texture.
Inhibition of pollen tubes in style	On the stigmatic surface, pollen germination and tube entry are prevented.
Male gametes have a haploid genome, while pistil tissues have a diploid genome (Haploid-Diploid).	The pollen-pistil interaction is governed by the genome of the plant that produces male and female gametes (Diploid-Diploid)
Codominance is seen in S alleles.	S Alleles show dominance or codominance.
Following the completion of meiosis, the S allele product is produced.	Before meiosis is completed, the S allele product is generated.
Binucleate pollen grains are found in such species.	Trinucleate pollen grains are found in such species.
Does not allow homozygotes to be produced.	Allow homozygotes to be produced.
There are no reciprocal differences.	Compatible and in compatible reciprocal differences occur frequently.
Compatibility is divided into three categories: compatible, incompatible, and partial compatible.	The genotype of the plant determines only compatible and incompatible

pollen produces exine exudates, which are either proteins or glycoproteins. This exudate causes callose production in incompatible stigma papillae (which come into direct touch with pollen). Callose is frequently produced on the immature projecting pollen tubes, limiting further pollen germination. Hence, stigma is a site of incompatibility reactions in the sporophytic system. Pollen incompatibility is caused by certain chemicals deposited on the pollen exine from the anther tapetum.

Pollen tube-style interaction : Most gametophytic systems result in pollen grains germinating and pollen tubes penetrating stigmas. When incompatible combinations are present, pollen tube growth in the stigma is slowed.

Pollen tube-ovule interaction : When pollen tube reaches the ovule, it interferes with fertilization.

Combinations that are incompatible, on the other hand, lead to premature embryo degeneration.

Biochemical basis for self-incompatibility

The development of pollen tubes was inhibited by pistil peroxidase in plum and peach.

Unlike sporophytic S.I., gametophytic S.I. produces repressor molecules in pollen tubes, which inhibit the activity of genes involved in pollen tube growth. Growing pollen tubes produce a chemical that promotes pollen growth, although it appears to be leaky (Arora,1993).

The presence of endogenous growth hormone in the anther and ovaries of Golden Delicious and Star King Delicious apples suggests a coordinated interaction between GA and Cytokinin in the self-incompatibility process (Bhartiya *et al.*, 1986).

Isoelectric focusing polyacrylamide gel electrophoresis was used to analyze stilar proteins in six cultivars of Japanese pear (*Pyrus serotina* Rehd.) with varying self-incompatibility alleles (IEF-PAGE).

Three bands were distinct, one of which was obviously related with the self-incompatibility S2-allele (hence referred to as S2-protein) and was easily identifiable due to its enormous abundance.

Molecular basis for self-incompatibility pollen RNase

Mechanism : Both incompatible and compatible pollen grains germinate in gametophytic self-incompatibility, resulting in the formation of pollen tubes. Those pollen tubes that are incompatible with the egg, on the other hand, stop growing in the style, while the ones that are compatible fertilize the egg. RNA molecules are degraded in the pollen tube by S-locus-encoded ribonuclease (S-RNase), which is generated in the style. This stops pollen tube growth.

Each S specificity is determined by a hyper variable area of RNase molecules, which is encoded by a distinct allele (S1, S2, S3, etc.). SLF (S-locus F-box protein) is a protein found in pollen tubes that binds to S-RNase. SLF is also seen in a variety of S specificities (S1, S2, S3, etc.). As a result of SLF or SCF (Skp1-Cul1-F-box-protein ubiquitin ligase) destroying the S-RNase (in proteasomes) in compatible (non self) pollen tubes, the pollen RNAs can survive and growth can proceed. For example, the S1 SCF and S1 S-RNase limits its degradation, damaging the pollen tube's RNAs and halting its growth in incompatible ('self') tubes.

S-RNases have recently been associated to gametophytic self-incompatibility in Japanese pear (*Pyrus pyrifolia*), apple (*Malus domestica*), and European pear (*Pyrus communis*), all of which belong to the Rosaceae family, similar to Solanaceae (McCubbin and Kao, 2000).

If cDNAs for sweet cherry S-RNases are cloned, it will be possible to use gene transfer procedures to create self-compatible cherries. Antisense expression of S-RNase cDNAs leads in self-compatible phenotypes in solanaceous plant species (Lee et al., 1994; Murfett et al., 1995).

Two-dimensional polyacrylamide gel electrophoresis (2D-PAGE) was used to examine pistil proteins from sweet cherry cultivar in order to find pistil S-proteins linked to gametophytic self-incompatibility. Glycoprotein was found in the highest quantity in the mature style's upper segment, and it had immunological features and N-terminal sequences with other plant species' S-RNases. The cDNAs encode S-RNases, according to genomic DNA and RNA blot studies and amino acid

sequences; thus, the pistil S-proteins found by 2D-PAGE are S-RNases.

S-locus : S-loci are actually clusters of three closely linked loci (Watanabe et al., 2000) :

S-Locus Glycoprotein, which encodes part of a cell wall receptor, is found on the stigma.

In the sporophytic system, SRK (S-Receptor Kinase) encodes the other part of the receptor. During protein synthesis, phosphate groups are attached to other proteins by kinases. SRK is a trans membrane protein found in the plasma membrane of stigma cells.

A soluble ligand for the same pollen-secreted receptor is encoded by the SCR (S-locus Cysteine-Rich Protein) gene.

The pollen coat contains the male determinant Cysteine-Rich protein (SCR). The S-locus, aserine/threonine receptor kinase, is the female determinant. There is only one receptor kinase found in stigma cells, the S-locus Receptor Kinase (SRK). If this happens, the SRK receptor triggers a signaling cascade that prevents pollen from hydrating and germinating. SCR1 and SCR2 are synthesized by S1S2 pollen-producing sporophytes and included in (and subsequently released from) both S1 and S2 grains. Upon binding one or both SCR molecules to one of the receptors on the stigma, the kinase generates a series of events that prevents seed germination. Among these events is ubiquitination, which targets proteins for degradation in proteasomes. When this path is not triggered (e.g., pollen from an S1S2 parent on an S3S4 stigma), the pollen germinates successfully.

Importance of Self-Incompatibility : Self-incompatibility efficiently restricts self-pollination, which has a significant impact on plant breeding strategies and goals :

To assure fruitfulness in self-incompatible fruit trees, two cross-compatible varieties must be planted.

In hybrid seed production, self-incompatibility may be exploited. Two self-incompatible but cross-compatible lines are using for this, with seeds derived from both lines being hybrid seed.

Hybrid seed can be produced without emasculation or genetic male sterility by self-incompatibility.

Cross-pollination allows desirable genes from two or more sources to combine in a single genotype, something that is not possible for species with self-compatibility.

Limitations

In a species with self-incompatibility, homozygous inbred lines are difficult to produce.

To keep the parental lines alive, bud pollination is required.

Environmental elements like as temperature and humidity have an impact on self-incompatibility. High temperatures and humidity reduce or break down incompatibility.

Due to the difficulties and costs of maintaining inbred lines through manual pollination, self-incompatibility is only used in limited circumstances.

Mixed planting of different cultivars depending on cross-compatibility results in inconsistent fruit quality.

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Effect of Plant Architecture on Seed Quality in Okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract

An experiment was conducted to check out effect of plant architecture on seed quality parameters like 100 seed weight, germination percentage, and seed vigour indices of harvested okra seeds during 2015 at farm and laboratory at Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh. Okra seeds were raised at four different spacing (S₁-60 cm ×30 cm, S₂-45 cm ×30 cm, S₃-60 cm ×20 cm, S₄-45 cm ×20 cm) in different plots and after sowing, pinching of terminal bud was done at different {P₀- No pinching, P₁- 15 days after sowing (DAS), P₂-Pinching 20 DAS, P₃- pinching 25 DAS, P₄- pinching 30 DAS and P₅- pinching 35 DAS} days. There were total 24 (4 spacing factors × 6 pinching factors) treatments and each treatment was replicated thrice in field experiment. Results regarding seed quality parameters was observed in laboratories and each combination have three replications in combined block design. Results of experiment revealed that interaction effect of spacing and pinching was non-significant on seed quality parameters. Germination percentage of harvested seeds was significantly affected by spacing but 100 seed weight seedling length, seedling dry weight, SVI-I and SVI-II were affected significantly by spacing and pinching both. Maximum germination, seedling length, seedling dry weight, SVI-I and SVI-II, 100 seed weight was maximum in widest spacing (S₁- 60 cm ×30 cm) and no pinching (P₀) was most favourable for these parameters.

Key words : Pea, pinching, seed quality, spacing.

Introduction

Okra, an export-oriented vegetable belongs to family Malvaceae and is native to tropical Africa (Thomson and Kelly, 1979). Okra is cultivated in different tropical and sub-tropical areas of world because it is rich source of vitamin A, B, C, protein, carbohydrate, minerals and fats (Jha and Dubey, 1998). India is largest producer of okra crop but productivity of crop is lower than average productivity of world.

Plant architecture refers to the three-dimensional organisation of a plant body. Architecture of plant depends on relative arrangement of each of its parts. Number or branches, size of leaves, number of leaves, inter-nodal distance etc. of plants decides final yield of crop. Pinching of terminal bud helps in monitoring growth of plant by reducing apical dominance. High lateral growth in okra plants rather than vertical growth reduced lodging and helps in developing thicker and wider canopy. Spacing is very basic management practices to achieve proper growth of plants. Proper spacing of sowing seeds decides exposure of plants to sunlight and availability of water and nutrients for plants.

Materials and Methods

Planting material : The lab experiment was carried out at experimental laboratory of Department of Seed Science and Technology, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, HP during 2015. Okra variety selected for lab trials was P8.

Treatment details :

Factor 1 : Spacing : 04

(a) S₁-60 cm ×30 cm,

(b) S₂-45 cm ×30 cm,

(c) S₃-60 cm ×20 cm,

(d) S₄-45 cm ×20 cm

Factor 2 : Pinching : 06

(e) P₀-No pinching,

(f) P₁-15 days after sowing (DAS),

(g) P₂-Pinching 20 DAS,

(h) P₃-pinching 25 DAS,

(i) P₄-pinching 30 DAS

(j) P₅-pinching 35 DAS

Replication : 03

Table-1 : Effect of spacing and pinching on seed quality parameters in okra cv. P8

Treatment		100 seed weight (g)	Germination percentage	Seedling length (cm)	Seedling dry weight (mg)	Seed vigour index-I	Seed vigour index-II
Spacing							
S ₁	60 cm x30 cm	6.44	93.37 (9.71)	23.95	24.25	2237	2265
S ₂	45 cm x30 cm	6.29	88.02 (9.43)	21.94	23.26	1765	1957
S ₃	60 cm x20 cm	6.29	84.49 (9.24)	20.05	22.23	1854	1965
S ₄	45 cm x20 cm	6.18	80.98 (9.05)	19.30	19.27	1563	1561
CD _{0.05}		0.11	0.05	0.15	0.08	28.04	23.04
Pinching							
P ₀	No pinching	7.00	86.85 (9.36)	22.28	23.01	1942	2005
P ₁	Pinching 15DAS	6.67	87.31 (9.39)	22.12	22.88	1939	2005
P ₂	Pinching 20 DAS	6.41	87.19 (9.38)	21.49	22.53	1879	1970
P ₃	Pinching 25 DAS	6.12	85.90 (9.31)	20.61	22.10	1778	1905
P ₄	Pinching 30 DAS	5.72	85.88 (9.31)	21.14	21.88	1851	1886
P ₅	Pinching 35 DAS	5.89	87.16 (9.38)	20.22	21.10	1741	1848
CD _{0.05}		0.13	NS	0.18	0.10	34.35	28.22
Interaction effect (Spacing × Pinching)							
CD _{0.05}		NS	NS	NS	NS	NS	NS

Design : Completely randomized design (CRD) factorial

Germination (%) was calculated by using the formula :

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds}} \times 100$$

Seed vigour index-I (SVI-I) and seed vigour index-II (SVI-II) were calculated as per the formula given by Khare and Bhale (2000).

$$\text{Seed vigour index-I (SVI-I)} = \frac{\text{Germination (\%)} \times \text{Seedling length (cm)}}{\text{Seedling dry weight (mg)}}$$

$$\text{Seedling vigour index-II (SVI-II)} = \frac{\text{Germination (\%)} \times \text{Seedling dry weight (mg)}}{\text{Seedling length (cm)}}$$

The statistical analysis for CRD (factorial) was done as per design of experiment as suggested by Gomez and Gomez (1984).

Results and Discussion

Numerical data of different seed quality parameters affected by spacing and pinching is presented in Table below. Any seed quality parameter wasn't affected by interaction effect of spacing and pinching. Different spacing and pinching treatments had significant effect on 100 seed weight, seedling length, seedling dry weight and seed vigour indices. Germination percentage of harvested seeds were significantly affected only by spacing. Pinching treatments didn't show any significant effect on germination percentage.

Maximum 100 seed weight (6.44g) of harvested seeds was found at widest spacing (60 cm x30 cm) and minimum (6.18) was at closest spacing (45 cm x20 cm). It might be attributed to fact that at wider spacing water and nutrient uptake was more which led to bolder seeds.

Pinching at different days also had significant effect on 100 seed weight of okra. Maximum 100 seed weight (7.00 g) was found when pinching was not done (P₀) and minimum was found P₄ treatment (Pinching 30 DAS). It might be attributed to fact that pinching led to more lateral growth of plants so number of pods was increased so number of seeds was also increased so nutrition and water supply was fewer in pinching treatments over no pinching. Sajjan *et al.* (2004) reported pinching after 20 days of sowing showed maximum 100 seed weight in case of Arka Anamika variety of okra.

Maximum germination (93.37%) was found when crop was raised at widest spacing (60 cm x30 cm) and minimum germination (80.98%) was observed in closest spacing (45 cm x20 cm). It might be attributed to fact that raising seeds at wider spacing faces less competition for water and nutrient that ensures good early growth which ultimately led to produce more healthy seeds but at closer spacing competition for essential inputs for growth was more. Similar findings were also observed in okra crop by Feleafel and Ghoneim (2005) but Moniruzzaman *et al.* (2008) reported that different spacing (60 cm x30 cm, 60 cm x40 cm, 60 cm x50 cm and 60 cm x60 cm) didn't had any significant effect on germination percentage.

Maximum seedling length (23.95 cm) was observed in seeds harvested from plants were spaced at 60 cm x30 cm (S₁) and minimum seedling length (19.30 cm) was observed at closest spacing of 45 cm x20 cm (S₄). At wider spacing more food reserves are available per fruit that produces high quality seeds which could be the reason for longer seedling length. Uddin *et al.* (2006) also recorded higher seedling length for maximum spaced plants in okra. Pinching also affected seedling length

considerably. Maximum seedling length (22.28 cm) occurred when no pinching was done (P_0) and minimum (20.22 cm) was recorded when pinching was done after 35 days of sowing (P_5). Possible reason for this could be that pinching produced more fruits per plant, therefore food reserves per fruit were less and this led to small seed size and ultimately resulted in lower seedling length.

The main effects revealed that spacing had significantly influenced the seedling dry weight. Seedling dry weight 24.25 mg was recorded when spacing was 60 cm $\times$ 30 cm (S_1), which was found to be significantly higher in comparison to other spacings; whereas, minimum seedling dry weight (19.27 mg) was obtained with closest spacing (S_4). Higher seedling length at wider spacing resulted in higher seedling dry weight in S_1 . Uddin et al. (2006) reported similar results for okra with maximum seedling dry weight at a spacing of 75 cm $\times$ 20 cm. In case of pinching, maximum seedling dry weight (23.01 mg) was obtained with no pinching (P_0) and it decreased with pinching being minimum (21.10 mg) for P_5 i.e. pinching 35 DAS. Pinching increases number of fruits per plant which reduced the amount of food reserves per fruit and ultimately per seed, resulting in less vigorous seeds.

Maximum SVI-I (2237.49) was noted at widest spacing of 60 cm $\times$ 30 cm (S_1) and minimum SVI-I (1563.22) when plants were spaced at 45 cm $\times$ 20 cm (S_4). In S_1 , seed germination and seedling length was maximum therefore, SVI-I was also maximum. Hence wider spacing produced vigorous seeds. Pinching led to decrease in seed vigour. Maximum SVI-I (1942.17) was calculated from P_0 (no pinching) and P_1 is at par to P_0 . Minimum SVI-I (1741.24) was calculated for P_5 (pinching 35 DAS). This decrease in SVI-I can be attributed to decrease in seedling length with subsequent pinching up to P_4 . Maximum SVI-II (2265.02) was reported in seeds extracted from plants spaced at 60 cm $\times$ 30 cm (S_1) and minimum (1561.38) was reported in minimum spacing of

45 cm $\times$ 20 cm (S_4). Since widest spacing recorded maximum seedling dry weight, SVI-II was also highest. Pinching also affected SVI-II significantly. Maximum SVI-II (2005.73) was calculated for P_0 (no pinching) which was at par with P_1 . Minimum SVI-II (1848.32) was calculated for P_5 (pinching 35 DAS). Pinching decreased overall seedling dry weight which led to decrease in SVI-II for okra seeds.

Conclusion

It could be concluded from results of experiment that sowing okra cv. P8 at wider spacing (60 cm $\times$ 30 cm) produce high vigorous seeds. Pinching of terminal buds is not favourable for producing high vigorous seeds.

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Role of Plant Growth Regulators in Guava : A Review

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Abstract

Guava is one of the most important and extensively cultivated fruit crop in India. The existing guava production is not able to meet our present demand of guava fruits to the increasing population of the country. The use of plant growth regulators has been proved as a powerful tool to meet this demand by influencing fruit production directly or indirectly. The PGR's include auxins, gibberellins, cytokinins, ABA, ethylene, growth retardants and growth inhibitors. PGRs are chemical compounds, which can regulate some important metabolic activities in plants. They influence on growth and development of plants, which influence the improve the seed germination by breaking seed dormancy, root initiation in cuttings and air layers, to regulate proper canopy, flowering, fruit set and increase in yield and quality.

Key words : Guava, rooting, canopy management, growth, yield, quality.

Introduction

Guava (*Psidium guajava* L., $2n = 22$) is the most valuable cultivated species of Myrtaceae family popularly known as "poor man's fruit" or "apple of tropics". It is native to Tropical America stretching from Mexico to Peru. It is popular due to its round year availability, nutritional and medicinal value and affordable price, suitability for transportation, handling and consumer preference. It exceeds most other fruits in productivity, hardiness, adoptability and vitamin C content^[1]. The major states of guava growing in India are Uttar Pradesh, Maharashtra, Madhya Pradesh, Bihar, West Bengal, Chhattisgarh, Punjab, Haryana, Gujarat, Karnataka and Andhra Pradesh. The total area in India under guava is 287.0 thousand ha with annual production 4304.0 thousand MT and average productivity of 14.99 MT/ha^[2]. The existing guava production is not able to meet our present demand of guava fruits to the increasing population of the country. It also necessitates enhancing the production potential of guava under available resources. Besides, all available high production technologies such as use high yielding varieties, high density orchard, the use of PGR's has been proved as a powerful tool to meet this demand by influencing fruit production directly or indirectly^[3].

The PGRs are the organic substances, which modify, promote, inhibit and regulate physiological processes in a reasonable measure in the plant in small concentrations. PGRs absorbed and move rapidly into the tissues, when applied in the plant parts and they are specific in their action. Thus, the application of plant growth regulators has resulted in some enhancements of

the growth, yield and quality in several fruit crops. Plant growth substances have key role in different physiological processes related to growth and development of crops. It is obvious that changes in the level of endogenous hormones due to biotic and abiotic stress alter the crop growth and any sort of manipulation including exogenous application of growth substances would help for yield improvement or at least sustenance of the crop. Plant growth regulators like NAA, GA₃ play an important role in guava production by direct or indirect influence like germination, rooting, growth and productivity of guava. Effect of NAA shows that T.S.S. and ascorbic acid content of fruits were increased with reduction in acidity. The application of GA₃ enhances the size, shape, fruit weight and fruit set. NAA reduces the number of seeds and heavier fruiting and promotes flowering. GA₃ and NAA were found to accelerate cell elongation and increase fruit size^[4].

Exogenous application of plant growth regulators (PGRs) not only increases the number of flower but also increases the quality of fruit and retention capacity of on the tree till maturity and reduces fruit drop^[5]. The seedless parthenocarpic guava will increase the commercial value of the fruit as those will have no seeds, easy to consume and a minimal-waste^[6]. The percentage of flowering and fruiting, poor fruit retention, poor yield and quality fruits are of major concern of the fruit growers. So, the present investigation was undertaken to find out response of plant growth regulators on yield and quality of guava.

Seed germination : Seed germination may require gibberellins for the activation of vegetative growth of the

Table-1 : Plant bio-regulators in crop regulation of guava.

Sr. No	Guava	PGRs	Concentration	Stage of application	Response/effect
1.	Allahabad Safeda	NAA	250 ppm	-	Highest de-blossoming of the crop during the rainy season and the highest yield and fruit quality during the winter season [21]
2.	Sardar	NAA	600 ppm	Full bloom stage (May)	Maximum winter crop yield (359.3 q/ha) [19]
3.	Sardar	Ethephon	1800 ppm	-	Highest yield (103.98 kg/tree) in during the winter season [22]
4.	Allahabad Safeda	NAA	100 ppm	Initiation of flowering stage (mid April)	Maximum yield in the winter season [23]

Table-2 : Effect of plant bio-regulators on fruit yield and quality in guava.

S. No.	Guava	PGRs	Response/effect
1.	L-49	NAA 10 ppm at blooming stage	Greatest fruit diameter (5.03 cm), fruit weight (88.9 g), flesh weight (83.6 g), number of fruits per tree (666) and fruit yield (56.9 kg) [27]
2.	Sardar	Paclobutrazol 500 ppm	Maximum fruit length (6.67 cm), fruit diameter (6.74 cm), fruit weight (179.32 g), fruit volume (172.45 cc) and thereby yield (6.83 kg/tree) [28]
3.	Allahabad Safeda and L-49	NAA 100 ppm	Increase fruit weight in rainy season
4.		NAA 200 ppm	Increased TSS in both season
5.		2,4-D 60 ppm	Average yield increased[23]

embryo. Gibberellin application also activates the alpha amylase synthesis in the aleurone layer where it converts starch to sugar which translocated to growing embryo to provide energy source. Pre-sowing treatment with GA₃ at 3000 ppm was found enhance the seed germination (83.2%), plant height, number of leaves/plant and leaf size^[7]. The highest germination 83.79 and 80.30 percentage was recorded with GA₃ (1000ppm) and (500 ppm), respectively^[8].

Micro-propagation : The guava micro-shoots were successfully rooted on ½ MS medium supplemented with different auxin types. IBA+NAA recorded the highest rooting percentage as well as the highest root length. Dipping shoot base in IBA solution recorded the highest root number^[9]. The best rooting was response on WPM supplemented with 0.2 mg l⁻¹ each of IBA & NAA and 200 mg/l activated charcoal. The regenerated plantlets were established on peat and soil rite based rooting mixture for hardening in the glass house. Finally, 50% of the plantlets survived on field transfer^[10].

Propagation by cuttings and stooling : Auxin is relatively helpful among cuttings to overcome difficulties in root induction. Indole butyric acid (IBA) is a plant growth hormone among the auxins and is used in many horticultural plants for root induction^[11]. Propagation of guava through cuttings can yield the best results in terms of the number of days to sprout, number of roots, and root length with the application of 1600 ppm of IBA followed by 7000 ppm of NAA. NAA application had positive effect on guava rooting^[12]. Treatment of guava cutting with PBZ suggested that its application could increase the guava

growth and survival at lower concentration. Higher PBZ concentration may induce toxic effects on shoot growth and sprouting^[13].

Propagation by air layering : The minimum days for root initiation (84 days), maximum number of roots (12.10), higher rooting (33.33%) and survival percentage (100%) in layers prepared in the month August applied with IBA 4000 ppm^[14]. The maximum number of primary and secondary roots, length and diameter of primary and secondary root was found in 15,000 ppm IBA^[15]. The realizing higher rooting and success of guava air layers under semi-arid tropical ecosystem of Vidarbha region may be performed in the month of August and IBA treatment at the rate of 10,000 ppm^[16]. The 15th July time of air layering, IBA 4500ppm concentration and sphagnum moss as a growing medium individually and in combination is the best and can be used for mass multiplication of true-totype plants of Pant Prabhat Guava through airlayering under the sub-tropical condition of Garhwal-Himalaya^[17].

Canopy management : Under high density planting system where fruiting starts from first year, a precise level of pruning is required to make the balance between vegetative and reproductive phase. In fact, guava responds well to canopy modification by pruning and training. Paclobutrazol produced most significant reduction in the length of the first internode due to reduced leaf number and thus transpiration, which in turn would have reduced the movement of paclobutrazol in the plant^[18]. Paclobutrazol application 1ml/litre/tree in guava cv. Lucknow-49 is best under high density planting system^[19].

Crop regulation and fruit thinning : The guava yields thrice in a year viz., rainy, winter and summer. Plant bio-regulators have been found very effective in thinning flowers and manipulating the cropping season *e.g.* two sprays of 600-800 ppm NAA done in April–May at 15 days interval in Tarai condition at 50% flowering is effective in regulating the crop in guava. The studies were earned out on 20 years old Sardar guava trees in which urea (10, 15 and 20%), potassium iodide (0.5, 1.0 and 2.0%), maleichydrazide (1000, 2000 and 3000 ppm), ethephon (600, 1200 and 1800 ppm) and NAA (200, 400 and 600 ppm) were sprayed during May for crop regulation. All the chemicals reduced the yield of rainy season crop significantly over control and subsequently increased the yield of winter season crop. NAA (600 ppm) application produced maximum winter crop yield (359.3 q/ha) followed by the application of 15 per cent urea (356.2 q/ha). The higher concentrations of urea were found very effective in improving the fruit quality and resulted in maximum TSS (14.0%), ascorbic acid (342.2 mg/100 g), total sugars (10.20%) and pectin (1.59%) content in the winter crop. Acidity was significantly reduced by 1800 ppm ethephon during both the seasons. Maximum profit (Rs.1,42,600/ha) was obtained with NAA 600 ppm followed by 15 and 20 per cent urea treatments. Crop regulation in guava ‘Sardar’ by reducing of crop load of rainy season crop through foliar application of NAA (600 ppm) produced maximum winter crop yield ^[20].

Flowering, fruit set, fruit growth and development :

Application of plant bio-regulators resulting in better quality and yield in fruit crops (Table 2) because it improved the internal physiology of developing fruit in terms of better supply of water, nutrients and other compounds vital for their proper growth and development which resulted in improved size, quality and ultimately greater yield ^[24]. The increase in fruit size is due to the acceleration of cell division and cell enlargement and more intercellular space with the application of higher concentration of growth substances like NAA. The increase in length and diameter of guava fruit may be due to higher concentration of plant growth regulators (NAA) that appears to have indirect role in hastening the process of cell division and cell elongation^[4].

The improvement in size of guava fruits due to pre-harvest foliar application of various concentration of NAA might be result of enhanced internal physiology during fruit development which induced efficient utilization of resources like water, nutrients and other vital compounds. ^[25] GA₃75 ppm and NAA 100 ppm are also effective to enhance the yield related attributes of guava fruits in winter season. The total number of flowers per plant (61.12), number of fruiting bud per plant (49.79),

numbers of fruits per plant (46.10), plant spread (120.05 cm), fresh fruit weight (173.31 g), dry fruit weight (166.64 g), fruit length diameter ratio (7.13 cm), and yield/plant (23.43 kg) were found to be higher under the treatment T₃-Naphthalene acetic acid had a significant effect on the yield^[26].

Quality parameters : NAA 150 ppm at the higher concentration augmented TSS content of the fruit. Increase in sugar content may be due to the higher concentration of NAA which promotes hydrolysis of starch into sugar. The higher percentage of total sugar, reducing and non-reducing sugar have been due to efficient translocation of photosynthates to the fruits by regulation of NAA. Acidity of fruits was reduced by application of plant growth regulators; however maximum reduction was noted with foliar spray of NAA 150 ppm^[4]. Application of 40 ppm and 20 ppm NAA significantly enhanced the quality parameters viz., TSS (10.95 and 10.87%), reducing sugar (3.79 and 3.65%), non-reducing sugar (2.65 and 2.56%), total sugar (6.44 and 6.21%) and ascorbic acid content ^[29]. Improving TSS content of fruit might be explained that GA₃ 50 ppm stimulated the functioning of number of enzymes in the physiological process which probably caused and increased in TSS content of fruit^[5]. Ethephon 300, 400 and 500 ppm in winter guava cv. Sardar was greatly improved palatability rating in fruits ^[30]. GA₃ 50 ppm proved to be the best in increasing the quality characters like TSS, ascorbic acid and total sugars ^[31].

The spray of GA₃ was found to be most effective in increasing the weight and specific gravity and decreased total acid content of guava fruits. Whereas, maximum reducing sugar and ascorbic acid content were recorded with NAA 80 ppm and GA₃ 60 ppm, respectively in cv. Sardar^[32]. The NAA 15, 30, 45, 60, 75 and 90 ppm through foliar spray and reported that 45 ppm spray reduced pre-harvest fruit drop, increased yield, pulp/acid ratio (11.31), TSS (11%), total sugar (7.45%), acidity and ascorbic acid in guava^[33]. The fruit weight, organoleptic rating, TSS, ascorbic acid and total sugar content of guava fruits increased significantly over control by the application of NAA 20 to 60 ppm and decreased fruit pressure (kg/cm²) significantly to make it more acceptable.^[34]

Conclusions

Thus, it can be concluded from this review that the use of plant growth regulator in guava has been found beneficial for improve seed germination, propagation, canopy management, flowering, fruit set, fruit growth, development, crop regulation, fruit thinning, yield and quality.

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Inheritance of Time to Pod Initiation in Chickpea (*Cicer arietinum* L.) under Cold Stress Conditions

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Abstract

Two parents having contrasting traits viz., cold tolerance (ICC16349) and cold susceptibility (GPF2) were selected for hybridization, where 'ICC16349' was selected as a donor and 'GPF-2' as a recipient. F₁ generation of cross GPF2 X ICC16349 was grown to get F₂ seed and F₂ progenies of each F₁ plants were grown separately. Phenotyping of F₂ plants resulting from the cross GPF2 X ICC16349 was conducted under field conditions and data pertaining to days to pod initiation was recorded to screen plants for cold stress tolerance. Individual plants were categorized into early podding and late podding by comparison with respective controls. The plants that showed podding along with cold tolerant parent (ICC16349) were considered as early podding and rest were categorized as late podding plants and podding time of these remaining plants coincided with cold susceptible parent (GPF2). The goodness of fit of time to pod initiation was tested by chi-square goodness of fit test (Pearson, 1900) for both monogenic/digenic control. Data on days to pod initiation revealed that F₂ progeny plants segregated into two categories, early podding and late podding. Of 577 F₂ plants, 222 showed early pod initiation and time of podding of these plants coincided with the cold tolerant parent (ICC16349) and remaining 355 plants showed late podding with podding time that coincided with cold susceptible parent (GPF2). The goodness of fit of the data was tested by chi-square goodness of fit test for monogenic/digenic control (Table 1 and 2). The data was found insignificant for both monogenic/digenic control and seemed to follow a complex pattern of inheritance involving polygenes.

Introduction

Grown in Turkey about 7000 BC (Philologos, 2005), Chickpea (*Cicer arietinum* L.) (2n=2x=16) is an important pulse crop. Being self pollinated crop, the crop is grown traditionally in semi-arid zones of Middle-East, Pakistan and India and belongs to kingdom Plantae, order Fabales, family Fabaceae, genus Cicer and species arietinum. According to Vavilov (1926), Ethiopia was designated as secondary centre and two primary centres of diversity namely South-West Asia and Mediterranean centre of chickpea. South-Eastern Turkey and Northern Syria are considered to be the centre of origin of the crop where it was known to be evolved from *Cicer reticulatum* (Maesen, 1987). Chickpea is also known as Chana, Shonagalu, Garbanzo bean and Bengal Gram and in different chickpea producing areas of the world.

Large seeded kabuli chickpea and small seeded desi chickpea are two broad types of chickpea. (Muehlbauer & Singh, 1987). Consumption of desi is restricted mainly to Middle East and Southeast Asia whereas, Kabuli is globally popular whereas.

Chickpea is important source of carbohydrates (60-62%), protein (17-22%), fat (varies from 2-70 to 6-48 %) and minerals (constituting 5-0 mg/100 g of Fe, 4-1 mg/100 g of Zn, 138 mg/100 g of Mg and 160 mg/100 g of Ca) mainly for vegetarian diet (Jukanti et

al. 2012). It has high beta-carotenoid content as compared to genetically engineered "golden rice" (Millan et al. 2006). Its amino acid profile has considerable amounts of essential amino acids except for sulphur containing types of amino acids. Starch is the major storage carbohydrate followed by dietary fibre along and some other oligosaccharides and simple sugars like glucose and sucrose. It is a great source of many vitamins like vitamin-A, folate, niacin, riboflavin and thiamine. It has various health benefits as it protects from cardiovascular diseases, type-2 diabetes, digestive diseases, and even some cancers (Jukanti et al. 2012). Hence, it is an important pulse crop having various nutritional and health benefits.

India contributes to sixty percent of the total world's production and is the largest producer as well as consumer of Chickpea (Varshney et al. 2014). In India, chickpea is mainly produced in Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, Chhattisgarh, Bihar and Jharkhand and these states contribute more than 95% to the total production. India still imports it from other nations besides being the largest producer of chickpea due to low productivity which is due to the abiotic and biotic stress prevalence and use of low yielding varieties.

As far as abiotic stresses are concerned, temperature stresses are considered of utmost

Table-1 : Chi-square table pertaining to days to pod initiation for testing goodness of fit for monogenic control.

Character	Observed	Expected	O-E	(O-E) ²	(O-E) ² /E
Early Podding	222	144.25	77.75	6045.0625	41.90684575
Late Podding	355	432.75	77.75	6045.0625	13.96894858
Total	577				² = 55.87579433

Table-2 : Chi-square table pertaining to days to pod initiation for testing goodness of fit for digenic control.

Character	Observed	Expected	O-E	(O-E) ²	(O-E) ² /E
Early Podding	222	252.4375	30.4375	926.4414063	3.669983288
Late Podding	355	324.5625	30.4375	926.4414063	2.859431446
Total	577				² = 6.529414734

importance. In northern India, cold or low temperature is a main stress where it affects growth and development of the crop and which hampers the overall productivity of the crop (Thakur *et al.* 2010; Awasthi *et al.* 2015). Cold temperatures lower than 10°C at flowering can reduce grain yield by 15–20% in chickpea (Chaturvedi *et al.*, 2009). Yield loss in chickpea increases if the stress ensues at the time of pod formation. Chickpea is highly sensitive to low temperature stresses especially at reproductive stage which results in significant loss of potential pods. Cold stress at the time of pod initiation results into reduced podding, thereby decreasing the yield of the crop. The cold stress at the time of podding interferes with seed development and leads to delayed pod development. It is believed that reduced nutrition supply to the developing pod under low temperature conditions causes delayed response thereby resulting in delayed or reduced pod formation. If cold persists during grain development, reduction in yield losses would be higher due to reduction in the number of pods per plant and pods whatsoever formed under cold stress, would either have no seed or less seed. The effects of cold stress in chickpea at reproductive and vegetative stages need to be studied by observing physiological and agronomic traits to develop cold tolerant cultivars (Kaloki *et al.* 2019). Thus, the knowledge about genetics of cold stress tolerance in chickpea is important in order to breed chickpea for cold stress tolerance through hybridization programmes and to minimize yield losses in chickpea due to cold stress.

Materials and Methods

Plant material : Two parents having contrasting traits viz., cold susceptibility (GPF2) and cold tolerance (ICC16349) and were selected for hybridization, where 'ICC16349' was selected as a donor and 'GPF-2' as a recipient. F₁ generation obtained from the cross GPF2 X ICC16349 was identified by using simple sequence repeat markers (Thakur *et al.* 2020) and was grown to get F₂ seed and the F₂ progenies of each F₁ plants were grown separately.

Experimental conditions : The experiment was undertaken during rabi season (2018-19) at the

experimental farm of the Department of Genetics & Plant Breeding, CSKHPKV, Palampur at 32°6' N latitude, 76°3' E longitude and an elevation of 1290.8 m (above mean sea level). Agro-climatically the location represents the mid-hill zone of Himachal Pradesh (zone-II) and is characterized by humid sub-temperate climate with high rainfall (2500 mm). The maximum temperature ranged between 7.0 to 29°C and minimum temperature ranged between 0.5-15.5°C. The relative humidity varied between 24-94% and sunshine hours between 0-10 hrs/day. The evaporation rate varied between 0.4-5.4 mm per day.

Observations recorded : Phenotyping of F₂ plants resulting from the cross GPF2 X ICC16349 was conducted under field conditions and data pertaining to days to flower initiation was recorded to screen plants for cold stress tolerance. The plants that showed podding along with cold tolerant parent (ICC16349) were considered as early podding and rest were categorized as late podding plants and podding time of these plants coincided with cold susceptible parent (GPF2).

Statistical analysis : For testing goodness of fit of genetic ratio, Chi square test (²) (Pearson, 1900) was applied to F₂ data. Following equation was used for calculating ² value :

$$\chi^2 = \sum_i \frac{(O_i - E_i)^2}{E_i}$$

where,

² = Chi-square value

O_i = Observed frequency

E_i = Expected frequency

The difference was regarded as significant between the expected and the observed values if calculated ² value was higher than the tabulated value at (n-1) degrees of freedom (df).

Results and Discussion

The cold stress tolerant germplasm line 'ICC16349' was selected as a donor whereas, the cold susceptible parent 'GPF2' was used as recipient in hybridization. Crosses

Table-3 : Days to pod initiation in F₂ plants obtained from cross GPF2 x ICC16349 at 129 days after sowing.

Sr. No.	Parents/F ₁	Early podding plants (up to 129 DAS)	Late podding plants	Early podding plants (No.)	Late podding plants (No.)	Total plants (No.)
1.	GPF2*	5	1,2,3,4,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1	20	21
2.	ICC16349*	1,2,3,4,5,6,7,13,15,16,17,18,19,21,22,23,24,25,26,27	8,9,10,11,12,14,20	20	7	27
3.	15S	2,3	1	2	1	3
4.	16S	1,2,7,14,15,17,19,20,22,23,24,25,28,29,30,31,33,34,44	3,4,5,6,8,9,10,11,12,13,16,18,21,26,27,32,35,36,37,38,39,40,41,42,43,45	19	26	45
5.	22S	1,4,7,8,10,12,16,19,21,25,26,30	2,3,5,6,9,11,13,14,15,17,18,20,22,23,24,27,28,29	12	18	30
6.	23S	1,3,5,7,17,18	2,4,6,8,9,10,11,12,13,14,15,16,19,20	6	14	20
7.	31S	1,2,3,4,5,7,9,10,11,13,14,15,17,20,21,24,25,27,28,29,30	6,8,12,16,18,19,22,23,26	21	9	30
8.	24S	1,3,4,7	2,5,6,8	4	4	8
9.	26S	1,2,8,10,17	3,4,5,6,7,9,11,12,13,14,15,16,18,19	5	14	19
10.	12S	2,11,13	1,3,4,5,6,7,8,9,10,12	3	10	13
11.	11S	9	1,2,3,4,5,6,7,8,10,11	1	10	11
12.	20S	1,2,4,5,7,12,13,14	3,6,8,9,10,11,15,16	8	8	16
13.	13S	8,10,12,14,18,20	1,2,3,4,5,6,7,9,11,13,15,16,17,19,21,22	6	16	22
14.	18S	5	1,2,3,4,6,7,8,9,10,11,12,13,14	1	13	14
15.	38S	1,3,4,6,7,8,9,13,15,20,26,28,29	2,5,10,11,12,14,16,17,18,19,21,22,23,24,25,27,30,31	13	18	31
16.	17S	1,2,3,5	4,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	4	16	20
17.	35S	1,2,3,6,8,14,15,16,17,18,19,23	4,5,7,9,10,11,12,13,20,21,22,24,25	12	13	25
18.	4S	4,5,6,10	1,2,3,7,8,9	4	6	10
19.	GPF2*	6	1,2,3,4,5,7,8,9,10,11,12,13,14	1	13	14
20.	ICC16349*	1,2,3,4,5,6,7,8,9	-	9	0	9
21.	29S	6,7,10,11,12,13,15,16	1,2,3,4,5,8,9,14,17	8	9	17
22.	28S	1,2,6,7,8,10,11,12,14,16,18,19,20,22,26	3,4,5,9,13,15,17,21,23,24,25,27	15	12	27
23.	37S	-	1	-	1	1
24.	1S	8	1,2,3,4,5,6,7,9,10,11,12,13,14,15,16	1	15	16
25.	19S	1,3,4,5,6,12,15,18,20,21,25	2,7,8,9,10,11,13,14,16,17,19,22,23,24,26	11	15	26
26.	9S	1,2	3,4,5,6,7	2	5	7
27.	34S	3,6,8,10,14,18,19	1,2,4,5,7,9,11,12,13,15,16,17,20,21	7	14	21
28.	GPF2*	-	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	0	21	21
29.	ICC16349*	4,5,6,7,8,9,10,11,12,13,14,15,16	1,2,3	13	3	16
30.	27S	3,9,11,18,19,25,28	1,2,4,5,6,7,8,10,12,13,14,15,16,17,20,21,22,23,24,26,27	7	21	28
31.	34P	1,2,7,10,12,16	3,4,5,6,8,9,11,13,14,15	6	10	16
32.	33P	2,3,5,8	1,4,6,7	4	4	8
33.	56P	1,5,6,12	2,3,4,7,8,9,10,11	4	8	12
34.	28P	1,3	2,4,5,6,7	2	5	7
35.	22P	-	1,2,3,4,5	0	5	5
36.	2P	7,8,9,11,12	1,2,3,4,5,6,10	5	7	12
37.	16P	4,8,9,10,11,13,14,15	1,2,3,5,6,7,12	8	7	15
38.	P-1-1**	2,3,4,11,12,14,15	1,5,6,7,8,9,10,13	7	8	15
39.	P-2-1**	2,3,4,5,7,6,9	1,8,10	7	3	10
40.	57P	6,7,8,14,15	1,2,3,4,5,9,10,11,12,13,16	5	11	16
41.	GPF2*	10	1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17,18,19,20,21,22	1	21	22
42.	ICC16349*	1,2,3,4,5,6,7,8,9,10	11,12,13	10	3	13

among germplasm line 'ICC16349' and variety 'GPF2' of chickpea were advanced to F₂ progeny. Data on days to pod initiation revealed that F₂ progeny plants segregated for pod initiation into two categories, early podding and late podding (Table-3). Of 577 F₂ plants, 222 showed early podding and time of podding of these plants coincided with the cold tolerant parent (ICC16349) and remaining 355 plants showed late podding which coincided with cold susceptible parent (GPF2). The goodness of fit of the podding time data was tested by chi-square goodness of fit test (Pearson, 1900) (Table 1 & 2). It was found that the data were not in accordance with the typical F₂ ratio of 3:1 (Dominant: recessive) nor with complementary gene ratio of 9:7 revealing that the data seemed to follow a complex pattern of inheritance involving polygenic control.

Similar conclusions were drawn by Gowda *et al.* (2011) in his studies on mapping QTLs governing agronomic and yield traits which confirmed that the number of pods per plant was found to be linked with quantitative trait loci (QTL) in chickpea. Various studies were conducted on cold stress tolerance in relation to pod formation and seed development in chickpea. Studies conducted by Berger *et al.* (2004) suggested that delay in podding and pod abortion contributes to lower yield of chickpea under cold stress. Similarly, according to findings of Crosser *et al.* (2003) and Thakur *et al.* (2010), chilling stress has a damaging effect on pod set, seed growth and seed development. Studies conducted by Srinivasan (1998), Berger (2004), Clark & Siddique (2004), Nayyar *et al.* (2005), Berger *et al.* (2006), Kaur *et al.* (2011) and Kumar *et al.* (2011), temperatures below 15°C results in abortion of chickpea flowers leading to decline in number of pods per plant and seed per pod. Clark & Siddique (2004) and Nayyar *et al.* (2005) agreed on the findings that cold stress impairs pollen tube growth in style and consequently fertilization failure leading to inability to undergo pod formation.

In present study, it can be concluded that pod initiation followed a complex pattern of inheritance involving polygenes. Complex traits are usually highly influenced by the environment, under such circumstances, marker assisted selection followed by linkage mapping of the target QTLs is required. As far as breeding methods are concerned, the pedigree method and SSD (single-seed descent) can be followed along with marker assisted selection.

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Effect of Various Nutrient Management Practices and Rice-Based Cropping System on Biological Properties of Soil under Irrigated Condition

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Abstract

The present investigation was conducted during two consecutive year of 2019-20 and 2020-21 entitled of effect of various nutrient management practices and rice-based cropping system on biological properties of soil under irrigated condition. The maximum microbial population like bacteria (45.93×10^5 cfu g⁻¹ soil), found in 100% organic nutrient management practices with rice-vegetable pea-sorghum (fodder) cropping system. The fungi (40.83×10^3 cfu g⁻¹ soil) of soil was slightly changed by nutrient management and cropping system. Whereas, actinomycetes (14.03×10^3 cfu g⁻¹ soil) was recorded maximum under organic nutrient management as compare to rest of treatment like integrated nutrient management (INM) and inorganic nutrient management practices. During the research work, the microbial population of soil gradually changed by initially status value but it was not significantly affected by rice-based cropping system.

Key word : Cropping system, bacteria, fungi, actinomycetes, INM.

Introduction

Rice-based cropping system affects the chemical and biological properties of soil. Rice-potato-mungbean cropping system give higher productivity, protein content, energy output, available P, population of fungi, actinomycetes, microbial biomass and higher CO₂ evolution in soil as compared to cereal-cereal cropping system. Sharma *et al.* (2009).

Organic nutrient management can play a vital role in improvement of physical properties like, pH, organic carbon, CEC, available N, P and K microbial activities, organic matter content, nutrient use efficiency as well as fertility status of soil in rice based cropping system for remunerative changes the economics of crop sequences (Gangwar *et al.*, 2004; Swapana *et al.*, 2012, Kachroo *et al.*, 2014). The major sources of organic manures are farm yard manure (FYM), cattle dung and urine, poultry and sheep manures, green manures, oil cakes are considered as a good source of all essential elements (primary, secondary and micro-nutrients) for plant growth.

The rice-wheat cropping system is considered as the backbone for food grain security. The use of inorganic fertilizer to sustain cropping was found to increase yield only for some few years but on long-term, it has not been effective and leads to soil degradation (Satyanarayana *et al.*, 2002).

Exploiting the production potential of high yielding rice varieties through agronomic management is one of the alternatives to feed the ever rising population. For this,

fertilizers have contributed substantially to the spectacular increase in rice yield. However, growing crop with indiscriminate use of fertilizers has resulted into degradation of lands owing to low yields with poor quality of produce as well as beneficial micro-organism population (Wolie and Admassu, 2016).

Nutrient management in different seasons also play an important role in productivity of systems as well as resource availability, particularly physical, biological properties and water availability of soil. (Kumar *et al.*, 2016).

Materials and Methods

A field experiment was conducted during 2019-20 to 2020-21 at Instructional Research Farm, Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. The soil of the region are medium to deep in depth and black in colour with Sandy Clay loam in texture with pH 7.19, electrical conductivity 0.381 dSm⁻¹, Available nitrogen 260 kg ha⁻¹, Available phosphorus 12.5 kg ha⁻¹ and Available potassium 283 kg ha⁻¹ content. The varieties and hybrids which were popular among local farmer with respect to their yield potential and insect-pest resistance were used. The varieties of different crops and their duration in the field, recommended fertilizer dose applied and planting spacing. The experiment was laid out in split-plot design with twenty four treatment combinations of six different nutrient management and four rice-based cropping system. The allocation of various treatments to different plots was done randomly by using random distribution with

three replication. Nutrient management practices were taken as main plot and cropping system was taken as sub plot. Main plot, NM₁ (100% organic), NM₂ (75% organic) NM₃ (50% organic + 50% inorganic), NM₄ (75% organic + 25% inorganic) NM₅ (Farmer practices) NM₆ (100% inorganic). Sub plot CS₁ (Rice(PB-1)–Wheat–Green manure (Sunhemp) CS₂ (Rice(PB-1)–Chickpea (JG-14)–Maize(African Tall)) CS₃ (Rice(PB-1)–Egyptian clover, F+S (JB-1)) CS₄ (Rice(PB-1)–Vegetable pea (Arkel)–Sorghum (MPchari)). The row to row spacing was 20 cm for rice, wheat, 30 cm for chickpea, maize, sorghum, sunhemp, vegetable pea, while *Egyptian clover* crop was broadcasted. All the recommended package of practices was adopted for the irrigated condition in all the *kharif*, *rabi* and *zaid* crops. In soil samples, and microbial population were estimated by the following methods; Thornton's medium (Thornton's, 1930) and Rose Bengal streptomycin agar media (Rao, 1988), Casenak Agar medium (Rao, 1988) respectively.

Results and Discussion

Biological properties of soil

Bacteria : The analyzed data Table-1 indicated that there were no statistical changes in soil microbial population due to various nutrient practices and cropping systems but in case of bacteria was not significantly differ from different nutrient management during both the years of field study and in pooled analysis. Mean values indicate that there were definite increment in population over initial values in respective micro-organism. However maximum population of total bacterial count (45.93×10^5 cfu g⁻¹ soil) was found under 100% organic nutrient management followed by 75% organic nutrient management (45.06×10^5 cfu g⁻¹ soil), integrated nutrient management (50:50) (42.57×10^5 cfu g⁻¹ soil), 100% inorganic nutrient management (41.97×10^5 cfu g⁻¹ soil), integrated nutrient management INM (75:25) (40.70×10^5 cfu g⁻¹ soil) Whereas, lowest population was obtained from farmer practices nutrient management (40.23×10^5 cfu g⁻¹ soil). The preferential stimulation of various microorganisms under various types of organic sources and their combinations might be due to the influence of growth promoting substances in soil.

The rice-chickpea-maize cropping system recorded the maximum population of total bacterial count (43.70×10^5 cfu g⁻¹ soil) followed by rice-wheat- green manuring cropping system (43.67×10^5 cfu g⁻¹ soil), rice-berseem (fodder+seed) cropping system (43.44×10^5 cfu g⁻¹ soil). Whereas, it was lower in rice-vegetable pea-sorghum (fodder) cropping system (42.35×10^5 cfu g⁻¹ soil) during both the years.

Minimum stimulation of bacteria was observed

without organics as well as total bacteria under treatments of neem oil cake as a component source of nutrient. Similar results has also been reported by Mukherjee *et al.* (1991) and Mohan Singh (1991). Different groups of soil microorganisms responded not significantly to the different types of rice based cropping system. The combination of various crops in different habitat which supported more numbers of different microflora bacteria in soil. The data revealed indicated that there were no statistical changes in soil bacterial population due to cropping systems during both the years of field study and in pooled analysis. Mean values indicate that there were definite increment in population over initial values in respective microbes. The rice-berseem (fodder+seed) cropping system recorded the maximum population of total microb count followed by rice-chickpea-maize cropping system over the other cropping system. Improvement in microbial counts of soil under legume based cropping sequence has been reported by Singh *et al.* (2001), Nath *et al.* (2011) and Tilak (2004) also reported that higher counts of bacteria due to growing of green gram after rice.

The interaction between different nutrient management and cropping sequences was turn out to be non-significant in both the years.

Fungi : It was noted that farmer practices nutrient management recorded the maximum population of fungi (40.98×10^3 cfu g⁻¹ soil) followed by integrated nutrient management (INM 75:25) (40.94×10^3 cfu g⁻¹ soil), 100% inorganic nutrient management (40.92×10^3 cfu g⁻¹ soil), integrated nutrient management (INM 50:50) (40.80×10^3 cfu g⁻¹ soil), and lowest population was obtained from 75% organic nutrient management (40.79×10^3 cfu g⁻¹ soil) respectively.

The rice-vegetable pea-sorghum (fodder) cropping system recorded the maximum growth (40.92×10^3 cfu g⁻¹ soil) it was at par with rice-berseem (fodder+seed) cropping system (40.92×10^3 cfu g⁻¹ soil), followed by rice-chickpea-maize cropping system (40.87×10^3 cfu g⁻¹ soil). Whereas, it was lower in rice-wheat- green manuring cropping system (40.80×10^3 cfu g⁻¹ soil) during both the years. They reported enhance soil micro flora by inclusion of pulses in cropping sequence. Davari *et al.* (2011)

The fungi was more in soil during first year as compared to second year in case of different nutrient management. While, in case of rice based cropping system, it was followed same trend as the fungi growth was more during first year as compared to second year respectively.

Actinomycetes : Further, an application of organic source of nutrients had significant effect on soil

Table-1 : Bacterial population of soil as affected by different nutrient management practices and rice-based cropping system.

Nutrient Management	Cropping System				
	Initial status-43.23 x 10 ⁵ cfu g ⁻¹ soil				
	CS ₁	CS ₂	CS ₃	CS ₄	Mean
100% Organic	45.53	46.20	45.56	46.43	45.93
75% Organic	45.12	45.45	44.81	44.85	45.06
INM (50% organic + 50% inorganic)	42.70	43.14	42.33	42.10	42.57
INM (75% organic + 25% inorganic)	44.55	44.03	43.84	30.37	40.70
Farmer Practices	40.51	40.53	39.94	39.94	40.23
100% Inorganic	41.86	42.14	41.93	41.95	41.97
Mean	43.67	43.70	43.44	42.35	
	Nutrient Management	Cropping System	Interaction		
			Factor B at same level of A	Factor A at same level of B	
Sem±	2.09	2.34	4.05	3.95	
CD (p =0.05)	NS	NS	NS	NS	

Where, CS₁ is Rice-wheat-green manure, CS₂ is Rice-chick pea-maize, CS₃ is Rice-berseem (F+S), CS₄ is Rice-vegetable pea-sorghum.

Table-2 : Fungi population of soil as affected by different nutrient management practices and rice-based cropping system.

Nutrient Management	Cropping System				
	Initial Status-41.25 x 10 ³ cfu g ⁻¹ soil				
	CS ₁	CS ₂	CS ₃	CS ₄	Mean
100% Organic	40.79	40.52	41.02	40.97	40.83
75% Organic	40.72	40.82	40.86	40.78	40.79
INM (50% organic+50%inorganic)	40.93	40.83	40.83	40.60	40.80
INM (75% organic+25% inorganic)	40.60	41.28	40.92	40.95	40.94
Farmer Practices	40.93	40.75	40.91	41.32	40.98
100% Inorganic	40.83	41.01	40.95	40.89	40.92
Mean	40.80	40.87	40.92	40.92	
	Nutrient Management	Cropping System	Interaction		
			Factor B at same level of A	Factor A at same level of B	
Sem±	0.17	0.16	0.27	0.25	
CD (p = 0.05)	NS	NS	NS	NS	

Table-3 : Actinomycetes population of soil as affected by different nutrient management practices and rice-based cropping system.

Nutrient Management	Cropping System				
	Initial Status-12.53 x 10 ³ cfu g ⁻¹ soil				
	CS ₁	CS ₂	CS ₃	CS ₄	Mean
100% Organic	13.85	14.08	14.07	14.14	14.03
75% Organic	12.97	12.81	13.01	13.09	12.97
INM (50% organic + 50%inorganic)	11.63	12.00	11.97	11.97	11.89
INM (75% organic + 25% inorganic)	12.05	12.24	12.22	12.13	12.16
Farmer Practices	10.77	10.85	10.85	11.05	10.88
100% Inorganic	11.07	11.16	11.20	11.26	11.17
Mean	9.55	8.76	7.78	6.52	
	Nutrient Management	Cropping System	Interaction		
			Factor B at same level of A	Factor A at same level of B	
Sem±	0.06	0.07	0.12	0.11	
CD (p =0.05)	0.22	0.26	0.44	0.41	

Where, CS₁ is Rice-wheat-green manure, CS₂ is Rice-chick pea-maize, CS₃ is Rice-berseem (F+S), CS₄ is Rice-vegetable pea-sorghum.

actinomycetes recorded during both the years of experimentation. Amongst the organic, inorganic and integrated nutrient management, 100% organic nutrient management registered significantly higher values of (14.03×10^3 cfu g⁻¹ soil) then other combinations like 75% organic nutrient management (12.97×10^3 cfu g⁻¹ soil) during both years pooled data. Followed by integrated nutrient management (INM 75:25) (12.16×10^3 cfu g⁻¹ soil), integrated nutrient management (50:50) (11.89×10^3 cfu g⁻¹ soil), 100% inorganic nutrient management (11.17×10^3 cfu g⁻¹ soil). However, lowest *actinomycetes* present in farmer practices (10.88×10^3 cfu g⁻¹ soil) respectively. It is evident from the Table 3. that the *actinomycetes* in soil gradually increased over initial value (12.53×10^3 cfu g⁻¹ soil) and subsequently completion of different nutrient management during both the years. Singh *et al.* (2011a). Microbial (*Actinomycetes*, Bacteria, Fungi and BGA) population also increase due to the application of different sources of organic nutrients.

The data investigated that was not significantly changed with different rice based cropping system. On an average, it was noted that the value of *actinomycetes*. The rice-vegetable pea-sorghum (fodder) cropping system recorded the higher *actinomycetes* value of (12.47×10^3 cfu g⁻¹ soil) whereas, no differences was observed between rice-berseem (fodder+seed) cropping system (12.42×10^3 cfu g⁻¹ soil), (12.39×10^3 cfu g⁻¹ soil) under rice-chickpea-maize cropping system and lowest *actinomycetes* was found (12.25×10^3 cfu g⁻¹ soil) in rice-wheat- green manuring cropping system during both the years, respectively. The interaction between cropping systems and sources of different nutrient management found to significant in both the years as well as pooled data respectively.

The interaction between 100% organic nutrient management and rice-vegetable pea-sorghum (fodder) cropping system recorded the higher *actinomycetes* population (14.14×10^3 cfu g⁻¹ soil) but statistically at par with 100% organic nutrient management in rice-chickpea- maize cropping system (14.08×10^3 cfu g⁻¹ soil) and rice-berseem (fodder+seed) cropping system with (14.07×10^3 cfu g⁻¹ soil), followed by 75% organic nutrient management in rice-vegetable pea-sorghum (fodder) cropping system with (13.09×10^3 cfu g⁻¹ soil). The lowest *actinomycetes* population was obtained in the interaction of farmer practices nutrient management in rice- wheat-green manure cropping system with (10.77×10^3 cfu g⁻¹ soil). The values of these microbes declined with integrated nutrient management over 100% inorganic nutrient management. Similar, improvement in microbial properties of soil with organic nutrient management has been reported by Nath *et al.* (2011) The combination of various crops in different habitat which supported more

numbers of different micro flora bacteria, fungi and actinomycetes in soil. The data revealed indicated that there were no statistical changes in soil microbial population due to cropping systems during both the years of field study and in pooled analysis. Similar results have been also reported by Upadhyay *et al.* (2011) Upadhyay and Vishwakarma (2014).

Conclusion

On the basis of present study it can be concluded that among different nutrient management and rice-based cropping system maximum population of bacteria, fungi and actinomycetes under 100% and 75% organic nutrient management with rice-berseem (F+S) cropping system. These nutrient management practices soil health improvement under present scenario of existing rice-berseem (F+S) cropping system.

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Genetic Variability for Yield and Component Traits in the Ricebean (*Vigna umbellata* (thunb.) Ohwi and Ohashi) Germplasm of North-Western Himalayan Region

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Abstract

The present investigation was carried out to estimate different genetic parameters in ricebean germplasm of NW Himalayas. Forty germplasm lines of rice bean were evaluated for yield and its components in *Kharif*, 2015 at the experimental farm of CSKHPKV, Palampur. High PCV and GCV was observed for seed yield/plant, plant height, pod length, pods/cluster and clusters/plant indicating the role of these characters for effective selection. The study also revealed that heritability in broad sense was high for days to flowering, plant height and pods/cluster indicating that the variation observed was mostly under genetic control and less influenced by environment. Overall high to moderate heritability with high genetic advance was observed for plant height and seed yield/plant indicating additive gene control of these traits. On the basis of mean performance the genotypes, RBHP-403, RBHP-43, RBHP-413, UURB-17, IC-419518, IC-395028 were found promising among all the germplasm lines. The genotype PRR-2007-2 was observed to be earliest and dwarfest genotype among all.

Ricebean is a multipurpose grain legume crop mainly cultivated for food, fodder and green manure specifically by the poor farmers in the marginal areas of South Asia and South East Asia. It is mainly cultivated in India, China, Korea, Japan, Myanmar, Malaysia, Indonesia, Philippines, Java, Fiji, Bangladesh, Sri Lanka and Nepal. It is an important crop of Mid Himalayan region. In India its distribution is mainly confined to the tribal region of the North-eastern hills and the western and Eastern Ghats in peninsular region, often in hilly tracts. However its cultivation and production is limited and restricted to small and marginal areas. Therefore ricebean is regarded as underutilized crop.

This underutilized crop has recently gained attention as an additional grain legume/pulse crop which keeps great potential to solve the food and nutritional problem. Since resource poor farmers in the marginal areas cultivate this crop, therefore it is directly related with the population who really suffers frequent food shortage and nutritional disorders.

Mostly it is cultivated on the non-irrigated and uncultivated lands which otherwise goes waste, hence cultivation of ricebean in such areas is considered important contribution to food and nutritional security and to utilize uncultivated marginal land and conserving biodiversity. The potential productivity of ricebean has been found superior over other pulse crops, such as greengram and blackgram in mid altitude, particularly Himalayan region, beyond 1500 m above mean sea level where other pulse crops like blackgram and green gram cannot be grown successfully. However, under these

conditions, ricebean gives reasonably good seed yield because of its better cold tolerance ability and better adaptation to acidic soil condition (Dutta *et al.*, 2000 and Shukla *et al.*, 2014).

The nutritive value of ricebean is exceptionally high. The protein contents of seeds vary from 14-24% and the amino acids, methionine and tryptophane are considerable high. It provides sizable amounts of important minerals such as Ca, P, Mg, K, Fe, Zn, Cu and Mn.

This crop has been left as a neglected one due to lack of attention and absence of any kind of scientific breeding. Although its nutritional quality and other associated benefits qualifies this crop for intensive research, and development efforts for increased and sustained production.

However, little research work on its qualities can enhance its properties according to our requirements and this crop which is highly adaptive to all sorts of marginal areas and soils can rise as a great source of edible nutrients for the poor people residing in those areas. For the effective selection of superior genotype to use in hybridization programme for the development of superior varieties, proper study of genetic variability due to genetic and non-genetic causes and other genetic parameters is necessary (Prasad *et al.*, 2012). So, the main objective of present investigation was to estimate the genetic variability, heritability, and genetic advance for different important economic characters in a set of diverse genotypes of ricebean.

Materials and Methods

The experimental material for the present study consisted of 38 ricebean germplasm lines and two checks namely PRR-1 and PRR-2. These genotypes along with checks were evaluated for different qualitative and quantitative traits in RBD design during *kharif*, 2015 with plot size of 3 m x 0.6 m with row to row and plant to plant distance of 30 cm and 10 cm, respectively in 3 replications at the experimental farm of the Department of Organic agriculture, CSKHPKV, Palampur. The crop was raised following recommended package of practices.

Observations were recorded on 10 randomly selected plants for days to flowering and maturity, plant height (cm), branches/plant, pods/plant, pod length, pod width (cm), seeds / pod, 100-seed weight(g) and seed yield/ plant. The mean values were used for statistical analysis. Analysis of variance was done according to procedure given by Panse and Sukhatme (1987). The genotypic, phenotypic and environmental coefficients of variation were estimated by following method of Burton and DeVane (1958). Heritability in broad sense was calculated by the formula given by Burton and DeVane (1958) and Johnson (1955). The estimates of genetic advance were obtained by the formula given by Burton and DeVane (1958) and Johnson (1955).

Results and Discussion

Perusal of the data on analysis of variance (ANOVA) revealed significant differences among the genotypes for seed yield and related traits indicating presence of sufficient variability for all the traits except pods/plant and seeds/pod. The estimate of genotypic and phenotypic coefficient of variation provides a better comparison of the characters for the estimation of genetic variation. The knowledge of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) is helpful in predicting the amount of variation present in the given stock which in turn helps in formulating an efficient breeding programme. The estimates of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance are presented in Table-1.

An assessment of variability parameters revealed presence of sufficient variation among the genotypes. In general, values of phenotypic coefficient of variation (PCV) were higher than their respective genotypic coefficient of variation (GCV) indicating considerable influence of environment on the performance of genotypes. High PCV (>15%) was observed for seed yield/plant, clusters/plant, pods/plant, plant height, pod length and pods/cluster.

Moderate PCV (10-15%) was observed for seeds/pod, 100-seed weight, branches/plant, days to maturity and low PCV (<10%) was observed for days to flowering. High GCV (>10%) was observed for seed yield/plant, plant height, clusters/plant, pods/cluster and pod length.

Moderate GCV (5-10%) was observed for days to flowering, 100-seed weight, days to maturity, pods/plant and branches/plant while low GCV (<5%) was observed for seeds/pod. Studies with similar research findings were carried out by various workers (Lakshmana *et al.*, 2010, Gill and Brar, 2007) (Table-2).

When a major portion of variability is due to heritable variation it could be measured in terms of degrees in which it is transmitted to the progeny, the term referred to as heritability. Burton and DeVane (1958) has suggested that a genetic coefficient of variability together with the heritability estimates would give the more reliable indication of the expected genetic gain by selection. Heritability in broad sense is of tremendous significance to the breeders as its magnitude indicates reliability with which a genotype can be recognized by its phenotypic expression.

The information on heritability estimates is useful in studying the inheritance of quantitative traits as well as for planning breeding programmes with desired degree of expected genetic progress. The present study revealed that heritability in broad sense was high (>60%) for only some traits studied *viz.*, days to flowering, plant height and pods/cluster indicating that the genetic variance for these traits are probably owing to their high additive gene effects and thus there is better scope for improvement of these traits through direct selection.

Moderate heritability (40-60%) was observed for days to maturity, seed yield/plant, branches/plant, 100-seed weight, pod length, and clusters/plant whereas low heritability (<40%) was observed for pods/plant and seeds/pod. High and moderate heritability values of these traits indicated that the variation observed was mainly under genetic control and less influenced by environment. Plant height, pods/cluster and seed yield/plant show high GCV and heritability, hence can be considered for selection.

Similar results were reported by different workers in ricebean. Lakshmana *et al.*, (2010) observed high heritability coupled with high genetic advance for days to flowering, number of seeds/pod, number of pods/plant, seed yield/plant and harvest index.

Similarly, Dash (2012) observed high heritability estimate for days to flowering, branches/plant, branch length, leaf weight and dry matter/plant.

PCV	>15%	High
	10-15%	Moderate
	<10%	Low
GCV & ECV	>10%	High
	5-10 %	Moderate
	<5 %	Low
Heritability (h ²)	>60%	High
	40-60%	Moderate
	<40%	Low
Genetic advance	>20%	High
	10-20%	Moderate
	<10%	Low

For categorizing the magnitude of different parameters, the following limits were used.

For an effective selection programme, knowledge of the estimates of heritability alone is not sufficient and genetic advance if studied along with heritability is more useful (Johnson *et al.*, 1955). Thus, the genetic advance has an added edge over heritability as a guiding factor to breeders in various selection programmes. Genetic advance may and may not be in proportion to genetic variability and heritability estimates, because both heritability and high genetic variability are important to obtain higher genetic gain. Genetic advance expressed as percentage of mean was observed to be low (<10%) for seeds/pod, pods/plant and branches/plant. It was high

Table-1 : Analysis of variance for different traits.

Character	Mean sum of square		
	Replication	Treatment	Error
Df	2	39	78
Days to flowering	275. 03	173. 39*	16. 71
Days to maturity	76. 76	434. 21*	79. 20
Plant height	309. 20	1, 544. 87*	162. 57
Branches/plant	0. 01	0. 07*	0. 03
Pods/plant	324. 02	201. 05	131. 91
Pod length	2. 40	4. 62*	1. 25
100- seed weight	1. 73	2. 60*	0. 69
Seeds/pod	1. 17	1. 86	1. 36
Clusters/pod	0. 73	34. 62*	9. 58
Pods/cluster	0. 09	0. 49*	0. 09
Seed yield/plant	1. 81	8. 55*	1. 86

*Significant at 5% level of significance.

Table-2 : Estimates of parameters of variability for various traits.

Traits	Mean $\pm$ S.E(m)	Range	PCV (%)	GCV (%)	ECV (%)	Heritability h ² bs (%)	Expected GA
Days to flowering	84.89	52-96	9.78	8.51	4.82	75.76	15.26
Days to maturity	131.64	106-152	10.68	8.26	6.76	59.91	13.18
Plant height	152.48	90-176.27	16.37	14.08	8.36	73.92	24.93
Branches/plant	1.88	1.53-2.16	10.80	6.16	8.87	32.54	7.24
Pods/plant	68.23	39.1-80	18.24	7.04	16.83	14.87	5.59
Pod length	9.65	5.95-11.68	15.96	10.20	11.57	47.49	15.61
100-seed weight	9.61	6.83-11.69	11.99	8.30	8. 65	47.96	11.85
Seeds/pod	9.15	6.06-10.43	13.49	4.48	12.73	11.04	3.07
Clusters/plant	22.38	11.8-28.96	18.92	12.91	13.84	46.55	18.14
Pods/cluster	2.99	2.06-3.53	15.63	12.18	9.80	60.69	19.55
Seed yield/plant	9.93	3.44-12.45	20.36	15.03	13.73	54. 51	22.87

Table-3 : Mean performance of rice bean genotypes.

Lines	Days to flowering	Days to maturity	Plant Height	Branche s/plant	Pods/ plant	Pod length	100-seed weight	Seeds/ pod	Cluster s/plant	Pods/c luster	Seed yield/plant
LRB-478	88.00	147.33	157.83	2.00	80.00	10.11	9.66	9.43	24.03	3.50	11.07
LRB-474	83.00	127.00	155.38	1.90	67.99	10.14	9.59	9.07	22.60	3.13	11.03
LRB-473	88.00	129.00	169.87	1.80	76.40	10.72	10.30	9.37	15.60	2.07	7.60
LRB-476	83.00	133.00	158.51	2.00	76.87	9.83	9.93	9.23	22.27	3.10	10.93
LRB-449	91.33	151.67	163.18	2.00	78.87	10.17	9.55	9.47	19.50	2.33	9.10
LRB-447	85.00	142.67	171.27	1.90	71.53	10.79	9.39	9.23	28.97	3.20	10.74
LRB-475	83.33	135.67	158.19	1.93	67.40	8.05	8.93	8.83	17.47	2.47	10.17
LRB-464	90.67	134.00	164.65	1.87	68.80	9.64	8.33	9.17	23.60	3.37	9.88
LRB-311	89.00	148.67	174.44	2.17	58.67	8.78	9.74	9.40	20.80	2.77	9.58
LRB-498	89.66	138.67	172.78	1.67	68.67	10.13	9.60	8.67	23.73	2.40	10.76
LRB-455	82.33	136.67	161.94	1.87	72.87	9.19	8.77	9.37	23.43	3.33	11.61
IC-395028	90.00	135.33	170.79	2.10	66.07	10.55	10.04	9.60	24.00	3.50	11.73
IC-538878	91.33	138.33	165.10	1.90	74.20	11.26	9.78	9.87	25.47	3.27	10.37
IC-23512	96.00	139.00	176.27	1.80	67.40	10.11	11.70	9.77	19.93	2.70	8.29
IC-538983	88.00	131.67	169.82	2.03	59.20	10.43	11.18	8.87	23.80	2.97	9.22
IC-419518	84.00	142.67	173.92	1.70	75.40	11.69	11.61	10.43	25.77	3.17	12.10
IC-359282	90.67	138.33	167.55	1.87	68.27	10.49	10.15	8.97	19.23	3.20	9.41
IC-524082	90.00	132.67	169.62	1.90	69.47	10.52	9.37	8.50	23.70	2.33	9.06
IC-421926	87.33	142.33	168.51	1.60	59.67	10.03	9.72	9.20	22.73	3.27	10.85
IC-538870	88.67	152.00	165.72	2.07	65.33	8.20	9.40	9.17	24.27	2.10	9.00
UURB-17	91.00	145.00	159.64	2.10	75.27	11.63	10.44	9.87	24.00	3.23	11.42
UURB-2014-I	79.33	134.33	173.23	1.77	75.53	10.09	9.52	9.57	24.33	2.70	9.97
PRR-2007-2	52.00	106.00	90.00	1.70	39.10	5.95	7.26	6.06	11.80	2.13	3.44
RBHP-401	96.00	112.33	98.00	1.90	43.09	6.67	6.83	7.00	14.97	2.73	5.76
RBHP-43	88.33	128.67	151.17	2.13	75.67	10.95	10.75	10.43	20.27	3.33	11.71
RBHP-38	87.00	140.33	149.00	1.93	64.73	9.39	9.96	8.93	18.13	3.07	9.62
RBHP-403	82.33	111.67	108.33	2.07	69.00	8.69	10.45	9.57	26.33	3.00	12.45
RBHP-404	81.33	115.33	108.33	1.77	73.00	8.39	9.06	8.83	23.53	3.00	9.60
RBHP-405	74.33	115.00	126.67	1.97	77.67	10.34	9.66	9.13	25.40	3.13	10.87
RBHP-406	81.33	114.33	140.67	1.70	73.53	9.39	9.22	9.13	23.33	3.03	11.12
RBHP-407	91.00	123.33	149.76	1.87	62.93	8.42	8.91	8.73	24.43	3.00	10.19
RBHP-408	77.00	118.33	139.85	1.90	67.67	8.33	8.98	8.67	24.33	3.37	9.05
RBHP-409	88.00	123.00	149.72	1.67	68.40	9.75	9.08	8.77	24.57	3.53	10.60
RBHP-410	81.33	120.00	116.67	1.96	67.67	9.97	9.15	8.40	23.73	3.07	8.36
RBHP-411	71.67	114.00	113.33	1.53	67.33	8.21	10.10	8.83	22.90	3.23	10.73
RBHP-412	79.67	130.00	154.20	1.83	69.67	8.88	9.48	10.37	23.53	3.33	9.573
RBHP-413	79.33	126.33	147.08	1.90	66.27	11.03	9.88	9.80	26.70	3.33	11.447
RBHP-414	89.33	125.33	160.45	1.90	65.27	8.77	9.21	9.60	22.33	2.87	8.880
PRR-I (C)	81.00	139.67	162.12	1.80	67.67	9.65	9.39	9.27	19.70	3.17	10.820
PRR-2 (C)	85.00	146.00	164.68	1.67	66.80	10.59	10.31	9.47	19.80	3.27	9.100
CD	6.64	14.47	20.72	0.27	NS	1.81	1.35	NS	5.032	0.48	2.2175

(>20%) for plant height and seed yield/plant while moderate genetic advance (10-20%) was observed for pods/cluster, clusters/plant, pod length, days to flowering, days to maturity and 100-seed weight. For predicting reliable estimates of additive and non-additive effects, heritability should be considered in conjugation with

genetic advance. On this consideration, high heritability with high genetic advance was found only for plant height indicating the presence of high additive gene effects providing scope for improvement of the trait through selection. High heritability with moderate genetic advance was observed for days to flowering and pods/cluster

indicating presence of additive and non-additive gene action in the inheritance of these traits, providing scope for improvement of these traits through hybridization and selection. Moderate heritability coupled with high genetic advance for seed yield/plant indicated the additive genetic control of this trait and further, selection would be effective on the basis of phenotype. The mean performance of the genotypes in respect of characters investigated in the present study is presented in Table 3. The germplasm line PRR-2007-2 was found earliest among all taking 52 days to flower and 106 days to mature. Eleven lines were earlier in maturity to the best check i.e. PRR-1. Line PRR-2007-2 was having lowest value of plant height (90 cm) among all the lines under study. Since most of the ricebean varieties are late maturing and indeterminate, this line will be of immense importance to the breeders for future breeding programmes for the improvement of this crop. Four lines viz., LRB 311, RBHP-43, UURB- 17 and IC-395028 were found to be superior for branches per plant over the best check PRR-1. None of the genotype was found superior to the best check for pod length and pods per cluster whereas one germplasm line IC-23512 was found to be superior to the best check for 100-seed weight. Among all, LRB-447 exhibited highest clusters/plant followed by RBHP-413, RBHP-403, IC-419548, IC-538878, RBHP-405 and RBHP-409. RBHP-403 was the highest yielder followed by IC-419518, IC-395028, RBHP-43, LRB-455, RBHP-413, UURB-17 and LRB-498. On the basis of mean performance of all the genotypes, RBHP-403, RBHP-43, RBHP- 413, UURB-17, IC-419518, IC-395028 was found promising among all the germplasm lines. The genotype PRR-2007-2 was earliest and dwarfest genotype among

all so it can be used as a potential parent for the incorporation of earliness and determinate habit which is major bottleneck in the popularization of this crop.

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Management of Dry Root Rot Disease of Clusterbean (*Cyamopsis tetragonoloba* L. Taub.) Caused by *Macrophomina phaseolina*

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Abstract

Clusterbean (Guar) is an important drought and high temperature tolerant arid legume crop of India. India is a major cluster bean producing country with almost 80% contribution of its global production. The production of the crop is limited by various biotic stresses viz. *Alternaria* blight, dry root rot and bacterial blight. In the present study, the experiments were conducted on the management of dry root rot disease of clusterbean in Western Rajasthan. The experiment was carried out in the research field of Agriculture Research Station, Mandor, Jodhpur with cluster bean variety RGM 112 with ten treatments under Randomised Block design. On the basis of field studies, the findings of the present study conclude that the treatment including seed treatment with Carbendazim 50 WP @ 2g/kg seed at par with seed treatment with *T. harzianum* @ 10g/kg seed were most effective for the management of dry root rot disease of clusterbean disease and increased the yield of clusterbean. Among all the treatments, seed treatment with *Trichoderma harzianum* @ 10g/kg seed performed best and is recommended to minimize diseases incidence of dry root rot disease of clusterbean.

Key words : Clusterbean, dry root rot, Integrated management, *Rhizoctonia bataticola*

Introduction

Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.) native to India is an important multipurpose legume crop (Fabaceae fam.) which is commonly referred as Guar. Being drought and high temperature tolerant crop, it is mostly confined to the dry regions under rainfed conditions of arid and semi-arid regions of the country and globe (Kumar and Rodge, 2012). India being most important cluster bean producing country with almost 80% contribution of its global production and is grown over an area of about 5.6 mha with an annual production of around 2.7 MT and the productivity of 485 kg/ha (Tripathy and Das, 2013; Anonymous, 2014). In India the crop is mainly confined to northwestern states which includes Rajasthan, Gujarat, Punjab, Haryana etc and Rajasthan alone accounts for the most (70-75%) of the cluster bean production with the production of 1.2 mt over an area of 2.8 mha and productivity of 452 kg/ha (Anonymous, 2020). India is the largest exporter of guar gum. India exported 513218 tons and 381880 tons of guar gum products worth Rs. 4,707 and 3,262 crores during 2018-19 and 2019-20 respectively (Anonymous, 2021).

Despite being the dollar earning crop of western Rajasthan, the production of cluster bean is severely affected by various insects and diseases. Among the various biotic stresses, dry root rot disease caused by *Macrophomina phaseolina* (*Rhizoctonia bataticola*) is a

major threat in cluster bean cultivation in the arid regions (Dhingra and Sinclair, 1978). The fungus affects a wide range of crops and weeds leading to great economic losses and is reported to cause yield losses of 30-40% in cluster bean (Lodha *et al.*, 1986) and is also known to cause significant yield losses in other leguminous crops like chickpea and soybean etc. (Sharma *et al.*, 2012; Gupta *et al.*, 2012). The pathogen mostly colonizes the embryo, seed coat and endosperms of the infected seeds resulting in reduced germination, quality and nutritional values of the seeds (Ashwini and Giri, 2014; Patil *et al.*, 1990). In clusterbean, the disease appears at any stage throughout the lifespan of the crop (Lodha, 1998). *R. bataticola* (*M. phaseolina*) was reported to cause around 30 per cent plant mortality and yield loss of 435 kg/ha (Lodha *et al.* 1998; Moradia and Khandar 2011). Being able to survive on plant debris and soil, the pathogen is pretty much difficult to manage this disease by a particular approach. Keeping all these facts in mind this study was formulated to see the impact of different chemicals and biocontrol agents on the dry root rot disease through seed treatment and soil treatment individually and in combination under natural conditions.

Materials and Methods

The experiments were carried out in the research field of Agriculture Research Station, Mandor, Jodhpur with cluster bean variety RGM 112. Different chemicals (Carbendazim, Thiram, Carboxin) and Bio control agents

(*Trichoderma harzianum* and *Pseudomonas fluorescence*) were used for control of the disease through seed dressing and soil enrichment with the biocontrol agents. FYM and Neem seed cake along with commercially available fungicides were used for the study. The formulation of *Trichoderma harzianum* was procured from ATC Rampura. *Pseudomonas fluorescence* was isolated, purified and mass multiplied for seed treatment and soil treatment.

Seed treatment : The seeds of cluster bean were treated with different fungicides and biocontrol agents before sowing. The seeds were treated with Carbendazim 50% WP @ 2g/kg seed, Thiram 37.5 + Carboxin 37.5 @ 3g/kg seed, *Trichoderma harzianum* @ 10g/kg seed and *Pseudomonas fluorescence* @ 10g/kg seed by slurry method. The seeds were kept for drying after treatment and sown in the field.

Soil treatment : In the present investigation, enriched biocontrol agents mixed with FYM were used as soil treatment. After the enrichment of the FYM it was mixed in the soil prior to sowing. The ten treatments used in the present study are as T₁: seed treatment with Carbendazim 50% WP @ 2g/kg seed; T₂: seed treatment with Thiram 37.5 + Carboxin 37.5 @ 3g/kg seed; T₃: seed treatment with *Trichoderma harzianum* @ 10g/kg seed; T₄: seed treatment with *Pseudomonas fluorescence* @ 10g/kg seed; T₅: soil treatment with *T. harzianum* @ 2.5 kg/ha with 100 kg of FYM before sowing; T₆: Soil treatment with *P. fluorescence* @ 2.5 kg/ha enriched with 100 kg of FYM before sowing; T₇: soil treatment with *T. harzianum* @ 2.5 kg/ha with 100 kg of FYM before sowing + 250 kg Neem seed cake; T₈: soil treatment with *P. fluorescence* @ 2.5 kg/ha with 100 kg of FYM before sowing + 250 kg Neem seed cake; T₉: Soil treatment with *T. harzianum* @ 2.5 kg/ha + *P. fluorescence* @ 2.5 kg/ha with 100 kg of FYM before sowing + 250 kg Neem seed cake before sowing and T₁₀: untreated control. The percent disease incidence (PDI) was calculated with the help of the formula :

$$\text{Percent Disease Incidence} = \frac{\text{No. of diseased plants}}{\text{No. of total plants}} \times 100$$

The inhibition of disease by various treatments was calculated using the formula :

$$\begin{aligned} &\text{Reduction in disease over control} \\ &= \frac{(\% \text{ Disease incidence in Control Plot} \\ &\quad - \% \text{ Disease incidence in treatment})}{\% \text{ Disease incidence in Control Plot}} \times 100 \end{aligned}$$

The yield of every plot was estimated to evaluate the impact of different management strategies on the crop yield over the control.

Results and Discussion

During the study, the dry root rot of cluster bean was recorded in the range of 4 to 23.5 per cent from the fields at Agricultural Research Station, Mandor, Jodhpur. The results obtained from the study for the year 2019 indicated that seed as well as soil treatment with bioagents (*Trichoderma harzianum*, *Pseudomonas fluorescence*) and fungicides (Carbendazim 50%WP, Thiram 37.5 + Carboxin 37.5) alone or in combination for the management of dry root rot disease of cluster bean were significantly superior over untreated control to manage dry root rot disease of cluster bean. Among different treatments, seed treatment with Carbendazim 50% WP @ 2g/kg seed (4.53 (12.3)) was found most effective and at par with soil application of *T. harzianum* @ 2.5 kg/ha enriched in 100 kg of FYM before sowing were found most effective (Dry root rot disease incidence: 4.66 (12.5) Per cent), seed treatment with Thiram 37.5 + Carboxin 37.5 @ 3g/kg seed (4.67 (12.5)) and soil treatment with *Trichoderma harzianum* @ 2.5 kg/ha + *Pseudomonas fluorescence* @ 2.5 kg/ha enriched in 100 kg of FYM before sowing + 250 kg Neem seed cake before sowing (Dry root rot disease incidence 4.76 (12.6) per cent). However, in untreated control, dry root rot disease incidence was 23.48 (29.0) percent. The findings of the present investigation are in close confirmation to the findings of the previous workers (Dutta and Kalha, 2011; Mishra and Sinha, 1999). Previously, various workers evaluated the efficacy of carbendazim and carbendazim + mancozeb against root rot pathogens (Dutta and Kalha, 2011; Manibhushanrao et al., 1979; Sinha and Khare, 1977). Later on, Ramadoss and Sivaprakasam (1994) studied and reported the inhibition of sclerotia production of *Macrophomina phaseolina* by carbendazim and thiram. Among the bioagents, the antagonistic activity of biocontrol agents was reported by various workers from India and abroad. In a study during 2020, the maximum mycelial growth inhibition of *M. phaseolina* by *Chaetomium globosum* (68.14%) was recorded by Ranvijay and coworkers. Similarly, the efficacy of *Trichoderma* against different pathogens was recorded by many workers (Sreedevi et al., 2011; Gaur et al., 2012) and the bio-efficacy of bio-agents i.e. *T. virens*, *P. fluorescence* and *Bacillus* spp against *M. phaseolina* was also evaluated which favors the findings of the present study (Mohan et al. 2006; Surianchandraselvan, 1997; Manoranjitham et al. 2000; Tewari and Mukhopadhyay, 2003 and Gaur et al., 2005). During the present study maximum disease reduction was recorded in treatment comprising seed treatment with carbendazim 50% WP @ 2g/kg seed (80.7 per cent) and seed treatment with Thiram 37.5 + Carboxin 37.5 @ 3g/kg seed (80.1 per cent)

Table-1 : Effect of different treatments on dry root rot disease incidence of cluster bean and yield.

S. No.	Treatment details	Yield (kg/ha)	YIOC (Per cent)	Dry root rot (Disease incidence)	RDOC* (Per cent)
1.	T ₁ : Seed treatment with Carbendazim 50 WP @ 2g/kg seed	492	154.9	4.53 (12.3)	80.7
2.	T ₂ : Seed treatment with Thiram 37.5 + Carboxin 37.5 @ 3g/kg seed	443	129.5	4.67 (12.5)	80.1
3.	T ₃ : Seed treatment with <i>Trichoderma harzianum</i> @ 10g/kg seed	324	67.9	10.30 (18.7)	56.1
4.	T ₄ : Seed treatment with <i>Pseudomonas fluorescence</i> @ 10g/kg seed	254	31.6	14.77 (22.6)	37.1
5.	T ₅ : Soil treatment with <i>Trichoderma harzianum</i> @ 2.5 kg/ha with 100 kg of FYM before sowing	519	168.9	4.66 (12.5)	80.2
6.	T ₆ : Soil treatment with <i>Pseudomonas fluorescence</i> @ 2.5 kg/ha with 100 kg of FYM before sowing	413	114.0	12.53 (20.7)	46.6
7.	T ₇ : Soil treatment with <i>Trichoderma harzianum</i> @ 2.5 kg/ha with 100 kg of FYM before sowing + 250 kg Neem seed cake	413	114.0	8.66 (17.1)	63.1
8.	T ₈ : Soil treatment with <i>Pseudomonas fluorescence</i> @ 2.5 kg/ha with 100 kg of FYM before sowing + 250 kg Neem seed cake	348	80.3	9.85 (18.3)	58.0
9.	T ₉ : Soil treatment with <i>Trichoderma</i> @ 2.5 kg/ha + <i>Pseudomonas fluorescence</i> @ 2.5 kg/ha with 100 kg of FYM before sowing + 250 kg Neem seed cake before sowing	456	136.3	4.76 (12.6)	79.7
10.	T ₁₀ : Untreated control	193	0.0	23.48 (29.0)	0.0
Trial Mean		385		10.94	
SE(m) ±		13.19		0.388	
CD at 5%		39.19		1.16	
CV (%)		5.991		6.835	

RDOC = Reduction in disease over control; YIOC = Yield increase over control

which was at par with soil treatment with *T. harzianum* @ 2.5 kg/ha enriched in 100 kg of FYM before sowing were found most effective (80.2 per cent) and soil treatment with *T. harzianum* @ 2.5 kg/ha + *P. fluorescence* @ 2.5 kg/ha enriched in 100 kg of FYM before sowing + 250 kg Neem seed cake before sowing (79.73 per cent). Similarly, maximum yield was obtained in treatment soil treatment with *T. harzianum* @ 2.5 kg/ha with 100 kg of FYM before sowing (519 kg/ha) with an increase in yield over control of 168 per cent followed by seed treatment with carbendazim 50% WP @ 2g/kg seed with a yield of 492 kg/ha and 154 per cent increase in yield over untreated control. However, least yield was recorded in untreated control (193 kg/ha). The findings of the present study are in close agreement to the earlier studies. Through this research it may be inferred that a combination of chemical as well as bioagents is highly

effective for the sustainable management of seed as well as soil borne diseases of field crops.

The findings of the present study conclude that that the treatment including seed treatment with Carbendazim 50 WP @ 2g/kg seed and seed treatment with *T. harzianum* @ 10g/kg seed were found most effective for the management of dry root rot disease of clusterbean disease and resulting in increased yield of clusterbean. The next effective treatment found was seed treatment with Thiram 37.5 + Carboxin 37.5 @ 3g/kg seed. No adverse effect or any disfigurements was perceived with the application of treatments on clusterbean in field condition proved firsthand information about its efficacy against a pathogen. Among all the treatments, seed treatment with *Trichoderma harzianum* @ 10g/kg seed performed best and is recommended to minimize

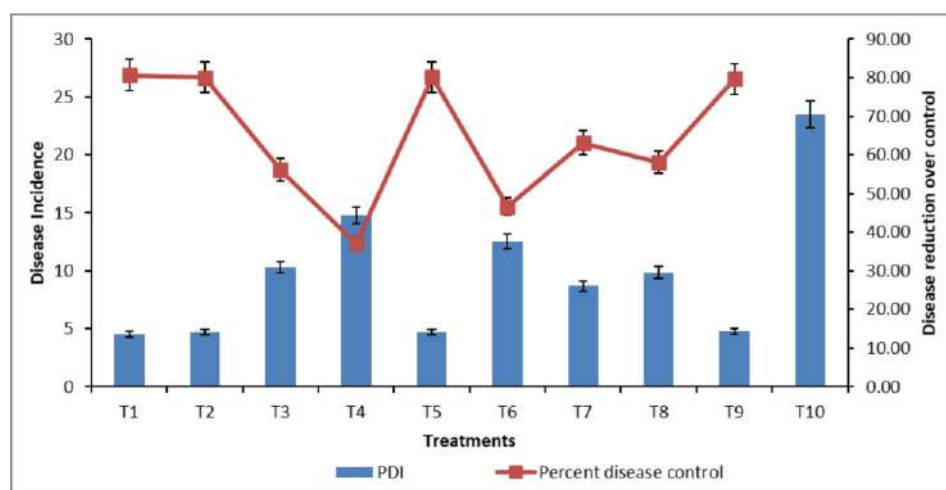


Fig.-1 : Effect of different treatments on disease incidence and disease reduction over control.

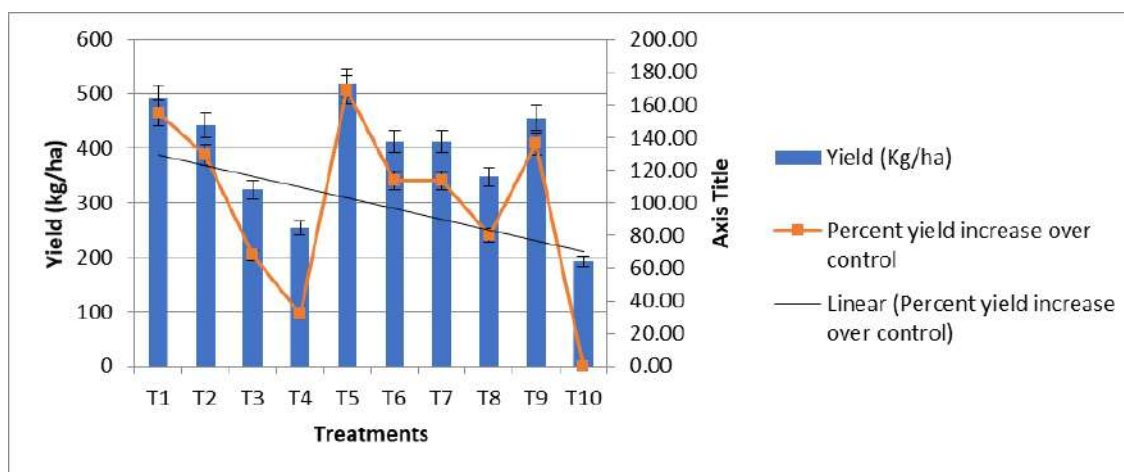


Fig.-2 : Effect of different treatments on yield and per cent yield increase over control.

diseases incidence of dry root rot disease of clusterbean which is an effective and sustainable and ecofriendly alternative to already used chemical fungicides for the management of dry root rot disease of clusterbean.

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Adoption Technology of Trained and Untrained Farmers of Different Villages of District– Sant Kabir Nagar

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Abstract

Studies of 280 farmers' who had undergone four days training and untrained on the subjects namely Scientific Mushroom farming, Dairy farming. Goat farming and Fish farming was carried out in four villages of (Malauli, Chapara magarvi, Kirahariya and Umila) Block Haiser, Pauli, Nathnagar and Semariyawa District-Sant Kabir Nagar. A total of 14 character were selected based on the examine performance and past research studies. It was found that among the various groups of character of the farmers group most of the farmers belonged to mid age group. Had primary level of education, opting equally to have either agriculture as the main or subsidiary occupation. Possessed medium to low level of farm experience, with medium level of annual income followed by medium to low level of contact with extension agency, social participation, mass media exposure, economic motivation, scientific orientation, innovativeness, perceived effectiveness towards the training and operated small size holding. This study was undertaken to assess the behavior of the farmers Sant Kabir Nagar - District which will help in giving appropriate policy implication based on the derived conclusions to uplift the behavior status of the farmers.

Key words : *Mushroom farming; dairy farming; goat farming; fish farming; extension agency; mass media exposure; economic motivation; scientific orientation; innovativeness; perceived effectiveness;*

Research Methodology

The studies were examined conducted in four clusters of villages namely Malauli, Chapara magarvi, Kirahariya and Umila adopted by Krishi Vigyan Kendra Sant Kabir Nagar Uttar Pradesh. The respondents in this study comprising of 280 farmers both who had undergone four days training and untrained on the subject namely Mushroom farming, Dairy farming, Goat farming and Fish farming were selected. For this purpose, 14 variables were identified in consultation with the experts and perusal of the available literature. The mean, standard deviations and percentage were calculated for categorizing the farmers. Relevant data on the character were collected through well structured interview schedule, observation technique subsequently analyzed and tabulated.

Results and Discussion

Its oviparous from the data on behavioral character of the respondents in the study of four categories is discussed here under :

Age : It could be observed from the Table I, that in the category of Mushroom farming exactly more than half (51.42%) of the farmers were of mid age followed by old (28.57%) and young (20%) in trained category, whereas in untrained category more than half of the farmers were of middle age group (54.24%) followed by old (31.42%) and young (14.24%).

In scientific Dairy farming most of the trained farmers (45.71%) belonged to middle age group followed by old (28.57%) and young (25.71%), whereas more than half (54.28%) were of middle age group followed by young (23.28.00%) and old (11.42%) in untrained category of farmers.

In goat farming exactly half of the trained farmers (45.71%) were of mid age group followed by young (34.28%) and old (20.00%), whereas in untrained category a more than half (57.14%) belonged middle age group followed by old (25.71%) and young age (17.14%).

In fish farming a more than half of the farmers (51.42%) were of middle age group followed by young (25.71%) and old (22.85%) in trained category, whereas the untrained farmers were found to be sharing near to half percentage in middle (48.57%) and old age (37.14%) followed by young (14.28%). It is amounted to indicate that the farmers differ in their age group. The studies of, Kavita Angadi *et.al* (2020). Soumya P.S *et.al* (2016). S.K Zamir Ahmed *et.al*. and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Farmers near to half (48.57%) had high school level of education followed by primary and middle are equal (20.00%) in Mushroom farming secondary (8.57) level of education followed by graduation level of education (2.85%), whereas middle less than one-fourth (22.85%) of

untrained farmers were primary percentage (2.85%), high school more than half (51.42%) and secondary (14.28%), followed by graduate are (8.51%) percent educated level.

In the trained category of dairy farming, middle less than one-fourth (22.85%) of the farmers had high school level of education (37.14), secondary (20.00%) and primary (5.71%) and graduate (14.28%) level of education, whereas in untrained category illiterate (22.85%) and primary (20.00%) middle (28.57) followed by high school and secondary are equal (11.42%) and collegiate (5.71%) of education level.

In the goat farming, illiterate less than one-fourth (17.14%) of the trained farmers and middle (20.00) had level of education and less than half (42.85) of high school level of education followed by secondary (5.71%) and collegiate (14.24%) level of education, whereas in untrained category illiterate (14.24), primary (28.57) level of education followed by less than half (40.00) percentage of level education and high school (17.14%) level of education.

In fish farming a less than half of the farmers (34.28%) level of education were of illiterate 20.00% and primary level of education (20.00%), followed by collegiate (14.28%), high school 5.71% and secondary (8.51%) level of education trained, whereas the untrained farmers were found to be illiterate and collegiate are equal level of education percentage (28.57%) primary (20.00%) followed by middle (22.85%) level of education percentage.

A wide range of literacy among the farmers was due to the establishment of more number of educational institutions for the islanders in every nook and corner of the village which acted as an instinct for the villagers to send their ward to the school. This study support from the S.K Zamir Ahmed *et.al.* (2010). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Occupational status : The Table-1, portrayed that with regard to occupational status in the category of mushroom farming, most of the trained farmers had agriculture as their main occupation (57.14%) followed by agriculture as a subsidiary (42.85%), whereas in the case of untrained farmers it was found to be reverse i.e., majority of the farm women had agriculture as their subsidiary occupation (57.14%) followed by (42.85%) percent having agriculture as their main occupation.

The trained farmers of dairy farming had agriculture as their subsidiary occupation (54.28%) followed by agriculture as main (45.71%), whereas in untrained category more than half (51.42 %) of agriculture as their main occupation, followed by (48.57%) percent having agriculture as their subsidiary occupation.

In goat farming, more than half of the trained farmers (51.42%) had agriculture as their subsidiary occupation followed by agriculture as main (48.57%), whereas in untrained category most of the farmers (57.14%) had agriculture as their main followed by agriculture as their subsidiary occupation (42.85%).

In fish farming, (62.85%) percent of the trained farmers had agriculture as their main occupation followed by agriculture as their subsidiary occupation (37.14%), whereas in untrained category more than half (60.00%) had agriculture as their subsidiary occupation followed by agriculture as their main occupation (40.00%).

Due to under employment on one side and higher price of daily essentials on the other side have motivated the farmers equally towards the agriculture as the main occupation and as well as subsidiary occupation, in order to meet and supplement themselves with fresh and nutritious produce besides generating self employment avenue. This observation was consistent with earlier Kavita Angadi and Belli (2020).

Farm experience : About (37.14) percent of the trained farmers of mushroom farming had high level of farm experience followed by medium (42.85%) and low (20.00%), the same trend was reflected in the untrained category i.e., high farm experience (37.14%) followed by medium (45.71%) and low (17.14) percent.

Less than half of the trained farmers (45.71%) in dairy farming had medium level of farm experience followed by high (40.00%) and low (14.28%), whereas the untrained farmers (51.42%) had medium level of experience followed by high (25.71%) and low (22.85%).

In goat farming, more than half of the trained farmers (57.14%) had medium level of farm experience followed by high (28.57%) and low (14.28%), whereas in untrained category little less than half (45.71%) had medium level of farm experience followed by high (31.42%) and low (22.85%).

Equal percentage of trained farmers of fish farming had high (42.85%) and medium level of farm experience, followed by low (14.28%), whereas exactly more than half of the untrained farmers (51.42%) had medium level of farm experience followed by high (37.14%) and low (11.42%).

The fact, that majority of the farmers belonged to young and middle age groups with agriculture as both main and subsidiary occupation got reflected in having medium level of experience. This observation was consistent with earlier of Kavita Angadi and Belli (2020). S.K. Zamir Ahmed, RC Srivastava and Rolokrishnam (2010). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Table-1 : Distribution of the Respondent According to Their Agriculture farming Characteristics (Trained (n=35), Untrained (n=35)).

S. No.	Variables / Category	Agriculture farming categories																	
		Mushroom Farming						Dairy Farming						Goat farming					
		T	%	No	UT	%	No	T	%	No	UT	%	No	T	%	No	UT	%	No
1.	Age	No	%	No	UT	%	No	T	%	No	UT	%	No	T	%	No	UT	%	No
	Young (up to 34 years)	7	20.00	5	14.28	09	25.71	12	34.28	12	23.28	12	34.28	6	17.14	9	25.71	5	14.28
	Middle (35 to 45 years) Old	18	51.42	19	54.28	16	45.71	19	54.28	16	54.28	16	45.71	20	57.14	18	51.42	17	48.57
	(above 45 years)	10	28.57	11	31.42	10	28.57	4	11.42	07	11.42	07	20.00	9	25.71	08	22.85	13	37.14
2.	Educational status																		
	Illiterate	-	-	-	-	-	-	8	22.85	6	22.85	6	17.14	5	14.28	7	20.00	10	28.57
	Primary	7	20.00	1	2.85	2	5.71	7	20.00	7	20.00	7	20.00	10	28.57	6	17.14	7	20.00
	Middle	7	20.00	8	22.85	8	22.85	10	28.57	15	28.57	15	42.85	14	40.00	12	34.28	8	22.85
	High school	17	48.57	18	51.42	13	37.14	4	11.42	2	11.42	2	5.71	6	17.14	2	5.71	-	-
	Secondary	3	8.75	5	14.28	7	20.00	4	11.42	5	11.42	5	14.24	-	-	3	8.51	10	28.57
	Collegiate	1	2.85	3	8.51	5	14.28	2	5.71	-	5.71	-	-	-	-	5	14.28	-	-
3.	Occupational status																		
	Agriculture(Main)	20	57.14	15	42.85	16	45.71	17	48.57	17	48.57	17	48.57	20	57.14	22	62.85	14	40.00
	Agriculture(Subsidiary)	15	42.85	20	57.14	19	54.28	18	51.42	18	51.42	18	51.42	15	42.85	13	37.14	21	60.00
4.	Farm Experience																		
	Low	7	20.00	6	17.14	5	14.28	8	22.85	5	22.85	5	14.28	8	22.85	5	14.28	4	11.42
	Medium	15	42.85	16	45.71	16	45.71	18	51.42	20	51.42	20	57.14	16	45.71	15	42.85	18	51.42
	High	13	37.14	13	37.14	14	40.00	9	25.71	10	25.71	10	28.57	11	31.42	15	42.85	13	37.14
5.	Farm size																		
	Marginal (up to 2.50 ac)	5	14.28	6	17.14	12	34.28	9	25.71	14	25.71	14	40.00	16	45.71	12	34.28	14	40.00
	Small (2.5 to 5.0 as)	23	65.71	17	48.57	16	45.71	11	31.42	15	31.42	15	42.85	8	22.85	4	11.42	6	17.14
	Medium (5.01 to 10.0ac)	7	20.00	5	14.28	7	20.00	5	14.28	3	14.28	3	8.51	4	11.42	7	20.00	-	-
	Big (Above 10.00)	-	-	7	20.00	-	-	10	28.57	3	28.57	3	8.51	7	20.00	12	34.28	15	42.85
6.	Annual Income																		
	Low (upto Rs. 5,000/-)	6	17.14	9	25.71	10	28.57	6	17.14	8	17.14	8	22.85	7	20.00	9	25.71	5	14.28
	Medium (Rs. 5,001 -10,000/-)	17	48.57	20	57.14	18	51.42	21	60.00	22	60.00	22	62.85	22	62.85	19	54.28	24	68.57
	High (Above 10,000/-)	12	34.28	6	17.14	7	20.00	8	22.85	5	22.85	5	14.28	6	17.14	7	20.00	6	17.14
7.	Contact with Extension agency																		
	Low	8	22.85	14	40.00	13	37.14	5	14.28	7	14.28	7	20.00	6	17.14	9	25.71	8	22.85
	Medium	20	57.14	18	51.42	16	45.71	22	62.85	17	62.85	17	48.57	20	57.14	19	54.28	21	60.00
	High	7	20.00	3	8.51	6	17.14	8	22.85	11	22.85	11	31.42	9	25.71	7	20.00	6	17.14
8.	Social Participation																		
	Low	6	17.14	7	20.00	10	28.57	9	25.71	8	25.71	8	22.85	17	48.57	5	14.28	10	28.57
	Medium	17	48.57	19	54.28	18	51.42	16	45.71	21	45.71	21	60.00	15	42.85	10	28.57	16	45.71
	High	12	34.28	9	25.71	7	20.00	7	20.00	6	20.00	6	17.14	3	8.51	20	57.14	9	25.71

Table-1 : Contd....

S. No.	Variables / Category	Agriculture farming categories																	
		Mushroom Farming						Dairy Farming						Goat farming					
		T	%	No	UT	T	%	No	UT	T	%	No	UT	T	%	No	UT	T	%
1.	Age	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
9.	Mass media Exposure																		
	Low	12	34.28	13	37.14	11	31.42	12	34.28	15	42.85	9	25.71	10	28.57	12	34.28		
	Medium	20	57.14	18	51.42	14	40.00	17	48.57	14	40.00	15	42.85	16	45.71	19	54.28		
	High	3	8.51	4	11.42	10	28.57	6	17.14	6	17.14	11	31.42	9	25.71	4	11.42		
10.	Economic Motivation																		
	Low	10	28.57	17	48.57	12	34.28	5	14.28	7	20.00	7	20.00	15	42.85	14	40.00		
	Medium	9	25.71	14	40.00	14	40.00	22	62.85	16	45.71	14	40.00	15	42.85	13	37.14		
	High	15	42.85	4	11.42	9	25.71	8	22.85	12	34.28	14	40.00	5	14.28	8	22.85		
11.	Risk orientation																		
	Low	8	22.85	15	42.85	11	31.42	13	37.14	12	34.28	6	17.14	4	11.42	14	40.00		
	Medium	17	48.57	8	22.85	17	48.57	20	57.14	18	51.42	17	48.57	20	57.14	16	45.71		
	High	10	28.57	12	34.28	7	20.00	02	5.71	5	14.28	12	34.28	11	31.42	5	14.28		
12.	Scientific Orientation																		
	Low	14	40.00	12	34.28	6	17.14	14	40.00	12	34.28	13	37.14	16	45.71	10	28.57		
	Medium	13	37.14	18	51.42	15	42.85	18	51.42	20	57.14	18	51.42	15	42.85	20	57.14		
	High	8	22.85	5	14.28	14	40.00	3	8.51	3	8.51	4	11.42	4	11.42	5	14.28		
13.	Innovativeness																		
	Low	7	20.00	17	48.57	11	31.42	13	37.14	7	20.00	12	34.28	8	22.85	12	34.28		
	Medium	18	51.42	12	34.28	14	40.00	16	45.71	18	51.42	15	42.85	20	57.12	17	48.57		
	High	10	28.57	6	17.14	10	28.57	6	17.14	10	28.57	8	22.85	7	20.00	6	17.14		
14.	Perceived effectiveness of the training																		
	Low	6	17.14	13	37.14	4	11.42	9	25.71	9	25.71	8	22.85	14	40.00	5	14.28		
	Medium	21	60.00	18	51.42	11	31.42	19	54.28	20	57.14	21	60.00	17	48.57	20	57.14		
	High	8	22.85	4	11.42	20	57.14	7	20.00	6	17.14	6	17.14	4	11.42	10	28.57		

Farm size : A glance at the Table-1, pointed out that in mushroom farming, more than half of the trained farmers (65.71%) had small land holdings followed by medium (20.00%) and marginal land holdings (14.28%), whereas in untrained category less than half of the farmers had small size holdings (48.57%), followed by big (20.00%), marginal (17.14%) and medium size land holdings (14.28%).

In Dairy farming, 45.71 percent of the trained farmers had small size land holdings followed by marginal (34.28%) and medium (20.00%), whereas in untrained category little more than one-third (31.42%) had small size holdings followed by of marginal (25.71%) and medium (14.28%). Remaining (28.57%) had big size land holdings.

The trained farmers in goat farming, had small size (42.85%) and marginal holdings (40.00%) followed by equal medium and big farm size holding (8.51%), whereas in untrained category less than half of the farmers (45.71%) had marginal size holdings followed by small (22.85%) and medium percentage of size of holding of the farmers (11.42) followed by big size holdings (20.00%).

In fish farming, the trained farmers are equal size holding (34.28%) had big and marginal size holdings and, medium (20.00%) and small size holdings (11.42%), whereas in untrained category of farmers had marginal (40.00%) and followed by big (42.85%) followed by small size holdings (17.14%).

Due to manifold increase in the population and the trend of nuclear type of family living would have forced them to divide ancestral property from generation after generation resulting in fragmentation of holding into smaller sizes. This might be the reason for more number of farmers operating small sized farms. Similar studies was consistent with earlier Kavita Angadi and Belli (2020). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Annual income : The data in the Table-1, revealed that the annual income of (48.57%) of the trained respondents were medium followed by high (34.28%) and low (17.14%), whereas the untrained farm women (57.14%) had medium level of annual income followed by low (25.71%) and high (17.14%), in the mushroom farming.

In dairy farming, more than half of the trained farmers (51.42%) had medium level of annual income followed by low (28.57%) and high (20.00%), whereas in untrained category more than half of the farmers (60.00%) had medium level of annual income followed by low (17.14%) and high (22.85%).

More than half of the trained farmers (62.85%) of goat farming had medium level of income followed by low (22.85%) and high (14.28%), whereas in untrained category more than half of the farmers (62.85%) had medium level of income followed by low (20.00%) and high (17.14%).

In fish farming more than half (54.28%) of the trained farmers had medium level of income followed by low (25.72%) and low (20.00%), whereas in untrained category more than half (68.57%) had medium level of income followed by high (17.14%) and low (14.58%).

This might be due to the practice of undertaking more than one farming of agriculture and allied fields in an integrated manner, so as to increase the production and productivity per unit for sustainable revenue to the farmers. This study was consistent with earlier Kavita Angadi and Belli (2020).

Contact with extension agency: In mushroom farming as evident from the Table-1, that in the category of trained farmers medium level of contract with the extension agency was exhibited by more than half (57.14%) followed by the of medium (20.00%) and high (22.85%) and high (20.00), whereas in untrained category more than half of the farmers (51.42%) reported to have medium level of contract with extension agency followed by low (40.00%) and high (8.51%).

A less than half (45.71%) of the trained farmers showed medium level of contract with extension agency followed by low (37.14%) and high (17.14%), whereas in the untrained category more than half (62.85%) had medium level of contact with extension agency followed by high (22.85%) and low (14.28%) in the dairy farming.

In goat farming less than half of the trained farmers (48.57%) had medium level of contract with extension agency followed by high (31.42%) and low (20.00%), whereas in untrained category of farmers, a little more than half (57.14%) had medium level of contact with extension agency followed by high (25.71%) and low (17.14%).

In the fish farming, in the category of trained farmers more than half (54.28%) had medium level of contract with extension agency followed by low (25.71%) and high (20.00%), whereas in the category of untrained farmers (60.00%) showed medium level of contact with extension agency followed by low (22.85%) and high (17.14%).

The extension activities are extended by the scientists and specialists of KVK Sant Kabir Nagar among the farming community. This resulted in maintenance of medium level of contact with extension agency. These studies carried out by S.K.Zamir Ahmed,

RC Srivastava and M.Balokrisnam (2010). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Social participation : The Table-1, apparently reveals that in mushroom farming, little less than half of the trained farmers (48.57%) exhibited medium level of social participation followed by high (34.28%) and low (17.14%), whereas in untrained category more than half of the farmers (54.28%) showed medium level of social participation followed by high (25.71%) and low (20.00%).

In dairy farming, the trained farmers (51.42%) had medium level of social participation followed by low (28.57%) and high (20.00%), whereas exactly less than half of the untrained farmers (45.71%) reported to have maximum level of social participation followed by low (25.71%) and high (20.00%).

The trained farmers (60.60%) of goat farming could show medium level of social participation followed by low (22.85%) and high (17.14%), whereas (48.57%) of the untrained farmers showed low level of social participation followed by medium (42.85%) and low (8.51%).

In the fish farming, more than half of the trained farmers (57.14%) exhibited high level of social participation followed by medium (28.57%) and one-third low (14.57%), whereas in untrained category of farmers, medium level of social participation was exhibited by (45.71%) farmers followed by low (28.57%) and low (25.71%).

The reason for the above substantiated results would have been due to existence of social stratification among the bight, small farmers and other minor communities of the villages. In addition, more work in the farm coupled with lack of time and interest might be the other valid reasons for facilitating the result. The result is in line with the studies Kavita Angadi *et.al.* (2020).

Mass media exposure : By glancing at the Table-1, it can be inferred that in mushroom farming, more the half (57.14%) of the trained farmers had medium level of exposure to mass media followed by low (34.28%) and high (8.51%), whereas in untrained category exactly half (51.42%) of the farmers showed medium level of exposure to mass media followed by (37.14%) low and (11.42%) high.

In dairy farming, the trained farmers exhibited medium (40.00%) and low (31.42%) levels of mass media exposure followed by high (28.57%), whereas in untrained category, little half (48.57%) showed medium level of mass media exposure followed by low (34.28%) and high (17.14%).

Less than half (42.85%) of the trained farmers

showed low level of exposure to mass media followed by medium (40.00%) and high (17.14%), whereas in untrained category less than half (42.85%) of the farmers exhibited medium level of mass media exposure followed by high (31.42%) and low (25.71%) in the goat farming.

In fish farming, half (45.71%) of the trained farmers showed medium level of mass media exposure followed by low (28.57%) and high (25.71%), whereas (54.28%) of the untrained farmers showed medium level of mass media exposure followed by low (34.28%) and high (11.42%).

Economic motivation : It is noticed from the data of the Table 1, that in mushroom farming, the trained farmers (42.85%) showed high level of economic motivation followed by low (28.57%) and medium (25.71%), whereas in untrained category little than half (48.57%) of the farmers exhibited low level of economic motivation followed by medium (40.00%) and high (11.42%).

In goat farming, (40.00%) of trained farmers exhibited medium level of economic motivation followed by low (34.28%) and high (25.71), whereas in untrained category (62.85%) of the farmers showed medium level of economic motivation followed by high (22.85%) and low (14.28%).

Less than half (45.71%) of the trained farmers showed medium level of economic motivation followed by (34.28%) as high and (20.00%) low, whereas in untrained category same value of medium level and high (40.00%) followed by low (20.00%) in goat farming.

In fish farming are equal of little half (42.85%) of the trained farmers exhibited low level and medium of economic motivation followed by high (14.28%), whereas in untrained category (40.00%) of the farmers showed low level of economic motivation followed by medium (37.14%) and high (22.85%).

The assured regular and sustained income derived from main and subsidiary farming paved way to increase more income from their farms. Also the desire to compete with each other in terms of standard of living might be another possible reason. All these factors would have contributed for exhibiting medium level of economic motivation.

Risk orientation : Regarding risk orientation, it could be discerned from the Table 1, that in mushroom farming, less than half (48.57%) of the trained farmers exhibited medium level of risk orientation followed by high (28.57%) and low (22.85%), whereas low level of risk orientation was shown by the (42.85%) of untrained farmers followed by high (34.28%) and medium (22.85%).

In dairy farming, less than half (48.57%) in the

trained farmers category showed medium level of risk orientation followed by low (31.42%) and high (20.00%), whereas in untrained category more than half (57.14%) showed medium level of risk orientation followed by low (37.14%) and high (5.71%).

In goat farming, (51.42%) of the trained farmers showed medium level of risk orientation followed by low (34.28%) and high (14.28%), whereas a little less than half (48.57%) of the untrained farmers exhibited medium level of risk orientation followed by low (34.28%) and low (17.14%).

More than half of the trained farmers (57.14%) exhibited medium level of risk orientation followed by high (31.42%) and low (11.42%), whereas in untrained category of the farmers exactly less than half (45.71%) showed medium level of risk orientation followed by low (40.00%) and high (14.28%) in the fish farming.

The reason might be due to the fact that the farmers who were found to be economically motivated had the sternness and determination to bear risk in taking up any other enterprises which would facilitate or generate additional income. These studies carried out of S.K.Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010)

Scientific orientation : It is clear from the table 1, that in the mushroom, the trained farmers showed equal distribution (40.00%) in exhibiting both medium and low level of scientific orientation followed by high (20.00%), whereas in the category of the untrained farmers exactly more than half (51.28%) exhibited medium level of scientific orientation followed by low (34.28%) and high (14.24%).

In dairy farming showed equal distribution (40.00%) in exhibiting both medium and high level of the trained farmers of scientific orientation followed by low (14.28%), whereas in untrained category more than half of the farmers (51.42%) showed medium level of scientific orientation followed by low (40.00%) and high (8.51%).

In goat farming, more than half (57.14%) of the trained farmers exhibited medium level of scientific orientation followed by low (34.28%) and high (8.51%), whereas in the untrained category (51.42%) of the farmers showed medium level of scientific orientation followed by low (37.14%) and high (11.42%).

In fish farming, less than half (45.71%) of the trained farmers reported for low level of scientific orientation followed by Medium (42.85%) and high (11.42%), whereas more than half (57.14%) of the untrained farmers expressed medium level of scientific orientation followed by low (28.57%) and high (14.28%).

The close association between the scientists of

KVK- Sant Kabir Nagar and the enterprising farmers motivated them to venture into any innovative technology extended to them, so as to hasten their remuneration. This reason would have inclined them to have medium level of scientific orientation. These studies carried out of S.K. Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010)

Innovativeness : The Table-I, revealed that in mushroom farming, more than half (51.42%) of the trained farmers was observed to have medium level of innovativeness followed by high (28.57%) and low (20.00%), whereas less than half (48.57%) of the untrained farmers exhibited low level of innovativeness followed by medium (34.28%) and high (17.14%).

In dairy farming, (40.00%) of the trained farmers exhibited medium level of innovativeness followed by showed distribution (31.420%) in exhibiting low and high (28.57) level, whereas in untrained farmers category (45.71%) of them showed medium level of innovativeness followed by low (37.14%) and high (17.14%).

In goat farming, more than half (51.42%) of the trained farmers showed medium level of innovativeness followed by high (28.57%) and low (20.00%), whereas in untrained farmers category (42.85%) showed medium level of innovativeness followed by low (34.28%) and high (22.85%).

In fish farming, in the trained farmers category (57.12%) expressed medium level of innovativeness followed by low (22.85%) and low (20.00%), whereas in untrained category less than half of the farmers (48.57%) showed medium level of innovativeness followed by low (34.28%) and high (17.14%).

Most of the farmers being energetic, enterprising, in theistic and venturesome having medium level of message exposure and annual income, paved way to grasp more of latest technologies from the experts of KVK Sant Kabir Nagar for early act on and thereby resulting in medium level of innovativeness. These studies carried out of S.K. Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010)

Perceived effectiveness of the training: It is vivid from the Table-I, that in mushroom farming (60.00%) of the trained farmers had medium level of perceived effectiveness of the training followed by high (22.85%) and low (17.14%), whereas in untrained farmers category little half (51.42%) expressed medium level of perceived effectiveness of the training followed by low (37.14%) and high (11.42%).

The trained farmers (57.14%) of dairy farming, showed high level of perceived effectiveness towards training followed by medium (31.42%) and low (11.42%),

whereas in the untrained category of farmers more than half (54.28%) expressed medium level of perceived effectiveness training followed by low (25.71%) and high levels (20.00%).

In goat farming, more than half (57.14%) of the trained farmers showed medium level of perceived effectiveness towards training followed by low (25.71%) and high (17.14%), whereas in the untrained category of farmers (60.00%) showed medium level of perceived effectiveness of the training followed by low (22.85%) and high (17.14%).

In the fish farming, the trained farmers less than half (48.57%) expressed medium level of perceived effectiveness towards training followed by low (40.00%) and high (11.42%), whereas in untrained farmers category (57.14%) training followed by high (28.57%) and low (14.28%).

The studies of the farmers and the delivery of the technology in the right form, place and time by the experts has given them a better understanding for capacity and confidence building. This may have routed to have a medium level of perceived effectiveness of training among the farmers. These studies carried out of S. K. Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010)

Conclusion

It can be concluded that, among the various categories of characteristics of the farmers (both trained and untrained)

most of the farmers belonged to middle age group, had primary level of education, opting equally to have either agriculture as the main or subsidiary occupation. Possessed medium to low level of farm experience, with medium level of annual income followed by medium to low level of contact with extension agency, social participation, mass media exposure, economic motivation, scientific orientation, innovativeness, perceived effectiveness towards the training and operated small size holding.

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Studies of Adoption Technology of Trained and Untrained Farm Women's of Different Villages of District–Chandauli

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Abstract

Studies of 280 farmers who had undergone six days training and untrained on the subjects namely Scientific Mushroom farming, Dairy farming. Goat farming and Fish farming was carried out in four villages of (Dulhipur, Baghahi, Karemua and Kodochak) Block Niyamtabad and Sahabganj of Chandauli -District. A total of 14 character were selected based on the examine performance and past research studies. It was found that among the various groups of character of the farm women; most of the farm women belonged to mid age group. Had primary level of education, opting equally to have either agriculture as the main or subsidiary occupation. Possessed medium to low level of farm experience, with medium level of annual income followed by medium to low level of contact with extension agency, social participation, mass media exposure, economic motivation, scientific orientation, innovativeness, perceived effectiveness towards the training and operated small size holding. This study was undertaken to assess the behavior of the farm women Chandauli- District which will help in giving appropriate policy implication based on the derived conclusions to uplift the behavior status of the farm women.

Key words : *Mushroom farming; dairy farming; goat farming; fish farming; extension agency; mass media exposure; economic motivation; scientific orientation; innovativeness; perceived effectiveness;*

Research Methodology

The studies were examined conducted in four clusters of villages namely Dulhipur, Baghahi, Karemua and Kodochak adopted by Krishi Vigyan Kendra Chandauli Uttar Pradesh. The respondents in this study comprising of 280 farmwomen both who had undergone six days training and untrained on the subject namely Mushroom farming, Dairy farming, Goat farming and Fish farming were selected. For this purpose, 14 variables were identified in consultation with the experts and perusal of the available literature. The mean, standard deviations and percentage were calculated for categorizing the farmers. Relevant data on the character were collected through well structured interview schedule, observation technique subsequently analyzed and tabulated.

Results and Discussion

Its oviparous from the data on behavioral character of the respondents in the study of four categories is discussed here under :

Age : It could be observed from the Table-I, that in the category of Mushroom farming exactly more than half (51.42%) of the farm women were of mid age followed by old (28.57%) and young (20%) in trained category, whereas in untrained category more than half of the farm women were of middle age group (54.24%) followed by old (31.42%) and young (14.24%).

In scientific Dairy farming most of the trained farm women (45.71%) belonged to middle age group followed by old (28.57%) and young (25.71%), whereas more than half (54.28%) were of middle age group followed by young (23.28.00%) and old (11.42%) in untrained category of farm women.

In goat farming exactly half of the trained farm women (45.71%) were of mid age group followed by young (34.28%) and old (20.00%), whereas in untrained category a more than half (57.14%) belonged middle age group followed by old (25.71%) and young age (17.14%).

In fish farming a more than half of the farm women (51.42%) were of middle age group followed by young (25.71%) and old (22.85%) in trained category, whereas the untrained farm women were found to be sharing near to half percentage in middle (48.57%) and old age (37.14%) followed by young (14.28%). It is amounted to indicate that the farm women differ in their age group. The studies of, Kavita Angadi *et.al* (2020). Soumya P.S *et.al* (2016). S.K Zamir Ahmed *et.al*. and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Farm women near to half (48.57%) had high school level of education followed by primary and middle are equal (20.00%) in Mushroom farming secondary (8.57) level of education followed by graduation level of education (2.85%), whereas middle less than one-fourth

(22.85%) of untrained farm women were primary percentage (2.85%), high school more than half (51.42%) and secondary (14.28%), followed by graduate are (8.51%) percent educated level.

In the trained category of dairy farming, middle less than one-fourth (22.85%) of the farm women had high school level of education (37.14%), secondary (20.00%) and primary (5.71%) and graduate (14.28%) level of education, whereas in untrained category illiterate (22.85%) and primary (20.00%) middle (28.57) followed by high school and secondary are equal (11.42%) and collegiate (5.71%) of education level.

In the goat farming, illiterate less than one-fourth (17.14%) of the trained farm women and middle (20.00) had level of education and less than half (42.85) of high school level of education followed by secondary (5.71%) and collegiate (14.24%) level of education, whereas in untrained category illiterate (14.24), primary (28.57) level of education followed by less than half (40.00) percentage of level education and high school (17.14%) level of education.

In fish farming a less than half of the farm women (34.28%) level of education were of illiterate 20.00% and primary level of education (20.00%), followed by collegiate (14.28%), high school 5.71% and secondary (8.51%) level of education trained, whereas the untrained farm women were found to be illiterate and collegiate are equal level of education percentage (28.57%) primary (20.00%) followed by middle (22.85%) level of education percentage.

A wide range of literacy among the farm women was due to the establishment of more number of educational institutions for the islanders in every nook and corner of the village which acted as an instinct for the villagers to send their ward to the school. This study support from the S.K Zamir Ahmed *et.al.* (2010). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Occupational status : The Table-1, portrayed that with regard to occupational status in the category of mushroom farming, most of the trained farm women had agriculture as their main occupation (57.14%) followed by agriculture as a subsidiary (42.85%), whereas in the case of untrained farm women it was found to be reverse i.e., majority of the farm women had agriculture as their subsidiary occupation (57.14%) followed by (42.85%) percent having agriculture as their main occupation.

The trained farm women of dairy farming had agriculture as their subsidiary occupation (54.28%) followed by agriculture as main (45.71%), whereas in untrained category more than half (51.42 %) of agriculture

as their main occupation, followed by (48.57%) percent having agriculture as their subsidiary occupation.

In goat farming, more than half of the trained farm women (51.42%) had agriculture as their subsidiary occupation followed by agriculture as main (48.57%), whereas in untrained category most of the farm women (57.14%) had agriculture as their main followed by agriculture as their subsidiary occupation (42.85%).

In fish farming, (62.85%) percent of the trained farm women had agriculture as their main occupation followed by agriculture as their subsidiary occupation (37.14%), whereas in untrained category more than half (60.00%) had agriculture as their subsidiary occupation followed by agriculture as their main occupation (40.00%).

Due to under employment on one side and higher price of daily essentials on the other side have motivated the farm women equally towards the agriculture as the main occupation and as well as subsidiary occupation, in order to meet and supplement themselves with fresh and nutritious produce besides generating self employment avenue. This observation was consistent with earlier Kavita Angadi and Belli (2020).

Farm experience : About (37.14) percent of the trained farm women of mushroom farming had high level of farm experience followed by medium (42.85%) and low (20.00%), the same trend was reflected in the untrained category i.e., high farm experience (37.14%) followed by medium (45.71%) and low (17.14) percent.

Less than half of the trained farm women (45.71%) in dairy farming had medium level of farm experience followed by high (40.00%) and low (14.28%), whereas the untrained farm women (51.42%) had medium level of experience followed by high (25.71%) and low (22.85%).

In goat farming, more than half of the trained farm women (57.14%) had medium level of farm experience followed by high (28.57%) and low (14.28%), whereas in untrained category little less than half (45.71%) had medium level of farm experience followed by high (31.42%) and low (22.85%).

Equal percentage of trained farm women of fish farming had high (42.85%) and medium level of farm experience, followed by low (14.28%), whereas exactly more than half of the untrained farm women (51.42%) had medium level of farm experience followed by high (37.14%) and low (11.42%).

The fact, that majority of the farm women belonged to young and middle age groups with agriculture as both main and subsidiary occupation got reflected in having medium level of experience. This observation was consistent with earlier of Kavita Angadi and Belli (2020).

Table-1 : Distribution of the Respondent According to Their Agriculture farming Characteristics (Trained (n=35), Untrained (n=35)).

S. No.	Variables / Category	Agriculture farming categories																	
		Mushroom Farming						Dairy Farming						Goat farming					
		T	%	No	UT	%	No	T	%	No	UT	%	No	T	%	No	UT	%	No
1.	Age	No	%	No	UT	%	No	T	%	No	UT	%	No	T	%	No	UT	%	No
	Young (up to 34 years)	7	20.00	5	14.28	09	25.71	12	34.28	12	23.28	12	34.28	6	17.14	9	25.71	5	14.28
	Middle (35 to 45 years) Old	18	51.42	19	54.28	16	45.71	19	54.28	16	54.28	16	45.71	20	57.14	18	51.42	17	48.57
	(above 45 years)	10	28.57	11	31.42	10	28.57	4	11.42	07	11.42	07	20.00	9	25.71	08	22.85	13	37.14
2.	Educational status																		
	Illiterate	-	-	-	-	-	-	8	22.85	6	22.85	6	17.14	5	14.28	7	20.00	10	28.57
	Primary	7	20.00	1	2.85	2	5.71	7	20.00	7	20.00	7	20.00	10	28.57	6	17.14	7	20.00
	Middle	7	20.00	8	22.85	8	22.85	10	28.57	15	28.57	15	42.85	14	40.00	12	34.28	8	22.85
	High school	17	48.57	18	51.42	13	37.14	4	11.42	2	11.42	2	5.71	6	17.14	2	5.71	-	-
	Secondary	3	8.75	5	14.28	7	20.00	4	11.42	5	11.42	5	14.24	-	-	3	8.51	10	28.57
	Collegiate	1	2.85	3	8.51	5	14.28	2	5.71	-	5.71	-	-	-	-	5	14.28	-	-
3.	Occupational status																		
	Agriculture(Main)	20	57.14	15	42.85	16	45.71	17	48.57	17	48.57	17	48.57	20	57.14	22	62.85	14	40.00
	Agriculture(Subsidiary)	15	42.85	20	57.14	19	54.28	18	51.42	18	51.42	18	51.42	15	42.85	13	37.14	21	60.00
4.	Farm Experience																		
	Low	7	20.00	6	17.14	5	14.28	8	22.85	5	22.85	5	14.28	8	22.85	5	14.28	4	11.42
	Medium	15	42.85	16	45.71	16	45.71	18	51.42	20	51.42	20	57.14	16	45.71	15	42.85	18	51.42
	High	13	37.14	13	37.14	14	40.00	9	25.71	10	25.71	10	28.57	11	31.42	15	42.85	13	37.14
5.	Farm size																		
	Marginal (up to 2.50 ac)	5	14.28	6	17.14	12	34.28	9	25.71	14	25.71	14	40.00	16	45.71	12	34.28	14	40.00
	Small (2.5 to 5.0 as)	23	65.71	17	48.57	16	45.71	11	31.42	15	31.42	15	42.85	8	22.85	4	11.42	6	17.14
	Medium (5.01 to 10.0ac)	7	20.00	5	14.28	7	20.00	5	14.28	3	14.28	3	8.51	4	11.42	7	20.00	-	-
	Big (Above 10.00)	-	-	7	20.00	-	-	10	28.57	3	28.57	3	8.51	7	20.00	12	34.28	15	42.85
6.	Annual Income																		
	Low (upto Rs. 5,000/-)	6	17.14	9	25.71	10	28.57	6	17.14	8	17.14	8	22.85	7	20.00	9	25.71	5	14.28
	Medium (Rs. 5,001 -10,000/-)	17	48.57	20	57.14	18	51.42	21	60.00	22	60.00	22	62.85	22	62.85	19	54.28	24	68.57
	High (Above 10,000/-)	12	34.28	6	17.14	7	20.00	8	22.85	5	22.85	5	14.28	6	17.14	7	20.00	6	17.14
7.	Contact with Extension agency																		
	Low	8	22.85	14	40.00	13	37.14	5	14.28	7	14.28	7	20.00	6	17.14	9	25.71	8	22.85
	Medium	20	57.14	18	51.42	16	45.71	22	62.85	17	62.85	17	48.57	20	57.14	19	54.28	21	60.00
	High	7	20.00	3	8.51	6	17.14	8	22.85	11	22.85	11	31.42	9	25.71	7	20.00	6	17.14
8.	Social Participation																		
	Low	6	17.14	7	20.00	10	28.57	9	25.71	8	25.71	8	22.85	17	48.57	5	14.28	10	28.57
	Medium	17	48.57	19	54.28	18	51.42	16	45.71	21	45.71	21	60.00	15	42.85	10	28.57	16	45.71
	High	12	34.28	9	25.71	7	20.00	7	20.00	6	20.00	6	17.14	3	8.51	20	57.14	9	25.71

Table-1 : Contd....

S. No.	Variables / Category	Agriculture farming categories																	
		Mushroom Farming						Dairy Farming						Goat farming					
		T	%	No	UT	T	%	No	UT	T	%	No	UT	T	%	No	UT	T	%
1.	Age	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
9.	Mass media Exposure																		
	Low	12	34.28	13	37.14	11	31.42	12	34.28	15	42.85	9	25.71	10	28.57	12	34.28		
	Medium	20	57.14	18	51.42	14	40.00	17	48.57	14	40.00	15	42.85	16	45.71	19	54.28		
	High	3	8.51	4	11.42	10	28.57	6	17.14	6	17.14	11	31.42	9	25.71	4	11.42		
10.	Economic Motivation																		
	Low	10	28.57	17	48.57	12	34.28	5	14.28	7	20.00	7	20.00	15	42.85	14	40.00		
	Medium	9	25.71	14	40.00	14	40.00	22	62.85	16	45.71	14	40.00	15	42.85	13	37.14		
	High	15	42.85	4	11.42	9	25.71	8	22.85	12	34.28	14	40.00	5	14.28	8	22.85		
11.	Risk orientation																		
	Low	8	22.85	15	42.85	11	31.42	13	37.14	12	34.28	6	17.14	4	11.42	14	40.00		
	Medium	17	48.57	8	22.85	17	48.57	20	57.14	18	51.42	17	48.57	20	57.14	16	45.71		
	High	10	28.57	12	34.28	7	20.00	02	5.71	5	14.28	12	34.28	11	31.42	5	14.28		
12.	Scientific Orientation																		
	Low	14	40.00	12	34.28	6	17.14	14	40.00	12	34.28	13	37.14	16	45.71	10	28.57		
	Medium	13	37.14	18	51.42	15	42.85	18	51.42	20	57.14	18	51.42	15	42.85	20	57.14		
	High	8	22.85	5	14.28	14	40.00	3	8.51	3	8.51	4	11.42	4	11.42	5	14.28		
13.	Innovativeness																		
	Low	7	20.00	17	48.57	11	31.42	13	37.14	7	20.00	12	34.28	8	22.85	12	34.28		
	Medium	18	51.42	12	34.28	14	40.00	16	45.71	18	51.42	15	42.85	20	57.12	17	48.57		
	High	10	28.57	6	17.14	10	28.57	6	17.14	10	28.57	8	22.85	7	20.00	6	17.14		
14.	Perceived effectiveness of the training																		
	Low	6	17.14	13	37.14	4	11.42	9	25.71	9	25.71	8	22.85	14	40.00	5	14.28		
	Medium	21	60.00	18	51.42	11	31.42	19	54.28	20	57.14	21	60.00	17	48.57	20	57.14		
	High	8	22.85	4	11.42	20	57.14	7	20.00	6	17.14	6	17.14	4	11.42	10	28.57		

S.K. Zamir Ahmed, RC Srivastava and Rolokrishnam (2010). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Farm size : A glance at the Table-1, pointed out that in mushroom farming, more than half of the trained farm women (65.71%) had small land holdings followed by medium (20.00%) and marginal land holdings (14.28%), whereas in untrained category less than half of the farm women had small size holdings (48.57%), followed by big (20.00%), marginal (17.14%) and medium size land holdings (14.28%).

In Dairy farming, 45.71 percent of the trained farm women had small size land holdings followed by marginal (34.28%) and medium (20.00%), whereas in untrained category little more than one-third (31.42%) had small size holdings followed by of marginal (25.71%) and medium (14.28%). Remaining (28.57%) had big size land holdings.

The trained farm women in goat farming, had small size (42.85%) and marginal holdings (40.00%) followed by equal medium and big farm size holding (8.51%), whereas in untrained category less than half of the farm women (45.71%) had marginal size holdings followed by small (22.85%) and medium percentage of size of holding of the farm woman (11.42) followed by big size holdings (20.00%).

In fish farming, the trained farm women are equal size holding (34.28%) had big and marginal size holdings and, medium (20.00%) and small size holdings (11.42%), whereas in untrained category of farm women had marginal (40.00%) and followed by big (42.85%) followed by small size holdings (17.14%).

Due to manifold increase in the population and the trend of nuclear type of family living would have forced them to divide ancestral property from generation after generation resulting in fragmentation of holding into smaller sizes. This might be the reason for more number of farm women operating small sized farms. Similar studies was consistent with earlier Kavita Angadi and Belli (2020). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Annual income : The data in the Table-1, revealed that the annual income of (48.57%) of the trained respondents were medium followed by high (34.28%) and low (17.14%), whereas the untrained farm women (57.14%) had medium level of annual income followed by low (25.71%) and high (17.14%), in the mushroom farming.

In dairy farming, more than half of the trained farm women (51.42%) had medium level of annual income followed by low (28.57%) and high (20.00%), whereas in untrained category more than half of the farm women

(60.00%) had medium level of annual income followed by low (17.14%) and high (22.85%).

More than half of the trained farm women (62.85%) of goat farming had medium level of income followed by low (22.85%) and high (14.28%), whereas in untrained category more than half of the farm (62.85%) had medium level of income followed by low (20.00%) and high (17.14%).

In fish farming more than half (54.28%) of the trained farm women had medium level of income followed by low (25.72%) and low (20.00%), whereas in untrained category more than half (68.57%) had medium level of income followed by high (17.14%) and low (14.58%).

This might be due to the practice of undertaking more than one farming of agriculture and allied fields in an integrated manner, so as to increase the production and productivity per unit for sustainable revenue to the farm women. This study was consistent with earlier Kavita Angadi and Belli (2020).

Contact with extension agency : In mushroom farming as evident from the Table-1, that in the category of trained farm women medium level of contract with the extension agency was exhibited by more than half (57.14%) followed by the of medium (20.00%) and high (22.85%) and high (20.00), whereas in untrained category more than half of the farm women (51.42%) reported to have medium level of contract with extension agency followed by low (40.00%) and high (8.51%).

A less than half (45.71%) of the trained farm women showed medium level of contract with extension agency followed by low (37.14%) and high (17.14%), whereas in the untrained category more than half (62.85%) had medium level of contact with extension agency followed by high (22.85%) and low (14.28%) in the dairy farming.

In goat farming less than half of the trained farm women (48.57%) had medium level of contract with extension agency followed by high (31.42%) and low (20.00%), whereas in untrained category of farm women, a little more than half (57.14%) had medium level of contact with extension agency followed by high (25.71%) and low (17.14%).

In the fish farming, in the category of trained farm women more than half (54.28%) had medium level of contract with extension agency followed by low (25.71%) and high (20.00%), whereas in the category of untrained farm women (60.00%) showed medium level of contact with extension agency followed by low (22.85%) and high (17.14%).

The extension activities are extended by the scientists and specialists of KVK Chandauli among the

farming community. This resulted in maintenance of medium level of contact with extension agency. These studies carried out by S.K.Zamir Ahmed, RC Srivastava and M.Balokrisnam (2010). and Singh S.P, Singh Ritesh, Goutam A.D and Kumar Sanjeet *Agriways* (2021).

Social participation : The Table-1, apparently reveals that in mushroom farming, little less than half of the trained farm women (48.57%) exhibited medium level of social participation followed by high (34.28%) and low (17.14%), whereas in untrained category more than half of the farm women (54.28%) showed medium level of social participation followed by high (25.71%) and low (20.00%).

In dairy farming, the trained farm women (51.42%) had medium level of social participation followed by low (28.57%) and high (20.00%), whereas exactly less than half of the untrained farm women (45.71%) reported to have maximum level of social participation followed by low (25.71%) and high (20.00%).

The trained farm women (60.60%) of goat farming could show medium level of social participation followed by low (22.85%) and high (17.14%), whereas (48.57%) of the untrained farm women showed low level of social participation followed by medium (42.85%) and low (8.51%).

In the fish farming, more than half of the trained farm women (57.14%) exhibited high level of social participation followed by medium (28.57%) and one-third low (14.57%), whereas in untrained category of farm women, medium level of social participation was exhibited by (45.71%) farm women followed by low (28.57%) and low (25.71%).

The reason for the above substantiated results would have been due to existence of social stratification among the bight, small farmers and other minor communities of the villages. In addition, more work in the farm coupled with lack of time and interest might be the other valid reasons for facilitating the result. The result is in line with the studies Kavita Angadi *et.al.* (2020).

Mass media exposure : By glancing at the Table-1, it can be inferred that in mushroom farming, more the half (57.14%) of the trained farm women had medium level of exposure to mass media followed by low (34.28%) and high (8.51%), whereas in untrained category exactly half (51.42%) of the farm women showed medium level of exposure to mass media followed by (37.14%) low and (11.42%) high.

In dairy farming, the trained farm women exhibited medium (40.00%) and low (31.42%) levels of mass media exposure followed by high (28.57%), whereas in untrained category, little half (48.57%) showed medium

level of mass media exposure followed by low (34.28%) and high (17.14%).

Less than half (42.85%) of the trained farm women showed low level of exposure to mass media followed by medium (40.00%) and high (17.14%), whereas in untrained category less than half (42.85%) of the farm women exhibited medium level of mass media exposure followed by high (31.42%) and low (25.71%) in the goat farming.

In fish farming, half (45.71%) of the trained farm women showed medium level of mass media exposure followed by low (28.57%) and high (25.71%), whereas (54.28%) of the untrained farm women showed medium level of mass media exposure followed by low (34.28%) and high (11.42%).

Economic motivation : It is noticed from the data of the Table-1, that in mushroom farming, the trained farm women (42.85%) showed high level of economic motivation followed by low (28.57%) and medium (25.71%), whereas in untrained category little than half (48.57%) of the farm women exhibited low level of economic motivation followed by medium (40.00%) and high (11.42%).

In goat farming, (40.00%) of trained farm women exhibited medium level of economic motivation followed by low (34.28%) and high (25.71%), whereas in untrained category (62.85%) of the farm women showed medium level of economic motivation followed by high (22.85%) and low (14.28%).

Less than half (45.71%) of the trained farm women showed medium level of economic motivation followed by (34.28%) as high and (20.00%) low, whereas in untrained category same value of medium level and high (40.00%) followed by low (20.00%) in goat farming.

In fish farming are equal of little half (42.85%) of the trained farm women exhibited low level and medium of economic motivation followed by high (14.28%), whereas in untrained category (40.00%) of the farm women showed low level of economic motivation followed by medium (37.14%) and high (22.85%).

The assured regular and sustained income derived from main and subsidiary farming paved way to increase more income from their farms. Also the desire to compete with each other in terms of standard of living might be another possible reason. All these factors would have contributed for exhibiting medium level of economic motivation.

Risk orientation : Regarding risk orientation, it could be discerned from the Table 1, that in mushroom farming, less than half (48.57%) of the trained farm women

exhibited medium level of risk orientation followed by high (28.57%) and low (22.85%), whereas low level of risk orientation was shown by the (42.85%) of untrained farm women followed by high (34.28%) and medium (22.85%).

In dairy farming, less than half (48.57%) in the trained farm women category showed medium level of risk orientation followed by low (31.42%) and high (20.00%), whereas in untrained category more than half (57.14%) showed medium level of risk orientation followed by low (37.14%) and high (5.71%).

In goat farming, (51.42%) of the trained farm women showed medium level of risk orientation followed by low (34.28%) and high (14.28%), whereas a little less than half (48.57%) of the untrained farm women exhibited medium level of risk orientation followed by low (34.28%) and low (17.14%).

More than half of the trained farm women (57.14%) exhibited medium level of risk orientation followed by high (31.42%) and low (11.42%), whereas in untrained category of the farm women exactly less than half (45.71%) showed medium level of risk orientation followed by low (40.00%) and high (14.28%) in the fish farming.

The reason might be due to the fact that the farmers who were found to be economically motivated had the sternness and determination to bear risk in taking up any other enterprises which would facilitate or generate additional income. These studies carried out of S.K.Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010)

Scientific orientation : It is clear from the table-1, that in the mushroom, the trained farm women showed equal distribution (40.00%) in exhibiting both medium and low level of scientific orientation followed by high (20.00%), whereas in the category of the untrained farm women exactly more than half (51.28%) exhibited medium level of scientific orientation followed by low (34.28%) and high (14.24%).

In dairy farming showed equal distribution (40.00%) in exhibiting both medium and high level of the trained farm women of scientific orientation followed by low (14.28%), whereas in untrained category more than half of the farm women (51.42%) showed medium level of scientific orientation followed by low (40.00%) and high (8.51%).

In goat farming, more than half (57.14%) of the trained farm women exhibited medium level of scientific orientation followed by low (34.28%) and high (8.51%), whereas in the untrained category (51.42%) of the farm women showed medium level of scientific orientation followed by low (37.14%) and high (11.42%).

In fish farming, less than half (45.71%) of the trained farm women reported for low level of scientific orientation followed by Medium (42.85%) and high (11.42%), whereas more than half (57.14%) of the untrained farm women expressed medium level of scientific orientation followed by low (28.57%) and high (14.28%).

The close association between the scientists of KVK- Chandauli and the enterprising farm women motivated them to venture into any innovative technology extended to them, so as to hasten their remuneration. This reason would have inclined them to have medium level of scientific orientation. These studies carried out of S.K. Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010)

Innovativeness : The Table-I, revealed that in mushroom farming, more than half (51.42%) of the trained farm women was observed to have medium level of innovativeness followed by high (28.57%) and low (20.00%), whereas less than half (48.57%) of the untrained farm women exhibited low level of innovativeness followed by medium (34.28%) and high (17.14%).

In dairy farming, (40.00%) of the trained farm women exhibited medium level of innovativeness followed by showed distribution (31.420%) in exhibiting low and high (28.57) level, whereas in untrained farm women category (45.71%) of them showed medium level of innovativeness followed by low (37.14%) and high (17.14%).

In goat farming, more than half (51.42%) of the trained farm women showed medium level of innovativeness followed by high (28.57%) and low (20.00%), whereas in untrained farm women category (42.85%) showed medium level of innovativeness followed by low (34.28%) and high (22.85%).

In fish farming, in the trained farm women category (57.12%) expressed medium level of innovativeness followed by low (22.85%) and low (20.00%), whereas in untrained category less than half of the farm women (48.57%) showed medium level of innovativeness followed by low (34.28%) and high (17.14%).

Most of the farm women being energetic, enterprising, in theistic and venturesome having medium level of message exposure and annual income, paved way to grasp more of latest technologies from the experts of KVK Chandauli for early act on and thereby resulting in medium level of innovativeness. These studies carried out of S.K. Zamir Ahmed, RC Srivastava and M. Balokrisnam (2010)

Perceived effectiveness of the training: It is vivid from the Table I, that in mushroom farming (60.00%) of

the trained farm women had medium level of perceived effectiveness of the training followed by high (22.85%) and low (17.14%), whereas in untrained farm women category little half (51.42%) expressed medium level of perceived effectiveness of the training followed by low (37.14%) and high (11.42%).

The trained farm women (57.14%) of dairy farming, showed high level of perceived effectiveness towards training followed by medium (31.42%) and low (11.42%), whereas in the untrained category of farm women more than half (54.28%) expressed medium level of perceived effectiveness training followed by low (25.71%) and high levels (20.00%).

In goat farming, more than half (57.14%) of the trained farm women showed medium level of perceived effectiveness towards training followed by low (25.71%) and high (17.14%), whereas in the untrained category of farm women (60.00%) showed medium level of perceived effectiveness of the training followed by low (22.85%) and high (17.14%).

In the fish farming, the trained farm women less than half (48.57%) expressed medium level of perceived effectiveness towards training followed by low (40.00%) and high (11.42%), whereas in untrained farm women category (57.14%) training followed by high (28.57%) and low (14.28%).

The studies of the farm women and the delivery of the technology in the right form, place and time by the experts has given them a better understanding for capacity and confidence building. This may have routed to have a medium level of perceived effectiveness of training among the farm women. These studies carried out of S. K. Zamir Ahmed, RC Srivastava and M. Balokrishnam (2010)

Conclusion

It can be concluded that, among the various categories of characteristics of the farm women (both trained and untrained) most of the farm women belonged to middle age group, had primary level of education, opting equally

to have either agriculture as the main or subsidiary occupation. Possessed medium to low level of farm experience, with medium level of annual income followed by medium to low level of contact with extension agency, social participation, mass media exposure, economic motivation, scientific orientation, innovativeness, perceived effectiveness towards the training and operated small size holding.

The study brought out the actual happenings on personal, economic, situational, communication and psychological characteristics of both trained and untrained category adopting four different farming to the forefront. On this basis, certain implication could be brought out which might be useful in formulating strategies and organizing quality and effective training programmers for bridging the knowledge deficit, change in attitude and finally adoption of the technological interventions by farm women to a desirable extent and thus in turn would result in improving socio-economic status of the farm women leading to overall development of the family and the nation as the whole.

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Effects of Rooting Hormones on the Propagation of *bougainvillea glabra* (cv. Barbara Karst) from Cuttings under Dhampur, Bijnor (U.P.) Condition

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Abstract

The field experiment was carried out from the month of March to June at the Department of Horticulture, R.S.M. (P.G.) College Bijnor, during the year 2021-22 The hardwood cuttings (20 cm, thickness) of *Bougainvillea glabra* cv. Barbara Karst, prepared in 14 march, and dip treatment were given (6 hour.) with Different concentrations of IBA+NAA (Indole-3 butyric acid+Naphthalene acetic acid) combination. The stock solution of ppm was prepared by dissolving IBA+NAA 1mg/litter normal water. The cuttings were planted in pro-tray with mixture of coco peat, garden soil, and sand (2:1:1) in month of March and kept in mini polyhouse conditions. IBA +NAA 3000ppm was found to be the best treatment with respect to the number of leaves per cutting after one month (9.42) and two months (16.43), number of days taken to first sprouting (9.45) and length of shoots per cutting after one month(2.96cm) and two month (10.55cm) in mini polyhouse.

Key words : *Bougainvillea*, IBA+NAA, mini polyhouse, coco peat, pro-tray.

Introduction

Bougainvillea is a genus of flowering plant belonging to the family of Nyctaginaceae native in South America (S³awomir *et al.*, 2010; Kent *et al.*, 2007). It has about eighteen species and generally used in the arid landscapes for beautification, horticulture, pharmaceutical industries, agriculture and environmental industries on account of the large flexibility in different agro climatic regions of the world (Suxia *et al.*, 2009; Simon, *et al.*, 2006). Besides its ornamental value in landscaping, recently it has been discovered that *bougainvillea* is a pollution tolerant plant and can help in the mitigation of air pollution (greenhouse gases) (Kulshreshtha *et al.*, 2009; Sharma *et al.*, 2005). On the basis of physical experiment in *bougainvillea* leaf, it can be referred that this plant is a dust mitigator and it absorbs the pollutants from the environment where it grows. Therefore, this plant was highly recommended for plantation in urban and industrial areas where particulate is a problem. Being well adapted to different growing techniques, it can be planted in traffic island, central verge, polluted soil and various other places (Kulshreshtha *et al.*, 2009). It is grown in tropical and subtropical zones and is enriched with different varieties having attractive shades. Considering its vast scope, introduction and alteration of flower color and size are highly desired and sought after traits. It's wide adaptability and multifarious usage has made this plant very popular all over the world (Fatma *et al.*, 2007).

Bougainvillea is an important ornamental plant of tropical and subtropical North Indian conditions commonly used as a shrub, hedge and climber in the garden. It bears varied coloured bracts with profuse flowering in dry and hot weather conditions. The modernization and urbanization have enhanced the use of *bougainvillea*, because landscape horticulture is getting lot of attention and also high in demand due to large scale plantation in urban areas, drought and pollution tolerant, low maintenance requirement in comparison to other plants and various uses. The difficult to root cultivars which are difficult to propagate and whose market demand is increasing day by day application of exogenous rooting hormone on hard wood cutting or on air layering propagation is applicable alternative. Certain nursery men who work at small scale and cannot afford to choose the tissue culture techniques, in such areas work on suitable productive method is very successful and important.

Materials and Methods

The field experiment was carried out from the month of March to June at the Department of Horticulture, R.S.M. (P.G) College Bijnor, during the year 2021-22 The hardwood cuttings (20cm, thickness) of *Bougainvillea glabra* cv. Barbara Karst, prepared in 14 march, and dip treatment were given (6 hour.) with Different concentrations of IBA+NAA (Indole-3 butyric acid+Naphthalene acetic acid) combination.

The stock solution of ppm was prepared by

dissolving IBA+NAA 1mg/liter normal water. The cuttings were planted in pro-tray with mixture of cocopeat, garden soil, and sand (2:1:1) in month of March and kept in mini polyhouse conditions. About one year old hard wood stem cutting of bougainvillea having length of about 15-20 cm were planted in three pro-tray having 40 hole per tray with three replications and six treatments followed by Randomized Block Design.

The hard wood cuttings were treated with growth regulator with different concentrations as given below:

T₀: Control (Without Hormones)

T₁: IBA+NAA 500ppm

T₂: IBA+NAA 1000ppm

T₃: IBA+NAA 1500ppm

T₄: IBA+NAA 2000ppm

T₅: IBA+NAA 2500ppm

T₆: IBA+NAA 3000ppm

Observations were recorded to assess the effect of IBA+NAA on rooting of cuttings of bougainvillea var. Barbara Karst namely number of days taken to first sprouting, number of leaves per cutting after one month and two months, number of rooted cuttings, length of

Shoots per cutting after one month and two month, number of roots per cutting, average root length, percentage of rooted cuttings.

All parameters were subjected to Analysis of Variance (ANOVA) to determine the level of significance of the treatments on the different cuttings of the bougainvillea plant.

Results and Discussion

The hardwood cuttings treated with growth regulators IBA+NAA were significantly better than the control with respect to rooting of cuttings. (*i.e.* days to first Sprout,

number of leaves per cuttings after one month and two months, number of rooted cuttings, length of shoot after one month and two months, number of root per cuttings, average root length and percentage of rooted cuttings).

Based on the Table-1 IBA+NAA was used for treating of *Bougainvillea glabra* (cv. Barbara Karst) and was found that an increase in the level of IBA+NAA from 500ppm to 3000ppm showed a significant effect on the all parameters in the mini polyhouse conditions. The 500ppm IBA+NAA treatment affected positively rooting per cent of cuttings and the other characteristics although it was not to the satisfactory level similar with findings of Polat and Caliskan (2009). IBA + NAA 3000ppm was found to be the best treatment with respect to the number of leaves per cutting after one month (9.42) and two months (16.43), number of days taken to first sprouting (9.45) and length of shoots per cutting after one month (2.96cm) and two month (10.55cm) in mini polyhouse.

Further increase in the concentration of IBA+NAA from 500ppm to 3000ppm showed a significant effect in mini polyhouse, 3000ppm IBA+NAA showed increase in number of rooted cuttings (6.17), percentage of rooted cuttings (57.91%). This effect of IBA+NAA is in conformity with the findings of Shepherd and Winston (2000) in cuttings of bougainvillea cv. Thimma, Singh (2001) in rooting ability of bougainvillea cv. Thimma, Singh and Singh (2002) in *Bougainvillea peruviana* cv. Thimma. Length of shoots per cutting after one month (2.96cm), length of shoots per cutting after two month (10.55cm) is in conformity with the findings of Shepherd and Winston (2000) in cuttings of bougainvillea cv. Thimma, Singh (2001) in bougainvillea cv. Thimma, Singh (2002) in bougainvillea cv. Thimma, Singh and Singh (2002) in *Bougainvillea peruviana* cv. Thimma. Number of roots per cutting (30.00), length of roots (12.85cm) and dry weight of the roots (0.43g) are in conformity with the findings of Singh (2001) in bougainvillea cv. Thimma, Singh (2002) in



Fig.-1 : Growth of Cuttings.

Table-1 : Effect of IBA + NAA treatment on the growth and development of Bougainvillea cv. Barbara Karst.

Treatment	Days taken to first sprout	No .of leaves/ cutting after one month	No. of leaves/ cutting after two month	Length of shoot/ cutting after one month	Length of shoot/ cutting after one month	No. of rooted cutting	No. of root/cutting	Average root length (cm)	Percentage of rooted cutting
T ₀	15.71	3.04	5.17	0.72	1.72	0.00	6.31	2.03	0.00
T ₁	13.06	6.39	8.35	1.31	3.98	1.80	10.34	4.50	12.44
T ₂	11.67	6.86	10.14	1.17	4.68	2.32	12.34	7.50	26.54
T ₃	10.51	7.17	10.80	1.94	4.75	4.12	15.05	8.82	40.16
T ₄	10.75	7.30	13.81	1.98	5.83	4.66	17.34	9.03	44.92
T ₅	10.39	9.24	13.82	2.67	7.68	4.67	20.68	9.25	45.61
T ₆	9.45	9.42	16.43	2.96	10.55	6.17	23.58	11.25	57.91
Mean	11.65	7.06	11.22	1.82	5.60	3.39	15.09	7.48	32.51
SE(m)	0.436	0.226	0.222	0.091	0.123	0.201	0.082	0.113	0.281
C.D. at 5%	1.359	0.703	0.693	0.282	0.384	0.627	0.256	0.353	0.876
C.V. (%)	6.488	5.536	3.434	8.602	3.816	10.276	0.942	2.619	1.498

bougainvillea cv. Thimma but this increase showed a negative effect earlier i.e. the number of leaves per cutting after one month and two months, number of days taken to first sprouting and length of shoots per cutting after two month.

Conclusion

Rooting characteristics of cuttings of Bougainvillea was enhanced when soaked in IBA+NAA 3000ppm while the without treatment of cuttings have no significant on the rooting ability of the cutting. Hard cutting used for propagation of Bougainvillea performed better in development in comparison with the semi-hard cutting of the plant.

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Dynamics of Nutrients during Composting of Lignocellulosic Crop Residues

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Abstract

An experiment was conducted to study dynamics of nutrients during composting of mustard stover, clusterbean straw and pearl millet husk at Rajasthan Agricultural Research Institute, Durgapura from June to September, 2019. Crop residues were composted in the 3 feet × 3 feet × 10 feet (Width × Depth × Length) size pits by inserting perforated PVC pipes to provide adequate aeration. Composting materials were analysed periodically at 0, 30, 60, 90 and 120 days of decomposition. Results of study revealed that C/N ratio narrows down gradually during decomposition period up to 120 days when proper moisture and aeration was maintained. Dynamics of nutrients changes in all the three crop residues during composting period. Mineralization of nitrogen and phosphorus tended to increase their content at 120 days in comparison to their initial levels. Content of potassium also increased during decomposition period. Among crop residues, the content of total carbon and C/N ratio followed a trend of mustard stover > pearl millet husk > clusterbean straw. Similarly content of total nitrogen and total phosphorus in crop residues followed a trend of clusterbean straw > pearl millet husk > mustard stover at 120 days of composting. Composting of lignocellulosic crop residues can prove a solution for their management to recycle plant nutrients for restoring soil fertility.

Key words : decomposition, crop residues, mustard stover, clusterbean straw, pearl millet husk and C/N ratio

Introduction

Crop residues have huge potential as a good source of plant nutrients. However, they are considered as waste materials in economic terms. Residue burning is a major environmental concern contributing to global warming, health issues, loss of valuable nutrients and soil biota (Dadhich *et al.*, 2012; Dadhich *et al.*, 2021).

Composting has developed as a viable option for managing biodegradable of agricultural and urban wastes, with the possibility of using composts for recycling plant nutrients in soil. Composting is a biological process that converts biodegradable organic matter into a humus-like substance known as compost using naturally existing microbes. Biodegradable agriculture waste management necessitates the ability to forecast the impacts of compost on carbon (C) and nitrogen (N) dynamics in the field. The degree of stability and maturity of compost are the most critical component impacting its performance as a source of plant nutrients. Nutrient dynamics during composting is important for the mineralization of elements. Organic residues that have been stabilized and composted are preferred because they are a source of available nutrients for plants and micro flora and their use reduces problems such as nutrients immobilization, minimizes seed germination inhibition, improves plant growth and reduce crop damage due to phytotoxic substances and improves product

quality (Pascual *et al.*, 1999; Fernandez *et al.*, 2007; Raj and Antil, 2011).

Composting of manure and other organic wastes is a microbiologically controlled process that degrades and stabilizes readily biodegradable organic materials. Part of the organic C is released as CO₂, while the remainder is absorbed into microbial cells and humified. Aerobic bacteria utilize organic materials as a substrate for their multiplication in the composting process. The microorganisms break down the substrate into simpler molecules from complicated products (Ipek *et al.*, 2002). Bacteria, fungi, and actinomycetes degrade organic C during composting depending on the stage of decomposition, properties of the materials, moisture content and the temperature. Bacteria are by far the most significant decomposers during the most active stages of composting at initial level due to their quick growth abilities on soluble substrates and tolerance to temperatures. Actinomycetes thrive in wet, aerobic environments with a neutral or slightly alkaline pH and play important role in decomposition of lingo-cellulosic crop wastes. Composting transforms C and N containing compounds into more stable humic substances through the activity of several bacteria (Pare *et al.*, 1998).

Several indicators have been proposed for monitoring the composting process and evaluating the stability of the compost. Compost maturity refers to the

degree of decomposition of phytotoxic organic substances produced during the active composting stage (Wu *et al.*, 2000). However, stability and maturity usually go hand in hand, since phytotoxic compounds are produced by the microorganisms in unstable composts (Zucconi *et al.*, 1985).

Compost maturity is used to describe product quality. The indicators of compost maturity include physical, chemical and biological parameters of the organic material. These parameters include drop in temperature, degree of self-heating capacity, oxygen consumption, biochemical parameters of microbial activities, analysis of biodegradable constituents, phytotoxicity assays, cation exchange capacity (CEC), organic matter, mineralization of nutrients, C/N ratio and humus content (Tiquia and Tam, 2002; Mari *et al.*, 2003). Oxygen consumption for respiratory activity and heat production is indicative of the amount of degradable organic matter which is inversely related to stabilization. Compost stability refers to the situation when the rate of energy released due to microbial degradation of the organic matter equals the rate of energy lost to the environment. Under these conditions, the temperature of the compost remains constant and equals that of the ambient. Compost stability is strongly related to the rate of microbial activity in the compost.

Maturity and stability are expressions, often used in description of high-quality compost. However, they are not easy to define and cannot be described in a single parameter. The degree of completion of the composting process can be evaluated by measuring various changes in the chemical, physical and biological properties of the substrate. Considering the key roles of microorganisms in the composting process, the microbiological properties as stability and maturity indicators are used. The immature compost may contain high level of free ammonia, organic acids or other water-soluble compounds which can limit seed germination and root development (US Composting Council, 2002).

Mustard, clusterbean and pearl millet are commonly cultivated crops across the length and breadth of Rajasthan, India. Leftover material of these crops is of lingo-cellulosic in nature, non edible to animals and decomposes slowly. Therefore, farmers adopt the wrong practice of burning these crop wastes. Hence, composting in a scientific way for managing crop residues is the need of the hour to curtail the ill-effects of residue burning, apart from maintenance of soil organic carbon and organic matter, the major determinants of soil microbes and nutrient cycling mechanisms.

Materials and Methods

Three crop residues namely, mustard stover, clusterbean straw and pearl millet husk were procured from the research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur. An experiment for the decomposition of these crop residues were carried out in the three pits of uniform size; 3 feet × 3 feet × 10 feet (Width × Depth × Length) from June to September, 2019 at RARI, Durgapura as per the procedure outlined earlier by Biswas and Narayanasamy (2006). Layers of fresh cattle dung were spread over the composting mass using as natural inoculants for faster decomposition of crop residues. Perforated PVC pipes were inserted in the compost pits to provide adequate aeration and to save the labour cost of turning during decomposition. Regular watering was employed to maintain the water holding capacity (about 50-60%) throughout the composting period. These pits were covered by a soil layer after filling above ground level.

About 200 g samples of compost materials were drawn from each compost pit periodically at 0, 30, 60, 90 and 120 days of decomposition. The representative samples were divided into two portions. One portion was kept in a refrigerator at 4 °C and used subsequently for analysis of total N whereas the other part was first air-dried and then oven-dried at 65±1 °C for 24 h, crushed to pass through a 2 mm sieve, thoroughly mixed and used for analysis of other nutrients. The total carbon was determined by ignition method (Nelson and Sommers, 1983). Total nitrogen content was determined by colorimetric method (Snell and Snell, 1949). Total phosphorus content was determined by vanadomolybdate yellow colour method (Jackson, 1973). Total potassium content was determined by flame photometry (Jackson, 1967). The C/N ratio was estimated using the following formulae :

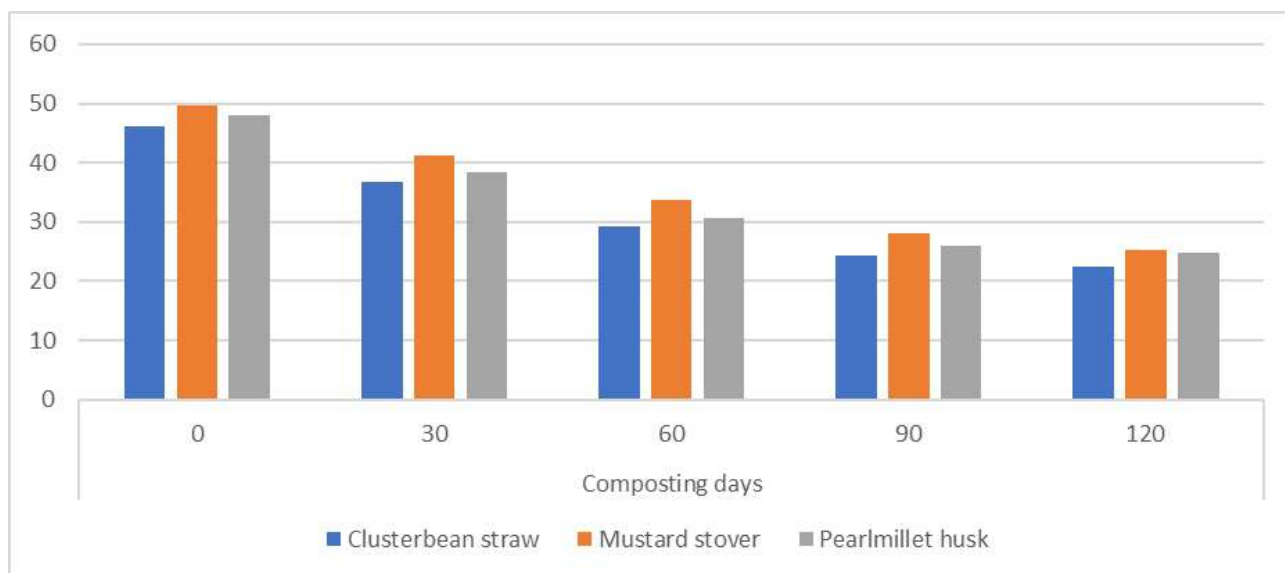
$$\text{C/N ratio} = \frac{\text{Total carbon content}}{\text{Total nitrogen content}}$$

Results and Discussion

Total carbon : Data presented in Table-1 and depicted in Fig.-1 revealed that the total carbon content decreased with the increase duration of composting in all the crop residues. The total carbon content in crop residues decreased at 90 and 120 days as compared to initial status of composting. At the end of the composting (120 days), the total carbon content in composts was recorded in the order of clusterbean straw (22.5%) < pearl millet husk (24.8%) < mustard stover (25.3%). The least total carbon was observed under the clusterbean straw compost and the maximum amount of total carbon was

Table-1 : Changes in total carbon content of crop residues during composting.

Crop residues	Total carbon (%)				
	Composting period (days)				
	0	30	60	90	120
Clusterbean straw	46.2	36.7	29.2	24.4	22.5
Mustard stover	49.6	41.3	33.7	28.1	25.3
Pearlmillet husk	48.1	38.5	30.6	25.9	24.8

**Fig-1 : Changes in total carbon content of crop residues during composting.****Table-2 : Changes in total nitrogen content of crop residues during composting.**

Crop residues	Total nitrogen (%)				
	Composting period (days)				
	0	30	60	90	120
Clusterbean straw	1.21	1.39	1.49	1.62	1.74
Mustard stover	0.64	0.73	0.85	1.01	1.18
Pearlmillet husk	0.67	0.75	0.86	1.08	1.23

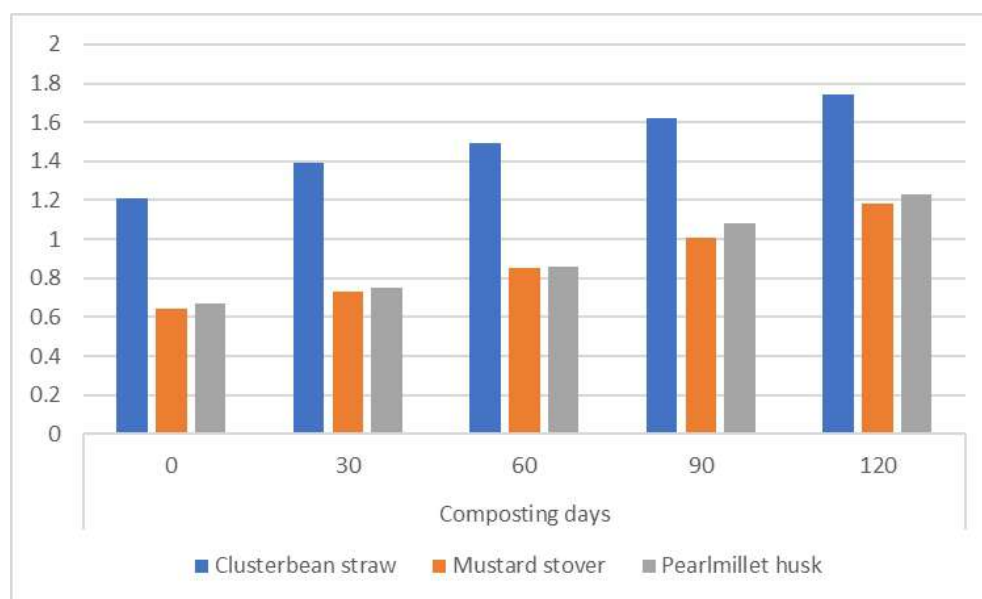
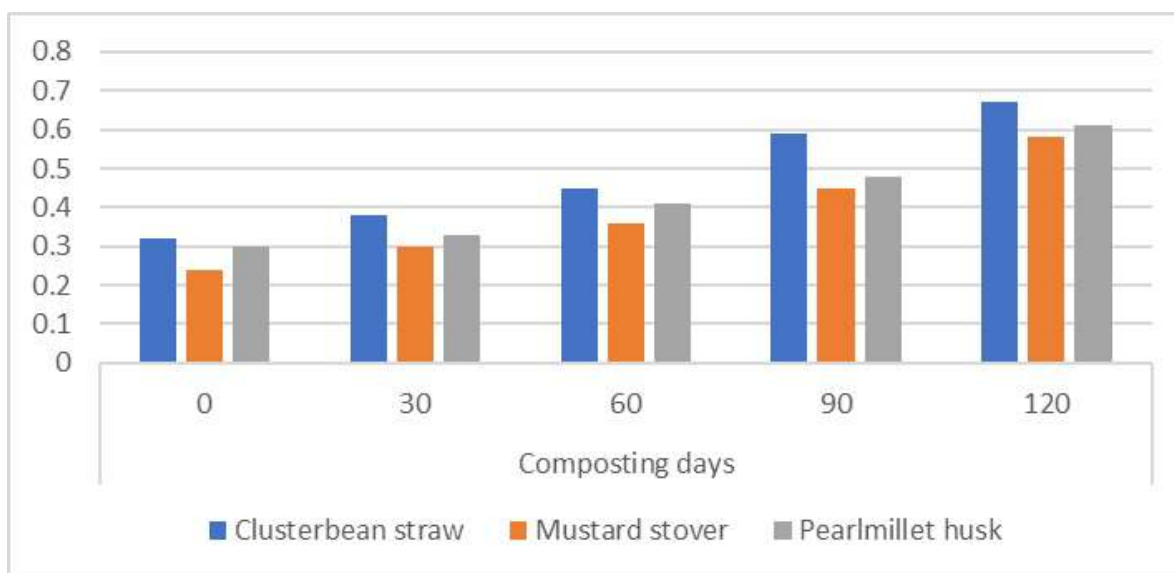
**Fig-1 : Changes in total carbon content of crop residues during composting.**

Table-3 : Changes in total phosphorus content of crop residues during composting.

Crop residues	Total phosphorus (%)				
	Composting period (days)				
	0	30	60	90	120
Clusterbean straw	0.32	0.38	0.45	0.59	0.67
Mustard stover	0.24	0.30	0.36	0.45	0.58
Pearl millet husk	0.30	0.33	0.41	0.48	0.61

**Fig-3 : Changes in total phosphorus content of crop residues during composting.****Table-4 : Changes in total potassium content of crop residues during composting.**

Crop residues	Total potassium (%)				
	Composting period (days)				
	0	30	60	90	120
Clusterbean straw	0.81	0.88	1.02	1.17	1.27
Mustard stover	0.80	0.89	1.10	1.20	1.31
Pearl millet husk	0.74	0.83	0.98	1.13	1.22

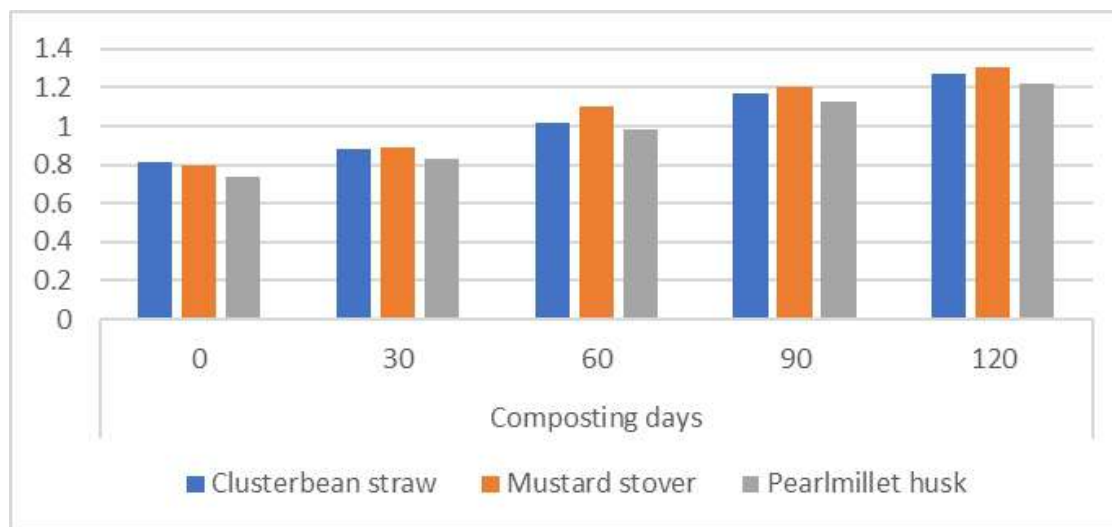
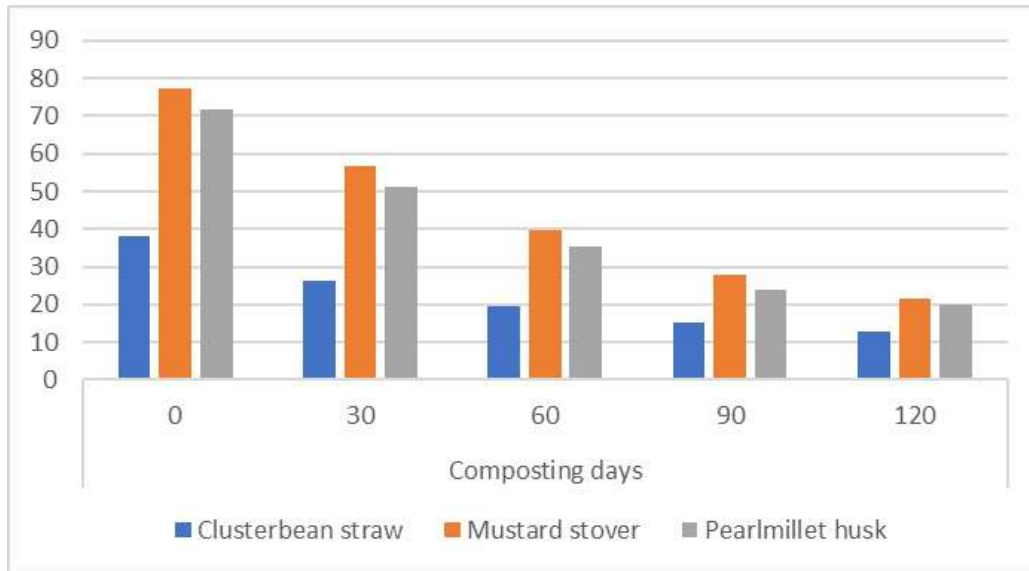
**Fig.-4 : Changes in total potassium content of crop residues during composting.**

Table-5 : Changes in C/N ratio of crop residues during composting.

Crop residues	C/N ratio				
	Composting period (days)				
	0	30	60	90	120
Clusterbean straw	38.18	26.40	19.59	15.06	12.93
Mustard stover	77.50	56.57	39.64	27.82	21.44
Pearl millet husk	71.79	51.33	35.58	23.98	20.16

**Fig-5 : Changes in C/N ratio of crop residues during composting.**

observed under mustard stover residue compost. The losses of carbon in compost materials during decomposition is attributed to the oxidation of organic matter, resulting in the evolution of carbon dioxide (CO₂) and generation of heat. A part of the carbon in the residues during decomposition is assimilated by the microbial biomass as a source of energy. Goyal *et al.* (2005) and Daniel *et al.* (2007) have reported decreasing trends in the total carbon content during composting of different organic wastes.

Total nitrogen : The total nitrogen content in all the three crop residues increased with time of composting (Table-2 and Fig.-2). The highest total nitrogen content was found in clusterbean straw (1.74 %) followed by pearlmillet husk (1.23 %) and least in mustard stover compost (1.18 %) at 120 days of composting. The decrease in total N content at early stages of decomposition was due to losses of N in the form of ammonia which in turn depends upon the type of material and its C/N ratio. The composting of materials with low C/N ratio result in more N losses than in comparison to high C/N ratio wastes (Sánchez-Monedero *et al.*, 2001b). The gradual increase in total nitrogen content in the compost materials may have been due to the net loss of dry mass as the loss of dry matter (total C) as CO₂. This might also be due to mineralization of

nitrogen with the progress of composting period (Biswas *et al.*, 2009).

Total phosphorus : Total phosphorus content in all the three crop residues increased with increase in composting period (Table-3 and Fig.-3). At the end of 120 days of composting, the total phosphorus was registered to be highest in the clusterbean straw (0.67%) followed by pearlmillet husk (0.61%) and least in mustard stover compost (0.58%). Total phosphorus content increased during decomposition period which was proportional to loss in organic matter during decomposition (Nishanth and Biswas, 2008).

Total potassium : Data presented in Table-4 and depicted in Fig.-4 reveal that the total potassium content decreased with the increase in composting period in all the crop residue based composts. At the end of 120 days of composting, the total phosphorus content was observed to be highest in the clusterbean straw (1.27 %) followed by mustard stover (1.31 %) and least in pearlmillet husk compost (1.22 %).

C/N ratio : The significance of C/N ratio and successive decrease suggests a degree of humification of organic matter. In the present study, it was observed that the C/N ratios of all the three crop residues in all the composts pits were high and variable at the initial stages, which

decreased substantially up to 120 days and became stable later on. The results revealed that irrespective of treatments, the C/N ratio decreased significantly with an increase in days of composting (Table 5 and Fig. 5). There was a gradual decrease in the ratio in all the three crop residues with time of decomposition and the narrower was observed at 120 days. After 120 days of decomposition, the lowest C/N ratio was observed under the composted material of clusterbean straw (12.93). The value of C/N ratio under the composted material of pearl millet husk was observed to be 20.16 and that under mustard stover residues was recorded to be 21.44 after 120 days of composting. The C/N ratio represents an important and a very good index of maturity for decomposition of the organic substance as it significantly affects the microbial growth. The C/N ratio narrows down gradually as the composting progresses because of the conversion of organic carbon into carbon dioxide. Substrates having higher C/N ratios require more time for completion of the maturation phase. During the composting process, carbonaceous materials such as carbohydrates, fats and amino acids degrade quickly in the first stage of decomposition while cellulose, hemicelluloses and lignin degrade at a later stage of decomposition which are partially mineralized, leading to carbon losses throughout the process (Bernal *et al.*, 2009). It can be inferred that the C/N ratio of compost should not be too high as an application of such composts can result in immobilization of available nitrogen, causing an N deficiency in plants (Bannick and Joergensen, 1993). The C/N ratio is traditionally used to establish the degree of maturity in compost (Hsu and Lo, 1999; Huang *et al.*, 2004).

Conclusion

Management of lignocellulosic crop residues by composting has become important for recycling plant nutrients in the soil during present context of declining soil fertility. Crop residues, possessing wider C/N ratio take more time in mineralizing plant nutrients. Study of nutrients dynamics during composting of mustard stover, clusterbean straw and pearl millet husk residues gives an idea of mineralization of important plant nutrients and represents the potential of nutrients, changes in their content during composting period and stability of compost.

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An Overview of the Status of Rice Production in India

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Abstract

Rice is one of the most important food crops and feeds more than 60 per cent population of India. In India, systematic hybrid rice research was initiated in 1989. The first hybrid rice was released in Andhra Pradesh during 1993–1994 and India became the second country after China to commercialize hybrid rice. India has made substantial progress and developed total 117 (*indica/indica*) rice hybrids having 15–20% yield superiority with 115–150 days duration for various rice ecosystems. In financial year 2021, the yield of rice across India was estimated to be approximately 2.7 thousand kilograms per hectare. A consistent increase in the yield of rice was noted since fiscal year 1991 except a fall in 2021. There are improved technologies and various interventions which could be adapted to increase the productivity in the country. Cultivation of hybrid rice has potential to increase the productivity and needs to be promoted.

Rice production and Yields in India: current status :

Rice accounts for a significant contribution to the total food grain production in India. Rice is one of the most important. Among food crop of India Major share of rice is cultivated during Kharif season. A small share of rice is grown in rabi /summer season with assured irrigation. Indian rice production largely depends on monsoon rains and only 59 per cent rice area has assured irrigation. The area during 1st plan was 30.68 m ha and it has reached to 43.64 million hectare during 11th plan which is nearly 42.2 per cent of 1st plan. The rice production has registered a appreciable increase from 25.03 m tonnes during 1st plan to 97.05 tonnes during 1st plan, which is nearly 4 times over the 1st plan. India is the world's second-largest producer of rice, and the largest exporter of rice in the world Production increased from 53.6 million tons in FY 1980 to 120 million tons in FY2020-21

As the rice production area either stabilizes or declines, and there is a wide gap between projected demand and current level of production, vertical growth in production through hybrid rice is a practically feasible and adoptable technology. As the seed production of hybrid rice is knowledge- and labor-intensive, different agro-techniques need to be adopted to make it more successful. Production is set to hit a record 303.34 million tonnes (MT) in 2020-21, according to the second advance estimates—higher than what was achieved during 2019-20 (297.50 MT) by 5.84 MT. A similar trend has been seen five times in the past 10 years. Amongst the major crops, the total production of rice during 2020-2021 is estimated to be 120.32 MT, 1.45 MT higher than the

previous year. For rice, too, production numbers have consistently been rising since 2016-2017.

The Ministry of Agriculture, China, has launched project on super hybrid rice development during 1996 which resulted altogether 73 super hybrids (52 three-line hybrids and 21 two-line hybrids) for commercial cultivation. At beginning, IRRI helped technically and supplied prerequisite parental materials. Later, most of the countries could establish their own hybrid rice breeding program and developed several heterotic hybrids. India was the second country after China that adopted this technology in 1989 and made substantial progress. At present, hybrid rice covers around 3.0 mha in India that has 6.8% of total rice area.

The plant breeders in the Government and Private sectors have evolved some hybrids for different states in India. These hybrids possess a mean grain yield of 6.0-7.9 t ha⁻¹ with 10-44% higher yield over the popular high yielding varieties (HYVs). Out of the hybrids released so far, large-scale seed production of only five hybrids viz., DRRH-1, KRH-2, Sahyadri, PHB-71 and PA-6201 has been taken up by the public and private sector seed agencies.

Strategies to boost Rice production through hybrids :

India has the largest area under rice in the world. Rice is cultivated in 534 districts of the country. Out of which, 218 districts are having productivity more than the national average productivity of 1,947 kg/ha. Remaining 316 districts are having productivity below the national average. Thus, 41% of total Rice growing districts are above the national average productivity and remaining

59% districts are below the national average productivity. It is evident from the above data that major rice growing areas are below the national average productivity. So following reasons are made to increase the rice productivity of rice through hybrid varieties :

Seed rate of hybrids is 65-70% less than that of HYVs.

Hybrid rice is more responsive to fertilizers than HYVs.

Average spikelet's per panicle produced in hybrids are generally more than that of HYVs.

During the vegetative growth stage, hybrid rice accumulates more dry matter which results in more spikelet's per panicle, whereas in HYVs spikelet's per panicle is governed by the accumulation of assimilates after heading.

About 90% of grain carbohydrates come from photosynthetic assimilation after heading in early maturing HYVs, while in hybrid rice 30-40% of the grain carbohydrate comes from assimilation before heading and remaining 60-70% comes after heading.

Future prospects of hybrid rice in India: New opportunities (NFSM, 2010)

- (i) Higher market price of rice
- (ii) Expansion of boro rice area in the country due to shallow tubewell development
- (iii) Short duration of hybrids to capture upland rainfed areas
- (iv) Cultivation of hybrids under SRI and direct seeding through drum seeder in wet land or drill in dry land will reduce the seed rate, besides increasing the yield.
- (v) Continued technological progress
- (vi) Expanded possibilities of public-private partnerships.
- (vii) Rising demand for rice from Africa.

Notified varieties of Basmati Rice: (APEDA, AIREA) :

Basmati 217, Basmati 370, Type 3 (Dehraduni Basmati), Taraori Basmati (HBC 19/ Karnal Local), Ranbir Basmati, Basmati 386, Punjab Basmati 1, PUSA Basmati 1, Kasturi, Haryana Basmati 1, Mahisugandha, Pusa Basmati 1121, Improved pusa Basmati 1, Vallabh Basmati 22, Pusa Basmati 6, Pusa Basmati 1509, Malviya Basmati dhan, Vallabh Basmati 21, Basmati 564, Vallabh Basmati 23, Vallabh Basmati 24, Pusa Basmati 1609, Pusa Basmati 1728, Pusa Basmati 1637, Punjab Basmati 3, Pant Basmati 1, Pant Basmati 2.

Varieties of Rice (Source: NICRA)

Low altitude : IR 64, Naveen, Gomati Dhan, Ranjit, RC-Maniphou-4, RC-Maniphou-5, RC-Maniphou-7, RC Maniphou 10, TRC Borodhan-1, DR 92, Shahsarang 1, Lampnah etc.

Mid altitude :

(a) Transplanted Lowland: Pre-kharif season: IR 64, Krishna Hamsha, Shahsarang 1, VivekDhan 82 Kharif season: Shahsarang 1, Lampnah, IR 64, VivekDhan 82, Subhadra etc.

(b) Direct seeded upland: Bhalum 1, Bhalum 2, IURON 514, Bhalum 3, Bhalum 4, RC Maniphou 6

Rice hybrids tolerant to various stresses.

High altitude transplanted : Megha rice 1, Megha rice 2, Megha rice 3

Short duration variety for lowland: VivekDhan 82, VL Dhan 61, Sahabhazi

Boro rice: TRC Borodhan 1, Naveen, Ranjit, Krishna Hamsha

Boro/Summer season : Rajalaxmi, CRHR-4, CRHR-32, NPH 924-1, PA 6444, Sahyadri, and KRH 2

Cold stress: Megha Rice 1, Megha Rice 2, Megha Rice 3

Iron Toxicity : Shahsarang 1, Lampnah

Submergence: Swarna sub 1, Sambhamahasuri, IR64 sub1, FR13 A

Flood tolerant: Jalashree, Plaban, Jalkuwari 2

Drought : Sahabhazi, VivekDhan 82

Rain-fed upland: DRRH-2, Pant Sankar Dhan-1, Pant Sankar Dhan-3, and KJTRH-4

Salinity: DRRH-28, Pant Sankar Dhan-3, KRH-2, HRI-148, JRH-8, PHB-71, and Rajalaxmi

Alkalinity: Suruchi, PHB-71, JKRH-2000, CRHR-5, DRRH-2, DRRH-44, and Rajalaxmi

BB resistant: BS 6444G, Arize Prima, Rajalaxmi, Ajay, CR Dhan 701, PRH 10, etc.

Hybrids suitable for specific condition.

Aerobic condition: PSD 3, PSD 1, Rajalaxmi, Ajay, ADTRH 1, PRH 122, DRRH 44, HRI 126, JKRH 3333, and KRH 2

Early duration: CRHR 105, CRHR 106, 25P25, 27P31 (heat-tolerant), US 382, Indam 200-17, US 312, DRRH3, JKRH 401 high N use efficient; PNPH 24 and RH 1531, Arize Tej-mid-early drought-tolerant; DRRH2, and KJTRH-4 (upland)

Table-1 : Following table provide data regarding Major Rice Producing Countries in the World (production in million tonnes).

Country	Production (2020-21)	Production (2021-22) estimated	Change over 2020-21
China	148.30	149.00	0.70
India	122.00	121.00	-1.00
Indonesia	35.20	35.30	0.10
Vietnam	27.10	26.90	-0.20
Thailand	18.83	19.50	0.67

Source : www.usda.gov

Table-2 : India Milled Rice Production by Year (Unit of Measure : 1000 MT).

Market year	Production	Growth rate
2010	95970	7.73%
2011	105301	9.72%
2012	105241	-0.06%
2013	106646	1.34%
2014	105482	-1.09%
2015	104408	-1.02%
2016	109698	5.07%
2017	112760	2.79%
2018	116480	3.30%
2019	118870	2.05%
2020	124370	4.63%
2021	129000	3.72%
2022	130000	0.78%

Source : United States Department of Agriculture.

Table-3 : Following table provide data regarding Production of rice Crop in Three Largest Producing States in 2020-21.

States	Production	Per cent Share of Production to All India	Cumulative per cent Share of Production
West Bengal	16.65	13.62	13.62
Uttar Pradesh	15.66	12.81	26.43
Punjab	12.18	9.96	36.39

Source : Economic Survey 2021-22 Statistical Appendix.

Long duration: CRHR 32, CRHR 34, CRHR 100, and Sahyadri 5

SRI: TNRH CO-4, KRH 4

MS grains: CRHR 32, DRRH 3, 27P63, 25P25, and Suruchi

Aromatic: PRH 122 (slight aroma), PRH 10

Recently, Savannah Private Limited from India has made another landmark by developing two two-line rice hybrids, viz., SAVA-124 and SAVA-134, for commercial cultivation. In addition, more than 100 CMS in diversified genetic and cytoplasmic backgrounds have been developed and utilized. In addition, more than 100 CMS in diversified genetic and cytoplasmic backgrounds have been developed and utilized.

Progress made over the years : India has done well to attain the status of the second highest producer of rice in the world, next only to China. With zero imports, growing exports, and sufficient stocks, the country is today self-sufficient in this food grain. rice remains a staple food

for two-thirds of the world's population and has become an item of commerce since the last two decades. Throughout history, rice has been one of the most favoured staple foods. India's annual rice production increased from 53.6 million tons in FY 1980 to 120 million tons in FY2020-21.

India's domestic annual consumption is approximately 100 million tonne out of approx. 120 million tonnes of production, which is 80%. The Indian Government has a mandatory norm to have 11.5 million tonnes of rice as operational stock and two million tonnes as a strategic reserve of rice.

More than 4000 varieties of rice are grown in India. The National Food Security Mission aims to increase rice production by a whopping 10 million tons by the 11th Plan period. Paradigm shifts in planning research programmes and new approaches will need to be followed to enhance rice production and productivity in the decades ahead, to meet not only the domestic demand but also to have an exportable surplus.

Table-2 : Projected domestic demand of Rice in India.

(Unit : Million Metric Tonnes)

Commodity	Base year	Scenario 1			Scenario 2		
	1999-2000	2011	2021	2026	2011	2021	2026
Rice	66.0	94.5	96.9	102.2	94.4	96.8	102.1

Scenario 1 : GDP is 8%; Scenario 2: GDP is 9%. Domestic demand takes account of the demand for seed, feed, industrial use and wastage^[8,10]

Table-3 : Projected annual per capita domestic demand for Rice.

(Unit : Million Metric Tonnes)

Commodity	Scenario 1			Scenario 2		
	2011	2021	2026	2011	2021	2026
Rice	80.2	72.0	72.3	80.1	71.9	72.2

Scenario1 : GDP is 8% per annum; Scenario 2 : GDP is 9% per annum.^[8,10]

Table-4 : Projected domestic supply for Rice.

(Unit : Million Metric Tonnes)

Commodity	Base Year	Supply projection		
	2003-04	2011	2021	2026
Rice	88.3	95.7	105.8	111.2

Area and yield growth rates for the period 1994/95 to 2004-05 on the base period triennium ending 1993-94 are used from Agricultural Statistics at a Glance, 2007, Directorate of Economics and Statistics, GOI.^[8,10]

Table-5 : Supply-Demand gap for rice

(Unit : Million Metric Tonnes)

Commodity	Gap (supply Demand)		
	2011	2021	2026
Rice	1.26	8.98	9.13

Demand scenario of GDP growth at 9% is considered here^[8,10]

Table-6 : Percent annual growth rate of projected supply and demand.

Commodity	Demand	Supply
Rice	1.55	1.01

Growth rates are between base year and 2026. Demand scenario of GDP growth at 9% is considered here^[8,10]

Table-7 : Rice requirement at various levels of per capita availability and projection at different production growth rate.

Year	Population (million)	Projected demand (mt)	Projected supply (mt) at growth rates of		Demand supply gap (mt) at growth rates of	
			1.34%	1.14%	1.34%	1.14%
2005	1116	94.5	91.8	91.8	2.7	2.7
2010	1210	100.7	94.0	94.0	6.7	6.7
2015	1288	106.8	101.5	100.5	5.3	6.3
2020	1370	112.8	108.5	106.4	4.3	6.4
2025	1445	117.3	116.0	112.5	1.3	4.8
2030	1523	121.6	123.6	119.1	-2.3	2.5

Source : S.K. Goyal, J.P. Singh (2002)

Paddy is cultivated globally being one of the most important cereal crops worldwide. USDA in its November report had estimated the global availability of rice at 67.10 million tons in 2019-20 marketing season. The same has been increased by 6 lakh tons to 67.16 million tons in the December report.

Challenges and Constraints in Technology adoption and Execution : Rice is the world's most important food

crop catering half of the world's population. It is the grain with second highest worldwide production of after maize. The problems/constraints in rice production vary from state to state and area to area. The major rice growing areas are concentrated in Eastern region and this region generally experiences high rainfall and severe flood almost every year. The loss to the rice crop is considerably very high. Besides, in upland areas the crop gets setback either from high rainfall or drought condition. It has also

been observed that certain category of soils do not give the desired yield response to the balanced application of N.P.K. fertilizers. The main reasons for this lack of response to the application of balanced fertilizers are associated with certain inherent characters of the soil. All these problems/constraints are affecting the productivity of the rice crops in different growing zones.

About 78% of the farmers are small and marginal in the country and they are poor in resource. Therefore, they are not in a position to use optimum quantity of inputs in their crops which are essential for increasing the productivity. Often rice crop suffers with soil moisture stress due to erratic and inadequate rainfall. Continuous use of traditional varieties due to the non-availability of seeds and farmers lack of awareness about high yielding varieties is also a constraint.

Some other constraints are Low soil fertility due to soil erosion resulting in loss of plant nutrients and moisture, Low and imbalanced use of fertilizers. Heavy infestation of weeds and insects/pests, Poor crop plant population in case of broadcast sowing method resulting in uneven, Delay in monsoon, Poor adoption of improved crop production technology due to economic backwardness, Non-availability of bullock drawn or power drew transplanter for timely transplanting of rice crop.

Low water retention capacity by the soil due to high permeability brings in moisture stress condition quickly after the cessation of rains. In the low-rainfall regions, the crop suffers from iron and zinc deficiency, damage due to birds and rodents. Acid, red laterite and lateritic soils, saline and saline-alkali soils, heavy texture of the soil, lack of freshwater source also creates various deficiencies. Highly dispersed soil under alkaline or saline-alkali situation, where drainage becomes a problem

Opportunities and Future Prospects : India's market year 2015-16 rice ending stocks are estimated to be 18.5 million tonnes (16.2 million government rice and 2.3 million tonnes private) on higher government rice stocks due to higher procurement and relatively weak offtake, according to the FAS. Market year 2016-17 ending stocks are also forecast higher at 16.4 million tonnes on normal procurement and government offtake. Prices are expected to remain firm in August/September on tight supplies, but favorable market year 2016-17 planting and production prospects and expected weak international prices are likely to contain significant price movements in the future.

IRIS is the rice implementation of the International Crop Information System (ICIS) which is a database system that provides integrated management of global information on genetic resources and crop cultivars. This

includes germplasm pedigrees, field evaluations, structural and functional genomic data (including links to external plant databases) and environmental (GIS) data.

Bringing Green Revolution to Eastern India (BGREI), a sub-scheme of Rashtriya Krishi Vikas Yojna (RKVY) is being implemented in seven eastern states namely Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, West Bengal and eastern Uttar Pradesh from 2010-2011 to address the constraints limiting the productivity of rice based cropping systems. Under this scheme, various activities like cluster demonstrations of improved package of practices, assets building, site specific activities and marketing support are being undertaken.

The National Food Security Mission (NFSM) during the 12th Five Year Plan has five components (i) NFSM-Rice; (ii) NFSM-Wheat; (iii) NFSM-Pulses, (iv) NFSM-Coarse cereals and (v) NFSM-Commercial Crops. According to NFSM report, the total financial implications for the NFSM were to be Rs 4,882.48 crore during the XI Plan (2007-08 2011-12). The implementation of the NFSM would result in increasing the production of rice by 10 million ton, wheat by 8 million ton and pulses by 2 million ton by 2011-12. Some salient features of NFSM are promotion and extension of improved technologies, Restoring soil fertility and productivity at the individual farm level and Productions of breeder seeds are done under ICAR while certified seeds and pulses are implemented by State and District agencies.

Rashtriya krishi vikas yojana (RKVY) is a scheme which is continuously working towards increasing hybrid rice production In India. National Rice Research Institute (NRRI) has developed a mobile app for Android called riceXpert which provides information related to farm practices. Another ICT initiative is Rice doctor, Rice Doctor is an interactive tool for extension workers, students, researchers and other users who want to learn and diagnose pest, disease, and other problems that can occur in rice; and how to manage them.

Future Rice demand Projections and prospects : Population trends project India to emerge as the most populous country in the world in the coming decades. Demand and supply prospects of food items become important indicators to the country's food security concerns. These projections are based on change in productivity levels, changes in price, growth of population and income growth.

Table-2 nad Table-3 depicts that demand for rice, is expected to be 102.1 mt. and annual per capita domestic demand is expected to be 72.2 mt. Rice production is also estimated to increase to 111.2 mt by 2026 as depicted in Table-5. There has been a diversification in the cropping

pattern towards high-value commodities in major rice producing regions.

Demand and supply projections act as indicators to policy makers to formulate their medium and long-term agricultural policies. The increase in total demand is mainly due to growth in population and per capita income. As far as supply is concerned, production is constrained by low yield growth. The gap between supply and demand is narrowing down over the years for all the food items.

The average productivity of rice in India, at present, is 2.2 tons/ha, which is far below the global average of 2.7 tons/ha. The supply projections have been made at two historical growth rates, i.e. 1.34% for the period 2000-2009 and 1.14% for the period 2006-2010. India is expected to surpass its demand by the year 2030, if the rice production grows at 1.34% per annum. But it will remain in deficit of around 2.5 million tons, if the present growth rate of 1.14% continues up to the year 2030.

Issue confronting in Achieving Future Demands : Rice is the staple food for more than 3.5 billion people worldwide, around half of the world's population. Importantly, rice is the staple food in India. Targeting improvements in rice production are directed to those who are in need of the most urgent assistance. Rice consumption is increasing, and demand for rice will outstrip supply if production does not increase faster than its current rate. This means we have to produce even more rice. So, rice varieties must have higher yield potential and crop management techniques have to help achieve this potential. With a sufficiently high and reliable supply of rice, prices are more likely to stay affordable and consistent, which is important for poor rice consumers. According to Food and Agricultural Organization (FAO), India's crop yield per hectare remains much lower than the global average. With around 2.4 tonnes of rice produce per hectare, India ranks much lower than even other BRICS nations in terms of productivity. Lack of availability of high-yield varieties, water shortage resulting in less than sufficient irrigation, absence of local R&D to improve yields and low per hectare usage of agrochemicals are among the reasons for India's low agro productivity. Addressing these factors is a major task at hand if we have to keep agriculture sustainable in the long run.

To meet the domestic food requirements, India either needs to increase agricultural production or depend on imports. Since agricultural growth is limited, imports can help improve the country's supply situation for a short term. But for the long term, the country will need to focus on productivity enhancement, through public investment in irrigation, research and efficient use of water, plant nutrition and other inputs (Kumar 1998, Fan et al 1999,

Evenson et al 1999, Singh 2001). These policies will induce efficiency and can help in maintaining balance between domestic production and demand.

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A Study on Perception of Farmers Towards Climate Change in Bundi District of Rajasthan

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Abstract

The study was carried out during 2020-21 in Bundi District of Rajasthan on "Perception of farmers towards climate change in Bundi district of Rajasthan". A multistage sampling technique was used to select respondents. A total No. of 175 respondents was selected for the study. The perception of the individual farmer about Climate Change was measured through a scale developed by Jaishi *et al.* (2018) with slight modification as per requirement for the study. The results of study showed that the overall farmers perception about impact of climate change was strongly agreed for agricultural production hampered by (39.43%) respondents, (30.29%) respondents agreed for loss of population of species of trees, (32.57%) and (24.57%) respondents were undecided for loss of population and species of animals, and for depletion of ground water. Further, (26.86%) respondents were agreed for incidence of crop failure.

Key words : *Perception, climate change.*

Introduction

Climate change is one of the most defining concerns of today's world and has greatly reshaped or in process of altering earth's ecosystems. Due to the anthropogenic activities the average temperature was risen by 0.9 °C since nineteenth century, mainly due to greenhouse gas (GHG) emissions in the atmosphere. As per estimates this rise is expected to be 1.5 °C by 2050 or may be even more, the way deforestation is occurring, GHG emission is increasing, and soil, water bodies and air are being polluted. The unprecedented hike in temperature has resulted in increased events of droughts, floods, irregular patterns of precipitation, heat waves and other extreme happenings throughout the globe. Climate change is resulting into a very high rate of land degradation causing enhanced desertification and nutrient deficient soils. People's perception is very much useful to establish the fact that the particular region is facing direct or indirect problems in agriculture and other activities due to climate change. Consequently, understanding the perception of climate change by farmers can shape the preparedness of these factors to adapt and change their practices. Furthermore, extensive data collection and field trials to assess the impact of prevailing climatic conditions in different agro-ecological zones can help in designing future strategies through computational simulation. Connecting and sensitizing farmers to sustainable technologies and activities is of utmost importance as they are the ones who can play a major role in implementation of the ecological goals. Keeping all the facts in mind we have decided to investigate farmer's perception, individual biases and prejudices on the part of respondents might

crop up. This study also tries to quantify the people's perception on various seasonal climate changes.

Research Methodology

The Bundi district of Rajasthan was selected purposely for the present investigation. Taking into consideration of time, resources and facilities at the disposal of the investigator Bundi district was selected purposively. A multi-stage sampling design was used to select the sample farmers as respondents. Villages were selected based on 3 Agro Ecological Situations as "Command area with assured irrigation and heavy soils, Command area with unassured irrigation and medium soils and Non command area with medium soils and well irrigation". From each of Agro Ecological situation 2 representative village were selected thus six villages were selected from above said Agro Ecological situation. Overall 175 farmers were selected as respondents of present study from six villages. The data were analyzed using Summation, Mean and Percentage for this study.

Results and Discussion

People's perception on extent of variability of climate change : The findings from the farmer's perception regarding extent of variability of climate change faced by farmers are presented in Table-1.

The results revealed that majority of the farmers in this area were experiencing aberrations in the climate as they have been farming there for many years. The results indicated that the majority of farmers (37.71%) were agreed for drastic change in rainfall pattern, (34.86%) respondents were agreed for timing of the

Table-1 : People's perception on extent of variability of climate change.

S. No.	Perceptual statement	Responses									
		Strongly agree		Agree		Undecided		Disagree		Strongly disagree	
		No.	%	No.	%	No.	%	No.	%	No.	%
1.	Rainfall pattern has been changed	58	33.14	66	37.71	23	13.14	17	9.71	11	6.29
2.	Timing of the rainfall is changing	47	26.86	61	34.86	32	18.29	23	13.14	12	6.86
3.	Amount of rainfall is changing	47	26.86	53	30.29	36	20.57	22	12.57	17	9.71
4.	Intensity of rainfall is changing	33	18.86	39	22.29	43	24.57	37	21.14	23	13.14
5.	Summer temperature is changing	23	13.14	36	20.57	87	49.71	17	9.71	12	6.86
6.	Winter temperature is changing	26	14.86	29	16.57	83	47.43	23	13.14	14	8.00
7.	Overall, of the annual temperature is changing	19	10.86	29	16.57	97	55.43	21	12.00	9	5.14
8.	Hail-storm events is changing	52	29.71	44	25.14	41	23.43	17	9.71	21	12.00
9.	Thunderstorm and Lightening events are changing	49	28.00	57	32.57	37	21.14	18	10.29	14	8.00
10.	Duration of dry spell during rainy season is changing	43	24.57	67	38.29	31	17.71	19	10.86	15	8.57
11.	Wind velocity is changing	29	16.57	32	18.29	29	16.57	48	27.43	37	21.14
12.	Increase in the insect pest incidence	47	26.86	61	34.86	28	16.00	21	12.00	18	10.29
13.	Increase in the disease pest incidence	49	28.00	67	38.29	27	15.43	19	10.86	13	7.43

No. – Number of the respondents, % - Percentage of the number

Table-2 : Overall perceptions about impact of climate change by farmers.

S. No.	Perceptual statement	Responses									
		Strongly agree		Agree		Undecided		Disagree		Strongly disagree	
		No.	%	No.	%	No.	%	No.	%	No.	%
1.	Agriculture production hampered	69	39.43	53	30.29	25	14.29	19	10.86	9	5.14
2.	Loss of population and species of trees	49	28.00	53	30.29	29	16.57	27	15.43	17	9.71
3.	Loss of population and species of animal	33	18.86	37	21.14	57	32.57	29	16.57	19	10.86
4.	Depletion of ground water table	37	21.14	39	22.29	43	24.57	37	21.14	19	10.86
5.	Incidence of crop failure	39	22.29	47	26.86	39	22.29	27	15.43	23	13.14

No. – Number of the respondents, % - Percentage of the number

rainfall, (30.29%) respondents were agreed for amount of rainfall and (24.57%) respondents were undecided for intensity of rainfall, (49.71%) respondents were undecided for Summer temperature is increasing, (47.43%) respondents were undecided for winter temperature is changing, (55.43%) respondents were undecided for overall, of the annual temperature is changing, (29.71%) respondents were strongly agreed for hail-storm events is changing, (32.57%) respondents were agreed for thunderstorm and lightning events are changing, (38.29%) respondents were agreed for duration of dry spell during rainy season is changing, (27.43%) respondents were disagreed for wind velocity is changing, (34.86%) respondents were agreed for increase in the insect pest incidence and (38.29%) respondents were agreed for increase in the disease pest incidence. A general perception prevalent among the minds of the respondents was that there has been an increase in hail-storm events, pattern of the rainfall, timing, and amount has been changed, and thunder & lightning events has been changing. Similarly, Singh *et al.* (2021) results showed that farmers perceived change in the distribution of rainfall, rise in temperature, and

increase in frequency of heat waves and droughts in the region. Further, degradation of common property resources, uncertainty in crop yields, increased soil salinity, farm unemployment and reduction in consumption were some of the potential non-climatic impacts as perceived by the farmers.

Perceptions of climate change impacts on agriculture: Farmer's perception on the overall impact of climate change principally: loss of agricultural production, loss of trees/gardens/houses, loss of domestic animals and loss of income are presented in Table-2.

It is evident from the findings presented in Table-2 that 39.43 per cent of the farmers strongly agreed that agriculture production hampered due to climatic variabilities. The farmers strongly pointed out that due to reduction in the water availability their livelihood was in trouble. Delay in the onset of the south-west monsoon and its poor performance in the months of June and July has affected the sowings of kharif crop. Delays in normal monsoonal pattern create challenges in the timing of preparatory tillage and sowing for commencing cultivation processes for the season. Such monsoonal delays have

repercussions on the crops cultivated for the entire agricultural year. Even after the onset of monsoon and the commencement of planting, there may be monsoonal withdrawal causing unexpected dry spells and moisture stress on plants and creating difficulties in the adoption and timing of approval cultural practices ultimately causing reactions in yields and outputs. Majority of the farmers have an opinion that the rainy season has been reducing, unreasonably and unpredictably for the past two decades, and heat is becoming piercing.

Nearly 21.14 per cent of respondents had strongly agreed whereas 22.29 per cent agreed that there was a substantial reduction in the water level due to high temperature and lack of timely rains. A large majority of respondents 26.86 per cent, as is evident from the above table, agreed to the statement that there has been an increase in incidence of crop failure incidence. Further, about 28.00 per cent of the respondents strongly agreed and 30.29 per cent of respondents only agreed for 'loss of population and species of trees' and 18.86 per cent strongly agreed and 21.14 per cent of respondents agreed to the statement for 'loss of population and species of animal'. The farmers perceived the effects of climate change on various agriculture-related aspects and the major response was focused on the reduction in ground water table, flora and fauna, production. Changing contours of climatic conditions are posing serious threat to the farm livelihood.

Similarly results were also supported by Shukla *et al.* (2019) that majority of respondents across all farmer types noticed a decrease in summer and winter

precipitation and an increase in summer temperature. Whereas the perceptions of impacts of climate change diverged across farmer types, as specific farmer types exclusively experienced few impacts. Impact of climatic risks on household food security and income was significantly perceived stronger by low-resource-endowed subsistence farmers, whereas the landless farmer type exclusively felt impacts the communities social bond.

Conclusion

It was noted that a general perception prevalent among the minds of the respondents was that there has been an increase in hail-storm events, pattern of the rainfall, timing, and amount has been changed, and thunder & lightning events has been changing. Further, overall results showed that most of the respondents were agreed for Agriculture production hampered, Loss of population and species of trees, Incidence of crop failure in this study.

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Evaluation of Mepiquat Chloride's Ability to Control Plant Development with Respect to Brinjal Growth and Physiological Characteristics (*Solanum melongena* L.)

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Abstract

During the 2015 rainy season (kharif), a field experiment was conducted at the Vegetable Research Farm, Department of Horticulture, Institute of Agriculture Sciences, Banaras Hindu University, Varanasi. The goal of the current study was to determine how mepiquat chloride affected the yield and yield characteristics of the New Kiran brinjal variety. An experimental design with randomised blocks was used. Mepiquat chloride solutions at concentrations of 1350 ppm, 1700 ppm, and 3400 ppm were foliar sprayed on brinjal plants. In addition to the three concentrations, the foliar spraying schedule included I the first spraying at the beginning of flowering followed by (ii) the second treatment at the same dose after fifteen days following the first spraying. The present study further aims to find out the stage of plant and concentration of mepiquat chloride to have maximum growth of plant and physiological attribute of brinjal variety New Kiran. Among the concentrations, significantly decrease in plant height at 0 and 15 days and stem height at 15 days (15.20 cm), (28.66 cm) and (7.26 cm) recorded under (T₃) respectively whereas significant increase in number of leaves at 0 day and 15 days (9.47) and (24.37), number of branches at 15 days (4.02), leaf area (72.66 cm²), total chlorophyll content (0.82 mg/g), chlorophyll a (0.58 mg/g) and chlorophyll b (0.30 mg/g) were recorded under (T₃) in 3400 ppm concentrations as against control (T₀). Similarly significant decrease in plant height stem height and significant increase in number of leaves, leaf area, number of branches chlorophyll content chlorophyll a chlorophyll b were recorded at initiation of flowering over fifteen days after initiation of flowering and first spraying at initiation of flowering followed by second spraying after fifteen days of first spraying.

Key words : Plant growth regulator, mepiquat chloride, Randomized block design.

Introduction

India is the second largest producer of vegetables in the world next to china. Brinjal (*Solanum melongena* L. 2n=24) is third most important vegetable crop after potato and tomato. Brinjal is an economically important vegetable crop widely cultivated in the tropics, subtropics and warm temperate regions. In India, it is one of the most common, popular and principal vegetable crops grown throughout the country. Thompson and Kelly (1957) distinguished 3 botanical varieties of *Solanum melongena* i.e., (1) variety esculentum, the common round fruited (2) variety serpentinum, long and slender fruited and (3) variety depressum with small pear shaped fruits on dwarf spreading plants of quick maturity.

The food value of brinjal is quite high. It contains protein (1.4 g), fat (0.3 g), minerals (0.3 g), fiber (1.3 g), calcium (18 mg), magnesium (16 mg) and phosphorus (47 mg) and vitamin A (124.14) per 100 g of edible fruit. (Zenja and Halim, 2008).

Indian agriculture has been becoming more mechanized and science has increased the possibilities of

using inputs to enhance production and food safety. Plant growth regulators may be promoters or retardants, play a key role in controlling internal mechanisms of plant by interacting with key metabolic processes such as, nucleic acid metabolism and protein synthesis. They might be a useful alternative to increase crop production. Recently, there has been global realization of the important role of PGR's in increasing crop yield. Plant growth regulators provide an immediate impact on crop improvement programmes and are less time consuming.

Growth retardants are natural or synthetic chemical substances which are directly applied to crops to alter some structural processes. It is expected that these alterations modify hormonal balance and growth, leading to increased yield, improved crop quality or facilitated harvesting. Plant growth regulators (PGRs) have a particularly interesting role in modern agriculture (Ashraf *et al.* 2010). Thereby increased total dry mass of a field crop (Chibu *et al.* 2000, Dakua 2002, Islam 2007, Cho *et al.* 2008). In Greece and other European countries the PGRs are commonly used on food crops (melon pepper, celery etc) in order to improve and accelerate plant productivity.

Table-1 :

Treatment	Plant height at 0 day (cm)	Plant height at 15 days (cm)	No. of leaves at 0 days	No. of leaves at 15 days	Stem height at 15 days (cm)
T ₁	21.30	38.13	7.79	19.63	12.43
T ₂	18.67	34.50	8.41	22.36	9.60
T ₃	15.20	28.66	9.47	24.37	7.26
T ₄	20.45	36.96	7.58	19.43	12.60
T ₅	18.96	35.12	8.28	22.30	9.76
T ₆	15.30	28.76	8.34	24.33	7.36
T ₇	18.45	35.56	8.75	22.47	9.56
T ₈	23.80	40.96	6.79	16.70	13.65
SE m ±	0.26	0.41	0.12	0.14	0.15
CD 5%	0.79	1.25	0.38	0.45	0.44

Table-2 :

Treatment	No. of branches at 15 days	Leaf area (cm ²)	Total chlorophyll (mg/g)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)
T ₁	2.73	54.60	0.56	0.41	0.15
T ₂	3.50	60.03	0.69	0.47	0.22
T ₃	4.02	72.26	0.82	0.58	0.33
T ₄	2.62	53.59	0.56	0.40	0.14
T ₅	2.76	62.00	0.69	0.46	0.21
T ₆	3.90	72.13	0.81	0.57	0.32
T ₇	3.57	60.23	0.62	0.52	0.23
T ₈	2.48	48.66	0.43	0.35	0.10
SE m ±	0.13	0.36	0.10	0.006	0.005
CD 5%	0.39	1.09	3.06	0.01	0.02

Growth and yield potential of brinjal can be improved with the adoption of scientific cultivation technology including use of plant growth regulators.

Materials and Methods

The present investigation was carried out at Vegetable Research Farm, Department of Horticulture, Institute of Agriculture Sciences, Banaras Hindu University, and Varanasi during the rainy season (kharif), 2015. The Vegetable Research Farm is situated at a distance about 10 km away from Varanasi railway station in South – Eastern direction of Varanasi city and is geographically situated at 25° 15' North latitude and 83° 03' East longitude. The altitude of the location is about 123.23 m above mean sea level. Varanasi is situated in the eastern part of Uttar Pradesh and lies in the centre of north alluvial plain on the left side of river Ganges and enjoys a humid sub-tropical climate with large variation in summer and winter temperature i.e. extreme of hot weather in summer and cold in winter.

The experiment consisted eight treatment combination comprising concentration of mepiquat chloride (T₁, T₄, T₇ 1350 ppm) (T₂, T₅ 1700 ppm) (T₃, T₆ 3400 ppm) and T₈ spray (control) and stage of plant T₁, T₂, T₃ at initiation of flowering, T₄, T₅, T₆ at fifteen days after

initiation of flowering and T₇ first spraying at initiation of flowering followed by second spraying at fifteen days after first spraying. The experiment was laid out in randomized block design with factorial concept in three replications having 24 plots. Healthy seedlings were transplanted in the well prepared beds. Each bed was having 12 plants, maintaining row to row and plant to plant 60 cm and 45 cm spacing respectively. The total plants (288) were accommodated in the entire experimental area.

Results and Discussion

Plant growth retardants are supposed to play a significant role in agriculture and horticulture in order to increase production. Thousands of synthetic chemicals are known that can retard the plant height. Muradi *et al.* (2003) reported that chlormequat treatments on mogra (*Jasminumsambac*) were effective in suppressing apical dominance, thus promoting the growth of axillary buds into new stems. Retarding of plant height and formation of lateral branches considerably increased the flowers and fruit bearing sites.

Plant height (cm) at 0 day after application of different concentrations of mepiquat chloride : Hojjati *et al.* (2009) noted that cycocel 1000 and 2000 mg l⁻¹ decreased *Zinnia elegans* plant height. A perusal of data presented in

Table 4.1 that treatments significantly reduced height of plant. The maximum (23.80 cm) height of plant was recorded under control, while it was the minimum (15.20 cm) with T₃. Never the less, T₂ (18.67 cm) and T₅(18.96 cm) did not differ significantly between themselves. Similarly, T₃ (15.20 cm) and T₆ (15.30 cm) were found at par with each other.

Plant height (cm) at 15 days after application of different concentrations of mepiquat chloride :

Maharana and Pani (1982) found that cycocel at 5000–10000 ppm reduced the height of hybrid rose and Tetracyclic inhibits cell division in suspension cultures of various plant species. A perusal of data presented in table-1 clearly shows that all treatments significantly reduced height of plant. The maximum (40.96 cm) height of plant was recorded under control while it was the minimum (28.66 cm) with T₃. Never the less T₁ (38.13 c) and T₄(36.96 cm) did not differ significantly between themselves. Similarly, T₅(35.12 cm) and T₇ (35.56 cm) were found at par with each other.

Number of leaves at 0 day after application of different concentrations of mepiquat chloride :

It is clear from the information in Table-1 unequivocally demonstrates that all treatments greatly outperformed the control. T3 recorded the most leaves (9.47), followed by T7 (8.75), T2 (8.41), and T5 (8.28). T1 and T4 did not significantly differ from one another, though. T8 (control) had the fewest number of leaves (6.80).

Number of leaves at 15 days after application of different concentrations of mepiquat chloride :

According to the data in Table-1, all treatments were shown to be significantly better than the control. T3 had the most leaves (24.37), followed by T6 (24.33), T7 (22.47), T2 (22.36), and T5 (22.30). T1 (21.63) and T4 (19.45) did not substantially differ from one another when taken as a whole. T2 and T5 also continued to be on level with one another. Under control, the fewest leaves (16.70) were counted.

Stem height (cm) at 15 days after application of different concentrations of mepiquat chloride :

Shah *et al.* (1991) investigated the effect of CCC on the growth and yield of moong bean (*Vigna radiata*). At 1000 ppm it reduced stem length. It is obvious from data presented in Table 4.1 that all treatments significantly reduced height of stem. The maximum (13.65 cm.) height of stem was recorded under control while it was the minimum (7.26 cm) with T₃. Never the less, T₁ and T₃ did not differ significantly between themselves by showing stem height (12.43 and 12.60 cm) respectively. Likewise, T₂ (9.60 cm) and T₅ (9.76 cm) were found at par with each other.

Number of branches at 15 days after application of different concentrations of mepiquat chloride :

An experiment of data presented in Table-2 shows that all treatments were significantly superior to control. The highest (4.02) number of branches were noted with T₃ followed by T₆ (3.90), T₇ (3.56), T₂ (3.50) and T₅ (2.76). However, T₃ and T₆ did not differ significantly between themselves. The lowest (2.48) number of branches were recorded under control i.e., T₈.

Leaf area (cm²) after application of different concentrations of mepiquat chloride :

Abolfazl *et al.* (2013) recorded that treating plants of banana with PBZ increased the total leaf area and chlorophyll content, when compared with the control treatment. It was observed from data presented in Table-2 that all treatments remained significantly superior to control. The highest (72.66 cm²) leaf area was noted with T₃. It was followed by T₆, T₅, T₂, and T₅ by showing leaf area (72.13, 62.00 and 60.03 and 60.00 cm²) respectively. Never the less, T₄ (53.59cm²) and T₁ (54.60cm²) did not differ significantly between themselves. Similarly, T₂ (60.03 cm²) and T₇ (60.23cm²) were found at par with each other. The lowest (48.66 cm²) leaf area was recorded under control

Total chlorophyll content (mg/g) after application of different concentrations of mepiquat chloride :

An examination of data given in Table-2 reveals that all treatments remained significantly superior to control. The highest (0.82 mg/g) chlorophyll content was recorded with T₃ followed by T₆ (0.81 mg/g), T₅ (0.69 mg/g), T₂ (0.64 mg/g) and T₇ (0.62 mg/g). However, T₇ (0.62 mg/g) and T₂ (0.64 mg/g) did not significantly differ between themselves. Similarly, T₆ (0.81 mg/g) and T₇ (0.82 mg/g) were found at par with each other. The lowest (0.43 mg/g) total chlorophyll content was noted under control.

Chlorophyll a content (mg/g) after application of different concentrations of mepiquat chloride :

A Perusal of data in the Table-2 clearly shows that all treatments were found significantly superior to control. The highest chlorophyll a content (0.58 mg/g.) was recorded with T₃ followed by T₆ (0.57mg/g.), T₇ (0.52 mg/g.), T₂ (0.47mg/g.) and T₅ (0.46 mg/g.). Never the less T₇ and T₃ did not differ significantly between themselves. The lowest chlorophyll a content (0.35 mg/g.) was noted under T₈ (control).

Chlorophyll b content (mg/g) after application of different concentrations of mepiquat chloride :

It is evident from data given in Table-2 that all treatments statistically significant over control. The greatest (0.3 mg/g) was noted with T₃ which was followed by T₆ (0.32 mg/g), T₇ (0.23 mg/g), T₂ (0.22 mg), and T₅ (0.20 mg/g). Not with standing, T₃ and T₆ were not found to differ

significantly between themselves. The lowest (0.10 mg/g) chlorophyll b content was discovered with control.

Conclusion

Treatment with mepiquat chloride (3400 ppm) at the beginning of the blooming stage was shown to be the most effective since it resulted in the lowest plant height (cm), stem height (cm), and more branches, leaves, and leaf area (cm²) in the brinjal variety New Kiran.

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Study on Inter Cropping Systems on Nutrient Uptake, Profitability and Yield in Coriander (*Coriandrum sativum* L.) Crop Production

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Abstract

A field experiment comprising 10 treatments viz., sole coriander, sole french radish, sole knolkhol, sole fenugreek, coriander intercropping with french radish, knolkhol and fenugreek in 1:1 and 2:2 row ratio was conducted in Randomized Block Design with four replications during *rabi* season, 2016-17 at research farm of ICAR-NRCSS, Ajmer. Intercropping of coriander with french radish in 1:1 row ratio resulted significantly higher land equivalent ratio (1.83), coriander equivalent yield (4272 kg/ha), gross return (Rs. 341728/- ha), net return (Rs. 283228/- ha) and BCR (4.84) followed by intercropping of coriander with french radish in 2:2 paired row ratio. After coriander has been harvested, the residual availability of nutrients has been altered by the intercropping system's inclusion of legumes. Coriander and fenugreek intercropped at ratios of 1:1 and 2:2 resulted in significantly higher residual N, P, and K availability following crop harvest. Thus, it can be concluded that intercropping coriander with french radish in a 1:1 row ratio is preferable for achieving higher yield and profitability, but intercropping coriander with fenugreek in a 1:1 ratio can achieve residual availability of N, P, and K after the crop has been harvested.

Key words : Coriander, intercropping, NPK fertilizer, net returns, LER, yield.

Introduction

Coriander (*Coriander sativum*) generally called as "Dhania" belongs to the Apiaceae family. It is mainly grown in Rajasthan, Gujarat, Madhya Pradesh, Tamilnadu and Uttar Pradesh. Coriander is an important seed spice crop of Rajasthan which is mostly grown in Kota, Bundi, Jhalawar and Baran. Area, production and productivity of coriander in Rajasthan is 2.48 lakh hectares, 1.98 lakh M tonnes and 680 kg/ha, respectively (Anon-2015). Ahlawat and Gangaiah (2010) reported higher system productivity in chickpea intercropped with linseed over sole chickpea. Mustard and chickpea intercropping have exhibited higher land equivalent ratio (1.41) over in sole crops (Thomas *et al.*, 2010). Vegetable shortages in the nation have drawn attention to intercropping systems, which can enhance the physical, biological, and chemical characteristics of soil (Mehta *et al.* 2010). Thus, by changing the crop configuration to include different crops in the current cropping system, the productivity of the system can be increased. To determine the most effective intercropping system for achieving greater system production and boosting residual nutrient availability in the soil, a study on the effects of coriander-based inter-cropping systems with vegetable crops was therefore done.

Materials and Methods

The experiment was laid out at Research farm of ICAR-National Research Center on Seed Spices, Ajmer, Rajasthan, during 'Rabi' season of 2016-17. The soil of research farm is sandy loam, poor in fertility and water holding capacity, having pH 8.3, and organic carbon 0.23 %, available N 68.49 kg/ha, P₂O₅ 7.05 kg/ha, K₂O 230.16 kg/ha. The experiment comprising of 10 treatments viz., sole coriander, sole French radish, sole knolkhol, sole fenugreek, coriander intercropping with French radish, knolkhol and fenugreek in 1:1 and 2:2 row ratio was laid in randomized block design with four replications. As per technical programme one row of radish, knolkhol and fenugreek was added between two rows of coriander in 1:1 intercropping ratio and two rows of vegetable crops were added in a pair of two rows of coriander (paired row having 25/35 cm). A uniform recommended dose of 60 Kg N and 40 kg P₂O₅ ha⁻¹ and 30 kg K₂O for sole coriander, 120 kg N, 60 kg P₂O₅ and 40 kg K₂O for sole knolkhol, 100 kg N, 50 kg P₂O₅ and 40 kg K₂O for french radish and 20 kg N, 40 kg P₂O₅ and 30 kg K₂O for fenugreek was applied. In intercropping of coriander and vegetables 100 % NPK requirement of sole coriander and 50 % NPK requirement of respective vegetables were applied. 1/3 N and full dose of phosphorus and potash were applied at the time of sowing and remaining 2/3 N was applied with

Table-1 : Effect of intercropping system on availability of residual NPK in soil after harvesting of crop.

Treatment	Available N	Available P ₂ O ₅	Available K ₂ O
Sole Coriander	90.00	6.72	267.65
Sole French radish	89.98	6.65	256.28
Sole knolkhol	89.61	6.59	251.47
Sole fenugreek	92.51	6.81	273.03
Coriander + French radish 1:1	89.56	6.63	252.50
Coriander + French radish 2:2	89.38	6.61	250.90
Coriander + knolkhol 1:1	88.51	6.58	246.20
Coriander + knolkhol 2:2	88.44	6.56	243.66
Coriander + fenugreek 1:1	90.47	6.75	268.60
Coriander + fenugreek 2:2	90.36	6.72	267.85
Initial value	100.57	7.60	354.74
SEm	3.32	0.33	8.59
CD (P=0.05)	9.62	0.94	24.92

Table-2 : Effect of intercropping systems on yield of coriander, inter-crops and coriander equivalent yield.

Treatment	Seed yield of Coriander (q/ha)	Seed yield of intercrops (q/ha)	Corinader equivalent (q/ha)
Sole Coriander	18.90	-	18.90
Sole French radish	-	273.62	27.36
Sole knolkhol	-	137.22	17.15
Sole fenugreek	-	276.64	27.67
Coriander + French radish 1:1	16.98	257.36	42.72
Coriander + French radish 2:2	15.60	253.72	40.98
Coriander + knolkhol 1:1	16.83	117.75	31.56
Coriander + knolkhol 2:2	15.42	113.75	29.65
Coriander + fenugreek 1:1	16.49	246.57	41.15
Coriander + fenugreek 2:2	15.10	238.28	38.94
SEm	0.59	7.98	1.15
CD (P=0.05)	1.76	23.3	3.35

low pressure drip irrigation through urea at an interval of 8 days. The standard agronomic practices were applied for raising healthy coriander crop as well as French radish, knolkhol and fenugreek. Immediately after sowing irrigation was provided with low pressure drip irrigation having normal operating pressure of 0.1 kg sq cm⁻¹. Available residual N in soil was determined by alkaline potassium permanganate method (Jackson, 1973), available P₂O₅ by Olsen *et al.* (1954) and available potassium by flame photometric method (Jackson, 1973.). The yield of coriander, french radish, knolkhol and fenugreek was converted into coriander equivalent yield as per prevailing rates in market and treatment evaluation was done accordingly. Economic analysis of the different treatment was done for drawing conclusion.

Results and Discussion

Effect of intercropping system on residual NPK availability in soil after harvesting of crop : Different intercropping system significantly influenced the N, P and K availability in soil after harvesting of crops. After crop harvest, all treatments have lower levels of available N, P, and K compared to the baseline value. N, P, and K are most abundant after harvesting in intercropping coriander with fenugreek in both 1:1 and 2:2 ratios, followed by intercropping coriander with knolkhol in both ratios, among the several intercropping systems that are available. When compared to intercropping with the corresponding vegetable crops, all solo crops have more readily available N, P, and K. N, P, and K availability after harvest is lower under different intercropping systems

Table-3 : Effect of intercropping system on availability of residual NPK in soil after harvesting of crop.

Treatment	Cost of Cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B : C ratio	LER
Sole Coriander	55300	151200	95900	1.73	1.00
Sole French radish	61750	218896	157146	2.54	1.00
Sole knolkhol	64500	137220	72720	1.12	1.00
Sole fenugreek	66250	221312	155062	2.34	1.00
Coriander + French radish 1:1	58500	341728	283228	4.84	1.83
Coriander + French radish 2:2	58500	327776	269276	4.60	1.74
Coriander + knolkhol 1:1	59700	252390	192690	3.22	1.74
Coriander + knolkhol 2:2	59700	237110	267876	2.97	1.63
Coriander + fenugreek 1:1	61300	329176	250124	4.36	1.76
Coriander + fenugreek 2:2	61300	311424	280376	3.08	1.65
SEm	-	-	-	-	0.05
CD (P=0.05)	-	-	-	-	0.15

than it is for the corresponding sole crops, which may be because coriander and the corresponding intercrops extract and use these nutrients to a greater extent. The enhanced N, P, and K availability in coriander and fenugreek intercropping in both 1:1 row ratio and 2:2 paired row ratio across intercropping systems may be the result of more nitrogen fixation in fenugreek nodules, which after being used by fenugreek and coriander, remain soil. Similar result has also been reported by Tanwar *et al.* (2011).

Yield of main crop and intercrops : When planted as a solitary crop as opposed to intercropping, coriander seed output was seen to be higher. Coriander intercropped with french radish in both a 1:1 and a 2:2 ratio to provide the highest seed production of all intercropping systems. Coriander's higher yield when grown as a single crop may be the result of less crop competition, which leads to better growth, yield qualities, and yield. Coriander may produce more seeds when intercropping with french radish than when intercropping with other crops since there is less competition between the two plants. In comparison to intercropping with coriander, yield of intercrops was seen to be higher in the respective sole crops. Further, perusal of data in Table 2 reveals that among different intercropping ratios, the higher yield of intercrops was exhibited in 1:1 ratio. In comparison to knolkhol and fenugreek, intercropping coriander + french radish in all ratios produced a higher economic yield of the latter crop. All intercrop crops produced more in a 1:1 ratio than a 2:2 ratio due to the higher plant population that resulted from accommodating more rows between interspaces. Mehta *et.al.* (2012 and 2015) also reported higher yield of intercrops in 1:1 intercropping ratio over 2:2 and 1:2 intercropping ratio.

Coriander equivalent yield and land equivalent ratio :

Coriander equivalent yield (CEY) and land equivalent ratio (LER) were significantly influenced with different intercropping system. Intercropping systems produced significantly greater coriander equivalent yields and land equivalent ratios than mono cropping (Table 3). In all ratios, the combination of coriander and french radish produced higher CEY and LER than its intercropping with knolkhol and fenugreek. An additional analysis revealed that coriander intercropping with all intercrops in a 1:1 ratio was superior to a 2:2 ratio, producing higher CEY and LER. Inter cropping of coriander + french radish in 1:1 ratio exhibited 126 and 83 % higher CEY and LER, respectively over sole coriander. The higher CEY and LER in intercropping system was on account of additional yield of intercrops without much reduction in yield of base crop. The higher CEY and LER in the 1:1 ratio with french radish, knolkhol, and fenugreek were caused by a proportionately less yield drop in coriander than in the 2:2 ratio, which improved intercrop yield. Ahlawat and Gangaiah (2010) reported higher system productivity in chickpea intercropped with linseed over sole chickpea. Thomas *et al.* (2010) reported the highest LER of 1.41 in mustard and chickpea Bhati (1992) reported higher fennel equivalent yield in intercropping as compared to sole crops. Intercropping over sole crops. Mehta *et.al.*(2015) also reported higher fennel equivalent yield and LER in intercropping system over sole cropping.

Economics : A variety of intercropping systems have an impact on gross return, net return, and BCR. Coriander and French radish intercropped in a 1:1 ratio produced significantly greater net returns (Rs 283228/ha) and B: C ratios (4.84), which were 195 and 179 percent higher than

solitary coriander, respectively. Coriander, French radish, Knolkhol, and Fenugreek were intercropped in a 1:1 ratio, which produced a greater net return and B:C ratio than a 2:2 ratio. Similar benefits of intercropping on economics in fenugreek + mustard was reported by Yadav *et al*, (2003). Khurana and Bhatia (1995) in intercropping of onion and potato with fennel and Ahlawat and Gangaiah (2010) in chickpea + linseed reported similar results. It is concluded that intercropping of coriander and french radish in 1:1 ratio is promising for higher productivity and profitability.

Thus, it can be concluded that intercropping coriander and french radish in a 1:1 row ratio will result in higher yield and profitability, but that intercropping coriander and fenugreek in a 1:1 row ratio will result in higher residual availability of N, P, and K after crop harvest.

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Estimation and Validation of Rice Production through Decision Support System for Agro-Technology Modeling

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Abstract

A field experiment was laid out in RBD design during Kharif season of 2015 to ground truth data of rice crop at Agrometeorological Research Farm of SHUATS, Prayagraj (U.P.). The treatment comprised of three dates of sowing viz. July 5th (D₁); July 15th (D₂) and July 25th (D₃) three varieties viz. Sarjoo-52(V₁); NDR-359 (V₂) and Swarna sub-1 (V₃). Validation in addition to field crop data of year 2015. DSSAT crop growth simulation model over set mated the days taken to Anthesis, days taken to physiological maturity, Leaf area index, test weight, grain yield, straw yield and harvest index of rice crop grown in region. Lower error % was recorded in LAI, days taken to Anthesis, test weight, straw yield and harvest index under timely (5 July) transplanting date and physiological maturity in D₂ (15 July) and error % increased with delay in transplanting, But DSSAT model better simulate for grain yield Sarju-52 under timely transplanted i.e. 5 July. The yield attributing characters were closely simulate to observed values under timely (5 July) transplanting of rice crop, suggested that the simulated yield were well within the accepted limits, therefore the model can be used for predicting rice yield and phenological events in eastern U.P.

Key words : Rice, DSSAT, Simulation.

Introduction

Rice (*Oryza sativa* L., 2n=24) is a member of Poaceae (gramineae) family, widely grown in tropical and sub-tropical regions. The major climatic factors affecting growth and yield include solar radiation, temperature and rainfall. The average temperature required throughout the life period of the crop ranges from 21 to 37°C. Rice production and consumption is concentrated in Asia, where more than 90% of all rice is consumed.

Rice is cultivated worldwide in an area of 156.80 million hectare having an annual production of 650.19 million tones with an annual productivity of 4.15 tons ha⁻¹. India has largest the area 39.47 million hectare and second in rice production 87.10 million tones having the productivity of 2207 kg ha⁻¹ while next to china (Anonymous 2012). The variation in potential rice farming scenarios makes the generation of timely and spatially explicit rice data set a critical component of rice crop management. (Dingkuhn *et al.* 1991; Kropff *et al.* 1994; Aggarwal *et al.* 1997).

The decision support system for agro-technology transfer (DSSAT) is decision support system that encompasses process based computer models that predict growth development and yield as a function of a local weather soil condition, crop management scenarios and genetic information. DSSAT also includes a basic set of tools to prepare the input data, as well as application

programs for seasonal, crop rotation and spatial analysis. The crop models not only predict crop yield, but also resource dynamics, such as for water, nitrogen and carbon and environment impact, such as nitrogen leaching. DSSAT includes an economic component that calculates gross margins based harvested yield and by products, the price of harvested product and input costs. (Hoogenboom *et al.* 1994).

Materials and Methods

Data requirement for DSSAT model : The decision support system for agro-technology transfer (DSSAT) model required the following dataset for simulation study.

Experimental Site data : Course of the time and location data, longitude, latitude and altitude. Soil classes, soil evaporation, soil albedo, runoff curve, soil profile, drainage coefficient, soil layer thickness, field capacity, wilting point, bulk density, organic carbon (%), sand, silt and clay (%).

Weather data : Sunshine (hours), maximum and minimum temperature (°C), rainfall (mm), wind speed (m/s), humidity (%) and pan evaporation (mm). For calibration and validation of the model, observed weather data were obtained from research farm, School of forestry & Environment, Sam Higginbottom University of Agriculture Technology & Sciences, Deemed-to-be-University Prayagraj, Allahabad, U.P.

Table-1 : Crop management details for the experiment.

	Parameter
Cultivar (V)	Sarju-52, NDR-359, Swarna Sub-1
Transplanting date (D)	5 July 2015, 15 July 2015, 25 July 2015,
Row spacing	20 cm
Soil	Sandy loam
Fertilizer	100 kg ha ⁻¹ urea in three applications, one basal and another two at 47 and 77 days after planting.
Irrigation	Irrigation was given at different intervals according to crop requirement.

Crop Management file : Crop Management file includes all relevant information regarding rice variety Sarju-52 NDR 359 Swarna sub-1 and field condition e.g. initial field condition fertilizer application irrigation scheduling row distribution cultivars, plant population, treatments, emergence date, simulation option etc. All important information is filled in crop management file in DSSAT model as essential inputs for crop modeling and rice yield.

Study area



Management data : Date and amount of irrigation, fertilizer application, herbicide/insecticide application, weeding, row spacing depth (mm), variety name and genetic coefficient data.

Model testing : Model testing involves verification, calibration, validation and sensitivity analysis. Before the use of any model, adequate validation of the magnitude of errors that may results through its use is necessary.

Verification : Verification and validation are two terms used synonymously in modeling. Verification involves the evaluation of the accuracy with which computer code represents the model. Verification means to test truthfulness or correctness.

Calibration : Calibration can be defined as a process involving adjustment of some parameters or coefficients in functional relationship so that the model behavior matches one set of real world data. Calibration is an elementary aspect of verification.

Validation : Model validation in its simplest form is a comparison between simulated and observed values. Validation is determining whether the model works with totally independent data sets that is, does it accurately predict growth yield and processes. From comparison between the values predict by the model and the values obtained from the real experiment validation can be done. If the simulated values lie within the predicted confluence level band, model can be considered valid. Test criteria from statistical analysis can determine this. Thus validation is used as evaluation of model for its usefulness.

Results and Discussion

Table-2 presents a comparison of anthesis, physiological maturity and LAI predictions of the model with the observed data for the nine treatments. It showed that anthesis prediction by the model was observed maximum 6.94% in treatment (D_3V_1) while minimum 3.70% in treatment (D_1V_3). The anthesis prediction of model shows that the variety Sarju-52 transplanted on 25th July was superior to other varieties. The physiological maturity prediction was found to be an error of maximum 8.80% in treatment (D_2V_1) while minimum 2.90% in treatment (D_2V_3). The physiological maturity prediction of model shows that the variety Swarna sub-1 transplanted on 15th July was superior to other varieties. LAI prediction was found to be an error of maximum -1.7% in treatment (D_2V_1) while minimum -11.8% in treatment (D_1V_1). 17%. The LAI prediction of model shows that the variety Sarju-52 transplanted on 15th July was superior to other varieties.

Table-2 represents a comparison of test weight, grain yield, straw yield and harvest index predictions of the model with the observed, for the nine treatments discussed above. It shows that the test weight prediction by the model is observed maximum 6.57% in treatment (D_1V_3) while minimum 3.24% in treatment (D_1V_1). The test weight prediction of model shows that the variety Sarju-52 transplanted on 25th July was superior to other varieties. Similar results have been found by (Nadeem *et al.* 2010) reported that 1000-kernel weight (g) was significantly affected by different sowing dates. The grain yield prediction was found to be an error of maximum 10.7% in

Table-2 : Comparison between predicted and observed growth performance of Rice crop on yield under different transplanting dates and varieties (O = observed; S = simulated).

Treatments	Test Weight (g)			Grain yield (kg ha ⁻¹)			Straw yield (kg ha ⁻¹)			Harvest Index (%)		
	O	S	Error (%)	O	S	Error (%)	O	S	Error (%)	O	S	Error (%)
D ₁ V ₁	21.6	22.3	3.24	4933	5136	4.1	4326	4216	-2.5	50.8	54.90	8.0
D ₁ V ₂	20.2	21.2	4.95	5310	5609	5.6	5226	5052	-3.3	46.11	52.60	14.0
D ₁ V ₃	21.3	22.7	6.57	5290	5460	3.2	6022	5810	-3.5	44.18	48.40	9.5
D ₂ V ₁	24.2	25.7	6.20	2740	3000	9.4	5162	4991	-3.8	35.20	37.50	37.5
D ₂ V ₂	22.3	23.1	3.59	2930	3188	8.8	5422	5244	-3.2	34.50	37.80	37.8
D ₂ V ₃	19.4	20.4	5.15	3220	3541	10.7	5669	5343	-5.7	33.70	37.70	37.7
D ₃ V ₁	25.2	26.4	4.76	4130	4444	7.6	4838	4419	-8.6	45.70	50.10	9.6
D ₃ V ₂	23.1	24.6	6.49	5120	5427	5.9	5140	4881	-5	47.11	52.60	11.6
D ₃ V ₃	19.2	20.3	5.73	4840	5146	6.3	5688	5306	-6.7	45.40	49.20	8.3

treatment (D₃V₂) while minimum 3.20% in treatment (D₃V₁). The grain yield prediction of model shows that the variety NDR-359 transplanted on 25th July was superior to other varieties. The grain yield (t ha⁻¹) decreased when the sowing date delayed after 1st August. The sowing dates 1st July and 15th July produced the maximum grain yield 2.9 t ha⁻¹ and 2.8 t ha⁻¹, respectively. The higher yield in case of sowing dates 1st July and 15th July was attributed to increase the cumulative mean value of appropriate temperature and sunshine hours. The straw yield prediction was found to be an error of maximum -2.50% in treatment (D₁V₁) while minimum -8.60% in treatment (D₃V₁). 17%. The straw yield prediction of model shows that the variety Sarju- 52 transplanted on 5th July was superior to other varieties. The harvest index prediction was found to be an error of maximum 14.00% in treatment (D₂V₁) while minimum 6.50% in treatment (D₁V₂). The harvest index prediction of model shows that the variety Sarju-52 transplanted on 15th July was superior to other varieties.

Conclusion

The DSSAT version 4.5 model was evaluated to simulate crop growth, development and yield in the state of Uttar Pradesh, India. DSSAT crop growth simulation model overestimated the days taken to anthesis, days taken to physiological maturity, leaf area index, straw yield and grain yield of rice crop grown in region. While model underestimated the test weight and harvest index of rice crop. Lowest error % was recorded in grain yield under timely (5 July) transplanting of rice crop with sarjoo-52 (D₁V₁) and error % increased with delay in transplanting, But DSSAT model better simulate for grain yield cv. sarjoo-52 under timely transplanted i.e. 5 July. The yield attributing characters were closely simulate to observed values under timely (5 July) transplanting of rice crop, suggested that the simulated yield were well within the accepted limits, therefore the model can be used for predicting rice yield and phenological events in eastern Uttar Pradesh.

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Impact of Phosphorous and Bio-Fertilizers on Growth and yield of garlic (*Allium sativum* L.)

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Abstract

Garlic (*Allium sativum* L.) is a plant with a major economic importance and has medicinal purposes. Garlic due to poor root system has high demands on soil and fertilizer needs. Therefore, a field experiment was conducted to study the effect of phosphorous and bio-fertilizers on growth and yield of garlic during rabi seasons of 2015-16 at SKN Agriculture University, Jobner. The experiment was laid out in factorial randomized block design with sixteen treatment combinations, four phosphorous levels viz. control, 25 kg P ha⁻¹, 50 kg P ha⁻¹ and 75 kg P ha⁻¹ as first factor and four seed inoculation with bio-fertilizer as second factor viz. control, PSB, VAM and PSB + VAM. The results of phosphorous levels revealed significantly higher growth, yield attributes and yield was recorded due to application of 75 kg P ha⁻¹. However, application of 75 kg P ha⁻¹ was statistically at par with 50 kg ha⁻¹ for all growth characters, neck thickness of bulb and bulb diameter. Among the bio-fertilizers, inoculation with PSB + VAM recorded higher values of growth characters, yield attributes and yield of garlic.

Key words : Bio-fertilizers, bulb diameter, inoculation, phosphorous and VAM.

Introduction

Garlic (*Allium sativum* L.) is an important crop widely used as a spice or condiment and belongs to Alliaceae family. It possesses several medicinal properties and very popular in almost all Indian families. Now a days garlic cultivation has aroused interest among the farmers of Rajasthan and other parts of the country because of its steadily increasing demand in the market at attractive rates. Increasing demand of garlic obviates the necessity to increase its production for which maximization of the bulb yield per unit area is rather a more desirable proposition than increasing the area under cultivation. But, garlic yield is low due to a number of constraints, among which lack of balanced nutrient supply, diseases and moisture stress are the major ones (Potgieter, 2006).

One of the major problems affecting crop production is the rapid depletion of nutrients in smallholder farms (Achieng *et al.*, 2010). According to Diriba-Shiferaw *et al.* (2015) report, both growth and yield of garlic can also be improved through phosphorous fertilization along with inoculation of bio-fertilizers. Application of phosphorous can improve

soil fertility and eliminate the effect of nutrient deficiencies for garlic productivity (Lujiu *et al.*, 2004). This may lead to enhanced household cash income and food security of smallholder farmers in the region. The current study, therefore, was undertaken to investigate the effects of phosphorous and bio-fertilizers on growth and yield of garlic in Jaipur conditions.

Materials and Methods

A field experiment was conducted during *rabi* season of 2015-16 at Horticulture Research Farm, SKN Agriculture University, Jobner (Rajasthan) situated at latitude of 26° 05' North and longitude of 75°28' East, with altitude of 427 meters above the mean sea level. Soil of the experiment field had loamy sand in texture, slightly alkaline in reaction, low in electrical conductivity, low in organic carbon, available nitrogen, phosphorus and medium in available potassium.

The experiment was laid out in factorial randomized block Design with sixteen treatment combinations, four phosphorous levels viz. control, 25 kg ha⁻¹, 50 kg ha⁻¹ and 75 kg ha⁻¹ as one factor and inoculation with bio-fertilizers viz. control, PSB

Table-1 : Plant height (cm), no. of leaves plant⁻¹, total chlorophyll content in leaves and fresh weight of leaves of garlic as influenced by application of phosphorous and bio-fertilizers at harvest

Treatments	Plant height (cm)	No. of leaves plant ⁻¹	Total chlorophyll content in leaves (mg g ⁻¹)	Fresh weight of leaves (g)
Phosphorous levels (kg ha⁻¹)				
Control	25.89	5.00	0.629	15.18
25 kg ha ⁻¹	28.19	7.40	1.050	18.41
50 kg ha ⁻¹	30.49	8.59	1.113	21.08
75 kg ha ⁻¹	32.80	8.89	1.140	21.93
SEm±	0.63	0.16	0.022	0.35
LSD (p=0.05)	1.83	0.47	0.063	1.01
Bio-fertilizers				
Control	26.30	5.60	0.681	15.13
PSB	28.00	7.29	1.040	18.21
VAM	30.46	8.13	1.100	20.78
PSB + VAM	32.60	8.86	1.110	21.87
SEm±	0.63	0.16	0.022	0.35
LSD (p=0.05)	1.83	0.47	0.063	1.01
Interaction	NS	NS	NS	NS

Table-2 : Yield attributes of garlic as influenced by application of phosphorous and bio-fertilizers at harvest.

Treatments	Neck thickness of bulb (cm)	Bulb diameter (cm)	Fresh weight of bulb (g)	Bulb weight after curing (g)	No. of cloves bulb ⁻¹
Phosphorous levels (kg ha⁻¹)					
Control	0.580	5.10	40.43	21.89	15.15
25 kg ha ⁻¹	0.630	5.64	48.94	30.43	16.74
50 kg ha ⁻¹	0.674	6.22	52.94	34.44	18.21
75 kg ha ⁻¹	0.720	6.49	57.95	39.58	19.76
SEm±	0.014	0.13	0.64	0.38	0.34
LSD (p=0.05)	0.041	0.36	1.85	1.11	0.97
Bio-fertilizers					
Control	0.590	5.40	43.33	24.95	16.63
PSB	0.625	5.64	48.82	30.41	17.27
VAM	0.670	6.11	52.85	34.13	17.72
PSB + VAM	0.719	6.31	55.25	36.85	18.24
SEm±	0.014	0.13	0.64	0.38	0.34
LSD (p=0.05)	0.041	0.36	1.85	1.11	0.97
Interaction	NS	NS	S	S	NS

(Phosphorous solubilizing bacteria), VAM (Vesicular Arbuscular Mycorrhizal) and PSB + VAM as second factor. The treatments were replicated three times. A fertilizer schedule of 120: 100 kg NK ha⁻¹ was adopted as the common practice for the experiment through prilled urea for nitrogen and muriate of potash for potash. Full potassium and 1/3 part of urea were applied at the time of sowing as basally and remaining 2/3 part of prilled urea was top dressed in the three equal splits. Garlic variety "G-282" were used for the investigation which was developed from NHRDF-Karnal (Haryana). Sowing of garlic was done on 03rd November, 2015 using seed rate of 500 kg ha⁻¹. Application of phosphorous and inoculation with bio-fertilizers was done as per treatment.

The heights (cm) of ten randomly selected plants from each plot were measured from the plots of each treatment using a ruler. The number of leaves plant⁻¹ of ten randomly selected plants from each plot was counted. Total chlorophyll content in leaves was estimated with the method as recommended by Arnon (1949). Fresh weight and bulb weight of five tagged plant leaves was taken at harvest in ?g ? by weighing on double pan balance. Neck thickness and bulb diameter of tagged plants was measured with the help of vernier calipers and average was calculated in cm. Total numbers of cloves were counted from five randomly selected bulbs to compute the mean number of cloves per bulb. Bulb yield of garlic ha⁻¹ (q) was calculated on the basis of yield plot⁻¹. The data relating

Table-3 : Bulb yield of garlic as influenced by application of phosphorous and bio-fertilizers at harvest.

Treatments	Bulb yield (kg plot ⁻¹)	Bulb yield (q ha ⁻¹)
Phosphorous levels (kg ha⁻¹)		
Control	2.176	120.88
25 kg ha ⁻¹	2.578	143.22
50 kg ha ⁻¹	2.794	155.21
75 kg ha ⁻¹	2.899	161.06
SEm±	0.023	1.35
LSD (p=0.05)	0.066	3.91
Bio-fertilizers		
Control	2.416	134.21
PSB	2.534	140.76
VAM	2.697	149.81
PSB + VAM	2.801	155.58
SEm±	0.023	1.35
LSD (p=0.05)	0.066	3.91
Interaction	S	S

to each character were analysed as per the procedure of analysis of variance and significance was tested by "F" test (Gomez and Gomez 1984).

Results and Discussion

Effect on growth : Application of phosphorous and inoculation with bio-fertilizers caused significant effect on growth characters of garlic at harvest (Table-1). Application of 75 kg P ha⁻¹ exerted significantly higher plant height (32.80 cm), no. of leaves plant⁻¹ (8.89), chlorophyll content in leaves (1.140 mg g⁻¹) and fresh weight of leaves (21.93 g) which was statistically at par with application of 50 kg P ha⁻¹. This may be due to phosphorus influences photosynthesis, biosynthesis of proteins and phospholipids, nucleic acid synthesis, membrane transport and cytoplasmic streaming. Increase in availability of phosphorus owing to its application in the soil which was otherwise low in its content improved the nutrient availability status resulting increased photosynthetic and carbohydrate synthesis in garlic. The energy obtained from photosynthesis and metabolisms of carbohydrates was stored in storage compound (ADP and ATP) and then translocated to different parts for promoting meristemic development in potential apical buds and inter calary meristems which ultimately increased in vigour or growth of plants. In line with the above-said facts, the experimental findings of Mulatu *et al.* (2014); Bhandari *et al.* (2012) in garlic are also in agreement.

Among the bio-fertilizers (Table-1), inoculation with PSB + VAM observed higher plant height (32.60

cm), no. of leaves plant⁻¹ (8.86), chlorophyll content in leaves (1.110 mg g⁻¹) and fresh weight of leaves (21.87 g) and superior over rest of the treatments. This was due to the fact that PSB produce organic acids like gluconic, guccinic, lactic, oxalic, citric and -ketogluconic acid which convert the insoluble phosphate to soluble one and synthesize growth promoting substances which augment plant growth (Gaiind and Guar, 1992). The PSB increases the availability of phosphorus in root zone which in turn resulted in better growth and development of roots and shoots and also helped in better nodulation. The overall development of plant might have absorbed more nutrients and enhanced photosynthesis and production of assimilates, which in turn increased the plant height and chlorophyll content in garlic leaves. However, VAM inoculation helps in uniform crop growth and also enhances resistance to root disease and improve hardiness of transplant stock. So due to its obligatory symbiont nature and above discussed characteristics, increases its use in various crops (Yawalkar *et al.*, 1996). Significant increase in plant height, chlorophyll content, number and weight of leaves plant⁻¹ with VAM were mainly attributed to mobilization of phosphorus to plant which might have helped in easy uptake. Similar results were also reported by Bahadur *et al.* (2006) in pea, Biswas and Patra (2007) in green gram, Djebali *et al.* (2010) in common bean, pea, alfalfa and Ramana *et al.* (2010) in French bean, Yogita and Ram (2012) in onion.

Interaction effect of phosphorous levels and inoculation with bio-fertilizers failed to show any significant effect on growth characters of garlic.

Effect on yield attributes and yield : Yield attributes and yield of garlic was significantly influenced with various phosphorous and inoculation with bio-fertilizers. Significantly higher neck thickness of bulb (0.720 cm), bulb diameter (6.49 cm), fresh weight of bulb (57.95 g), bulb weight after curing (39.58 g) and number of cloves bulb⁻¹ (19.76) was observed under phosphorous fertilization of 75 kg ha⁻¹ (Table 2) which was statistically at par with application of 50 kg P ha⁻¹ except for bulb fresh weight, bulb weight after curing and number of cloves bulb⁻¹. This was due to the levels of phosphorus during this period regulates starch/sucrose ratio in the source leaves and the reproductive organ (Giaquinta and Quebedeaux, 1980). Phosphorus deficiency limits N₂ fixation mainly by reducing the growth of host plant. Thus, application of phosphorus might have resulted in increased

carbohydrate accumulation and their remobilization to reproductive part of the plant, being the closest sink and hence higher bulb diameter and garlic production.

Data pertaining (Table-3) to bulb yield plot⁻¹ (2.899 kg) and ha⁻¹ (161.06 q) was also observed under application of 75 kg P ha⁻¹ and showed superiority over rest of the treatments. This might be due to the fact that under adequate availability of nutrients, more nutrients might have taken up by the plants for greater photosynthesis and excess assimilates stored in the leaves and later translocated into parts at the time of senescence, ultimately led to higher bulb yield. These findings corroborate the results of Nasreen *et al.* (2009) in garlic.

In case of inoculation with bio-fertilizers (Table 2), PSB + VAM recorded significantly higher values of neck thickness of bulb (0.719 cm), bulb diameter (6.31 cm), fresh weight of bulb (55.25 g), bulb weight after curing (36.85 g) and number of cloves bulb⁻¹ (18.24) which was statistically at par with inoculation of VAM except for neck thickness of bulb, fresh weight of bulb and bulb weight after curing. Result suggested that (Table-3) inoculation with PSB + VAM recorded significantly higher bulb yield plot⁻¹ (2.801 kg) and ha⁻¹ (155.58 q) over rest of the treatments. This might be due to combined effect of PSB and VAM enhance nutrient uptake and available P status of soil. Similar findings were also reported by Singh *et al.* (2004) in pea, Narayanamma *et al.* (2005) in cauliflower, Dadhich *et al.* (2006) in soybean and Rathore *et al.* (2010) in urd bean.

Interaction effect of phosphorous levels and inoculation with bio-fertilizers could not reach the level of significance except for fresh weight of bulb, bulb weight after curing and bulb yield of garlic.

Conclusions

From the above overall study, it is recommended that to obtain higher growth and yield of garlic should be grown by application of 75 kg p ha⁻¹ along with inoculation of PSB + VAM under ago-climatic conditions of Jaipur region of Rajasthan.

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Effect of Sowing Schedules and Varieties on Growth and Yield of Cowpea (*Vigna unguiculata*)

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Abstract

A field experiment was conducted during the *kharif* season 2015 at the Crop Research Farm, Department of Environmental Science, SHUATS, Prayagraj (U.P.) to conclude the experiment on effect of sowing schedules and varieties on growth and yield of cowpea (*Vigna unguiculata*) in factorial Randomized Block Design with nine treatment combinations and replicated thrice. The results revealed that highest plant height (61.10 cm), number of branches (6.55). Yield and yield attributes viz., number of pods plant⁻¹ (21.58), grains pod⁻¹ (10.75), pod length (18 cm), Test weight (150g), seed yield (1482.50 kg ha⁻¹), straw yield (2797.75 kg ha⁻¹), were highest recorded in treatment T₃ (Variety Kashi Unnati + 2nd August DOS).

Key words : Sowing date, cowpea, *Vigna unguiculata*

Introduction

Cowpea is called as vegetable meat due to high amount of protein in grain with better biological value on dry weight basis. On dry weight basis, cowpea grain contains 23.4 per cent protein, 1.8 per cent fat and 60.3 per cent carbohydrates and it is rich source of calcium and iron (Gupta, 1988). Cowpea is one of common names in English: cowpea, bachapin bean, black-eyed pea. There are usually 8-20 seeds per pod. Seeds vary considerably in size, shape and colour. They are relatively large, 2-12 mm long and weigh 5-30g/100 seeds. Cowpea is considered more tolerant to drought than soybean or mung bean because of its tendency to form a deep taproot. It has a competitive niche in sandy soils and does not tolerate excessively wet conditions and should not be grown on poorly drained soils. One of the most remarkable things about cowpea is that it thrives in dry environments.

Based on FAO data and correspondence with scientists in different countries, annual cowpea production has increased from about 0.87 million tons in 1961 to 1.2 million tons in 1981 to 2.4 million tons in 1991, to more than 6.3million tons in 2011. The major increases have been in Niger, Nigeria, Mali, Burkina Faso, Senegal, Tanzania, Uganda, Congo, Myanmar, India, and Brazil.

The cowpea is grown worldwide with an estimated cultivation area of about 12 to 14 million hectares annually and an annual worldwide production of over 4.5 million metric tons (Singh *et al.*, 2002). India is one of the major countries contributing cowpea production in the World. It

is grown for its green pods, dry seeds and forage which are used for food and feed.

The cowpea is grown in 10 million hectares with the productivity of 387 kg ha⁻¹ (FAO, 2004). The cowpea is grown in an area of about 3.9 million hectares with the productivity of 567 kg per ha. The cowpea is grown on about 0.5 million ha with an average productivity of 600 to 750 kg grains ha⁻¹ in India (Ahlawat and Shivakumar, 2005).

The advances of science and technology have resulted mastery of many problems of the farmers, but not all of them have been solved. Weather and climate have not yet been brought under human control. Indeed, only a beginning has been made in the matter of its application in agriculture through weather forecasting and yield prediction. Because of weather, yields of even adopted crops fluctuate immensely each year despite all other inputs being optimum. Most of the crops are adapted to very specific localities and the crop yields suffer periodically. These variations are very delicate and are only partly explainable in terms of weather. About 80 per cent of phenotypic variability in plants may highly be attributed to the uncontrolled environment. The climatic factors can be used as a tool in the analysis of the processes of plant growth and development.

Plant growth and development are integrated responses to many agro- meteorological factors. These factors are affected by climate, soil and often a complex interaction of both. Crop production in an environment is a function of many variables, out of which weather is the

Table-1 : Interaction table on effect of different varieties and different sowing dates on growth and yield of cowpea (*Vigna unguiculaata*).

Treatment Combination	Plant height (cm) at different physiological stages				Number of branches	Number of pods plant ⁻¹	Number of grains pod ⁻¹	Pod length (cm)
	Branching	Flowering	Pod development	Pod maturity	At maturity	At maturity	At maturity	At maturity
T ₁ : V. Gomati + 2 nd August DOS	18.78	38.70	54.10	58.60	5.88	18.58	9.75	17.33
T ₂ : V. Kashi Kanchan + 2 nd August DOS	19.70	39.75	54.78	59.75	6.13	19.65	10.25	17.40
T ₃ : V. Kashi Unnati + 2 nd August DOS	22.03	42.20	56.20	61.10	6.55	21.58	10.75	18.00
T ₄ : V. Gomati + 12 th August DOS	18.30	38.30	53.40	58.35	5.63	17.88	9.25	15.50
T ₅ : V. Kashi Kanchan + 12 th August DOS	19.20	39.20	54.20	59.28	5.88	18.65	9.75	16.00
T ₆ : V. Kashi Unnati + 12 th August DOS	20.25	40.25	55.25	60.20	6.23	20.65	10.75	17.00
T ₇ : V. Gomati + 22 nd August DOS	17.55	37.55	52.55	57.55	5.30	15.83	7.75	15.10
T ₈ : V. Kashi Kanchan + 22 nd August DOS	18.50	38.25	53.25	58.25	5.48	17.58	8.50	15.50
T ₉ : V. Kashi Unnati + 22 nd August DOS	19.68	39.68	54.68	59.65	5.88	18.65	9.50	15.85
F- test	NS	NS	NS	NS	NS	NS	NS	NS
S. Em (±)	0.44	0.92	1.32	1.44	0.14	0.45	0.22	0.38
C. D. at 5%	-	-	-	-	-	-	-	-

Table-2 : Interaction table on effect of different varieties and different sowing dates on yield and yield attributes of cowpea.

Treatment combinations	Seed yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Test weight (gm)
T ₁ : Variety Gomati + 2 nd August DOS	12.75	24.22	126.00
T ₂ : Variety Kashi Kanchan + 2 nd August DOS	13.38	23.51	137.00
T ₃ : Variety Kashi Unnati + 2 nd August DOS	14.82	27.97	150.00
T ₄ : Variety Gomati + 12 th August DOS	12.25	22.05	115.00
T ₅ : Variety Kashi Kanchan + 12 th August DOS	12.88	21.37	130.00
T ₆ : Variety Kashi Unnati + 12 th August DOS	14.33	25.80	143.00
T ₇ : Variety Gomati + 05 August DOS	11.75	21.15	109.00
T ₈ : Variety Kashi Kanchan + 05 August DOS	12.38	20.37	120.00
T ₉ : Variety Kashi Unnati + 05 August DOS	13.66	24.90	135.00
F-test	S	NS	NS
S. Em (±)	0.19	52.98	3.00
C. D. at 5%	0.58	-	-

most important. Among weather variables temperature and rainfall are the most important factors, which affect the growth, productivity and adaptability of crops (Wallies *et al*, 1980).

Materials and Methods

The experiment was carried out during *kharif* season 2015 at Crop Research Farm, Department of Environmental Science, School of Forestry and Environment, Sam Higginbottom University of Agriculture, Technology and Sciences, Pratyagraj (U.P.), which is located at 25°24' 42" N latitude, 81° 50' 56" E longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna by the side of Allahabad Rewa Road about 5 km away from Allahabad city. It consists of three sowing date 2nd August, 12th August, 22nd August and three varieties Gomati, Kashi Kanchan and Kashi Unnati. The soil was sandy loam in texture, the pH of the soil was slightly alkaline in reaction (7.4), it was low in organic carbon (0.32 %), low in available nitrogen content (188.3

kg ha⁻¹), medium in available phosphorus (34.5 kg ha⁻¹), low in available potassium (87.3 kg ha⁻¹) and low in available sulphur (6 ppm) contents. Treatments were T₁-(D₁ + V₁) @ 2nd August DOS + Variety- Gomati, T₂ - (D₁ + V₂) @ 2nd August DOS + Variety- Kashi Kanchan, T₃-(D₁ + V₃) @ 2nd August DOS + Variety- Kashi Unnati, T₄ - (D₂ + V₁) @ 12th August DOS + Variety- Gomati, T₅-(D₂ + V₂) 12th August DOS + Variety- Kashi Kanchan, T₆- (D₂ + V₃) @ 12th August DOS + Variety- Kashi Unnati, T₇-(D₃ + V₁) @ 22nd August DOS + Variety- Gomati, T₈ - (D₃ + V₂) @ 22nd August DOS + Variety- Kashi Kanchan, T₉-(D₃ + V₃) @ 22nd August DOS + Variety- Kashi Unnati.

Interaction effects of three different varieties and sowing date on yields attributes and yield of cowpea :

The interaction effects of different varieties and sowing dates on number of branches plant⁻¹, pods plant⁻¹, grains pod⁻¹, pod length, straw yield, and test weight was non-significant. The highest number of branches, pods, grains, pod length, straw yield and test weight recorded

6.55, 21.58, 10.75, 18cm, 2797.75 kg ha⁻¹, 150 g respectively in T₃- 2nd August DOS + variety-Kashi Unnati.

The interaction effects of different varieties and sowing date on number of seed yield was significant. The highest seed yield recorded 1482.50 kg ha⁻¹ in T₃- 2nd August DOS + variety- Kashi Unnati. The decrease in seed yield of cowpea with late date of sowing also reported by Yadav (2003). The first week of August is best for sowing in compare to second and third week of August. Ravinder and Singh (1998), Taipodia and Nabam (2011), Patange *et al.* (2006).

Conclusions

Results of our study showed that date of sowing of 2nd August for Kashi Unnati variety of cowpea was best in terms of plant height, plant population per 2m² area; number of pods, seeds, pod length, pod yield, grain yield & straw yield. The same combination of sowing date and variety showed the best cost benefit ratio in cowpea.

On the basis of agrometeorological indices like growing degree days (GDD), photo thermal units (PTU), heliothermal units (HTU) and heat use efficiency (HUE) and heat unit requirement Kashi Unnati variety of cowpea performed best on sowing date of 2nd August.

Therefore, it can be concluded that to get the better growth and yields, Kashi Unnati variety of cowpea should be sown in second August under Allahabad weather conditions.

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Effect of Nutrient Management on Soil Fertility and Productivity of Rice under Different Crop Establishment Methods

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Abstract

A field experiment was conducted during kharif seasons of 2019 and 2020 at JNKVV, Jabalpur, M.P. to study the effect of nutrient management on soil fertility and productivity of rice under different crop establishment methods. Total eighteen treatment combinations consisted of three crop establishment methods (M₁:Transplanting, M₂:SRI and M₃:Wet seeded rice) put in main plot and six nutrient management practices (F₁:100% NPK, F₂:50% RDN + 50% N through sunhemp+100% P+100%K, F₃:75% RDN + 25% N through sunhemp+100% P+100% K, F₄ : 50% RDN + 50% N through vermicompost + 100%P+100%K, F₅:75% RDN + 25% N through vermicompost + 100%P+100% K and F₆ :100% NPK as per recommended dose + two spray of PGPR (*Pseudomonas*) were allocated to subplot. The experiment was laid out in split plot design with three replications. The crop established under SRI system proved significantly superior conventional transplanting and wet seeded rice and recorded 48.65 and 75.27 q/ha grain and straw yields, respectively. The productivity of crop enhanced with the integrated use of mineral fertilizer 75% RDN and 25%N through vermicompost and recorded 47.10 and 74.96 q/ha grain and straw yields, respectively in pooled data. The addition of either vermicompost or green manure crop along with 50% N to rice crop proved to be the best combination for maintaining the soil fertility and enhanced the fertility status of soil N 280.09, 287.8 and 284.44 kg/ha during first, second years and pooled data, respectively over initial value of 249.0 kg/ha. This treatment also showed the enhancement in phosphorus (13.70 kg/ha) and potassium (294.03 kg/ha) over initial value of 11.18 and 278.0 kg/ha, respectively after two years of experimentation. However, the crop establishment method found to be non significant with respect to fertility status of soil measured after post harvest of crop during both the years.

Key words : Rice, productivity, nutrient management and soil fertility.

Introduction

In India, national food security system largely depends on the productivity of rice. Conventionally, rice is grown by transplanting one month-old seedlings in puddled and continuously flooded soil. While water resources, both surface and underground, are shrinking and water has become a limiting factor in rice production (Farooq *et al.*, 2009). About 80% of the available water resources are being used by the agricultural sector (Sujono, 2007). Currently, on-farm availability of fresh water is reducing due to many reasons (Uphoff, 2006). It is estimated that 15-20 million hectares of irrigated rice, which provide three quarters of the world's rice supply, are expected to suffer upto some degree of water scarcity (IWMI, 2007). Hence, it is urgent need to save water for eliminating hunger. Now the cultivation practice of rice has been shifted from conventional transplanted rice to nonconventional production systems. These are resource conserving and economical which are direct seeded rice (DSR) and system of rice intensification (SRI). System of rice intensification emerged as an alternative for enhancing rice production by using less water, seeds, fertilizers, labor etc. Direct wet seeding is another way of rice growing over

transplanting. While transplanting in puddled fields involves raising of nursery, uprooting and transplanting of seedlings. In the wet method, pre- germinated seeds are used to sow on well prepared puddled field.

Management of plant nutrients is played an important role for growth and development of rice. Proper utilization and integration of nutrients sources have a significant effect on the growth which in turn enhances its yield attributes and yield (Das *et al.* 2008). Nutrient availability as well as uptake pattern from the organic and inorganic sources differ and thus may have differential influence on growth, physiological process and productivity. Chemical fertilizers contain very high amount of nutrients and these are the and easily availability of nutrient. However, chemical fertilizers alone had led to detrimental effect on soil health. In contrast, organic manure are nearly complete source for most of the nutrients and remain available for longer duration due to slow decomposition and gradual release of the nutrients into the labile pool (Das *et al.* 2014). Therefore, an integrated approach with the use of organic and inorganic inputs that nourishes the soil in many ways and supplies all the essential nutrients to the crops in sufficient amounts and make the nutrients readily available during

Table-1 : Effect of different methods of sowing and nutrient management on soil fertility status after two years of experimentation.

Particulars	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potash (kg/ha)		
Initial Values	249.0			11.18			278.0		
Treatments	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
A. Sowing Methods									
M ₁ -Transplanting	269.45	276.37	272.91	12.26	12.56	12.41	281.87	282.97	282.42
M ₂ -SRI	273.12	277.13	275.13	12.92	13.05	12.99	283.83	284.52	284.17
M ₃ -Wet seeded rice	270.06	274.42	272.24	12.04	12.53	12.28	280.76	281.51	281.13
SEm ±	0.93	0.85	0.77	0.25	0.29	0.24	2.60	2.63	2.61
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
B. Nutrient Management									
F ₁ -100% NPK (RD)	253.98	261.30	257.64	11.32	11.72	11.52	276.49	277.03	276.76
F ₂ -50% RDN+50% N through sunhemp + 100% P + 100% K	279.31	283.87	281.59	13.03	13.24	13.14	283.31	283.98	283.65
F ₃ -75% RDN + 25% N through sunhemp +100% P + 100% K	275.68	278.70	277.19	12.33	12.72	12.53	280.19	281.40	280.80
F ₄ -50% RDN + 50% N through vermicompost + 100% P + 100% K	280.99	287.89	284.44	13.55	13.85	13.70	293.66	294.40	294.03
F ₅ -75% RDN + 25% N through vermicompost + 100% P + 100% K	277.60	280.81	279.21	12.62	12.86	12.74	280.78	282.00	281.39
F ₆ -100% NPK (RD)+ PGPR (<i>Pseudomonas fluorescens</i>)	257.71	263.27	260.49	11.58	11.87	11.72	278.47	279.17	278.82
SEm ±	1.07	0.98	1.12	0.14	0.12	0.12	2.73	2.70	2.71
CD (P=0.05)	3.10	2.83	3.37	0.40	0.36	0.35	7.88	7.80	7.83

Table-2 : Grain, straw yields and harvest index of rice as influenced by crop establishment methods and nutrient management practices.

Treatments	Grain Yield (q ha ⁻¹)			Straw Yield (q ha ⁻¹)			Harvest index (%)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
A. Sowing methods									
M ₁ -Transplanting	41.01	44.20	42.61	66.05	70.61	68.33	38.38	38.56	38.47
M ₂ -SRI	47.67	49.64	48.65	75.21	75.33	75.27	41.63	39.75	40.69
M ₃ -Wet seeded rice	33.25	38.19	35.72	53.71	63.91	58.81	38.16	37.67	37.92
SEm ±	0.52	1.04	0.64	0.81	2.54	1.18	0.34	1.14	0.62
CD (P=0.05)	2.05	4.08	2.52	3.19	NS	4.62	1.33	NS	NS
B. Nutrient management									
F ₁ -100% NPK (RD)	37.10	38.88	37.99	60.27	63.74	62.00	38.43	37.60	38.01
F ₂ -50% RDN + 50% N through sunhemp + 100% P + 100% K	38.98	43.40	41.19	62.69	68.89	65.79	39.12	38.76	38.94
F ₃ -75% RDN + 25% N through sunhemp + 100% P+100% K	42.45	46.47	44.46	67.32	72.33	69.82	39.72	39.06	39.39
F ₄ -50% RDN + 50% N through vermicompost + 100% P+100% K	41.07	44.91	42.99	65.40	69.15	67.27	39.51	39.31	39.41
F ₅ -75% RDN + 25% N through vermicompost + 100% P+100% K	45.81	48.38	47.10	71.66	78.25	74.96	40.67	39.33	40.00
F ₆ -100% NPK (RD) +PGPR (<i>Pseudomonas fluorescens</i>)	38.46	41.99	40.23	62.60	67.32	64.96	38.87	37.91	38.39
SEm ±	0.80	0.41	0.45	1.26	2.23	1.44	0.72	0.81	0.55
CD(P=0.0 5)	2.32	1.19	1.30	3.65	6.46	4.16	NS	NS	NS

entire crop growth is required. The N management modules envisage use of vermicompost and green manures along with fertilizers and opportunity to achieve long term sustainability in crop production systems (Reddy *et al.* 2003). With this facts in view, experiment was conducted to study the effect of nutrient management on soil fertility and productivity of rice under different crop establishment methods.

Materials and Methods

The experiment was conducted during *Kharif* seasons of 2019 and 2020 at Soybean Research Farm, College of Agriculture, JNKVV, Jabalpur (M.P.) to assess the nutrient management on soil fertility and productivity of rice under different crop establishment methods. The climate of this region is sub-tropical with cool winter and hot summers

and mean annual rainfall of Jabalpur is 1350 mm. Jabalpur belongs to “Kymore Plateau and Satpura Hills” agroclimatic zone. The maximum temperature rises upto the extreme of 45°C and minimum temperature falls as low as to the limit of 4°C. The soil of experimental field was sandy clay loam in texture, neutral in reaction (7.3 pH) and normal in electrical conductivity (EC 0.33 dSm⁻¹) medium in organic carbon (0.65%), available N (249 kg/ha), available P (11.18 kg ha⁻¹) and high in available K (278.30 kg ha⁻¹). Eighteen treatments comprising of 3 sowing methods (M₁:transplanting, M₂:System of Rice Intensification and M₃:Wet seeded rice) put under main plot and 6 nutrient management practices (F₁:100 % NPK, F₂:50% RDN + 50% N through sunhemp+ 100% P + 100%K, F₃:75% RDN + 25% N through sunhemp+ 100%P + 100%K, F₄:50% RDN + 50% N through vermicompost + 100%P+100%K, F₅:75% RDN + 25% N through vermicompost + 100%P+100%K, F₆:100 % NPK as recommended dose + PGPR (*Pseudomonas*) in subplot. These treatments were arranged in split plot design with three replications. The rice variety JR-81 was used to sown. The recommended dose of N @ 120 kg/ha as was given in the form of urea and applied in 3 equal splits at transplanting, tillering and panicle-initiation stages as per treatments. In vermicompost treatments, well prepared vermicompost was incorporated before planting as per the treatments. Application of P₂O₅ and K₂O @ 60 kg and 40 kg/ha as single super phosphate and murate of potash, respectively given as per recommended dose of and applied as per treatments. Green manuring crop (sunhemp) was incorporated in soil before transplanting. Twenty five old days seedlings of rice were transplanted with 20 × 10 cm planting geometry under conventional transplanting method. Twelve old days seedlings of rice were transplanted with 20 × 20 cm planting geometry in SRI method. For wet seeded rice method, healthy seeds of rice variety were soaked for 24 hours in normal water incubate the seed in a gunny bag for an about 4-6 hours in order to facilitate sprouting. After this, direct seeding of wet seeded rice was directed seeded at 20 cm row apart. Grain and straw yields were as well as fertility status of post harvest soil was analyzed chemically and used for statistical analysis.

Results and Discussion

Results of study revealed that the status of soil with respect to fertility did not changed significantly due to methods of crop establishment in any of the crop season. However, fertility status of post harvest soils were slightly increased over initial values. The nutrient status was higher in the SRI method of crop establishment over rest of the two methods. Among the various nutrient management practices, it was come into the notice that

the integration of nutrient sources pose the significant positive results over 100% NPK alone. The significantly higher values of nitrogen, phosphorus and potassium were recorded where 50% N was given through mineral fertilizer and remaining 25%N given in vermicompost and recorded 280.99, 287.89 and 284.44 kg N/ha, 13.55, 13.85 and 13.70 kg/ha, phosphorus and 293.66, 294.40 and 294.03 kg/ha during 2019, 2020 and pooled data, respectively. Moreover, application of either 50% or 25% N through organics (either vermicompost or green manure) improved the soil fertility status over control (Table-1).

This improvement in fertility status under integrated nutrient management with organics (either of vermicompost or green manure) might be attributed to release of organic acids and other microbial products through the mineralization of organic matter might have influenced the availability of all these essential nutrients (Katyal *et al.* 2003).

Effect of crop establishment methods on yield of rice crop : Crop establishment methods, bring out the significant change in yields of rice during both the years and pooled data. It is clear from the pooled data of two years that yield of grain and straw both were higher in subsequent years over previous years. The establishment of crop under SRI system recorded significantly higher yields of grain (48.65 q/ha) and straw (75.27) q/ha yields which were superior over conventional transplanting and wet seeded rice. However, conventional transplanted rice proved superior over wet seeded rice (Table-2).

Similarly the integrated nutrient management practices pose the significant superiority over 100% RD of NPK alone and 100 RD of fertilizer + two spray of *Pseudomonas*. The significantly higher yields of 45.81, 48.38 and 47.10 q/ha grain and 71.66, 78.25 and 74.96 q/ha straw yields during first, second years and in pooled data, respectively under F₅. The treatment F₃ in which 75% N through mineral fertilizer and recommended 25% N through green manuring also proved superior over other treatments. Thus, it could be concluded that the application of 25% nitrogen either through vermicompost or green manure crop proved to be good with respect to grain and straw yields whereas, the soil fertility was maintain with the use of organics either vermicompost or green manure crop as supplemental source for 50% N and remaining 50% as mineral fertilizers. These findings are in close conformity with the findings of Kumar *et al.* (2016).

Conclusions

From the present investigation, it may be concluded that treatment receiving organic manure along with reduce dose (50 or 25%) of chemical fertilizer provide higher

productivity along with improvement in soil health under system of rice intensification method of rice cultivation.

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Evaluations of Quinoa for Yield Attributes and Yield under Different Thermal Regimes and Fertility Levels for Bundelkhand Agro Climatic Zone

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Abstract

The performance of new crop quinoa for yield attributes and yield under three thermal regimes and four fertility levels was evaluated at KVK Farm, College of Agriculture, JNKVV, Tikamgarh (MP) during 2019-20 and 2020-21. The twelve treatments comprising of three thermal regimes i.e. 15th November, 30th November and 15th December and these were super imposed with four fertility levels viz., F₀ (Control): (NPK 0:0:0), F₁: (NPK 80:40:40 kg/ha), F₂: (NPK 100:50:50 kg/ha) and F₃: (NPK 120:60:60 kg/ha) in split plot design with three replication. The panicles per plant, grains per panicle, harvest index, test weight and grain yield of quinoa were significantly affected by different thermal regimes being the maximum when sown on the thermal regime of 15th November and proved significantly superior over thermal regime of delayed sowing (30th November and 15th December). All the above yield and yield attributes were also affected by different fertility levels as values of said parameters increased proportionately with increasing fertility levels being the maximum in plots receiving 120 N: 60 P₂O₅: 60 K₂O kg/ha and found superior to other fertility levels.

Key words : Quinoa, thermal regime, fertility levels, yield attributes and yield.

Introduction

Bundelkhand agro-climatic zone of Madhya Pradesh is a semi-arid, drought prone and crops are mostly grown under rainfed conditions. This area is also affected badly by extreme weather events like frost in *Rabi* season and which affect the crops adversely. Malnutrition and protein deficiency are prevalent in this zone. Quinoa (*Chenopodium quinoa* Willd.), gaining importance all over the world as it is being grown in various agro-ecological conditions under wide range of temperature (-4 to 38°C) and tolerant to drought (Minh *et al.* 2022). The undulated fields, lack of irrigation facilities and abiotic stress affects crop yield and its attributes to a great extent. The drought event, decreasing ground water level and increasing migration in the recent past in rural areas (Anonymous, 2016). Quinoa has high nutritional, medicinal values and rich in amino acids, high quality protein content, vitamins and minerals (Kadam *et al.* 2018). Due to frequent abiotic stress, lack of irrigation facility and low productivity, the farmers of this zone are looking for an alternative crop, which is cost effective, attained sustainable yield and have high nutritive value as well. However, for the horizontal and vertical spread of this crop in Bundelkhand region, there is need to evaluate its performance under different thermal regimes and fertility levels for getting higher yields of quinoa, as very meagre information on suitable

agronomy of quinoa is available in the literature for this Zone. Henceforth, a comprehensive study was under taken to find out the suitable thermal regime and nutrient management for higher yields of quinoa in Bundelkhand region.

Materials and Methods

A field experiment was conducted at KVK Farm, College of Agriculture, JNKVV, Tikamgarh (M.P.) during *Rabi* season of 2019-20 and 2020-21. The twelve treatments comprising of three date of sowing (D₁: 15th November, D₂: 30th November and D₃: 15th December) as a main plots and four fertility levels of N:P:K (F₀: 0:0:0 control, F₁: 80:40:40, F₂: 100:50:50 and F₃: 120:60:60 kg/ha) as sub-plot treatments were assigned in split plot design with three replication. The quinoa was sown at a spacing of 45 cm X 10 cm with seed rate 5 kg/ha. The soil was medium black in texture, neutral in reaction (7.02 pH), medium in organic carbon (0.60%), low in available nitrogen (266 kg/ha) and high in available phosphorous (27 kg/ha) and potassium (256 kg/ha). The crop was irrigated 5 times during the crop season as and when crop showed moisture deficiency symptoms (drooping of leaves in the afternoon). The observations on yield attributes like, panicle per plant, grains per panicle, test weight, harvest index and yield were recorded at harvest for the analysis.

Table-1 : Yield attributes and yield of quinoa as affected by different treatments (mean data of two seasons).

Treatment	Panicles per plant	grains per panicle	Test weight (g)	Harvest index (%)	Grain yield (kg/ha)
Thermal regimes					
D ₁ (15 th Nov.)	15.92	197.02	2.200	13.31	1,620.50
D ₂ (30 th Nov.)	10.37	191.53	2.088	8.59	948.55
D ₃ (15 th Dec.)	8.96	165.45	1.957	6.81	667.72
SEm±	0.04	0.97	0.014	0.397	6.94
C.D. (P=0.05)	0.18	3.94	0.058	1.602	28.00
Fertility levels					
F ₀ (Control)	7.90	160.21	1.928	6.78	545.50
F ₁ 80:40:40	10.26	178.58	1.996	8.17	828.66
F ₂ 100:50:50	12.38	192.28	2.131	10.22	1,159.48
F ₃ 120:60:60	16.46	207.59	2.272	13.13	1,782.05
SEm±	0.08	1.18	0.011	0.538	4.37
C.D. (P=0.05)	0.24	3.54	0.034	1.611	13.09

Results and Discussion

Effect of thermal regimes on yield attributes and yield

: The mean data of two years on yield attributes and yield of quinoa as influenced by different thermal regimes and fertility levels are shown in Table-1. It is evident that thermal regimes had marked influence on yield attributes viz., panicles per plant, grains per panicle, harvest index, test weight and grain yield of quinoa. The sowing of quinoa on thermal regimes of 15th November had significantly superior values of panicles per plant (15.92) and grains per panicle (197.02) compared to other thermal regimes (30 Nov and 15 Dec) as appropriate time of sowing provides favourable weather conditions at different phenol phases for the plants and optimal physiological growth in comparison to delayed sowing of 30 November and 15 December thermal regimes. These results are in agreement with the findings of Shoman (2018). He reported that the number of inflorescence per plant, number of seeds per inflorescence attained higher values in case of December 1st sowing compared to other dates (Oct 1st and Nov 1st) in Hyderabad, Ramesh *et al.* (2017) also reported superiority of October 15th thermal regime for sowing with respect to yield attributes and yield due to efficient utilization of natural resources (water and nutrients) with optimum vegetative growth and higher translocation of photosynthates from source to sink. However, in case of delayed sowing (November 30 and December 15), the yield attributes and yield had lower values. The grain yield of quinoa also influenced by different thermal regimes. The grain yield of quinoa was maximum (1620.50 kg/ha), when it was sown on thermal regime of 15th November and proved significantly superior over thermal regimes of late sowing i.e. 30th November and 15th December and both the latter treatments had 41.46 and 58.79 per cent lower yield as

compared to sowing done on the thermal regime of 15th November. The higher yield might be due to superior values of yield attributes in case of thermal regime of 15th December but reverse was true in case of sowing done in the thermal regimes of November 30th and December 15th. Similar result have been reported by Hirich *et al.* (2014) and Sajjad *et al.* (2014).

Effect of fertility levels : It is obvious from the data given in Table-1 that different fertility levels had marked influence on panicles per plant, grains per panicle, test weight, harvest index and grain yield. The values of yield attributes namely panicle per plant, grain per panicle and grain yield were also affected significantly by different fertility levels. The grain per panicle, test weight, harvest index and grain yield were having minimum values in control plots where no major nutrients were given through fertilizers. However, the panicles per plant, grains per panicle, test weight, harvest index and grain yield were increased correspondingly with increasing fertility levels being the maximum when the quinoa was fertilized with 120 N: 60 P₂O₅: 60 K₂O kg/ha and it was found significantly superior over lower fertility levels (100 N: 50 P₂O₅: 50 K₂O and 80 N: 40 P₂O₅: 40 K₂O kg/ha).

Adequate supply of nitrogen, phosphorus and potassium leads to vigorous vegetative growth, high photosynthetic activity and dark green colour, which finally influence the better utilization of carbohydrates. While, adequate supply of phosphorus increase panicles per plant, especially grains per panicle and their survival helped in increasing the yield through efficient regulation of carbohydrates and supply of potassium facilitated better photosynthesis, protein and chlorophyll formation as well as translocation of assimilates from leaves to storage organs. These findings are in close proximity to that of Daughtry (2000). Maurya *et al.* (2014), Basra *et al.*

(2014), Ramesh *et al.* (2017) and Shoman (2018). Where as reduction in yield and poor values of yield attributes in lower fertility levels might be due to poor and imbalanced supply of major nutrients which produced inferior yield attributes and finally gave lower grain yield . These results are in agreement with the findings of Jat *et al.* (2013) as they found that sowing dates and fertilizer levels significantly affected the number of tillers, plant height, dry-matter accumulation, 1000- grain weight, grain and straw yield in wheat during *rabi* season.

Conclusions

It is concluded that sowing of quinoa in the thermal regime of 15th November and application 120 N: 60 P₂O₅: 60 K₂O kg/ha was found to be more productive for Bundelkhand region as compared to other thermal regimes and fertility levels.

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CHALLENGES FACED BY INDIAN WOMEN ENTREPRENEURS

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ABSTRACT

This study is an attempt to look into the challenges faced by women in pursuing entrepreneurship in India. This article is based on secondary research and observations. It is an attempt to identify the challenges that exist in women entrepreneurship in today's economic environment. It also looks at the factors that motivate women to take up entrepreneurship. This has been done with the help of reviewing of research articles and various reports.

INTRODUCTION

The origin of the word entrepreneurship is from French, which primarily means a director or a manager who organises certain musical or similar entertainments. This organiser ensures that the entertainment is well arranged. Over the centuries this term has been associated with military expeditions and civil engineering. Entrepreneurship denotes creating wealth in the economy by setting up a new business or revamping an existing one. This enables the entrepreneur to capitalise on emerging opportunities. It also helps in creating jobs, good and services.

Women Entrepreneurship: Not every one of us is an entrepreneur. It requires an attitude to make a difference and implementing great ideas. He or she is responsible for providing or creating everything that is needed for ensuring the running of the business. The entrepreneur has a great eye to spot opportunities, can see long term and has a personality of taking risks and following his passion which often is the business. This attitude is evolved over a period of time through our surroundings, learning's, experiences that are interwoven in the social fabric of life. When a woman manages the process of entrepreneurship that requires her to manage and organise the creation and running of the business, we refer to her as women entrepreneur.

Women account for half of the world's population. Indeed their presence in the professional world is increasing day by day. Women account for more than forty percent of the world's workforce. Economic liberalisation has ensured that women are joining the business world in great numbers. Education and economic and financial empowerment is helping women explore new opportunities. Yet, it's difficult to spot women in the senior management or boards. It is no different in entrepreneurship. In a business environment where

venture capitalist funding is catching up women entrepreneurs are outnumbered by men. The duality of the roles that women perform is a major cause for women unable to venture successfully into entrepreneurship. Added to that the social demarcation of the responsibilities that women have to perform causes a big hindrance from women foraying into self set ups.

This gender gap in entrepreneurship is also visible in the fundamental reason to initiate the entrepreneur journey. Men often identify a business opportunity whereas women often start their venture out of necessity. Further, the financial targets of women owned ventures are also found to be considerably lower than that of men. The difference also exists in the number of staff employed and the investment done in the ventures. Women often are tied down heavily by family and child rearing responsibilities that also becomes a major reason for closing the shop.

Challenges to women entrepreneurship : There are very many hinderances to women entrepreneurship. They can be categorised under the following headings.

1. Personal factors
2. Economic and legal factors
3. Social factors

Personal factors these include :

1. Inability to take risks : Women by their mere nature do not take risks and the Indian society also looks at this as a male domain than a female domain. This is a critical component of entrepreneurship.

2. Inability to take decisions : Indian women by their nature of upbringing itself are not to allowed take decisions. This is a big obstacle as entrepreneurship requires lot of independent decision making especially at the initial stages.

3. Ability to be consistent and deliver : Women give up easily. At the smallest obstacle they resort to winding up their business.

4. No big financial targets : Indian women do not aspire to make it big. Mostly entrepreneurial ventures are an extension of their own needs and they are happy to earn something more. Moreover lack of financial independence is a big hurdle to entrepreneurship.

5. Self confidence : Self confidence is a big issue with women entrepreneurs. It needs immense courage and mental agility to take business decisions which often women entrepreneurs lack.

6. Difficulty in travelling : Mobility and travelling are often challenging to women entrepreneurs due to the dual roles that they perform. This affects new set ups as one may need to travel to meet new people or work related purposes.

7. Lack of time : Women entrepreneurs are not able to dedicate long hours to their entrepreneurial set ups as the family and child care responsibilities take priority. This affect business ventures.

8. Lack of mentoring, networking and up skilling opportunities : Any entrepreneur gains a lot from experience sharing and mentoring. Women often find such initiatives taxing and therefore do not give much importance to it. Mentoring and up skilling on the other hand helps a lot to make considerable positive difference to business ventures.

Economic and legal factors

1. Women often have to kill their ideas or enthusiasm as they lack the government support in implementing their ideas. Though the government on paper talks of loans and funds getting them in reality is a bureaucratic nightmare. Often women are not even aware of such economic and financial supports either.

2. Lack of financial knowledge : Entrepreneurship calls for financial management skills as finances are a critical component of growth and sustenance of any business. Further, women often do not have the financial freedom to invest or reinvest in the business.

Social factors

1. Multiple roles : Women are considered home makers and it's difficult for women to convince the family members and society the need to be economically independent. Lot of times women have to face the issue of role conflicts.

2. Gender issue : Often women have to undergo harassment or negative behaviours because of their

gender and as a result they may give up even before they begin. Entrepreneurship has a big connect to the attitudes that have deep roots in our upbringing and experiences. This sadly is grey areas for Indian women.

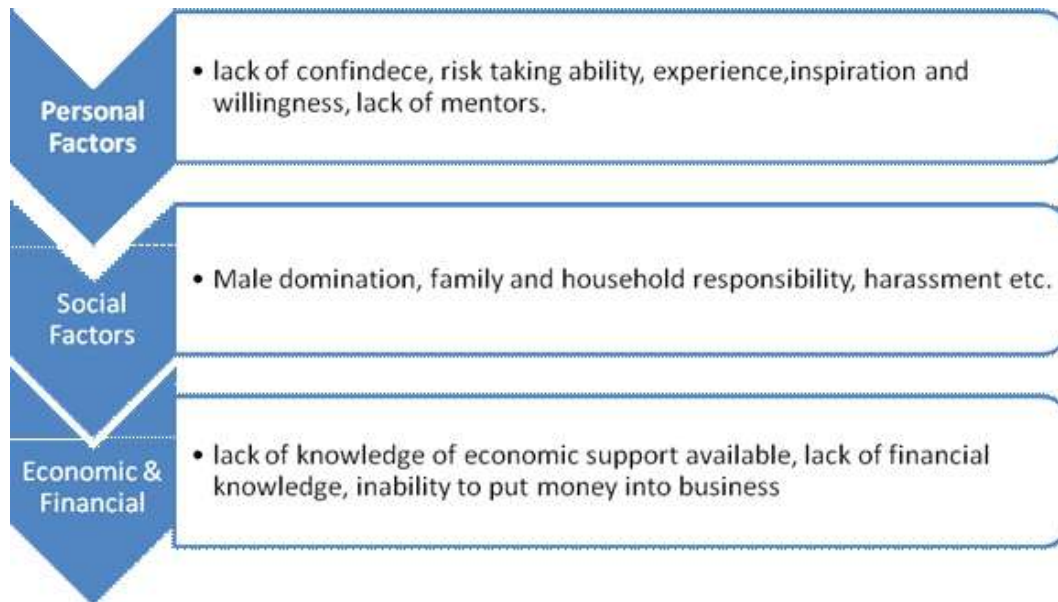
3. Male domination : Male dominance in our society does not let women prosper as most of the decisions are taken by males whether in households or in businesses. Women are not given the values of being ambitious and earners in the Indian society.

A Quick Glance at Some Recent Success Stories : The Founder Director of Mycutestickons and Think Cutieful, Ms. Romilla Tewari also began her journey like many of her counterparts out of her own need. She wanted to design the bedrooms of her two young daughters. It is what gave her the idea to start her own venture and identify the opportunity that existed in that space. She had a corporate stint in firms like Barista and Finnish.

Though none in her family had the interest to start their own venture forget dreaming of it, Romilla did not give up. She did not let her enthusiasm die down and went ahead to make it a reality. But it has not been easy for her and is open to admit that it was indeed difficult that she was a woman. That however did not let her spirit die. Another inspiring story is of the eighty seven year old Shila Ghosh. She had to resort to selling snacks and papad after the family responsibility came on her as her son passed away at the age of 47. Initially she tried selling wax candles, which did good business but the profits were less. That did not stop her. She was smart enough to change her product from candles to snacks and papad. She travels three hours daily to be at her place in Exide crossing to sell her produce. She suggests that it's better to follow one's own ideas and thoughts than others.

Smita Agarwal, was quick to spot the need for comfortable quality stays other than the five or four star hotels. That made her start Staywithus in Bangalore. This hospitality firm does both short and long stays and also offers homemade food for guests. She started her venture in 2012 and does not have any formal education in the hospitality business. That though did not stop her from creating her own stay options.

Ranjana Naik the Director of Swan Suites, located in Hyderabad is truly an inspiring one. The business offers an array of swanky serviced apartments to NRI's and corporate professionals. Ranjana dabbled with two ventures earlier on. What more her partner left as the business started going down. However that did not deter Ranjana. She restarted the venture with full energy and determination and from 15 rooms she touched 45 rooms in a span of two years and since then has not looked back.



She was adamant to succeed and did not let her motherhood come in her way.

The Motivational factors : Having said all this women are increasingly creating and experimenting with entrepreneurial ventures. The following factors work in favour of women.

1. The feminine characteristics give women an advantage of the monopoly in certain businesses like for example child care.

2. The entrepreneurial ventures given them the freedom to manage work life balance in a manner convenient to them thereby providing them the flexibility to take care of their family.

3. It provides them an opportunity to be economically independent and take their own decisions.

4. Identifying an opportunity that may also be a personal need helps women as they are equipped with the customer expectation and the product or service required. This is better than creating a new product line.

5. Entrepreneurship gives women the 'me time' with the family. It gives them the time to plan their day at their own free will.

6. Social media is a big boon to entrepreneurs. Even the household pickle to solar lamps can all be sold in virtual markets. This technological boom can be used beneficially by women entrepreneurs. It can also be used to learn the experiences of other entrepreneurs. It is also a good tool to network with prospective clients and customers.

CONCLUSIONS

Women entrepreneurs need to be encouraged and

motivated to start business ventures and grow them. They not only make them financially independent it also results in the overall betterment of the family, society and the country. It will also have a social impact on the outlook towards females. Women entrepreneurs are role models and inspire other women to experiment and pursue business ideas. This in turn generates employment opportunities and improves the economic situation of a country. Women need to be mentored and coached to help them realise the benefits of entrepreneurial ventures.

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Studies on Genetic Diversity, Variability and Character Association for Yield and Yield Attributes in Chickpea (*Cicer arietinum* L.)

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Abstract

Chickpea (*Cicer arietinum* L.) commonly known as gram is considered as an important pulse crop and a regular source of human nutrition. Despite its nutritional values and economic importance, chickpea production is relatively low in our country due to poor genetic variability of cultivars available. The effectiveness of selection depends on magnitude of variability, GCV, PCV, heritability and genetic advance for yield and its component traits. Study of inter-relationships among yield and its contributing traits is also necessary. The study was conducted to determine the variability, heritability and correlations between yield and yield components in 39 genotypes of desi chickpea (*Cicer arietinum* L.). Hence, present study on chickpea was conducted to define the appropriate selection criteria for screening high yielding chickpea genotypes. The objective of present study was to estimate magnitude of different parameters of genetic variability for yield and its attributes. Present study was evaluated in completed randomized block design replicated thrice at research farm of Krishi Vigyan Kendra, Ujjain during rabi-2017-18. Observations were recorded on plant height (PH), days to 50 per cent flowering (DTF), days to maturity (DTM), number of pods per plant, number of primary branches per plant (PBN), seed index (SI) and seed yield (SY). Present study revealed highly significant differences for days to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches, number of pods per plant, 100-seed weight (gram) and seed yield (kg/ha). The value of PCV was slightly higher than its respective value of GCV. The genotypic variance was highest for number of pods per plant followed by number of primary branches per plant. Broad sense heritability ranged from 53.8% (seed yield) to 99% (days to 50 per cent flowering). In this study heritability was high (greater than 80%) for all studied characters except seed yield. The genotypic correlation coefficients were in general, observed to be higher than that of phenotypic correlation coefficient for all the traits studied. Positive and significant relationships were determined between seed yield and number of pods per plant. On the basis of mean performance of all the characters except seed yield over all the checks *i.e.* BG-256, JG-16, & GCP-101 and Ujjain-21 (local check) only four genotypes (10 % genotypes) namely; HIR-70, Tungbhadra, RKG-135 and BDNG 2001-2-1 found promising indicated that these promising genotypes can be utilised for further improvement of chickpea.

Key words : Chickpea, gcv, pcv, heritability, genetic advance, correlation coefficient analysis.

Introduction

Chickpea (*Cicer arietinum* L.) considered as an important pulse crop and a regular source of human nutrition. This crop known as climate smart crop due to its unique production system reflecting resilient to climate change. It is prime food legume among pulses due to its manyfolds uses by the populations. It covered 149.66 lakh ha area, with production of 162.25 lakh tonnes and productivity of 1252 kg/ha during 2017-18 in the world (FAOSTAT, 2019). India placed on 1st position in area(71 %) and production(70 %) but lags behind several countries regarding productivity due to poor spread of improved varieties and technologies. It is the fifth place among food legume crop in the world following soybean, groundnut, drybean and dry pea. It is the major pulse crop of *rabi* season of India pre-dominantly cultivated on rainfed area. It improves the soil fertility in arid land due to leguminaceae. In India, chick raised on 105.61 lakh ha area with production of 112.29 lakh tonnes and 1063

kg/ha productivity during 2017-18. Madhya Pradesh is leading state regarding area(34%) and production(40%) in the nation (Annual Report 2017-18, Directorate of Pulses Development). The introduction of chickpea in a cereal based rotation, which is used particularly in developing countries, can break the disease and pest cycle, and increase the productivity of the entire rotation (Jodha and Subba Rao, 1987). There are two major types of chickpea *i.e.* kabuli and desi(brown). The former is grown in temperate regions while later *i.e.* desi chickpea is grown in semi-arid tropics (Muehlbauer and Singh, 1987). Chickpea plant is very sensitive to excess moisture, high humidity and cloudy weather which adversely affect its yield through limited flower production and seed set (Key, 1979).

Gram is the cheapest and readily available source of protein (19.5%), fats (11.4%), carbohydrates (57-60%), ash (4.8%) and moisture (4.9% - 15.59%) {Huisman and Vander Poel, 1994}. Despite its nutritional values and economic importance, chickpea production is relatively

low in our country due to majorly its poor genetic diversity among available cultivars. Hence, to enhance the genetic variability is first most requisite for any breeding programme targeted for improvement of crop yields. Because of increased recognition and its importance, evaluation and characterization of chickpea germplasm has received attention of the plant breeders (Virmani *et al.* 1983; Bakhs *et al.*, 1992).

The main objective of the most of the breeding programmes is to increase the yield (Lal and Tomer, 1980). To evolve cultivars having high yield potential, it becomes necessary to study the extent of variability in the available germplasm. The effectiveness of selection depends on magnitude of variability for yield and its component traits. Keeping all these facts in view, the present investigation was planned to study the variability present in different selection parameters and associations between yield and its components in advance breeding lines of chickpea.

Materials and Methods

The experimental material comprised of 39 diverse genotypes of desi chickpea (Table-4) including three checks namely; BG-256, JG-16, and GCP-101 and one local check (Ujjain-21) were evaluated in completed randomized block design replicated thrice at research farm of Krishi Vigyan Kendra, Ujjain during *rabi*-2017-18. Each plot has four rows of four meter row length spaced at 30 cm apart. The recommended package of practices was followed to raise a good crop. Observations were recorded on days to 50 per cent flowering (DTF), days to maturity (DTM), seed index (SI) and seed yield (SY) on plot basis whereas plant height (PH), number of pods per plant and number of primary branches per plant (PBN) were recorded on ten randomly selected plant basis. Mean data of various characters were subjected to statistical analysis (Panse and Sukhatme, 1969). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), heritability in broad sense (h^2) and genetic advance as per cent of mean were estimated using the procedure suggested by Johanson *et al.* (1955) as cited by Singh and Chaudhary (1979). Genotypic and phenotypic correlation coefficients were computed as per method suggested by Fisher (1918). Lush (1949) method was used to estimate expected genetic advance.

Results and Discussion

Analysis of variance disclosed highly significant differences among the genotypes for all the characters studied indicated that there is significant variability present among genotypes and have bright scope for improvement in these traits through which we can alter the yield levels.

The various parameters (general mean, range, genotypic and phenotypic coefficient of variation, heritability etc.) of genetic variability presented in table-1. Table-1 Unfolded that sufficient variability was present for days to 50 per cent flowering, plant height, primary branches per plant, number of pods per plant, seed index and seed yield. This variability can be utilized effectively to develop high yielding chickpea cultivars through hybridization followed by selection. Genotypic and phenotypic variations play an important role to understand the significant of each component on the expression of different characters. Table 1 showed low GCV and PCV for all the characters except for number of pods per plant and primary branches per plant only. In spite of this table-1 showed that phenotypic coefficient of variation are slightly higher than its respective genotypic coefficient of variation for all the traits indicating that environment played a minor role in the expression of traits and showing the pre dominance of additive type of gene action. Gautam *et al.* (2021) found similar findings in chickpea. Hence selection for these traits will be beneficial for improving the genetic make up of plant. Phenotypic coefficient of variation was maximum for number of pods per plant followed by primary branches per plant, seed yield, seed index, plant height, days to 50 per cent flowering and days to maturity. The genotypic variances for days to flowering, days to maturity, plant height and seed index are same as their phenotypic variances resulting in minimal environmental variances. This makes the heritability of these characters nearby 100%. The offspring of these lines will be exactly like their parents because there are no visible environmental effects on the expression of these characters. Low coefficients of variation of phenotype and genotype for all the characters except the yield parameters encourages the use of yield parameters in selection of suitable parents for crosses or lines for further improvement. The significant difference between the phenotypic and genotypic coefficient of variation of seed yield emphasized the significant role of environment in the inheritance of the characters. Genotypic coefficient of variation was found high for number of pods per plant and number of primary branches per plant. It was moderate for 100-seed weight, seed yield and plant height whereas low for days to 50 per cent flowering. Hasan *et al.* (2008) low genotypic coefficient of variation value for days to 50 per cent flowering and days to maturity, moderate for plant height, seed index and seed yield. Khan and Sharma (1999) reported high genotypic coefficient of variation for number of pods per plant. Similar trend was found for genotypic coefficient of variation (GCV) for all the traits though they were slightly low compared to PCV.

Heritability is the percentage of phenotypic variance

Table-1 : Genetic variability for seed yield and its component characters in chickpea.

Character	Mean	Range	GCV (%)	PCV (%)	h ² (%)	GA	GA (as % of mean)
Days to 50% flowering (Nos)	61.0	45.3 - 70.3	9.76	9.81	99.0	12.2	20.0
Days to maturity (Nos)	102.9	94.0 - 109.7	3.41	3.60	88.6	6.8	6.6
Plant height (cm)	49.9	33.0 - 66.1	13.52	13.78	96.2	13.6	27.3
Number of primary branches per plant	9.2	3.5 - 16.3	28.3	29.0	95.5	5.2	57.1
Number of pods per plant	44.7	19.5 - 83.6	31.5	32.0	97.3	28.6	64.1
Seed Index (g)	23.1	16.0 - 31.7	18.9	19.0	98.8	8.9	38.7
Seed Yield (kg/ha)	1815	1167 - 2444	16.4	22.4	53.8	44.9	24.8

Table-2 : Genotypic (G) and phenotypic(P) correlation coefficients for seed yield and its component characters in chickpea.

Character		DTF(50%)	DTM	PH(cm)	PBN	Pods/PI	SI(g)
DTM	G	0.559**					
	P	0.523**					
PH(cm)	G	0.355**	0.300**				
	P	0.346**	0.269**				
PBN	G	-0.017	0.150	-0.108			
	P	-0.018	0.152	-0.105			
Pods/PI	G	-0.265**	-0.171	0.196*	0.356**		
	P	-0.261**	-0.148	0.189*	0.352**		
SI(g)	G	0.012	-0.107	-0.123	-0.010	-0.087	
	P	0.010	-0.102	-0.123	-0.006	-0.088	
SY(kg/ha)	G	-0.267**	-0.353**	-0.094	0.056	0.482**	-0.302**
	P	-0.198*	-0.243**	-0.068	0.036	0.329**	-0.205*

*, ** significant at 5 and 1 per cent level of significance, respectively.

DTF(50%)= Days to 50% flowering; DTM = Days to maturity; PH(cm) = Plant height (cm).

PBN = Number of primary branches per plant; Pods/PI. = Number of pods per plant.

SI (g) = Seed Index(g); SY (kg/ha) = Seed Yield (kg/ha)

that is attributed to genetic variance. In the present study heritability, was high (greater than 80%) for all studied characters except seed yield. High heritability indicates that the environmental influence is minimal on characters. Any of the characters can, therefore, be used for selection. The selection for improvement of these characters may not be useful because broad sense heritability is based on total genetic variance which includes both fixable (additive) and non-fixable (dominance and epistatic) variances. Hasan *et al.* (2008) reported high heritability for seed index, days to 50 per cent flowering, plant height, number of primary branches per plant. Arun and Ram (1998) reported high heritability for days to 50 per cent flowering and seed index; Tripathi (1998) and Kumar *et al.* (1999) reported high heritability for number of pods per plant and seed index. In the present study, seed yield showed moderate heritability (53.8%). The comparatively lower heritability for seed yield, in this study, may be due to the fact that yield is a low heritable character which that is controlled by many genes. The progress in selection for this character in chickpea is general slow. Earlier study of Kumar and Krishna (1998) reported low heritability for seed yield.

Though high heritability indicates the effectiveness of selection on the basis of phenotypic performance, it does not show any indication of the amount of genetic progress for selecting the best individuals. The high genetic advance was observed for seed yield (44.9%) indicated that the character (seed yield) is governed by additive genes and selection would be rewarding for improvement of the yield. The moderate genetic advance was recorded for number of pods per plant (28.6%), plant height (13.6%) and days to 50 per cent flowering (12.2%) whereas seed index, days to maturity and primary branches per plant revealed low genetic advance indicated non-additive type governance and heterosis breeding for improvement of days to maturity, seed index and number of primary branches per plant may be useful.

Heritability and genetic advance are the important selection parameters. The expected genetic advance that was low for days to maturity, primary branches per plant and seed index may be compensated by their high heritability. Ali *et al.* (2002), Najeeb *et al.* (2009) found that high heritability may not always linked with high genetic advance. Since high value heritability does not always indicate a high genetic gain, heritability is recommended

Table-3 : Promising genotypes over different checks for all the traits in chickpea.

SN	Check	Promising genotype	Check	Promising genotype	Check	Promising genotype	Local Check	Promising genotype
1.	JG-16	Phule G 00110	GCP-101	HIR-70	BG-256	HIR-70	U-21	GJG-0703
2.		HIR-70		JG-16(C)		JG-16(C)		H-04-08
3.		Tungbhadra		Tungbhadra		Tungbhadra		HIR-70
4.		RVSSG-1		RVSSG-1		GCP-101(C)		JG-16(C)
5.		BG-3004		RKG-135		GNG-1936		H-04-75
6.		RKG-135		JG-14-11		BG-3004		Tungbhadra
7.		BDNG 2001-2-1		PBC-161		RKG-135		BG-256(C)
8.				GL-26083		PBC-161		IPC-2004-1
9.				BDNG 2001-2-1		BGM-569		GNG-1958
10.						BDNG 2001-2-1		KGD-1209
11.								IPC-1204-17
12.								BAUG-7
13.								GCP-101(C)
14.								BAUG-12
15.								GL-26054
16.								RKG-135
17.								RVSSG-2
18.								RKG-141
19.								JG-14-11
20.								Phule G 97030
21.								PBC-161
22.								BGM-569
23.								BDNG 2001-2-1
24.								PBC—88

to be considered in association with genetic advance to predict the effect of selecting superior crops genotypes. The characters namely; days to maturity, number of primary branches per plant, and 100-seed weight showed high heritability accompanied with low genetic advance indicated the non-additive type of gene action. The high heritability is being exhibited due to favourable influence of environment rather than genotype and selection for these traits may not be rewarding. Similarly, Arshad *et al.*, (2003) observed high heritability and low genetic advance for days to flower, days to maturity and hundred seed weight in chickpea and indicated that these characters were controlled by dominant and epistatic genes. The characters namely; days to flowering, plant height, and number of pods per plant showed high heritability coupled with moderate genetic advance indicated that these traits are governed by the additive type of gene action. The selection of genotypes based on these traits would be rewarding. The main economic trait *i.e.* seed yield had moderate heritability accompanied with high genetic advance showed that character was governed by additive gene effects. The moderate heritability is being exhibited due to environmental effects and selection would be rewarding for this character. Gautam *et al.* (2021)

observed high heritability and high genetic advance for seed yield and indicated that these characters can be improved upon by selection since they were under control of additive gene effect.

Correlation Coefficients : The inter-relationship among different characters of gram was given in table-2. In the present investigation, the genotypic correlation coefficients were in general, observed to be higher than that of phenotypic correlation coefficient indicating the strong inherent association for the various traits studied pointing out the possibility of effective phenotypic selection. At phenotypic level, association of seed yield was positive and significant with number of pods per plant and 100-seed weight. These results suggested that any positive increase in such traits will enhance the seed yield. These results were in accordance with those reported by Güler *et al.* (2000) and Uddin *et al.* (1990). Whereas it revealed significantly negative association with days to 50 per cent flowering and days to maturity. It indicated that late flowering genotypes had short reproductive period that results into low yield. In this case early flowering lines could be selected for higher yield. Days to 50 per cent flowering revealed highly significant and positive association with days to maturity and plant height but

Table-4 : List of desi chickpea entries evaluated during Rabi 2017-18.

S.No.	Variety	S.No.	Variety
1.	GJG-0703	21.	KDG-1249
2.	BG-3003	22.	RVSSG-1
3.	H 04-08	23.	BAUG-12
4.	Phule G 00110	24.	GJG-0714
5.	JG 9-3	25.	BG-3004
6.	HIR-70	26.	GL-26054
7.	JG-16(C)	27.	RKG-135
8.	H 04-75	28.	RVSSG-2
9.	CSJ-515	29.	RKG-141
10.	NDG 9-21	30.	JG 14-11
11.	Tungbhadra	31.	NBeG-13
12.	BG-256(C)	32.	Phule G 97030
13.	IPC 2004-1	33.	PBC-161
14.	RSG-811	34.	GL 26083
15.	GNG-1958	35.	BGD-1053
16.	KDG-1209	36.	BGM-569
17.	IPC 2004-17	37.	BDNG 2001-2-1
18.	BAUG-7	38.	PBC-88
19.	GCP-101(C)	39.	U-21(LC)
20.	GNG-1936		

highly significant negative correlation with number of pods per plant and seed yield, indicated that early flowering had more number of pods per plant that results into high yield. Days to maturity showed highly significant positive association with days to 50 per cent flowering and plant height whereas it was negative with seed yield. Plant height revealed significant positive association with days to 50 per cent flowering, days to maturity and number of pods per plant. Number of primary branches per plant showed positive correlation with number of pods per plant. Number of pods per plant revealed highly significant positive association with seed yield, number of primary branches per plant and plant height whereas it was negatively correlated with days to 50 per cent flowering. Mather and Mathur (1996) and Arshad *et al.* (2003) reported negative correlation of days to 50 per cent flowering with grain yield in chickpea. Tripathi (1998) and Yucel *et al.* (2005) found significant positive correlation of number of pods per plant with seed yield. Hasan *et al.* (2008) reported that seed yield showed positive significant association with number of pods per plant. Deshmukh and Patil (1995) and Khorgade (1995) also reported positive correlation of seed yield with number of pods per plant.

Promising genotypes : The promising genotypes which were significantly superior to the checks for various characters are given in table 3. Only one genotype BG-3004(2444 kg ha⁻¹) found higher seed yield over checks for central zone (GCP-101 and JG-16) and local check (U-21) for seed yield whereas fifteen genotypes

revealed seed yield superiority over an another zonal check (BG-256).

Days to 50 per cent flowering : Fourteen genotypes revealed earliness in flowering than Check JG-16 (60.7 days), twenty one genotypes showed early flowering than check GCP-101(62.3 days), twenty five genotypes showed early flowering than check BG-256(63.7 days) and thirty one genotypes disclosed earliness in flowering than U-21(local check, 66.3 days) whereas remaining seven genotypes could not showed earliness in flowering over any check used in the trial.

Days to maturity : Nine genotypes revealed early maturity than Check JG-16 (99.0 days), fifteen genotypes showed early maturity than check GCP-101(103.0 days), twenty nine genotypes showed early maturity than check BG-256(105.3 days) and all thirty eight genotypes disclosed earliness than U-21(local check, 109.7 days) in the present study.

Plant Height(cm) : Twenty-six genotypes showed tallness over local check U-21(47.6 cm), twenty-three genotypes revealed higher plant height than check GCP-101(48.3 cm), nineteen genotypes showed tallness over check JG-16(49.9 cm) and only four genotypes namely; GNG-1958 (59.5 cm), CSJ-515 (60.9 cm), GJG-0703 (63.6 cm) and H 04-75(66.1 cm) disclosed higher plant height over check BG-256.

Number of primary branches : Thirteen genotypes showed superiority in primary branches over check JG-16(10.1), four genotypes revealed higher primary branches than check BG-256(12.0), none of the genotype showed superiority in primary branches over check GCP-101(16.3) whereas all thirty eight genotypes disclosed superiority in primary branches over U-21(local check, 3.5) in the present study.

Number of pods : Ten genotypes showed superiority over check JG-16(48.9), fifteen genotypes revealed higher pods than check BG-256(45.3), none of the genotype showed superiority in pod numbers over check GCP-101(83.6) whereas twenty five genotypes disclosed superiority in pod numbers over local check, U-21(41.0).

100-seeds weight(g) : Two genotypes(JG 9-3 & GNG-1958) showed superiority over check BG-256(29 g), twenty four genotypes revealed higher seed index than check JG-16(21 g), thirty two genotype showed superiority over check GCP-101(18.7 g) whereas thirty five genotypes disclosed superiority over local check, U-21(17.7 g).

Seed Yield(kg/ha) : Eighteen genotypes showed yield superiority over check BG-256(1861 kg/ha), three

genotypes namely; BG-3004(2444 kg/ha), U-21,LC(2425 kg/ha) & JG-16,C(2278 kg/ha) revealed higher seed yield than check GCP-101(2274 kg/ha), two genotypes {BG-3004(2444 kg/ha), U-21,LC(2425 kg/ha)} showed superiority over check JG-16(2278 kg/ha) whereas only BG-3004(2444 kg/ha) disclosed yield superiority over local check, U-21(2425 kg ha⁻¹). These promising genotypes could be used as parental lines in future hybridization programme for developing high yielding varieties of desi chickpea.

As per the table-3; The present study revealed that only seven genotypes found promising over check (JG-16), nine genotypes including check JG-16 disclosed promising over check (GCP-101), ten genotypes exhibited superiority over check (BG-256) and twenty four genotypes including all three checks utilised for the study revealed superiority in desired direction for most of the characters studied. On the basis of all the characters except seed yield over all the checks *i.e.* BG-256, JG-16, and GCP-101 and Ujjain-21 (local check) only four genotypes (10 % genotypes) namely; HIR-70, Tungbhadra, RKG-135 and BDNG 2001-2-1 found promising indicated that these promising genotypes can be utilised for further improvement of chickpea yield plateau.

Conclusions

To develop high yielding cultivars, it becomes necessary to study the extent of variability present in the available germplasm. The effectiveness of selection depends on magnitude of variability for yield and its component traits. Keeping all these facts in view, the present investigation was conducted to study the extent of variability present in different selection parameters and inter-relationship between yield and its components in available group of breeding lines of chickpea. Sufficient variability was observed for days to 50 per cent flowering, plant height, primary branches per plant, number of pods per plant, seed index and seed yield. The PCV are slightly higher than its respective GCV for all the traits indicating the pre dominance of additive type of gene action. GCV was found high for number of pods per plant and number of primary branches per plant; moderate for 100-seed weight, seed yield and plant height whereas low for days to 50 per cent flowering. At phenotypic level, association of seed yield was positive and significant with number of pods per plant and 100-seed weight. Whereas it revealed significantly negative association with days to 50 per cent flowering and days to maturity. Heritability, was high (greater than 80%) for all studied characters except seed yield. High heritability indicates that the environmental influence is minimal on characters. The high genetic advance was

observed for seed yield (44.9%) indicated that the character (seed yield) is governed by additive genes and selection would be rewarding for improvement of the yield. The moderate genetic advance was recorded for number of pods per plant (28.6%), plant height (13.6%) and days to 50 per cent flowering (12.2%) whereas seed index, days to maturity and primary branches per plant revealed low genetic advance indicated non-additive type governance and heterosis breeding for improvement of traits may be useful. The characters namely; days to flowering, plant height, and number of pods per plant showed high heritability coupled with moderate genetic advance indicated that these traits are governed by the additive type of gene action. The main economic trait *i.e.* seed yield had moderate heritability accompanied with high genetic advance showed that character was governed by additive gene effects. The selection of genotypes based on these traits would be rewarding. Table 3 revealed promising genotypes over different checks used in the study.

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Pedospheric Variations in Distribution of Dtpa-Extractable Micronutrients as Influenced by Physiography in Nagenahalli Micro Watershed, Bengaluru Rural District of Karnataka

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Abstract

The five soil profiles developed on different physiographic units (1. Level to nearly level linear upland summit 2. Level to nearly level upland convex upper sector 3. Very gently sloping upland convex middle sector 4. Very gently sloping upland convex lower sector and 5. Gently sloping upland concave lower sector) in Nagenahalli micro-watershed, Karnataka (India) were studied for the distribution of DTPA extractable micronutrients. The changes in physiography had a strong influence on micronutrient distribution. The DTPA Zn, Cu and Fe decreased with increasing soil depth but DTPA Mn did not follow a definite trend. Maximum soil properties had significant effect on DTPA extractable micronutrients. Based upon the linear coefficient of correlation between DTPA-extractable micronutrients and soil properties according to physiography (i) the highest and significant relationship between DTPA Fe and OC ($r = 0.944^*$) was found in soils of Level to nearly level linear upland summit (ii) organic carbon had a pronounced effect on increasing the Cu ($r = 0.866^*$) availability in soils of very gently sloping upland convex middle sector (iii) organic carbon had least effect on availability of Zn ($r = 0.054^*$) in soils of level to nearly level upland convex upper sector. The additive effect of organic carbon was found to be more pronounced in Cu among all the micronutrient cations, irrespective of physiography.

Key words : Pedospheric; micronutrients; physiographic units; India.

Introduction

Variation in soil properties from place to place arise from differences in parent material, climate, topography, biosphere and the age of ground surface. Soil physiography play an important role in the distribution of mineral nutrients. The pedospheric variations due to soil properties, parent material, physiography, climate, etc., leads to spatial variation of nutrients in soils (Verma *et al.*, 2005). Even if the parent material does not vary, the variation in physiography in a given area significantly affects the soil properties and, in turn, nutrient availability.

With the introduction of high yielding varieties, the removal of nutrients including micronutrients from the soils is very large. In the present study area, over the past couple of decades, the farmers have started cultivation of maize being exhaustive in terms of nutrient removal, results in increased pressure on native nutrient reserve of soil. Hence, now, the soil ill health due to nutrient deficiency is becoming a major challenging issue. Therefore, for an effective correction of a nutrient deficiency in the field, it is necessary to get information about the inherent capacity of soil to supply nutrient from the lower soil layers (Setia & Sharma, 2004).

The distribution of nutrients may differ among the profiles developed on different parent materials and landforms. As the distribution of nutrients in soils is closely

related to pedogenic development, the present study was, therefore, undertaken to analyze the influence of physiography on vertical distribution of available nutrients vis-a-vis soil characteristics in the soils developed on different land forms of Nagenahalli micro water shed, Doddaballapur taluk in Bangalore rural district of Karnataka.

Materials and Methods

The study area covering 225.2 ha constitutes a part in eastern dry agro climatic zone, lies between 13°22'20.66" N to 13°22' 20.2" N latitude and 77°32' 55.30" E to 77°33' 27.7" E longitude. The elevation is in the rage of 911 to 930 m above MSL. Detailed soil survey was done using Base maps, google earth images, toposheets and satellite imagery (1:12,500 scale) collected from Karnataka State Remote Sensing Application Centre, Bangalore. Geologically, the area is dominated by Archaean granites and gniesses on upland and colluvium on convex lower sectors. Small patches are there with basic rocks in granitic landscape itself. Climate of the study area is semiarid tropical monsoonic type. Mean nnuual rainfall is 826.3 mm (IMD 2001), rainy days extends from July to mid-October and qualifies for isohyperthermic soil temperature regime and Udic soil moisture regime.

In order to understand the landform –soil relationships of the watershed, a measured cross section

Table-1 : Details of pedons identified for assessment micronutrient status of the watershed.

Study area	Pedon no.	Land forms	Land use
Nagenahalli	1	Very gently sloping upland	Ploughed land (Maize in nearby plots)
	2	Gently sloping upland	Eucalyptus plantation (Rattoon crop)
	3	Very gently sloping upland	Fallow land (Ground nut and eucalyptus in nearby plots)
	4	Nearly level upland	Ploughed land (Red gram and ragi in nearby plots)
	5	Nearly level upland	Fallow land (Ragi and eucalyptus in nearby plots)

Table-2 : Physico-Chemical Characteristics of Soils of Nagenahalli micro water shed, Karnataka, India.

Depth (cm)	Horizon	BD Mg m ⁻³	Particle-size distribution (%)			Texture	OC (%)	CEC Cmol (P+) kg ⁻¹
			Sand (mm)	Silt (mm)	Clay (mm)			
Pedon 1								
0-12	Ap	1.50	86.50	3.50	10.00	ls	0.39	15.24
12-27	Bt1	1.46	72.50	1.50	26.00	scl	0.36	16.39
27-48	Bt2	1.65	72.00	2.00	26.00	scl	0.29	7.99
48-59	Bt3	1.40	54.05	5.50	44.40	sc	0.25	16.28
59-81	Bt4C	1.50	48.00	3.50	48.50	vgsc	0.14	2.48
81-125	Bt5C	1.34	49.00	2.50	48.50	gsc	0.07	2.92
125-150+	Bt6C	1.27	45.50	7.00	47.50	gc	0.07	2.62
Pedon 2								
0-14	A1	1.66	85.00	3.00	11.00	ls	0.43	16.69
14-37	Bt1	1.69	85.00	4.00	7.00	ls	0.36	13.43
37-56	Bt2	1.66	56.50	2.00	41.50	sc	0.32	16.85
56-80	Bt3	1.66	57.50	2.50	40.00	sc	0.25	1.79
80-120	Bt4	1.67	54.5	5.00	40.50	sc	0.29	1.72
9120-150+	Bt5	1.67	54.5	3.50	42.00	sc	0.03	3.38
Pedon 3								
0-13	Ap	1.62	85.50	1.50	13.00	ls	0.36	10.86
13-41	Bt1	1.63	83.50	16.00	13.50	sl	0.32	16.74
41-66	Bt2	1.71	76.50	4.50	19.00	sl	0.25	12.72
66-104	CB1	1.52	69.00	7.00	24.00	scl	0.07	18.40
104-133	CB2	1.45	58.00	13.50	28.50	scl	0.04	20.57
133-150+	CB3	1.65	55.00	4.50	40.50	sc	0.01	19.82
Pedon 4								
0-13	Ap	1.60	83.00	2.00	15.00	sl	0.27	15.41
13-29	Bt1	1.60	61.50	1.00	37.50	sc	0.24	17.56
29-48	Bt2	1.60	51.00	7.50	41.50	sc	0.26	19.67
48-96	Bt3C1	1.60	59.50	4.50	36.00	egsc	0.14	18.98
96-125	Bt4C2	1.58	56.50	9.50	34.00	gscl	0.03	4.41
125-150+	Bt5C3	1.50	46.50	11.00	42.50	sc	0.01	3.49
Pedon 5								
0-16	Ap	1.60	79.00	2.50	18.50	sl	0.29	9.45
16-44	Bt1	1.30	60.50	1.50	38.00	sc	0.25	18.76
44-70	Bt2	1.20	49.50	4.00	46.50	sc	0.12	19.31
70-122	Bt3	1.30	46.50	6.50	47.00	sc	0.04	21.47
122-150+	Bt4	1.30	43.50	9.00	47.50	c	0.01	17.98

was studied using Sunto clinometers. Slope angles were measured at 10 to 20 meter intervals between the elevation of 950 and 920 m above MSL. The measured slopes were grouped together and based on the angular discontinuity; landforms were identified. The soil land-form was studied based on the terrain analysis study is given in table 1. Five soil profiles representing different

physiographic units were exposed (Fig. 1) and horizon wise sampling was done. The processed soil samples were analyzed for pH, electrical conductivity (EC), organic carbon (OC), BD, CEC and micronutrients using methods outlined by Jackson (1973). The relationship between various soil properties and micronutrient distribution was established by using simple correlation analysis.

Table-3 : Distribution of DTPA extractable micronutrients in the soils of Nagenahalli micro water shed, Karnataka, India.

Depth (cm)	1:2.5 (Soil : water)		Micronutrients (mg kg ⁻¹)			
	pH	EC	Zn	Cu	Fe	Mn
Pedon 1						
0-12	5.96	0.07	2.60	1.22	23.00	10.20
12-27	5.35	0.09	0.56	1.60	22.20	30.80
27-48	5.86	0.09	0.62	2.80	18.80	10.20
48-59	6.27	0.09	0.44	0.92	12.40	4.96
59-81	6.51	0.03	0.14	0.50	5.40	4.86
15 81-125	6.51	0.04	0.12	0.40	1.00	3.38
125-150+	6.89	0.03	0.18	0.16	1.80	2.56
Pedon 2						
0-14	4.70	0.02	0.30	0.82	22.66	18.20
14-37	5.60	0.02	0.38	0.80	18.04	11.20
37-56	5.80	0.02	0.12	0.70	16.80	10.80
56-80	6.51	0.01	0.16	0.40	8.20	8.20
80-120	6.77	0.03	0.34	0.54	7.80	7.00
120-150+	6.73	0.02	0.30	0.50	7.60	2.20
Pedon 3						
0-13	5.42	0.03	0.26	0.56	20.20	12.42
13-41	5.42	0.02	0.22	0.42	15.00	18.50
41-66	6.32	0.09	0.18	0.52	12.22	32.00
66-104	6.64	0.06	0.32	0.40	19.80	34.20
104-133	6.64	0.05	0.10	0.28	12.20	16.60
133-150+	6.92	0.07	0.18	0.24	9.40	13.40
Pedon 4						
0-13	4.77	0.06	0.54	0.60	21.00	29.00
13-29	5.67	0.04	0.50	0.90	16.40	46.80
29-48	5.97	0.04	0.28	0.72	9.00	16.70
48-96	6.82	0.02	0.04	0.28	8.00	6.12
96-125	6.94	0.01	0.30	0.36	7.20	12.30
125-150+	6.94	0.02	0.28	0.40	7.60	12.42
Pedon 5						
0-16	4.57	0.02	0.34	1.02	23.30	25.20
16-44	5.37	0.02	0.24	1.28	15.61	34.40
44-70	6.59	0.02	0.24	1.04	7.00	15.60
70-122	6.80	0.03	0.22	0.64	6.80	17.00
122-150+	6.80	0.07	0.33	0.70	6.00	18.50

Table-4 : Correlation between soil properties and DTPA-extractable micronutrient.

	BD	Sand	Silt	Clay	OC	CEC
Zn	0.298803	-0.43754073*	-0.129907736	0.455663832*	0.59071511*	0.002696
Cu	0.416386*	-0.633344343*	0.495051267*	0.555470896*	0.766004092*	0.120383
Fe	0.451955*	-0.785039703*	0.459979163*	0.765745696*	0.696511064*	0.178075
Mn	0.170185*	-0.492060592*	0.469244627*	0.438098703*	0.571607642*	0.267706



(Source: Google earth)

Plate-1 : Land scape and pedon locations in Nagenahalli watershed, Doddaballapur taluk, Bangalore Rural District.

Results and Discussion

Soil land form relationship : Most of the area under watershed is cultivated and were observed to have dark red colour with uniform texture due to the presence of eucalyptus plantations. Slight decreased red colour indicates ragi and maize based cropping systems and light pinkish red colour indicates the cultivable waste lands which are left as fallow where naturally grown grasses were observed, light green tones indicate the ploughed areas which are presently under fallow, and blue colour indicates the water body, rarely at one or two places dark brown patches were observed in the imagery and they were identified as boulders or rock lands from the toposheet. Very gently sloping uplands and gently sloping uplands were observed with whitish tones due to dominance of sand in surface, since whitish tones were higher along the dried natural water courses like streams (Plate-1).

The physiography of the area comes under nearly level upland to very gently sloping upland. In each physiographic unit, profiles were studied depending upon slope in order to establish relationship between

physiography and soil characters. In general sheet wash/slope wash are the dominant geomorphic processes of erosion observed on this erosional upland. The profiles examined showed increasing soil development with increasing depth. The weathering front is observed to be more than 150 cm from the surface. The soil profiles examined have showed well developed illuvial horizon with their clay cutons. The pedon in the level to nearly level uplands on the convex middle sector and pedon in the gently sloping uplands on the convex lower sector are characterized by gravel layer on subsurface at above 45 cm with mostly of quartz and feldspars. Accordingly, the area was selected to assess the micronutrient status of soils to have better nutrient management options.

Physico-Chemical Characteristics : The soils were acid in reaction (pH varied from 4.57 to 6.94) and usually increased with increasing soil depth (Table 2). There was a variation in salt content of different horizons. The electrical conductivity of A horizons of all the pedons ranged from 0.02 to 0.07 dSm⁻¹ and decreased with increasing soil depth. The surface soils are generally medium in organic carbon in all the profiles and a regular

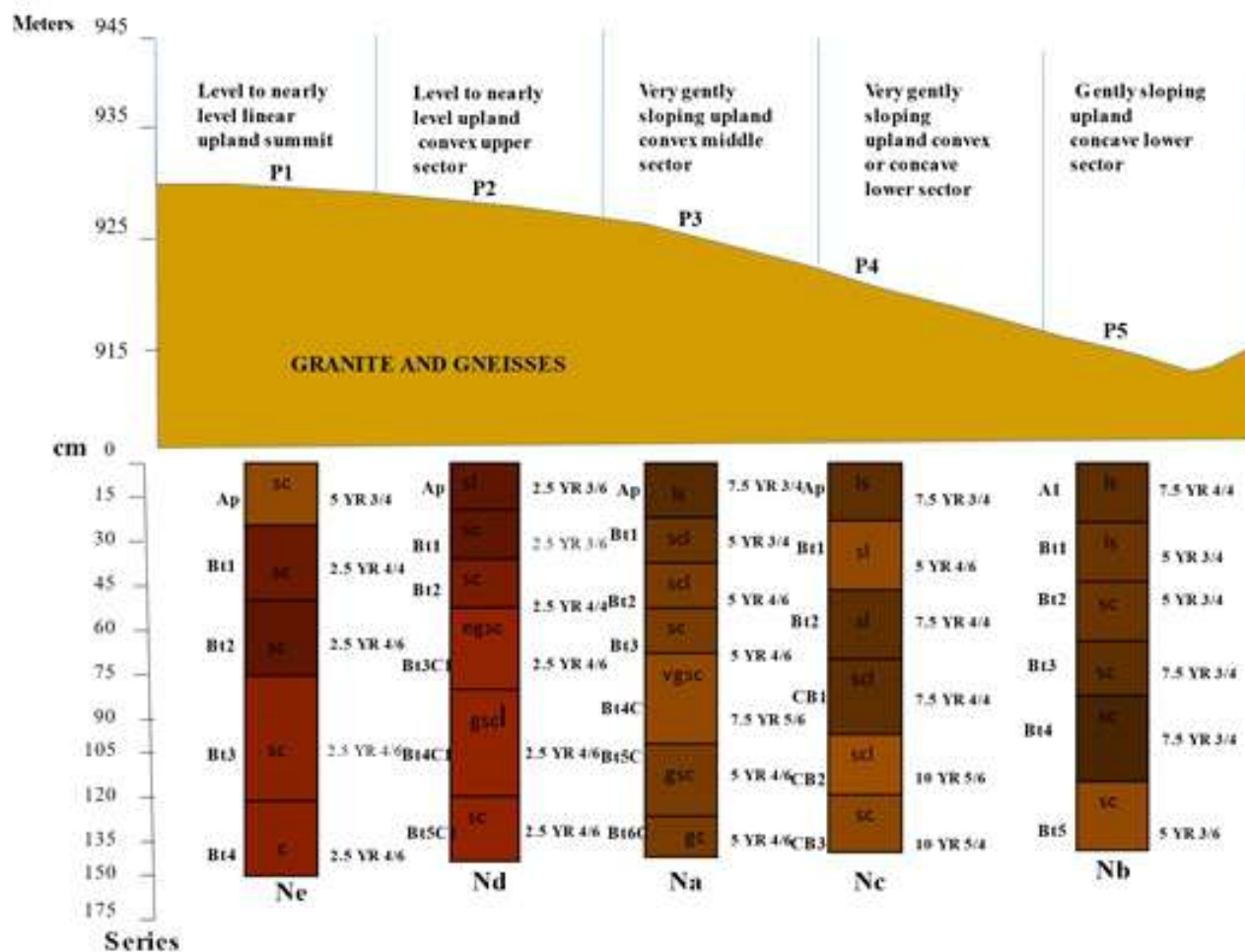


Fig-1 : Landform-soil relationship in Nagenahalli watershed, Doddaballapur taluk, Bangalore Rural District.

decrease in organic carbon content was observed with increasing soil depth. The soils of the area have been developed by Archaean granites and gneisses on upland and colluvium on convex lower sectors and variation in texture of the soils is found depending upon topographic position. The finer soil texture is due to erosion and deposition.

Pedospheric Distribution of DTPA Extractable Micronutrients

DTPA-Zinc : The DTPA-Zn in surface soil ranged from 0.04 to 2.60 mg kg⁻¹, irrespective of physiography and depth (Table-3). All the pedons contain higher amount of Zn in the surface layer (Vijay kumar *et al.*, 1994) but there was a regular decrease in Zn content in the soil profile (Singh *et al.*, 1990). The accumulation of Zn in surface horizon in all the pedons might be due to the addition through plant residues left over by the preceding crop (Jalali *et al.*, 1989) as intensive cropping system is followed in the studied area which resulted in complexing

of Zn with organic matter. The physiography had a strong influence on Zn distribution in the soils. It was higher in the soils of upland (Mean = 0.75 mg kg⁻¹) and very gently concave lower sector (Mean = 0.32 mg kg⁻¹) soils followed by linear upland upper sector (Mean = 0.27 mg kg⁻¹). The soils of gently concave lower sector had a Zn content of 0.25 mg kg⁻¹ and least content of DTPA Zn (Mean = 0.21 mg kg⁻¹), was recorded in the soils of very gently sloping convex middle sector. It indicates that the distribution of DTPA Zn coincided with the physiography. Thus, the upland soils and depressions of slopy concave lower sectors shows highest deposition. The level of plant available Zn is also low and the soils which are low in organic matter are more prone to Zn deficiency. While studying the soils representing different agro climatic zones of Karnataka, Krishna murthy and Srinivasmurthy (2005), noticed the Zn deficiency in large number of soils studied. The highest and significant relationship between DTPA Zn and OC ($r = 0.590^*$) found in soils indicates the influence of organic matter on Zn availability.

DTPA-Cu : The DTPA Cu varied from 0.16 to 2.80 mg kg⁻¹ with a mean value of 0.72 mg kg⁻¹, irrespective of depth and physiography. The available Cu status decreased with increasing soil depth which may be attributed to the accumulation of biomass in the surface layer of soils leading to higher organic carbon content in the surface than subsurface soils (Verma *et al.*, 2005). The decreasing trends of available micronutrients with depth was also reported by Dayananda *et al.* (2002). The distribution of Cu showed a close relationship with physiography. The DTPA extractable Cu was highest in the upland soils (Mean = 1.08 mg kg⁻¹) followed by gently concave lower sector (Mean = 0.94 mg kg⁻¹), linear upland upper sector (Mean = 0.63 mg kg⁻¹), very gently sloping concave lower sector (Mean = 0.54 mg kg⁻¹) and very gently convex middle sector has lowest Cu of (Mean = 0.40 mg kg⁻¹). The organic carbon had a pronounced effect on increasing the Cu availability in soils ($r = 0.766^*$).

DTPA-Fe : The content of DTPA Fe ranged between 20.20 to 23.30 mg kg⁻¹ in the surface horizons of all the pedons (Table 3). There was a sharp decrease in Fe content with increasing depth and the decrease was very sharp after the Bt2 horizon, this may be attributed to the movement of finer fractions to lower horizons during the process of illuviation which indicates that a relationship exists between soil processes and Fe movement in the soils. The decreasing trends of available iron down the depth was also observed by Dhane and Shukla (1995) in soils of Maharashtra and Maji *et al.* (1993) in coastal soils of Sundarbans, West Bengal. DTPA-Fe increased with change in physiography from very gently convex middle sector (Mean = 14.80 mg kg⁻¹) to gently sloping concave lower sector (Mean = 11.74 mg kg⁻¹) and very gently concave lower sector (Mean = 11.53 mg kg⁻¹) which were also recorded appreciably good contents of Fe as much of uplands may be due to deposition of Fe even after losing other cations through surface wash. The significant positive coefficient of correlation of DTPA-Fe with organic carbon ($r = 0.696$) was observed in these soils.

DTPA-Mn : The data presented in Table-3 indicated available Mn did not show any specific pattern with increasing soil depth in all the pedons, though it had a tendency to increase up to a certain depth followed by irregular pattern in all the profiles. Sangwan and Singh (1993) also observed irregular pattern in available Mn content of soil with increasing soil depth. This might be due to weak pedological manifestation and colluvial nature of the soils. At the same time, fluctuation in organic carbon also caused the inconsistent pattern of available micronutrient distribution (Rajkumar, 1994). There was a little variation in DTPA- Mn up to B and C horizon due to

leaching of Mn in these soils (Khattak and Jarrel, 1989). The distribution of Mn according to physiography revealed that DTPA-Mn was highest in soils of gently concave lower sector (Mean = 22.14 mg kg⁻¹) followed by very gently convex middle sector (Mean = 22.14 mg kg⁻¹), very gently sloping concave lower sector (Mean = 22.56 mg kg⁻¹) soils, compared to level to nearly level uplands (Mean = 9.56 and 9.60 mg kg⁻¹). The DTPA-Mn had a positive correlation with OC ($r = 0.57$), from this association, it can be inferred that addition of organic matter to soils encourages the availability of Mn.

Relationship between Soil Properties and DTPA Extractable Micronutrients

The simple correlations were worked out to ascertain the degree of relationship between soil properties and DTPA extractable micronutrients, irrespective of physiography (Table-4). A significant positive correlation of Zn, Cu, Fe and Mn with organic carbon indicates that complexing agents generated by organic matter promote availability in soils (Hodgson, 1963 and Verma *et al.*, 2005). The availability of copper appears to be mainly influenced by OC as it bore a significant correlation with OC ($r = 0.766^*$). The DTPA extractable micronutrients found to be negatively correlated with sand, however, both clay and organic carbon contents of soils had a marked influence on the availability.

Conclusions

The variations in distribution of micronutrients indicated that physiography and physicochemical processes plays a major role in controlling the availability of micronutrients. Among the micronutrients, the deficiency of Zn is of major concern and these soils require application of Zn fertilizers to maximise the crop yield.

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Comperative Therapeutic Efficacy of Chemical and Herbal Anthelmintics and Miticides Packages in Growing Piglets

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Abstract

Present study has been planned to achieve a long term effective control of concurrent natural infection of gastro-intestinal helminthes, lice and mange infections in pigs. Piglets were randomly divided in to two groups (I and II) each group contains six piglets. For the comprehensive control of common G.I. helminthes and mite infection acquired by the piglets born from parasite free pregnant sows on or after 35th to 40th days after birth, were also treated with the same chemical and herbal anthelmintic and miticidal control packages respectively. Haemato biochemical study revealed significant ($P < 0.01$) decrease in the values of Hb, PCV TEC and Ca, P, Zn, Cu, TSP and Albumin before treatment. Group-I treated chemical anthelmintics and miticide completely recovered of piglets from G.I. helminthes was observed on 10th DPT onwards and negative for *Sarcoptes scabiei* infestation from 15th DPT. In group-II, treated with herbal anthelmintics and miticides package complete cure of piglets from G.I. helminthes was observed on 25th DPT onwards and negative for *Sarcoptes scabiei* infestation from 15th DPT. In both treatment groups restoration of haemato- biochemical parameters on were recorded in different days post treatment. Chemical anthelmintics and miticide drugs and herbal anthelmintics and miticide package were also found very effective for a long time sustainable and comprehensive control of endo and ectoparasite, these animals were treated at intervals with the same drugs as and when reinfection appeared so that animals could be kept parasite free up to the entire period of observations.

Key words : Piglet, helminthes, mange, DPT, haemato-biochemical, chemical drug, herbal package.

Introduction

In Jharkhand, pig rearing has remained a traditional occupation of tribals and socio-economically backward people. Several endo and ectoparasites have been observed to undermine the health and production capability of the animals at all stages of production causing heavy economic losses to the industry. *Fasciolopsis*, *Ascaris*, *Strongyloides*, *Oesophagostomum* and other G.I. parasites are the major health hazard while lice and mange mites are the commonest ectoparasites affecting health and production of pigs. A variety of chemical and herbal antiparasitic agents have been used to control the parasitic infections in pigs. But these parasites are still a problem of economic importance in both intensive and semi-intensive system of swine rearing. Therefore, there is an urgent need to develop suitable packages for the comprehensive control of common endo as well as ectoparasites so that maximum economic return may be obtained from the enterprise. Recently, some of the chemical drugs have been used to control the gastro-intestinal helminthes and ectoparasites by Prasad *et al.* (2001) (1). But the chemical drugs have many side effects. Therefore, it is essential to develop suitable parasite control package having minimum side effects for the host but highly effective against

gastro-intestinal helminthes and ectoparasites. Therefore, the present study has been planned to achieve a long term effective control against gastro-intestinal helminthes, lice and mange infections in pigs by the application of suitable chemical and herbal control packages.

Materials and Methods

Sustainable comprehensive control of common G.I. helminthes and mite was achieved by giving suitable chemical and herbal anthelmintic and miticidal packages to naturally infected growing piglets aged about 2½ months, pregnant sows and their litters maintained at Ranchi Veterinary College Piggery Unit on normal balanced feeds. Any other erroneous infections were managed therapeutically. Detail experimental schedule followed were as shown in tables-1.

Pre and post treatment EPG twice weekly up to 20 days, on 25th day and then fortnightly upto 10 months, live and dead mite counts on every 3rd day upto 15th DPT and then at monthly interval upto 10 months were recorded. Hb, PCV and TEC noted on zero day before treatment and then fortnightly upto 3 months and then monthly upto 10 months. Ca, P, Zn, Cu, TSP and albumin estimated on zero day before treatment and then on 20th day post treatment (DPT). Body weight gain - Pre and post treatment fortnightly till the end of experiment.

Drugs Used :**(i) For common G.I. helminthes :**

(a) Fenbendazole	150 mg and Praziquantel 50 mg.
(b) Herbal anthelmintic consisting of :	
Pure mercury	100 mg
Pure sulphur	200 mg
Ajmod (<i>Trachyspermum roxburghianum</i>)	
seed powder	300 mg
Bayavidenga (<i>Embeliaribes</i>) seeds powder	400 mg
Pure Nux-vomica (<i>Strychnos nux-vomica</i>)	
seed powder	400 mg
Palas (<i>Butea monosperma</i>) seed powder	600 mg
Pumpkin (<i>Cucurbita maxima</i>) seed powder	3000 mg
Jira (<i>Cuminum cyminum</i>) seed powder	4000 mg
Areca nut (<i>Areca catechu</i>) powder	3000 mg
Black Til (<i>Sesamum indicum</i>) seed powder	3000 mg
Total	15 gm

The above raw herbal ingredients were procured from the local market and sun dried, then all ingredients were ground up in mixer grinder separately to make it fine powder and mixed in the ratio indicated above.

(ii) For mite control :

(a) Dermeez® consisting of Cypermethrin high-cis 100 gm/litre.

(b) Herbal miticide :

Neem (<i>Azadirachta indica</i>) oil –	50 ml
Karanj (<i>Pongamia glabra</i>) oil –	50 ml
Camphor (<i>Camphor officinarum</i>) –	10 gm
Sulphur –	10 gm

The commercially available oil of Neem and Karanj were mixed in 50:50 ratio and to this camphor (10 g) and Sulphur (10 g) added to make a suspension mixture. This herbal acaricide was applied with cotton or soft cotton cloth on the whole body of animals. Statistical analysis was done as per the methods described by Snedecor and Cochran (1968)^[2].

Results and Discussion

The first group of growing piglets having natural common G.I. helminths and mite infestation were treated with chemical anthelmintic i.e. Fenbendazole + Praziquantel and chemical miticide as Cypermethrin. All the animals were completely cured from G.I. helminths on 10th day post treatment onwards which indicated that the chemical anthelmintic was found to be highly effective against common G.I. helminths. Similarly, these animals also became negative for *Sarcoptes scabiei* from 15th day post

treatment with the chemical miticide. For the comprehensive control of common G.I. helminths and mite infection acquired by the piglets born from parasite free pregnant sows on or after 35th to 40th days after birth, were also treated with the same chemical anthelmintic and miticidal control packages. The infected piglets also became negative for both endo and ectoparasites after application of the drugs. For a long time sustainable and comprehensive control of endo and ectoparasite, these animals were treated at intervals with the same drugs as and when reinfection appeared so that animals could be kept parasite free upto the entire period of observations. If the results of G.I. helminths control package given to different age group of pigs were compared with the findings of others, it was evident that the results of the present investigations were in general agreement with the reports of earlier workers (1,3,4,5,6,7). Likewise, the results of the chemical miticidal control package applied to the pigs of different ages were almost similar to the observations of (1,8,9,10,11,12,13). The perusal of literature indicated that only limited references were available for the long term sustainable comprehensive control of both endo and ectoparasites simultaneously with chemical anthelmintics in pigs, the findings of the present study were almost similar to the observations of Prasad *et al.* (2001) (1). Hence, there is need to carry out similar trials of comprehensive sustainable control of both types of parasitic infections on larger population of pigs at different ages under different farming situations for confirming the results of the present study. The second set of experiment was conducted to control G.I. helminths and mite infections in growing piglets with herbal anthelmintic and miticidal control packages. The findings obtained indicated that the herbal miticidal agent was found to cure all the animals by 15 DPT whereas the herbal anthelmintic could eliminate most of the G.I. helminths by 25th DPT. There was lack of information on the use of herbal anthelmintics for the control of internal parasites in pigs. Though the herbal anthelmintic was found a slow acting medicine but the preparation could be an alternative anthelmintic for the poor farmers residing in remote rural areas especially in Jharkhand where such herbal plant products are abundant in villages surrounded by forests. The control of mange mites in pigs by herbal miticides have also been reported earlier worker (13,14,15) in pigs. Their results were almost similar to the findings of the present study. The present study, however, showed that the treatment of mange mites in pigs with herbal ingredients available in villages could be an effective, economical and convenient control measures useful for the pig farmers in rural village conditions. Piglets born from parasite free pregnant sows were found to acquire

Table-1 : Schedule for the comprehensive control of common G.I. helminths and mite by chemical and herbal control packages in growing Deshi piglets.

Groups (No. of animals)	Nature of infection	Drugs used, doses and route of admn.	Day of treatment	Period of observations
I(6)	<i>A. suum</i> , <i>T. suis</i> , <i>O. dentatum</i> , <i>Strongyloides</i> spp. and <i>S. scabiei</i> .	Fenbendazole + Praziquantel 200 mg /30 kg body weight, once, orally + Cypermethrin 2 ml /litre of water, topical, twice in a week + Supportive drugs	0 (Day on infection detected)	10 months
II(6)	-do-	Herbal anthelmintic Pure Mercury, Pure sulphur, Ajmod, Bayavidanga, Pure Kuchla, Palas seed, Pumpkin seed, Cumin, Arecanut and Black til, 500 mg/kg b. wt., twice daily for 7 days. + Herbal miticide : Neem oil, Karanj oil, Camphor and Sulphur. Topical daily for 5 days + Supportive drugs	-do-	10 months
III(6)	(-do-)	No treatment		10 months

Supportive drugs – Liver stimulants, antidiarrhoeal, appetizers, minerals, vitamins, antibiotics and other drugs were given as per requirements.

Table-2 : Efficacies of Fenbendazole + Praziquantel and herbal anthelmintic parasite control packages against common G.I. helminths* infecting growing Deshi piglets.

Groups (No. of animals)	Drugs used	Dosage and admn.	Average pre-treatment EPG (0 day)	Average post treatment EPG and efficacies (%)						
				3 rd day	7 th day	10 th day	14 th day	17 th day	20 th day	25 th day
I (6)	Fenbendazole + Praziquantel + supportive drugs	200 mg/ 30 kg body weight, orally, single dose	1950 ±147.8	500 ±57.7 ^a (74.35)	216.6 ±30.7 ^a (88.89)	00.00 (100)	00.00 (100)	00.00 (100)	00.00 (100)	00.00 (100)
II (6)	Herbal anthelmintic + Supportive drugs	500 mg/kg body weight, twice daily for 7 days	1816.66 ±230.1	1125 ±130.2 ^b (38.08)	700.00 ±81.7 ^b (61.45)	333.30 ±49.4 ^a (81.65)	86.00 ±15.28 ^a (95.25)	56.33 ±8.18 ^a (96.90)	27.50 ±3.5 ^a (98.48)	00.00 (100)
III (6)	-	-	1850 ±99.1	2133.33 ±111.68 ^c	1950 ± 99.2 ^c	2200 ±121.13	2300 ±148.3 ^b	2350 ^b ±201.2	2516.66 ±117.83	2402 ±105.25
CD value				311.52	229.80	191.48	258.50	350.44	309.41	

*Common G.I. helminths – *A. suum*, *T. suis*, *O. dentatum*, *Strongyloides* spp., *F. buski*, *S. suis* and others.

infection of both endo and ectoparasites from 35th to 40th days after birth were also treated with the same herbal anthelmintic and miticidal control packages. The observations indicated that all the piglets became free from both the infections upto 98 percent and above. Due to unavailability of literature about comprehensive control of parasitic infections from early life in growing piglets, the present results could not be comparatively discussed. However, the application comprehensive control measures from early stage of life of piglets appeared very useful.

Haematological observations during chemical and herbal anthelmintic and miticidal control packages applications in pigs : Haematological profiles of growing piglets during common G.I. helminths and mite infestation and chemical and herbal anthelmintics and miticides treatment were carried out to monitor the health status of the infected and treated animals. The findings of the studies showed that for assessing the effectiveness of chemical and herbal anthelmintics and miticides against common G.I. helminths and Scarcoptic mite infestation in pigs. The variation in haematological parameters also

Table-3 : Efficacies of Cypermethrin and Karanj oil + Neem oil + Camphor + Sulphur packages against mite infesting growing Deshi piglets

Groups (No. of animals)	Drugs used	Dosage and admn.	Average pre-treatment mite count in 6 cm ² area (0 day)	Average post-treatment mite count and efficacies (%)				
				3 rd day	6 th day	9 th day	12 th day	15 th day
I(6)	Cypermethrin + supportive drugs	2 ml/litre of water, topical, twice in a week	110.33 ±5.27	77.5 ±3.74 ^a (29.73)	53.16 ±2.63 ^a (51.80)	33.16 ±1.64 ^a (69.93)	3.16 ±0.47 ^a (97.13)	00.00 (100)
II(6)	Herbal miticide + supportive drugs	Topical daily for 5 days	116.5 ±4.65	101.16 ^b ±3.68 ^b (13.13)	64.16 ^b ±2.71 ^b (44.89)	35.00 ^a ±1.41 ^a (69.95)	12.00 ^b ±0.78 ^b (89.69)	00.00 (100)
III(6)	-	-	108 ±7.34	120.5 ±10.32 ^c	117 ±8.96 ^c	99.66 ±6.61 ^b	106.66 ±3.90 ^c	126.66±4.77
CD value				17.68	20.14	12.11	6.96	8.30

Table-4 : Comprehensive sustainable therapeutic control of common G.I. helminths and mite infestation in growing Deshi piglets. .

Groups (No. of animals)	Nature of infection	Drugs and admn.	Mild (+ to ++) reinfection appeared on DPT					Treatments repeated on	Status of infection
I (6)	Common G.I. helminths	Fenbendazole +	80 th	170 th	260 th			Next day of reinfection	Completely cured, stool negative for EPG
		Praziquantel + Supportive drugs							
	Mite	Cypermethrin +	105 th	190 th	270 th			-do-	Completely cured, Skin scraping negative for mite
		Supportive drugs							
II (6)	Common G.I. helminths	Herbal anthelmintic +	65 th	140 th	235 th			-do-	Completely cured, stool negative for EPG
		Supportive drugs							
	Mite	Herbal miticide +	80 th	150 th	220 th			-do-	Completely cured, Skin scraping negative for mite
		Supportive drugs							
III (6)	Common G.I. helminths			EPG				-	++ to +++ remained during period of observation
			65 th	80 th	140 th	170 th	235 th	260 th	
			3127± 218.3	3020± 178.5	3712± 103.8	4325± 105.2	4002± 217.3	4500± 115.6	
	Mite				Mite count				-do-
			80 th	105 th	150 th	190 th	220 th	270 th	
			125 ±7.8	150 ±5.2	130 ± 4.3	140 ±5.3	153 ±4.8	158 ±7.9	

indicated that the harmful substances produced by G.I. helminths and mite probably caused significant decrease in the values of Hb, PCV and TEC before treatment but these values however, were found to return almost towards the normal ranges on different days post treatment observations. Almost similar results were also reported (1,13,14,16,17) in helminthes and mite infected pigs and subsequently treated with respective drugs. The

marked reduction in Hb, PCV and TEC value in G.I. helminths and mite infested pigs were also supposed to have occurred due to the suppressive effects of the toxic substance secreted or excreted by the G.I. helminths and sucking of blood and tissue fluid by the mite and the decreased feed intake due to constant irritation caused by mites leading to deficiency of essential nutrients needed for normal haemopoiesis (1,17).

Table-5 : Haematological profiles (Mean $\pm$ S.E.) of growing Deshi piglets during common G.I. helminthic and mite infestation and their treatment with chemical and herbal anthelmintics and miticides.

Parameters	Observation period (days)	Group-I (6)	Group-II (6)	Group-III (6)	CD value
Hb (g/dl)	0	8.26 $\pm$ 0.17	8.83 $\pm$ 0.32	8.78 $\pm$ 0.35	
	15	10.82 $\pm$ 0.33 ^a	10.47 $\pm$ 0.42 ^a	8.51 $\pm$ 0.30 ^b	1.07
	300	13.51 $\pm$ 0.36 ^a	13.64 $\pm$ 0.30 ^a	8.23 $\pm$ 0.22 ^b	0.92
PCV (%)	0	28.31 $\pm$ 0.45	29.48 $\pm$ 0.73	29.01 $\pm$ 0.50	
	15	32.46 $\pm$ 0.67 ^a	33.46 $\pm$ 0.99 ^a	27.74 $\pm$ 0.98 ^b	2.70
	300	44.58 $\pm$ 1.21 ^a	43.23 $\pm$ 1.56 ^a	25.00 $\pm$ 0.61 ^b	3.60
TEC ($\times 10^6$ /cumm)	0	4.67 $\pm$ 0.21	4.27 $\pm$ 0.23	4.75 $\pm$ 0.32	
	15	5.96 $\pm$ 0.22 ^a	5.64 $\pm$ 0.17 ^a	4.71 $\pm$ 0.22 ^b	0.61
	300	7.00 $\pm$ 0.25 ^a	6.57 $\pm$ 0.16 ^a	4.67 $\pm$ 0.13 ^b	0.44

Group-I Fenbendazole + Praziquantel and Cypermethrin treated.

Table-6 : Biochemical profiles (Mean $\pm$ S.E.) of growing Deshi piglets during common G.I. helminthic and mite infestation and their treatment with chemical and herbal anthelmintics and miticides.

Parameters	Observation period (days)	Group-I (6)	Group-II (6)	Group-III (6)	CD value
Calcium (mg/dl)	0	10.64 $\pm$ 0.36	9.87 $\pm$ 0.32	10.12 $\pm$ 0.43	
	20	11.73 $\pm$ 0.44 ^a	11.31 $\pm$ 0.40 ^a	9.23 $\pm$ 0.20 ^b	1.14
Phosphorus (mg/dl)	0	5.31 $\pm$ 0.34	4.81 $\pm$ 0.15	5.09 $\pm$ 0.19	
	20	5.87 $\pm$ 0.27 ^a	5.29 $\pm$ 0.12 ^a	4.52 $\pm$ 0.18 ^b	0.60
Zinc (μ g/dl)	0	41.73 $\pm$ 2.48	40.71 $\pm$ 3.92	38.50 $\pm$ 2.33	
	20	54.03 $\pm$ 1.83 ^a	55.71 $\pm$ 2.54 ^a	36.25 $\pm$ 1.16 ^b	7.57
Copper (μ g/dl)	0	46.19 $\pm$ 1.71	44.59 $\pm$ 2.97	42.95 $\pm$ 2.39	
	20	61.14 $\pm$ 3.47 ^a	60.37 $\pm$ 3.14 ^a	38.21 $\pm$ 2.80 ^b	9.49
TSP (g/dl)	0	5.44 $\pm$ 0.36	4.98 $\pm$ 0.27	4.90 $\pm$ 0.22	
	20	6.62 $\pm$ 0.25 ^a	6.00 $\pm$ 0.26 ^a	4.70 $\pm$ 0.24 ^b	0.86
Albumin (g/dl)	0	2.80 $\pm$ 0.28	2.52 $\pm$ 0.23	2.51 $\pm$ 0.13	
	20	3.48 $\pm$ 0.19 ^a	3.23 $\pm$ 0.17 ^a	2.44 $\pm$ 0.22 ^b	0.52

Group-I Fenbendazole + Praziquantel and Cypermethrin treated.

Group-II Herbal anthelmintic and miticide treated.

Group-III Infected untreated control.

Figures having same superscripts did not differ significantly.

Figures having different superscripts differ significantly; ($P < 0.01$).

Biochemical observations during chemical and herbal anthelmintic and miticidal control packages application in pigs :

Biochemical changes of growing piglets, pregnant sows and piglets born from parasitized and parasite freed pregnant sows during common G.I. helminths and mite infestation and treated with chemical and herbal anthelmintics and miticides control packages were studied in respect of Ca, P, Zn, Cu, TSP and Albumin. The values of these were found to remain at reduced levels during infections in all the experimental animals but they got significantly ($P < 0.01$) improved on 20th day post treatment in growing piglets and pregnant sows and on 60th day post birth (DPB) treatment in piglets born from parasite freed pregnant sows. Similar

observations were also reported by earlier workers (14,17) in mange affected pigs and Rajguru *et al.* (2002) and Lakra *et al.* (2007) (17,18) in G.I. helminths infected goats. The reduced biochemical profiles observed in the present study could be due to harmful effects caused by the parasites on the host in the form of direct damage of intestinal mucosa resulting in malabsorption and interference in the uptake of micro and macro elements and then increased values of the same parameters after treatment indicated the stoppage in release of the harmful substances produced by the common G.I. helminthes and mite. The estimations of different haemato biochemical parameters during parasitic infections and subsequent treatments could also be useful in determining the

appropriate line of treatments with specific and supportive drugs in time for keeping the farming animals in good health and optimum production.

Conclusion

The chemical and herbal helminths and mite control packages were found very suitable and useful for long term comprehensive control of common endo and ectoparasites in Deshi pigs. The long term chemical and herbal endo and ectoparasitocidal control packages were found very encouraging for maintaining optimum health and economical production characters in Deshi pigs. However, the present findings need more replicated trials in different cross-bred and pure bred animals under different farming conditions.

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Prevalence, Haemato-Biochemical and Therapeutic Study of Demodicosis in Canine

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Abstract

Skin affections are among the one of the most common prevailed in Canine. The present investigation was conducted to study the prevalence of different dermatological affections in canine and haemato-biochemical alteration and therapeutic efficacy of Moxidectin and Ivermectin in canine demodicosis. During the investigation period July 2019 to June 2020 1223 case were examined of them 294 (24.03%) dogs were suffered from different skin problems. The sarcoptic mange infestation was found to be most prevalent (21%) followed by ticks, lice, mite infestations, pyoderma and allergic dermatitis. Most of the skin disorders were recorded during rainy season (27.21%) followed by summer season (18.02%). The Skin problems were high (55.1%) in males as compared to females (44.9%). The prevalence of skin infection was recorded high (34.01%) in dogs of age between 1-3 years and low (15.3%) in dogs of more than 5 years. The hemato- biochemical study found significantly low in Hb, PCV, TEC and albumin and significantly high in TLC, neutrophils, eosinophils, total protein, albumin, ALT and AST in dogs suffered from demodicosis as compared to healthy dogs. The therapeutic study revealed that Moxidectin and Ivermectin were found equally effective against in canine demodicosis and complete recovery were observed on 14th day after treatment.

Key words : Canine, demodicosis, moxidectin, ivermectin.

Introduction

The history of human-dog companionship is very old at least fourteen thousand years. The dogs are considered the most intelligent and loyal pet animal to the human. Dogs have found increasing popularity with changing socio-economic scenario in our country and are considered an integral part in scores of households. During their service to the mankind, dogs suffer with so many ailments. Out of these ailments, skin affections contribute a lot to their suffering. Skin is considered as the mirror of health as there are several systemic diseases that may clinically be reflected by some skin abnormalities. Skin is home to an immense range of natural living things. The skin is the most sensitive part of dog's body, which has aesthetic virtues to pet owners. An inflammatory condition of the skin irrespective of the cause is described as dermatitis. The canine dermatology is a very challenging field. It requires a very wide knowledge of different topics including bacteriology, mycology, parasitology, immunology, endocrinology, oncology etc. In canine practice, it has been estimated that in on an average 20% to 75% of the case have skin problems as a main or concurrent owner complaint. The skin diseases are of many kinds such as infectious, non infectious, congenital and hereditary diseases, immunological diseases, endocrine skin disorders, psychogenic dermatoses, environmental diseases,

nutritional skin diseases, neoplastic diseases and miscellaneous diseases. Dogs are at more risk of infectious causes include parasites, bacteria, fungi and virus. These organisms stay alive on the outside of skin alongside different skin extremities like hair follicles, sebaceous and sweat organs. Of them ectoparasites infestation in dogs are very devastating and difficult to control and require long term of treatment (1). Some of the skin infections are capable of transmitting to human. Mange is one of the contagious canine skin affections which maintain to pose troubles for dog lovers and veterinarians. Numerous mange mites encompass demodex and sarcoptes inflicting demodicosis and scabies, respectively and reason pores and skin problem have already been isolated from the dogs. Sarcoptic or demodectic mange, as a result of mites is a pivotal and common skin disorder of dogs. Dogs are usually infested with many ecto-parasites making them miserable due to consistent scratching, intense itching, irritation and reduction of health and wellbeing of dogs through their blood sucking behaviors resulting to sever anemia, dermatitis which can lead to lifestyles-threatening allergy (3). These conditions end up worse in hot and humid weather consequently becoming hard to resolve. Several studies from India and overseas have indicated that skin affections make up a substantial percentage of the small animal case load (12,16,19). The feeding habit of ectoparasites results within the alteration

of numerous blood parameters. These hematological and biochemical parameters assist in diagnosing the severity of infestation and additionally helps to control infested dogs. Impacts of ecological elements, sex and age on event of ectoparasitic skin maladies in dogs were examined and detailed.

Materials and Methods

The present study was carried out in Koderma district of Jharkhand. Dogs with clinical signs suggestive of dermatological problems were included in the study. Information such as history, clinical signs, age, sex etc. was recorded. Analysis of collected data was done to determine occurrence of various skin disorders in dogs. Skin scrapings suspected for mite infestation was collected from the dogs and examined by the method of Soulsby (1982) (24). The scrapings were also collected from the 'recently rubbed' or 'appeared raw' lesions. Detection of the mite was done by direct method or by using 10% potassium hydroxide solution. A total of 12 dogs positive for *D. canis* were selected for the evaluation of comparative efficacy of Moxidectin and Ivermectin injection. These dogs were randomly divided into 2 treatment groups (T-1 and T-2) and each group having 10 dogs. The dogs of T-1 and T-2 were treated with Moxidectin @ 0.5mg/Kg b.wt. and Ivermectin @ 0.2mg/kg b.wt. respectively. The treatment groups were also given supportive therapy Inj. Chlorpheniramine maleate @ 30mg/kg b. wt., i.m., multi vitamin and omega fatty acid. The dogs of group T3 kept as healthy control.

Table-1 : Treatment schedule :

Group	No. of animals	Drug used	Dose	Days of treatment
1	10	Moxidectin	0.5mg/KG b.wt.; s/c	Once in a week for three weeks
2	10	Ivermectin	0.2 mg/KG b.wt.; s/c	Once in a week for three weeks
3	10	Healthy control	—	—

Collection of samples : The samples of the dogs were collected first on day 0 i.e. pre therapy and then after 21st day of post therapy in all groups to evaluate the effect of the treatment. About 2 ml of blood sample was collected from cephalic vein of each dog, immediately after collection, blood was transferred to EDTA vials for the analysis of blood cellular components. The blood samples were analysed within 2 hours of blood collection for following parameters, deploying standard laboratory procedures. Packed cell volume (PCV), haemoglobin (Hb), total leucocyte count (TLC), total erythrocyte count (TEC) and differential count was measured by standard methods. Another 5 ml of blood was collected in serum

vial for the separation of serum from the blood for the estimation of biochemical test. The serum, thus collected, was stored in deep freeze at minus 20°C in glass vials which were properly capped and labelled. The blood sugar, total protein, albumin, ALT and AST were estimated as per kit methods.

Results and Discussions

During the present investigation 1223 dogs were examined, of them 294 (24.03%) dogs suffered from different skin affections. Khurana *et al.*, 2016 (15) reported 21.34 % cases affected with skin diseases during a study period of 5 years whereas Shyma and Vijaya kumar (2011) (23) reported 12% dermatological problems in one year in dogs. Scott *et al.*, 2001 (20) and Hill *et al.*, 2006 (12) reported the prevalence of skin disorders ranging from 15-25% in dogs. Increasing trend of dermatological disorders discovered during this study might most likely result to updated information in identification and diagnosis of skin diseases, increasing population of pets. The higher prevalence of dermatological disorders could also be because of season, environmental conditions factors and management factors adopted in a very explicit space as expressed by Sharma *et al.*, (2008) (22). The prevalence of sarcoptic mange infestation (21.01%) was higher followed by tick-infestation (14.96%), lice infestation (10.88%), demodectic mange infestation (10.88%), pyoderma (5.78%), allergy/eczema dermatitis (3.40 %) and others skin problems (3.3%). Khurana *et al.*, 2016 (15) recorded sarcoptic mange infestation as a major dermatological problem in dogs, which was in accordance with present study. Month-wise prevalence of different skin infection were recorded high maximum number of cases (21 %) in the month of August followed by April (10.20%). In the month of January, least number of cases (3.74%) was recorded. Kumar *et al.* (2006) (16) and Sharma *et al.* (2018) (21) also reported the similar findings. A year was broadly divided into four seasons; winter (January to March), summer (April to June), rainy (July to September) and autumn (October-December). There was a positive correlation amongst the different skin affections with monthly ambient temperature. Almost throughout the year dermatological disorders were recorded but more cases were recorded in rainy season followed by summer, autumn and then winter. Cases of sarcoptic mange, demodectic mange and pyoderma were maximum in rainy season whereas in summer season, higher cases were of pruritus and flea allergy dermatitis was recorded. Dimri and Sharma (2004) (7) and Kumar *et al.*, 2006 (16) also reported maximum cases of skin diseases during summer and rainy months of the year. Amongst the dermatological disorders affected dogs, 55.1

Table-1 : Haematological parameters of demodicosis and healthy dogs.

Parameters	Group	0 th Day	21 st Day
Hb (g/dl)	1	9.18±0.48 ^b	12.84±0.81
	2	9.22±0.26 ^b	12.66±0.18
	3	12.80 ±0.68 ^a	13.12±0.16
PCV (%)	1	29.12±0.71 ^b	40.06±0.27
	2	28.4±0.35 ^b	39.97±0.32
	3	42.63±0.92 ^a	41.23±0.31
TEC (10 ⁶ /mm ³)	1	5.17±0.64 ^b	7.12±0.42
	2	6.01±0.21 ^b	7.16±0.18
	3	7.12±0.31 ^a	7.36±0.19
TLC (10 ³ /mm ³)	1	18.33±0.96 ^b	12.19±0.36
	2	18.94±0.44 ^b	11.86±0.33
	3	11.01±0.52 ^a	12.16±0.48
Neutrophils (10 ³ /mm ³)	1	76.18±0.93 ^b	71.09±0.36
	2	79.23±1.08 ^b	72.61±0.71
	3	71.17±0.76 ^a	72.66±0.41
Lymphocytes (10 ³ /mm ³)	1	17.26±0.77 ^b	22.48±0.54
	2	17.14±0.71 ^b	21.08±1.41
	3	22.18±0.73 ^a	23.14±1.83
Monocytes (10 ³ /mm ³)	1	1.49±0.07 ^b	2.29±0.09 ^a
	2	1.24±0.23 ^b	2.46±0.13
	3	2.13±0.22 ^a	2.31±0.31
Eosinophils (10 ³ /mm ³)	1	3.18±0.33 ^b	2.01±0.07
	2	3.62±0.42 ^b	1.59±0.23
	3	1.91±0.19 ^a	2.01±0.02
Basophils (10 ³ /mm ³)	1	1.29±0.22 ^a	1.23±0.06
	2	1.31±0.04 ^a	1.27±0.04
	3	1.78±0.21 ^a	1.54±0.06

Biochemical Alterations :

Table-2 : Biochemical parameters of demodicosis and healthy dogs.

Parameters	Group	0 th Day	21 st Day
Glucose (mg/dl)	1	56.66±0.38 ^b	81.18±1.29
	2	58.61±2.21 ^b	82.13±1.14
	3	95.75±1.39 ^a	92.8±0.26
Total protein (g/l)	1	8.12±0.17 ^b	6.13±0.15
	2	8.43±0.13 ^b	6.75±0.26
	3	6.41±0.08 ^a	7.21±0.15
Albumin(g/l)	1	1.63±0.09 ^b	2.46±0.13
	2	1.44±0.23 ^b	2.71±0.12
	3	2.81±0.05 ^a	2.52±0.17
ALT (IU/l)	1	105.15±1.16 ^b	49.46±1.31
	2	102.57±1.13 ^b	54.21±1.29
	3	55.49±1.34 ^a	55.43±1.17
AST(IU/l)	1	77.71±1.44 ^b	46.42±0.42
	2	82.63±1.52 ^b	42.17±0.27
	3	44.25±1.48 ^a	49.61±0.43

Table-3 : Skin scraping examination of affected dogs (n-10).

Group	Day 0	7 th Day	14 th Day	21 st Day
G-1	++++	++	-ve	-ve
G-2	++++	++	-ve	-ve

% male dogs were found to be infected with dermatological disorders as compared to females 44.9 %. Sex wise occurrence of dermatological disorders of dogs is shown. These findings of this study are well supported by Chen *et al.*, (2012)(5) Khurana *et al.*, (2016)(15) and Sharma *et al.*, (2018) (21). The highest dermatological disorders was noticed in dogs of age 1 to 3 years (34.01%), followed by 0 months to 1 year (31.29 %), 3 to 5 years (18.01 %) and above 5 years (15.3%). These findings are similar to the findings of Sharma *et al.*, (2018)(21). Sarcoptic mange, tick infestation and eczema were more in dogs of less than one year of age where as flea allergy and demodectic mange was more in dogs of 1-3 years of age. Delay in the development of host immunity inclined the young animals to dermatological disorders (8).

Haematological alterations : Haemoglobin values (gm/dl) in healthy control dogs and demodicosis affected dogs (T-1, T-2 and T-3) were 9.18 ± 0.48 , 9.22 ± 0.26 and 12.80 ± 0.48 , respectively on day 0 which clearly indicated that the level of haemoglobin was significantly lower in dogs that were affected with demodectic mange (Table-1). PCV and TEC values in T1 were recorded in group T1 were 29.12 ± 0.71 and 5.17 ± 0.64 and in T2 were 28.4 ± 0.35 and 6.01 ± 0.21 respectively which shows a decrease in both of the values in the affected group of dogs (Table-2). These findings verified with the findings of Lodh and Das (2014)(17) and Prathibha (2000)(18). Decrease in haemoglobin, PCV and TEC values is indicative of anaemic of the affected dogs, which may lead to reduced food intake, illness, septicaemia and toxemia caused by demodicosis (23). These values came to normal on 21st day of treatment in T1 and T2 (Table-1). Non-significant differences in haematological values among all the groups were observed on 21st day of treatment. Total leucocyte count was significantly elevated whereas lymphocyte values were significantly decreased in affected dogs in this study (Table 1) on day 0 which is in accordance with the findings of Thapa and Sarkar (2018). (9) The mean values of eosinophil, monocytes and basophils have no effect. This result agreed with the findings of some researchers (2) Gera *et al.*, 2012(10) also reported elevated level of neutrophils in dermatological disorders which might be due to the injury to the cells resulting into the release of leukotoxins and leucocytosis which causes the release of more neutrophils in the blood stream [(17). Eosinophilia might be due to irritation of the skin tissues resulting in the stimulation of mast cells to release histamine. Hence histamine is chemotactic for eosinophils, eosinophilia develops (4). Significant increase in serum glucose, total protein alanine amino transferase, aspartate amino transferase and significant decrease in serum albumin values were recorded in

affected dogs than the healthy dogs in this study (Table 2) on day 0. Increased serum total protein may be due to increased immunoglobulins, inflammatory responses and circulatory immune responses (23) Gupta and Prasad, (2001)(11) also reported a significant increase in total proteins in both mange and scabies. Jani *et al.* (2004) (13) and Chhabra *et al.* (2000)(6) also reported lower glucose values in parasitic infestation *Demodicosis* in dogs. The increased liver specific enzymes were may be due to the hepatic damage caused by the toxic byproducts of tissue breakdown (14). All the biochemical values in this study came to normal on 21st day of treatment. Comparative efficacy of moxidectin and ivermectin for the treatment of demodicosis in dogs showed non-significant variations between both the treatment groups. Both the drugs showed equal effective against demodectic mange. The reduction in mites count were recorded on 7th day after the treatment and skin scrapings were found negative for mite on 14th day of post treatment and all clinical signs were vanished in on 21st day of post treatment (Table-3).

Conclusion

Sarcoptic mange infestation was found to be most prevalent dermatological disorder in dogs. Skin disorders were more during rainy season followed by summer season. The dermatological disorder were high in male dogs. Significantly low in Hb, PCV, TEC and albumin and significantly high in TLC, neutrophils, eosinophils, total protein, albumin, ALT and AST were seen in dogs suffered from demodicosis. Moxidectin and Ivermectin were found equally effective against in canine demodicosis and complete recovery was observed on 14th day of treatment.

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Study on Perception and Utilization of Services of RBK by Farmers of Visakhapatnam District

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Introduction

Agriculture and allied sectors are considered as main employment and income generating activities in Andhra Pradesh. The Rythu Baharosa Kendras were started with an aim of providing extension activities at village level for well being of the farming community. The success of RBKs depends upon the knowledge of farmers on services provided through RBKs and perception towards the functioning of RBKs. Hence it is necessary to study the Perception and Utilization of services of RBK by farmers.

Objectives :

To study the Perception and Utilization of services of RBK by farmers of Visakhapatnam.

To study the constraints/ Reasons for non utilization of RBK services by the farmers.

To study the suggestions of farmers for better utilization of services of RBKs.

Sampling :

S. No.	District Name	Mandal Name	Villages Name	No. of Respondents in each village
1.	Visakhapatnam	Chodavaram	Adduru	12
2.			R.Narsapuram	12
3.		Butchaipeta	V.R.RPeta	9
4.		Madugula	Mukundapuram	12
5.		K.Kotapadu	Varada	12
6.		Ravikamatham	Medivada	9
Total		5	6	66

The study was undertaken in Visakhapatnam district of Andhra Pradesh. The study was taken up in six villages from 5 mandals spreading in Paderu and Araku mandals. A sample of 66 farmers selected from 6 villages. The data was collected by personal interaction method.

1. Age

Table-I.1 : Distribution of farmers according to their Age. (n = 66)

S. No.	Category of farmers	No. of farmers	
		Frequency	Percentage
1.	Young age (<31 years)		
2.	Middle age (31-50 years)	54	81.81
3.	Old age (> 50 years)	12	18.81
Total		66	100

The findings in Table 1.1 revealed that a more than three-fourth of the respondents belong to middle age (81.81%) followed by old age (18.18%) categories.

2. Education

Table-I.2 : Distribution of respondents according to Education levels. (n = 66)

S. No.	Level of Education (score)	No. of farmers	
		Frequency	Percentage
1.	Illiterate(1)	28	42.42
2.	Primary education(2)	5	7.57
3.	Secondary education(3)	23	34.84
4.	College education(5)	10	15.15
		66	100.00

The findings in Table 1.2 shows that 42.42 per cent of the respondents were illiterate, followed by secondary education (34.84%), college education (15.15%) and primary school (7.57%).

3. Occupation

Table-I.3 : Distribution of respondents according to their Occupation. (n = 66)

S. No.	Category of Occupation	No. of farmers	
		Frequency	Percentage
1.	Farming	66	100.00
2.	Govt employee		
3.	Self employee		
4.	Others		
Total		60	100.00

The findings presented in table 1.3 depicts that cent percent of the respondents had farming as their main occupation.

4. Caste

Table-I.4 : Distribution of respondents according to their Caste. (n = 66)

S. No.	Category of farmers (Score)	No. of farmers	
		Frequency	Percentage
1.	Schedule caste(1)	11	16.67
2.	Schedule Tribe(2)		
3.	Backward caste(3)	42	63.64
4.	Others(4)	13	19.69
Total		66	100.00

The findings presented in Table 1.4 shows that more than half of the respondents belong to Backward caste (63.64%), followed by others (19.69%) and scheduled caste (16.67%).

5. Experience in Farming

Table–1.5 : Distribution of respondents according to their Experience in Farming. (n = 66)

S. No.	Experience in Farming	No. of farmers	
		Frequency	Percentage
1.	Less than 5yrs	4	6.06
2.	5-10 yrs	12	18.18
3.	10-20 yrs	8	12.12
4.	Above 20 yrs	42	63.63
	Total	66	100.00

The findings in table 1.5 revealed that 63.63 per cent of the respondents had above 20 yrs farming experience, followed by 5-10 yrs (18.18%), 10-12 yrs (12.12%) and only 6.06 per cent had less than 5 years farming experience.

6. Size of Land holding

Table–1.6 : Distribution of respondents according to their Land holding. (n = 66)

S. No.	Land holding Category	No. of farmers	
		Frequency	Percentage
1.	Marginal Farmers (<2.5 Acres)	56	84.84
2.	Small Farmers (2.5 to 5 Acres)	10	15.15
3.	Big farmers (>5 Acres)		
	Total	66	100.00

It was evident from the Table 1.6 that more than three-fourth of the respondents had marginal landholdings (84.84%) followed by small size land holdings (15.15%).

7. Annual Income

Table–1.7 : Distribution of respondents according to their Annual income. (n = 66)

S. No.	Annual Family Income	No. of farmers	
		Frequency	Percentage
1.	Low (up to 50000)	12	18.18
2.	Medium (50000 to 100000)	46	69.69
3.	High (above 100000)	8	12.12
	Total	66	100.00

It was evident from the Table 1.7 that majority of the respondents had medium annual income (69.69%), followed by those coming under low(18.18%) and high (12.12%). annual income.

8. Sources of information

Table–1.8 : Distribution of respondents according to their Source of information. (n = 66)

S. No.	Family size	No. of farmers	
		Frequency	Percentage
1.	AEO	17	25.75
2.	AO	6	9.09
3.	ADA	14	21.21
4.	Scientist	10	15.15
5.	Neighbours	11	16.67
6.	Friends	8	12.12
7.	Family		
8.	If any specify		
	Total	66	100.00

It was evident from the Table 1.8 that slightly more than one fourth (25.75%) of the respondents went to AEO as source of information followed by ADA (21.21%), neighbours (16.67%), scientist (15.15%), friends (12.12%) and 9.09 per cent are from AO as source of information.

9. Family Size

Table–1.9 : Distribution of respondents according to their Family size. (n = 66)

S. No.	Family size	No. of farmers	
		Frequency	Percentage
1.	Small Family (upto 5 Members)	57	86.36
2.	Large Family (> 5 Members)	9	13.64
	Total	66	100.00

It was evident from the Table 1.9 that majority (86.36%) of the respondents were belonged to small family followed by large family (13.64%).

10. Family type

Table–1.10 : Distribution of respondents according to their Family type. (n = 66)

S. No.	Family type	No. of farmers	
		Frequency	Percentage
1.	Joint Family	10	15.15
2.	Nuclear Family	56	84.84
	Total	66	100.00

It was evident from the Table 1.10 that majority (84.84%) of the respondents were belonged to Nuclear Family followed by Joint Family (15.15%).

11. Social Participation

The findings given in Table 1.11 revealed that 92.42 per cent of the respondents had no membership category followed by membership in one organization (7.57%).

S. No.	Social Participation	No. of farmers	
		Frequency	Percentage
1.	No membership	61	92.42
2.	Membership in one organization	5	7.57
Total		66	100.00

12. Extension contact :

Table-I.11 : Distribution of respondents according to Extension contact. (n = 66)

S. No.	Levels of Extension Contact	No. of farmers		Purpose	
		Frequency	Percentage	Agril	Non Agril
1.	Frequently	49	74.24	66	
2.	Some time	12	18.18		
3.	Rarely	5	7.57		
Total		66	100.00	66	

It was evident from the Table 1.12 that majority of the respondents had frequent level of extension contact (74.24%), followed by sometimes (18.18%) and rare level of extension contact (7.57%).

According to the study conducted regarding perception of farmers on 33 services provided by RBK, it was observed from the above table 2 that E-crop booking, Distributing quality fertilizers, Provision of Free vaccination – First aid ranks Ist followed by organizing polambadi/thotabadi/pasu vigan badi, Provision of Animal health cards, Provision of all inputs Viz. fertilizers, Pesticides, seed at low cost ranks IInd provision of quality crop seed/fodder seed/concentrate feed), Digital library services provided by RBK, ranks IIIrd followed by RBK is maintaining digital kiosk for booking inputs ranks IVth, Provision of seed germination test facility ranks Vth

Table-2 : Perception of services of RBKs by farmers of Visakhapatnam.dt. (n= 66)

S. No.	Perception	Yes	No	Undecided	Rank
1.	RBK is providing soil & water testing facility	50	16		VIII
2.	RBK is providing seed germination test facility	56	10		V
3.	RBK is doing e-crop booking	66			I
4.	RBK is providing free crop insurance/ animal insurance	52	8	6	VII
5.	RBKs providing quality crop seed/fodder seed/concentrate feed)	63		3	III
6.	RBK is distributing quality fertilizers	66			I
7.	RBK is distributing quality pesticides	55	8	3	VI
8.	RBK is providing loan, weather and market prices information through CM APP	29	13	24	XIII
9.	RBK is maintaining custom hiring centres	23	18	25	XVI
10.	RBK is providing need based information to farmers on crop health management	52	7	7	VII
11.	RBK is maintaining digital library and information material for enhancement of farmers knowledge	63	1	2	III
12.	RBK is organizing capacity building programmes to farmers in recent advances in agriculture by scientists	25	13	18	XV
13.	RBK is organizing polambadi/ thotabadi/ pasuvigyan badi	64	2		II
14.	RBK is maintaining digital kiosk for booking inputs	62	2	2	IV
15.	RBK is maintaining smart TV for interaction with scientists and other experts through audio and video conferences and dissemination of technology	42	6	18	XI
16.	Integrating with ICC/RBK channels for farmers queries & farmers scientists interaction.	28	11	27	XIV
17.	Provision of free vaccination to animals, First aid for animals & Treatment after consulting VAAs, Semen collection centres.	66			I
18.	Provision of Animal health cards	64	2		II
19.	Provision of guidance on extent of loan eligibility through bank mitra & Information on Schemes.	25	21	20	XV
20.	Identification of beneficiaries for various government schemes.	56	8	2	V
21.	Provision of Bio fertilizers and Bio pesticides.	48	10	8	IX
22.	Provision of IPM kits like pheromone traps, Sticky traps, Lures etc.	33	19	14	XII
23.	Provision of farmers groups like FPOs, Cooperative societies, FIGs	15	26	25	XVIII
24.	Purchase of surplus produce at MSP when market price falls below MSP.	28	36	12	XIV
25.	Provision of Godowns to store the produce during glut.	11	34	21	XX
26.	Conduct of advisory board meeting once in a month.	52		14	VII
27.	Provision of all inputs Viz. fertilizers, Pesticides, seed etc at low price compared to local market.	64	1	1	II
28.	Provision of all inputs readily or on demand.	55	4	7	VI
29.	Promotion of Organic farming/ natural farming /ZBNF.	14	13	39	XIX
30.	Provision of Organic inputs like neem cake, vermi compost, neem oil, natural farming products	20	37	9	XVII
31.	Provision of separate market for organically produced goods and services.	2	30	34	XXI
32.	Assistance in Organic certification.		45	21	XXII
33.	Any other information.	45	8	13	X

Table-3 : Utilization of services of RBKs by farmers of Visakhapatnam dt. (n=66)

S. No.	Utilization	Yes	No	Ranking
1.	RBK is providing soil & water testing facility	41	25	XII
2.	RBK is providing seed germination test facility	55	11	VII
3.	RBK is doing e-crop booking	66		I
4.	RBK is providing free crop insurance/animal insurance	50	16	IX
5.	RBKs providing quality crop seed/fodder seed/concentrate feed)	55	5	VII
6.	RBK is distributing quality fertilizers	65	1	II
7.	RBK is distributing quality pesticides	49	17	X
8.	RBK is providing loan, weather and market prices information through CM APP	23	33	XVI
9.	RBK is maintaining custom hiring centres	18	48	XIX
10.	RBK is providing need based information to farmers on crop health management	54	12	VIII
11.	RBK is maintaining digital library and information material for enhancement of farmers knowledge	58	8	V
12.	RBK is organizing capacity building programmes to farmers in recent advances in agriculture by scientists	20	46	XVIII
13.	RBK is organizing polambadi/ thotabadi/ pasuvigyan badi	54	12	VIII
14.	RBK is maintaining digital kiosk for booking inputs	36	30	XIV
15.	RBK is maintaining smart TV for interaction with scientists and other experts through audio and video conferences and dissemination of technology	40	26	XIII
16.	Integrating with ICC/RBK channels for farmers queries & farmers scientists interaction.	21	45	XVII
17.	Provision of free vaccination to animals, First aid for animals & Treatment after consulting VAAs, Semen collection centres.	56	4	VI
18.	Provision of Animal health cards	62	4	IV
19.	Provision of guidance on extent of loan eligibility through bank mitra & Information on Schemes.	20	46	XVIII
20.	Identification of beneficiaries for various government schemes.	56	10	VI
21.	Provision of Bio fertilizers and Bio pesticides.	42	24	XI
22.	Provision of IPM kits like pheromone traps, Sticky traps, Lures etc.	32	34	XV
23.	Provision of farmers groups like FPOs, Cooperative societies, FIGs	15	51	XX
24.	Purchase of surplus produce at MSP when market price falls below MSP.	15	51	XX
25.	Provision of Godowns to store the produce during glut.	2	64	XXII
26.	Conduct of advisory board meeting once in a month.	32	34	XV
27.	Provision of all inputs Viz. fertilizers, Pesticides, seed etc at price compared to local market.	63	3	III
28.	Provision of all inputs readily or on demand.	31	35	XVI
29.	Promotion of Organic farming/ natural farming /ZBNF.	4	45	XXII
30.	Provision of Organic inputs like neem cake, vermi compost,neem oil , natural farming products	17	49	XIX
31.	Provision of separate market for organically produced goods and services.		66	XXIII
32.	Assistance in Organic certification.		66	XXIII
33.	Any other information.	7	59	XXI

distributing quality pesticides, Provision of inputs readily or on demand ranks VIth. RBK is providing free crop insurance/ animal insurance, RBK is providing need based information to farmers on crop health management, Conduct of advisory board meeting once in a month rank VIIth. RBK is providing soil & water testing facility rank VIIIth. Provision of Bio fertilizers and Bio pesticides rank IXth. Any other information rank Xth. RBK is maintaining smart TV for interaction with scientists and other experts through audio and video conferences and dissemination of technology rank XIth. Provision of IPM kits like pheromone traps, Sticky traps, Lures etc. rank

XIIth. RBK is providing loan, weather and market prices information through CM APP rank XIIIth. Purchase of surplus produce at MSP when market price falls below MSP rank, integrating with ICC/RBK channels for farmers queries & farmers scientists interaction rank XIVth. RBK is organizing capacity building programmes to farmers in recent advances in agriculture by scientists, Provision of guidance on extent of loan eligibility through bank mitra & Information on Schemes rank XVth, RBK is maintaining custom hiring centres rank XVIth. These are the main services perceived by the farmers as per the order of priority.

According to the study conducted regarding Utilization of 33 services of RBK by the farmers, it was observed from the table 3 that E-crop booking ranks Ist, Distributing quality fertilizers ranks IInd, Provision of all inputs Viz. fertilizers, Pesticides, seed at low cost ranks IIIrd, Provision of Animal health cards ranks IVth, Digital library services provided by RBK ranks Vth, Provision of Free vaccination – First aid, Identification of beneficiaries for various government schemes ranks VIth followed by provision of quality crop seed/fodder seed/concentrate feed, Provision of seed germination test facility ranks VIIth, RBK is providing need based information to farmers on crop health management, RBK is organizing polambadi/thotabadi/pasuvigyan badi rank VIII. RBK is providing free crop insurance/animal insurance rank IX, RBK is distributing quality pesticides rank X, Provision of Bio fertilizers and Bio pesticides Rank XI, RBK is providing soil & water testing facility rank XII, RBK is maintaining smart TV for interaction with scientists and other experts through audio and video conferences and dissemination of technology rank XIII, RBK is maintaining digital kiosk for booking inputs rank XIV, Provision of IPM kits like pheromone traps, Sticky traps, Lures etc. Conduct of advisory board meeting once in a month rank XV, RBK is providing loan, weather and market prices information through CM APP, Provision of all inputs readily or on demand. Rank XVI. These are the main services utilized by the farmers as per the order of priority

Constraints/Reasons for non-utilization of services of RBKs (n=66)

1. Non availability of RBK services.
2. Lack of awareness on RBK services among the farmers.
3. Some services are not available to the farmers.
4. Lack of awareness about availability of inputs.
5. Rarely visiting fields.
6. Trainings are not conducted for farmers.
7. RBK officials are not giving proper advises.
8. Farmers are not having proper faith on RBKs.
9. Lack of timely information at RBKs.

10. Lack of permanent building.
11. Not aware about many services offered by RBKs
12. RBK officials are not available in time.

Non availability of RBK services is the foremost constraint elicited by farmers followed by Lack of awareness on RBK services among the farmers, Some services are not available to the farmers, Lack of awareness about availability of inputs, Rarely visiting fields, Trainings are not conducted for farmers, RBK officials are not giving proper advises, Farmers are not having proper faith on RBKs, Lack of timely information at RBKs, Lack of permanent building, Not aware about many services offered by RBKs, RBK officials are not available in time.

Suggestions of farmers for better utilization of services of RBKs (n=66)

1. RBKs services may be provided extensively.
2. Create awareness about inputs availability at RBKs.
3. Educate farmers through Polambadi.
4. Subsidies need to be given irrigation facilities.
5. More inputs should be given on subsidy
6. Conduct more awareness programs.
7. Daily visits to fields by RBK officials.
8. Create awareness about latest technologies.
9. Provision of fertilizers at RBKs.
10. Timely provision of Inputs.
11. Explain benefits with or without RBKs

RBKs services may be provided extensively is the foremost suggestion by farmers followed by Create awareness about inputs availability at RBKs, Educate farmers through Polambadi, Subsidies need to be given irrigation facilities, More inputs should be given on subsidy, Conduct more awareness programs, Daily visits to fields by RBK officials, Create awareness about latest technologies, Provision of fertilizers at RBKs, Timely provision of Inputs, Explain benefits with or without RBKs.



Efficiency of Different Phytohormones in *In Vitro* Regeneration among UP-2338 and C-306 Genotypes of Bread Wheat (*Triticum aestivum* L.)

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Abstract

In vitro cultivation of mature wheat embryos was used to produce the callus and a reliable regeneration mechanism. The ability to quickly access mature embryos year-round is a benefit of wheat embryos that have reached maturity. Various combinations of plant growth hormones are used in the current study's efficient embryogenic-based regeneration protocol to improve callus induction and the regeneration system. The optimized callus induction combinations marked the highest rate 100% callus induction in C306 genotype as compared to 96.67% attained by explants of UP2338 genotype. However, the UP2338 genotype showed higher regeneration of 100% with 4.67 number of shoots per explant at the optimal concentration of shoot regeneration (2.0 mg L⁻¹ BAP+0.5 mg L⁻¹ TDZ+1.0 mg L⁻¹ NAA) compared to 88.88% of regeneration with 3.67 number of shoots per explant in the C306 genotype. Although, 8.0 number of roots in the UP2338 genotype were found in MS media supplemented with 2.0 mg L⁻¹ IAA+ 0.5 mg L⁻¹ NAA, which is more than the 7.0 roots identified in the C306 genotype. The current work would be helpful in improving Indian wheat cultivars and would presumably overcome challenges in creating a new plant with a targeted gene alteration employing various cutting-edge technologies, such as CRISPR-Cas9 and gene engineering techniques.

Key words : *In vitro* regeneration, mature embryo, CRISPR-Cas9, wheat.

Introduction

Wheat is a significant food crop on a global scale with the highest protein content among cereals. After China, India produces the most wheat worldwide. In 2019–20, 106.21 million tonnes of wheat produced. While it is more than the output during 2018–19 by 2.61 million tonnes and higher above the average wheat production of 94.61 million tonnes by 11.60 million tonnes, respectively (Sharma *et al.*, 2020). Despite the economic importance of wheat, its productivity is impacted by a number of factors, including biotic and abiotic stressors. Due to challenges in crossing with wild relatives and a small hereditary base, conventional breeding may aid in wheat improvement, but the process is fairly sluggish (El-Arabi *et al.*, 2018). Genetic modification is speedier and more exact when it comes to enhancing crop improvement. Elite cultivars can get transgenes or cisgenes in a comparatively shorter amount of time without losing their agronomic features (Adero *et al.*, 2019). Since they all entail manipulating wheat axenic cultures *in vitro*, these techniques all rely on tissue culture. Additionally, they need a powerful regeneration system (Miroshnichenko *et al.*, 2016). Genotype, explant source, geographic origin, culture medium, and their interactions all affect how plants regenerate (Dargahlou *et al.*, 2017). Zhou and Lee revealed wheat's first effective regeneration (1984). On mature embryo culture, they looked into the impact of

several auxins. The auxin that causes callus in wheat most frequently employed is 2,4-dichlorophenoxyacetic acid (2,4-D), a powerful herbicide and synthetic auxin (Kumar *et al.*, 2017). The quality and effectiveness of a callus induction system in wheat is greatly influenced by the sterilising procedure, the type of explants used, the genotypes used, the media's composition and pH, the growth hormones and inducers used, and the incubation conditions. Immature embryos can only be used for *in vitro* culture and genetic transformation after 12 to 20 days post-anthesis, which limits their availability throughout the year (Krishnaveni *et al.*, 2019). Because mature embryos are readily available year-round and are simple to isolate, they have been employed as a successful substitute for immature embryos (Parmar *et al.*, 2012).

There have been reports of wheat cultivar-specific callus induction and regeneration. Compared to their other counterparts, Indian cultivars have proven to be very resistant (Jasdeep *et al.*, 2019). In order to standardise a procedure for *in vitro* regeneration in wheat that would be helpful in the future production of improved wheat genotypes, the wheat genotypes UP2338 and C306 are used in the current work.

Materials and Methods

Collection of germplasm : The mature seeds of two high yielding varieties UP2338 and C306 were procured from

Table-1 : Composition of various MS media used to induce calluses, regenerate roots, and induce roots in wheat genotypes UP2338 and C306.

Medium Name	PGRs (30 g L ⁻¹ sucrose + 8 g L ⁻¹ Agar + pH 5.8)
Callus Induction Medium	
CI	4.0 mg L ⁻¹ 2,4-D + 1.0 mg L ⁻¹ NAA + 1.0 mg L ⁻¹ ABA
Regeneration Medium	
RM0	Control (without PGRs)
RM1	0.5 mg L ⁻¹ TDZ + 0.5 mg L ⁻¹ BAP + 0.1 mg L ⁻¹ NAA
RM 2	0.5 mg L ⁻¹ TDZ + 1.0 mg L ⁻¹ BAP + 0.5 mg L ⁻¹ NAA
RM 3	0.5 mg L ⁻¹ TDZ + 1.5 mg L ⁻¹ BAP + 0.5 mg L ⁻¹ NAA
RM 4	0.5 mg L ⁻¹ TDZ + 2.0 mg L ⁻¹ BAP + 1.0 mg L ⁻¹ NAA
RM 5	1.0 mg L ⁻¹ TDZ + 0.5 mg L ⁻¹ BAP + 0.1 mg L ⁻¹ NAA
RM 6	1.0 mg L ⁻¹ TDZ + 1.0 mg L ⁻¹ BAP + 0.5 mg L ⁻¹ NAA
RM 7	1.0 mg L ⁻¹ TDZ + 2.0 mg L ⁻¹ BAP + 1.0 mg L ⁻¹ NAA
RM 8	1.0 mg L ⁻¹ TDZ + 2.0 mg L ⁻¹ BAP + 1.0 mg L ⁻¹ NAA
Rooting Media	
RTM 0	Control (without PGRs)
RTM 1	0.5 mg L ⁻¹ IAA + 0.5 mg L ⁻¹ NAA
RTM 2	0.5 mg L ⁻¹ IAA + 1.0 mg L ⁻¹ NAA
RTM 3	1.0 mg L ⁻¹ IAA + 0.5 mg L ⁻¹ NAA
RTM 4	1.0 mg L ⁻¹ IAA + 1.0 mg L ⁻¹ NAA
RTM 5	1.5 mg L ⁻¹ IAA + 0.5 mg L ⁻¹ NAA
RTM 6	1.5 mg L ⁻¹ IAA + 1.0 mg L ⁻¹ NAA
RTM 7	2.0 mg L ⁻¹ IAA + 0.5 mg L ⁻¹ NAA
RTM 8	2.0 mg L ⁻¹ IAA + 1.0 mg L ⁻¹ NAA

Table-2 : Callus induction response in genotype UP2338 and C306 at fourth week after inoculation.

Medium	Callus Induction (%)		Precocious Germination (%)	
	UP2338	C 306	UP 2338	C 306
CI	96.67±3.33 ^g	100.00±0.00 ^g	6.67±6.67 ^a	3.33±3.33 ^a

Percentage callus induction = Calli with visible mass of tissue/total cultured embryos x 100

Krishi Vigyan Kendra Nagina, Uttar Pradesh and Department of Genetics and Plant Breeding, SVPUAT, Meerut. Moreover, C306 was released in 1969 (HAU), timely sown, rain fed and good chapatti making variety. The UP2338 variety, which was released in 1994 (Pantnagar), was timely and late seeded, irrigated, resistant to stem rust, vulnerable to leaf rust, and only moderately susceptible to stripe rust. Utilizing various plant growth regulators at various concentration combinations, mature embryos were cultured for the assessment of *in vitro* plant regeneration potential.

Explant Sterilization : The current investigation used mature wheat embryos as explants. Wheat mature seeds were sterilised by using 0.5% Bavistin + 4% sodium hypochlorite + 0.1% HgCl₂(30s) (Sharma *et al.*, 2020) after being washed twice with sterile distilled water (SDW). Mature seeds were placed in a petri dish that had been sterilised, covered with parafilm, and soaked in SDW overnight. Using a sterile needle and laminar air flow, embryos were excised from mature seeds.

Callus Induction : In order to begin the callus-forming process, mature embryos were punctured with a sterile needle and placed on the MS culture medium (Murashige and Skoog, 1962) and utilised for various media preparations with various concentrations of plant growth regulators, solidified by the addition of agar (HI-MEDIA^R) (8 mgL⁻¹). The medium were set to have a pH of 5.8. Approximately ten excised embryos were placed on each petri dish to begin the process of embryogenic callus induction utilising previously standardized concentrations of auxin (2, 4-D, and NAA) with ABA (Sharma *et al.*, 2020) to control precocious germination among the explants of UP2338 and C306 genotypes (Table 1). In order to prevent contamination, the culture was incubated for 30 days at 24°C before being covered with parafilm. The experiment was carried out three times, and the callus induction was tracked on a weekly basis for four weeks.

***In vitro* regeneration and rooting :** Using callus induction medium, 28 days old calli obtained and then transferred to regeneration medium involving different

Table-3 : *In vitro* regeneration response in genotype UP2338 and C306 using different concentrations of plant growth regulators at fourth week after inoculation.

Medium	Regeneration (%)	
	UP2338	C306
RM0	33.33±0.00 ^a	33.33±0.0 ^a
RM1	44.44±11.11 ^a	33.33±0.00 ^b
RM2	55.55±11.11 ^{ab}	44.44±11.11 ^{bc}
RM3	88.38±11.11 ^c	66.66±0.00 ^{cd}
RM4	100.00±0.00 ^c	88.88±11.11 ^d
RM5	77.70±11.11 ^{bc}	55.55±11.11 ^{bc}
RM6	44.44±11.11 ^a	44.40±11.11 ^{bc}
RM7	44.44±11.11 ^a	44.40±11.11 ^{bc}
RM8	33.33±0.00 ^a	33.33±0.00 ^b

Regeneration percentage = Numbers of compact calli with green spots/total number of calli×100.

Table-4 : *In vitro* rooting response in genotype UP2338 and C306 using different concentrations of plant growth regulators after inoculation.

Medium	Rooting (%)	
	UP2338	C306
RTM0	3.50±0.33 ^a	3.00±0.00 ^a
RTM1	4.0±0.0 ^a	3.67±0.33 ^{ab}
RTM2	4.33±0.33 ^a	4.0±0.57 ^{abc}
RTM3	4.67±0.33 ^{ab}	4.67±0.33 ^{bcd}
RTM4	5.66±0.33 ^{bc}	4.67±0.33 ^{bcd}
RTM5	6.67±0.33 ^{cd}	5.33±0.33 ^{cd}
RTM6	7.0±0.57 ^{de}	6.0±0.57 ^{de}
RTM7	8.0±0.57 ^e	7.0±0.57 ^e
RTM8	4.33±0.33 ^{ab}	3.67±0.33 ^{ab}

The average values of three replications of each treatment are represented by the data for each characteristic.

concentrations of BAP, TDZ and NAA (Table-1). For four weeks, the incubation conditions for regeneration included a temperature of 24±1°C, a 16/8-hour photoperiod, and a cool fluorescent light. The experiment was carried out three times, and the percentage of regenerated shoots and the quantity of sprouts per plant were noted. The root initiation effectiveness of the explants was tested using a similar pattern. The mature shoots were divided aseptically and grown on different MS media with a control and eight different auxin (NAA) concentrations.

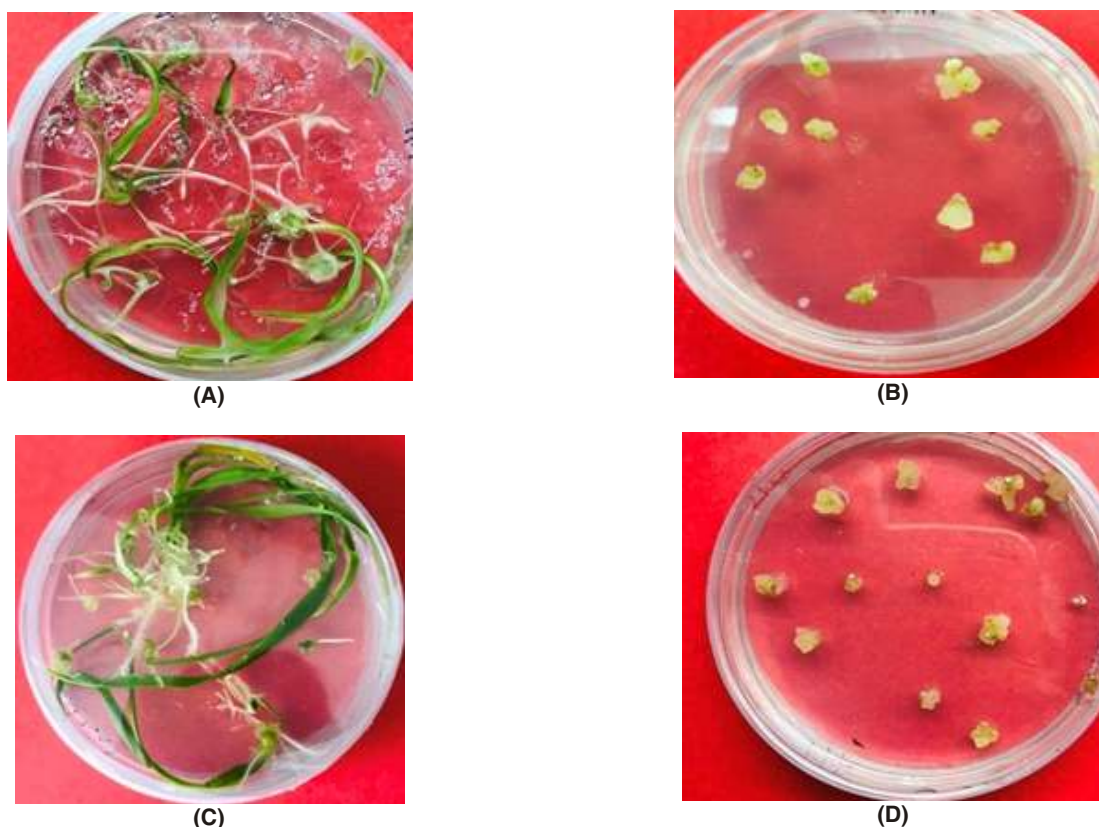
Hardening : The *in vitro* rooted shoot plants are taken out of the culture media and washed with double-distilled water in order to remove any last traces of agar. Plants are moved into perforated plastic containers containing 1:1 (v/v) cocopeat: vermicompost at 25°C for 16/8 hours. In order to maintain the humidity, plantlets were then given 50 ml of Hoagland solution and covered with a polythene bag with three to four holes.

Data Analysis : A minimum of three cultures per treatment were included in the experiment's completely randomised design (CRD). Using SPSS version 19

software, one way analysis of variance (ANOVA) was performed on all the data. In order to detect a difference at 5% (P<0.05) level, the means were compared using critical difference. As a mean SE of three replications, the findings are presented.

Results and Discussion

Explant Sterilization : The sensitivity of explants to chemical treatment during sterilisation made it difficult to surface sterilise wheat mature embryos. According to the findings of the current investigation, the explants were sterilised using a combination and concentration of Bavistin (0.5%) 2 min + Sodium hypochlorite (4%) 20 min + 0.1% HgCl₂(30s), which was found to be the most effective where the greatest number of explants showed the highest regeneration with no contamination in cultures. Similar research on surface sterilisation was conducted by Kumar *et al.*, (2017), who used mature wheat seed embryos that were surface sterilised for 10 minutes with a 10% sodium hypochlorite (NaOCl) solution. This study revealed that the surface sterilised wheat seeds had less contamination than other treatment combinations.



- A : Callus Induction response in UP2338 (control).
 B : Callus Induction response after 28 days of inoculation in UP2338.
 C : Callus Induction response in C306 (control).
 D : Callus Induction response after 28 days of inoculation in C306.

Figure-1 : Callus Induction response of treatment CI (4.0 mg L⁻¹ 2,4-D +1.0 mg L⁻¹ NAA + 1.0 mg L⁻¹ ABA) among UP-2338 and C-306 genotypes after fourth week of inoculation.

Callus Induction : For callus induction, two wheat genotypes, C306 and UP2338, were grown on a total of fourteen distinct combinations of MS media; each combination resulted in a different percentage of early germinations. To prevent premature germination, MS media is combined with the stress hormone ABA and other PGRs. The control treatment (CI 0, or without utilising any concentration combination of growth hormone) exhibits no callus induction and exhibits significant precocious germination, according to the findings of the current study. Callus induction was responsive to treatment CI (4.0 mg L⁻¹ 2,4-D +1.0 mg L⁻¹ NAA +1.0 mg L⁻¹ ABA) among all. With no premature germination occurring during the fourth week of observation, wheat genotype C 306 attained highest level of callus induction, or 100%. Precocious germination was 6.67% with strong callus induction (96.67%) in genotype UP 2338, in contrast (Table 2). According to Mahmood and Razzaq (2017), Nigar *et al.*, (2017), and Ahmadpour *et al.*, (2016), a good callus induction was achieved using mature wheat embryos in a solution containing 6 mgL⁻¹ 2,4-D.

In vitro regeneration and rooting : Eight distinct combinations, each with a different concentration and level of effectiveness, were examined for their ability to promote roots and regeneration. The twenty-eight day old calli were transplanted to a regeneration medium containing different quantities and mixtures of the plant growth regulators BAP, TDZ and NAA. After a week of incubation on regeneration media, the first signs of regeneration appeared as green patches on calluses. The treatment RM4 (2.0 mgL⁻¹ BAP+ 0.5 mgL⁻¹ TDZ+ 1.0 mgL⁻¹ NAA) recorded highest regeneration rate among all. In comparison to genotype C306, which had 88.88% regeneration and 4.67 average shoots, genotype UP 2338 had 100% regeneration (Table-3). According to Kumar *et al.*, (2017), BAP concentrations of 2.5 mgL⁻¹, kinetin of 0.5 mgL⁻¹, and IAA of 0.1 mgL⁻¹ on MS media showed better regeneration percent and greatest number of regenerated shoots observed. Furthermore, when 1.0 mg/l TDZ and 2-4D were mixed during *in vitro* culture, a good number of shoots were formed, according to studies by Parmar *et al.*, (2012) and Jasdeep *et al.*, (2019). Although, Kumar *et al.*,



(a) MS basal medium treatment RM 4 with different concentrations of plant growth regulators for regeneration in wheat genotype UP-2338.



(b) MS basal medium treatment RM 4 with different concentrations of plant growth regulators for regenerations in wheat genotype C306.

Figure-2 : *In vitro* regeneration response among UP-2338 and C-306 genotypes.

(2015) reported that more shoots were seen in BAP-containing MS medium.

Eight different concentration combinations of NAA and IAA were used for *in vitro* rooting. The current study reports that the UP 2338 genotype had the highest *in vitro* rooting response to treatment RTM 7 (2.0 mgL⁻¹ IAA+0.5 mgL⁻¹ NAA), with an average of 8.0 roots obtained per regenerated plant. The C306 genotype came in second with 7.0 roots (Table-4). Krishnaveni *et al.*, (2019) carried out a similar investigation employing concentrations of IAA for *in vitro* rooting. The separated, successfully planted elongated shoots were placed on half MS medium containing 0.2 mgL⁻¹ indole-3-acetic acid (IAA).

Hardening : Using 50 ml of Hoagland solution, the rooted plantlets were hardened. A controlled environment was used to cultivate the plants that were retrieved from the

culture material. The morphologically sound plantlets were planted into a sterilised coco-peat: soil (1:1) mixture. Following acclimation, over 70% of plants fared well.

Conclusions

In the current study, we use mature embryo culture to design an effective regeneration procedure for wheat. It is obvious that interactions among a genotype source, concentration of a carbon source and a gelling agent, and several growth hormones are critical for induction of calluses and plant regeneration. The standardised medium and methodology may be used successfully with many wheat genotypes and may be used to create new lines utilising various techniques of gene engineering and mutagenesis to incorporate various features in the future for rapid improvement in wheat.

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Entrepreneurship Opportunities and Startup in Livestock Sector

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Abstract

Innovation is the core of a startup. An entrepreneur, having motive to work for finding out solutions or addressing the societal needs either through application of an innovative idea; method, process or offering a specific product (goods or services) can think to become a startup company. Of course, startups endeavour to gain competitive advantage in the market and always intends to upscale the business.

Key Words : *entrepreneur, startup, adaptability, flexibility.*

Entrepreneurship : Entrepreneurship pays a pivotal role in economic development of a country in various ways. It creates employment, generates income and induces economic growth, which are much needed to set the trajectory of social change and economic development. Before we discuss about livestock entrepreneurship, it is imperative to understand about an entrepreneur.. An entrepreneur is a person who organizes the resources, makes endeavours and takes risks while implementing his new idea, method, process to create new goods or services for satisfaction of human needs and wants. Entrepreneurs, propelled by their dreams and passions, have been the engine for creating new jobs, generating revenue, advancing innovation, enhancing productivity, and improving business models and processes. Entrepreneurship is the cornerstone of the free enterprise system around the world.

Higgins asserts that entrepreneurship stood for the function of foreseeing investment and production opportunities, raising capital, hiring labour, arranging the supply of raw materials, finding site, introducing a new technique, discovering new resources or raw materials and selecting top managers for day to day operations of the enterprise. In other words, entrepreneurship is a process of identifying opportunities in the market place, arranging the resources required to pursue these opportunities and investing the resources judiciously to exploit the opportunities for long term gains.

It involves creating wealth by bringing together resources in new ways to start and operate an enterprise. It is thus understood that entrepreneurship is set of activities performed by the entrepreneur - a person who undertakes entrepreneurship to pursue his dreams for creating economic goods and services innovatively. However, the main crux of entrepreneurship lies in

making new choices for pursuing innovations and taking associated risks. It is to be understood that due to risk return trade off possibilities of earning more income is also very high.

Startup : Startup is a young company established by an individual or a few entrepreneurs to create unique products or services. It refers to a company in the first stage of operations that endeavours to bringing innovations and building ideas in creation of products and services which are scalable and capable of yielding high returns. It is important to understand that a startup is a company that works to solve a problem where the solution is not conspicuous and success is also not assured.

Features of Startup : There are certain attributes which are generally common to all start-ups. Some of the most important and common features of startups are :

Innovation : Innovation is the core of a startup. An entrepreneur, having motive to work for finding out solutions or addressing the societal needs either through application of an innovative idea; method, process or offering a specific product (goods or services) can think to become a startup company. Of course, startups endeavour to gain competitive advantage in the market and always intends to upscale the business.

Age and Stage of the Company : A startup is a new company which is often less than three years i.e. still in early stages of brand management, sales and hiring of employees. However, this rule is not very specific. A company having specific set of features, convincing business prospects and promising future can be considered as a startup company even if it six-seven years old.

Motive to Grow : A startup has a unique goal to grow and expand rapidly in its area. It makes a startup different from

a small business because a startup is always adjudged on the basis of its uniqueness, growth potential and scalability whereas a small business attempts to earn profit by offering common goods and services.

Taking Risk : A startup is a company that attempt to offer solution to some obvious problems but often the solutions are unobvious and involve high risks because people take time in realizing and accepting its benefits. Though a start-up has very high economic potential but it has a high failure rate. For the same reasons, it is also considered as a very risky venture.

Adaptability and Flexibility : A startup should always be ready to adopt and accommodate changes, which are required to cope with any adversities that may arise in business. For success, customization of products as per the customers need and validation of ideas are very much required.

Problem Solving : Identifying a problem and offering an affordable and plausible solution to an existing problem is one of the imperatives for the success of a startup. An startup is company in constant search of a business model that is scalable and repeatable, that is, it can grow without the need to increase human or financial resources.

Working Team : Startup usually involves very few people in the beginning. A startup is a company that is an young company which is in its early stage of development in order to solve real-life problems through a product or innovative service.

Startup India : The Startup India is a flagship initiative of the Government of India, which was first announced in 15 August 2015. The action plan of this initiative focuses on three issues viz. Simplification and Handholding, Funding Support and Incentives and Industry-Academia Partnership and Incubation. It aims at fostering entrepreneurship and promoting innovation by creating an ecosystem that is conducive for growth of Startups. The objective is that India must become a nation of job creators instead of being a nation of job seekers.

Entrepreneurship opportunities and startup in livestock sector : Evidences indicate that the demand for livestock products and services are never going to subside in near future. Growth in family income, changing consumption pattern, increased choices for quality livestock products, and contributions of livestock in household economy are fueling the growth in livestock sector, which offers enormous opportunities for entrepreneurship in India. Some of the profitable enterprises are :

Starting Livestock and Poultry Farms : The rural youth/

entrepreneurs can go for establishing start their own livestock/ dairy/ fish/ poultry farm or start integrated production units. The new technologies are available which can be applied by infusing scientific management techniques on their farms. Practicing proven scientific management techniques will improve productivity of animals that would lead to overall quantitative and qualitative improvement of livestock sector.

Manufacturing of livestock feed : This is one of the grey areas where tremendous entrepreneurship opportunities lie. There is a huge demand for balanced ration/ feed for livestock. The rural youth who are willing to seek their career in this area can think of this venture to pursue chase their dreams and earn income. Commercial feed availability for various unconventional poultry species such as Quail, Emu, Ostrich, etc. are far less than the demand. Manufacturing feed for these species is a niche business as their energy requirement is different from the existing commercially available broiler or layer feed.

Fodder Supplier : The main constraint which hampers the growth of livestock production is the inadequacy of nutritious fodder. Indian livestock sector is 60% fodder deficit. Here lies the opportunity for entrepreneurship in India. Fodder production, silage preparation, processing and packaging of fortified fodder bricks, starting a fodder banks are some of the activities, which can be taken up by an entrepreneur

Manufacturing of Machine and Equipment : Various types of farm machineries and equipment are required for livestock farms. For example, in case of dairy farms, chaff cutter, milking machine, feeding manager, etc. are needed. Poultry farmers need debeaker, vaccinator, automatic feeder, waterer, etc. These equipment and machineries can be manufactured by the entrepreneurs or sold by taking dealership.

Other options : Besides, there are some very important areas in which entrepreneurship opportunities can be harnessed. Starting a dog breeding farm or clinics for companion animals like dogs can also be think edof for doing a remunerative business in urban areas. Veterinary consultancy services and marketing of feeds and accessories for dogs also have very high economic potential.

Establishing a hatchery for hatching eggs to produce chicks of poultry birds is another area in which entrepreneurs can find an exciting business opportunity. Though starting a hatchery requires higher investment, it offers good return.

There is a huge gap between the requirement and availability of veterinary services in the rural areas of the

country. Particularly, in case of large ruminants access to veterinary services in time becomes very difficult. Veterinary hospitals and clinics are remotely placed and carrying the animals to the hospitals becomes extremely difficult or sometimes virtually impossible. Thus, establishment of animal clinics and providing ambulatory veterinary services at the doorstep provide an excellent business/ entrepreneurship opportunity. This can also include artificial insemination (AI) services.

Value addition to the livestock products such as milk, egg, meat, and fish also has very huge economic potential. Establishing a processing plant or small processing unit or milk parlour, where they can sell processed milk and milk products like flavoured milk, ice cream, etc. or meat centre where cooked products could be sold. Marketing of these value-added products in its own brand name can be started or a chain of parlours / hotels can be established.

Conclusions

Livestock sector provides tremendous opportunities for entrepreneurship and also for startups. There are huge demand for various livestock products and services in the country and identifying the needs, gaps and problems in different areas entrepreneurs can successfully start a number of business and earn income.

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Response of Sources of Biochar Incubated With FYM on Yield And Soil Carbon Pools After Harvest of Fodder Maize

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Abstract

The field experiment was conducted at Instructional Farm, Department of Soil Science and Agriculture Chemistry, Post Graduate Institute, Research Farm, M.P.K.V., Rahuri during kharif season of 2019-20 to find out "Response of sources of biochar incubated with FYM on yield and soil carbon pools after harvest of fodder maize". The initial soil samples were collected from the experimental field and analysed the initial chemical properties. The texture of the soil was clay loam. The soil was low in available N, medium in available P, and high in available K. The field experiment was laid out in Randomized Block Design (RBD) and consisted of seven treatments and three replication. The application of FYM incubated biochar of cotton stalk significantly increased yield of fodder maize (50.63 t ha^{-1}), which was at par with T_5 , (48.51 t ha^{-1}), T_7 , (46.26 t ha^{-1}), T_6 , (46.23 t ha^{-1}) and T_4 (45.16 t ha^{-1}) treatments. The lowest yield of fodder maize (21.36 t ha^{-1}) was recorded in absolute control treatment.

The higher soil organic carbon (0.82%) was recorded with the application of T_3 treatments, (Cotton stalk biochar incubated with FYM (1:1) ($2.5:2.5 \text{ t ha}^{-1}$), which was at par with T_7 (0.78 %) treatments. The significantly maximum total organic carbon (1.23 %), which was at par with T_5 (1.13 %), T_7 , (1.10%) and T_6 , (1.09 %) as compared to control. The application of T_3 treatments, (Cotton stalk biochar incubated with FYM (1:1) ($2.5:2.5 \text{ t ha}^{-1}$) recorded significantly higher soil microbial biomass carbon (219.6 mg kg^{-1}), which was at par with T_5 treatments (208.1 mg kg^{-1}) Pigeonpea stalk biochar incubated with FYM (1:1) ($2.5:2.5 \text{ t ha}^{-1}$) and T_2 , (195.2 mg kg^{-1}) GRDF ($100:50:50 \text{ kg ha}^{-1} + 5 \text{ t ha}^{-1}$ FYM). The lowest soil organic carbon (0.63 %), total organic carbon (0.95 %), soil microbial biomass carbon (131.9 mg kg^{-1}) was recorded in absolute control treatment.

Key Words : Biochar, Cotton stalk, Fodder maize, soil carbon pools, POXC, Pomc, SMBC, WSC

Maize or corn (*Zea mays* L.) is one of the most important cereal crop of the world used as food and feed. Although maize fodder has low protein content but it is relished by the animals due to being succulent and palatable (Ali *et al.* 2004). The maize fodder plays a vital role in increasing the productivity of the livestock and making this enterprise more profitable. The crop has an edge over cultivated fodder crops due to its adaptability and excellent fodder quality and usage in the form of silage. The green forage of maize is a valuable cattle food on account of its high albuminoidal and fat content, which is highly succulent, palatable and digestible with rich leafy growth.

Maize has very high nutrient demand and its productivity mainly depends upon nutrient management system. FYM is one of the oldest manure used by the farmers in growing crops. It contains 0.5% N, 0.2% P and 0.5% K. It improves the soil physical, chemical and biological properties which enhance the crop growth. Biochar is a highly porous, fine-grained, carbon dominant product rich in paramagnetic centres having both organic and inorganic nature, with large surface area possessing oxygen functional groups and aromatic surfaces and it obtained by slow pyrolysis from biomass waste with the

primary goal of soil improvement (Amonette and Joseph. 2009). Recently, application of biochar along with other organic amendments has found an effective management to improve soil fertility and crop yield.

To take the advantage of the technique, lots of agriculture wastes are available that remain unutilized at farm scale. These wastes are potential source for preparation and utilization as biochar. These include pigeon pea stalk, cotton stalks, maize stubbles etc. The Biochar developed from these wastes can be added to soil to increase soil carbon and to improve crop yields. Some literature showed clear evidence that biochar is highly effective for acidic and neutral soil, improve soil nutritional availability, plant growth and yield but not yet clearly know the effects of biochar amendment on alkaline tropical soils. Therefore, the present study was undertaken the "Response of sources of biochar incubated with FYM on yield and soil carbon pools after harvest of fodder maize".

Materials and Methods

The field experiment was conducted at Post Graduate Institute Research Farm, Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth,

Rahuri, Dist. Ahmednagar during 2019-20 in *kharif* season.. The experimental soils was medium deep black belonging to *Inceptisols* order. Biochar was prepared at PGI, Farm, MPKV, Rahuri, by pyrolysis klin method with help of metallic drum and brick. The material used for preparation of biochar was cotton stalk, pigeon pea stalk, sugarcane trash, sugarcane bagasse and *Prosopis juliflora* wood. The experiment was laid out in a randomized block design with 7 treatments and 3 replications. The fodder maize were sown at recommended spacing of 30 cm x 5 cm adopted for dibbling. Treatments consist of T₁ - Absolute Control, T₂ - GRDF (100:50:50 kg ha⁻¹ N: P₂O₅: K₂O + 5 t ha⁻¹ FYM), T₃ - Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹), T₄ - Sugarcane trash biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹), T₅ - Pigeonpea stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹), T₆ - Sugarcane bagasse biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹), T₇ - *Prosopis juliflora* (Vedi Babul) biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹). Soil samples (0-15 cm depth) were randomly taken with the help of soil auger to make a composite sample for evaluating the initial fertility status and after harvest.

Results and Discussion

The result revealed that yield of fodder maize, carbon fractions in soil viz., soil organic carbon, total organic carbon, soil microbial biomass carbon, water soluble carbon, particulate organic matter carbon and potassium permanganate oxidizable organic carbon are influenced by FYM incubated biochar of different sources in soil at harvest of fodder maize are reported in Table-1 and Table-2.

Fodder Yield of Maize : The application of FYM incubated biochar of cotton stalk significantly increased yield of fodder maize (50.63 t ha⁻¹), which was at par with T₅, (48.51 t ha⁻¹), T₇, (46.26 t ha⁻¹), T₆, (46.23 t ha⁻¹) and T₄ (45.16 t ha⁻¹) treatments. The lowest yield of fodder maize (21.36 t ha⁻¹) was recorded in absolute control treatment. This might be due to the nutritional effect of biochar, in addition to improvement in physical and chemical properties of the soil. Addition of more nutrients through combination of biochar, FYM and inorganic fertilizers resulted in higher yield of fodder maize. The increase in maize fodder yield in biochar applied pots might be due to impact of biochar on soil physico-chemical properties like enhanced water holding capacity, increased cation exchange capacity and providing a medium for absorption of plant nutrients and providing congenial condition to soil micro-organisms (Gandahi et al. 2015). The inorganic nitrogen from biochar increased the yield of sugarcane as reported by Chen et al. (2010).

The nitrogenous fertilizers applied along with biochar increased the yield (Asai et al. 2009).

Soil Organic Carbon : The data pertaining to effect of biochar application on soil organic carbon content at harvest of fodder maize are presented in Table-1. Application of FYM incubated biochar of cotton stalk in 1:1 proportion recorded significantly higher value (0.82%) at harvest which was at par with application of FYM incubated biochar of *Prosopis juliflora* (0.78%). The application of FYM incubated biochar of pigeonpea stalk and FYM incubated biochar of sugarcane bagasse are statistically on par with each other (0.75% and 0.73%). The rest of the treatments were found on par with each other for their organic carbon. The lower values were noticed in the absolute control (0.63%) treatment. The higher content of soil organic carbon recorded in FYM incubated biochar of cotton stalk and *Prosopis juliflora* might be associated with both sources contain higher lignin content in their organic matter content which enriched the soil organic carbon content. The high carbon content in the biochar might have enriched the soil with organic carbon content (Shenbagavalli and Mahimairaja. 2012) and Masto et al. (2013). The increase in the soil organic carbon due to addition of biochar was also observed by Timilsina et al. (2017), Lehmann. (2007) and Van Zwieten et al. (2010).

Total Organic Carbon : The total organic carbon content was significantly influenced by the FYM incubated biochar prepared from cotton stalk, sugarcane trash, pigeon pea stalk, sugarcane bagasse and *Prosopis juliflora* which are represented in Table-1. The significantly maximum total organic carbon (1.23 %), was observed in T₃ treatment (Cotton stalk biochar incubated with FYM in (1:1)), which was at par with T₅ (1.13 %), T₇, (1.10%) and T₆, (1.09 %) as compared to control. Application of biochar in combination with FYM increased the soil total organic carbon (Arunkumar et al. 2019). This might be due to the carbon content in the biochar and FYM.

Soil Microbial Biomass Carbon : The results of FYM incubated biochar of cotton stalk, pigeonpea stalk, sugarcane trash and bagasse and *Prosopis juliflora* in 1:1 proportion on soil microbial biomass carbon at harvest of fodder maize are presented in Table 1. The application of T₃ treatments, (Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha⁻¹)) recorded significantly higher soil microbial biomass carbon (219.6 mg kg⁻¹), which was at par with T₅ treatments (208.1 mg kg⁻¹) and T₂, (195.2 mg kg⁻¹) GRDF (100:50:50 kg ha⁻¹ + 5 t ha⁻¹ FYM) as compared to absolute control. This might be due to the more intensive activity of microorganisms which results in more decomposition of soil organic matter and labile

Table-1 : Effect of FYM incubated biochar of different sources on carbon fractions in soil at harvest of fodder maize.

Tr. No.	Treatment	Yield (t ha ⁻¹)	Soil organic carbon (%)	Total organic carbon (%)	Soil microbial biomass carbon (mg kg ⁻¹)
T ₁	Absolute control	21.36	0.63	0.95	131.9
T ₂	GRDF (100:50:50 kg ha ⁻¹ N:P ₂ O ₅ :K ₂ O + 5 t ha ⁻¹ FYM)	46.26	0.67	1.00	195.2
T ₃	Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha ⁻¹)	50.63	0.82	1.23	219.6
T ₄	Sugarcane trash biochar incubated with FYM (1:1) (2.5:2.5 t ha ⁻¹)	45.16	0.68	1.02	169.9
T ₅	Pigeonpea stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha ⁻¹)	48.51	0.75	1.13	208.1
T ₆	Sugarcane bagasse biochar incubated with FYM (1:1) (2.5:2.5 t ha ⁻¹)	46.23	0.73	1.09	161.1
T ₇	<i>Prosopis juliflora</i> (Vedi Babul) biochar incubated with FYM(1:1) (2.5:2.5 t ha ⁻¹)	47.47	0.78	1.10	181.7
	S.E. ±	2.53	0.019	0.06	10.73
	C.D. at 5%	7.80	0.059	0.19	33.06

Table-2 : Effect of FYM incubated biochar of different sources on carbon fractions in soil at harvest of fodder maize.

Tr. No.	Treatment	Water soluble carbon (mg kg ⁻¹)	Particulate organic matter carbon (mg kg ⁻¹)	Potassium permanganate oxidizable organic carbon (mg kg ⁻¹)
T ₁	Absolute control	18	0.89	1.70
T ₂	GRDF (100:50:50 kg ha ⁻¹ N:P ₂ O ₅ :K ₂ O + 5 t ha ⁻¹ FYM)	32	1.03	1.71
T ₃	Cotton stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha ⁻¹)	36	1.73	1.74
T ₄	Sugarcane trash biochar incubated with FYM (1:1) (2.5:2.5 t ha ⁻¹)	34	1.06	1.73
T ₅	Pigeonpea stalk biochar incubated with FYM (1:1) (2.5:2.5 t ha ⁻¹)	33	1.56	1.74
T ₆	Sugarcane bagasse biochar incubated with FYM (1:1) (2.5:2.5 t ha ⁻¹)	38	1.26	1.72
T ₇	<i>Prosopis juliflora</i> (Vedi Babul) biochar incubated with FYM (1:1) (2.5:2.5 t ha ⁻¹)	32	1.50	1.72
	S.E. ±	2.68	0.09	0.1
	C.D. at 5%	NS	0.27	NS

organic carbon (Demisie *et al.* 2014). Addition of biochar increases soil microbial biomass carbon due to increase in the microbial population observed by Arun kumar *et al.* (2019). Higher carbon mineralization rates in biochar treatments results in higher microbial biomass carbon and enzyme activities (Ouyang *et al.* 2014). The enhanced SMBC might be due to the large surface area of biochar particles and pores available to hold water molecules which adhere to biochar particles (Azeem *et al.* 2018).

Water Soluble Carbon : The results of water soluble carbon obtained in soil after harvest of fodder maize was statistically non significant. The water soluble carbon content was recorded numerically the highest in treatment FYM incubated biochar of sugarcane bagasse (38 mg kg⁻¹) .

Particulate Organic Matter Carbon : The data pertaining to response of biochar application on fodder maize are presented in Table-2. The particulate organic matter carbon as influenced due to addition of FYM incubated biochar prepared from cotton stalk, sugarcane trash, pigeon pea stalk, sugarcane bagasse and *Prosopis juliflora*. The particulate organic matter carbon content was recorded significantly the highest in treatment T₃, FYM incubated biochar of cotton stalk (1.73 mg kg⁻¹), which was statistically at par with treatment T₅, FYM incubated biochar of pigeon pea stalk (1.56 mg kg⁻¹), T₇, (1.50 mg kg⁻¹) after harvest of fodder maize. The increased particulate organic matter carbon yield and organic carbon storage was due to the biochar particles which most likely lead to a change in the soil ecological function of this fraction (Cooper *et al.* 2020).

Potassium Permanganate Oxidizable Organic Carbon

: The results of potassium permanganate oxidizable organic carbon obtained in soil at harvest of fodder maize were statistically non significant. The highest potassium permanganate oxidizable organic carbon content was recorded in treatment FYM incubated biochar of cotton stalk and pigeon pea stalk (1.74 mg kg^{-1}). The potassium permanganate oxidizable organic carbon is the most easily decomposable or labile carbon the result are in agreement with the finding of Blair *et al.* 1995. Which is based on the oxidation action by KMnO_4 under neutral condition and comparable to the oxidative process associated with the microbial decomposition of organic matter in soil.

Conclusions

The treatment cotton stalk biochar incubated with FYM was found significantly beneficial over all other treatments with respect to soil organic carbon (0.82%), total organic carbon (1.23%), soil microbial biomass carbon ($219.61 \text{ mg kg}^{-1}$), particulate organic matter carbon (1.73 mg kg^{-1}) and the fodder yield (50.63 t ha^{-1}). The present investigation, concluded that the treatment receiving cotton stalk biochar incubated with FYM was found significantly superior over all the treatments, improved the soil carbon fractions viz. soil organic carbon, total organic carbon, soil microbial biomass carbon, particulate organic matter and increased the yield of fodder maize in *Inceptisols*.

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Effect of Coinoculation of PGPR Consortia on N Supply, Growth and Grain Yield of Wheat Crop

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Abstract

Present investigation aims to study the inoculation effect of PGPR consortia on N supply, growth and grain yield of wheat. Results revealed the highest nitrate reductase activity with inoculation of PGPR at recommended dose of N fertilizer compared to all other treatments, indicating bioinoculant on availability of nitrogen. The highest root length was recorded in T4 (50%N+ Consortium of PGPR) which was statistically at par with T6 and T5. The root length measured for T2 (Consortium of PGPR only) ($p < 0.05$; 14.4cm) was at par with T3 (Recommended Dose of Fertilizers). The straw yield of wheat was found significantly higher when PGPR consortia was applied along with recommended dose of inorganic fertilizers ($p < 0.05$; 13.27g/pot) which was equal to recommended dose of chemical fertilizers ($p < 0.05$; 13.27g/pot) and at par with T5 ($p < 0.05$; 12.22g/pot). The grain yield of wheat was found numerically higher in T6 ($p < 0.05$; 11.68g/pot) but was statistically at par with T3 i.e. RDF treatment ($p < 0.05$; 10.28g/pot). Study suggested that after confirmation these isolates can be utilized as potential bioinoculants for enhancing wheat productivity.

Key words : PGPR consortia, Wheat, N supply, Grain yield, Bioinoculant.

Introduction

Wheat, together with rice, represent the most important staple food crops used to sustain humanity, as they provide more calories and proteins in the diet than any other crop. Many a time the response of effective inoculums gets diluted compared to the efficiency observed in lab study primarily because the interaction between microbes and plants in soil environments are complex and difficult to manage. To achieve the maximum growth promoting activity, it is important to understand the interaction between PGPR and associated plants and how the beneficial attribute of PGPR are altered by various biotic and abiotic soil factors. Therefore, it is necessary to develop efficient strains for real conditions. Some PGPR release a blend of volatile components like 2, 3-butanediol and acetoin that promote growth of *Arabidopsis thaliana* (Ryu *et al.*, 2003). The diazotroph bacterial inoculation significantly increases the seed cotton yield, plant height and microbial population in soil (Anjum *et al.*, 2007). The plant growth stimulating efficiency of bacterial inoculants is affected by soil nutritional condition. The bacterial inoculation has a much better stimulatory effect on plant growth in nutrient deficient soil than in nutrient rich soil (Egamberdiyeva, D., 2007). Plant growth-promoting bacteria (PGPB) influences the growth, yield, and nutrient uptake by an array of mechanisms. Some bacterial strains directly regulate plant physiology by mimicking synthesis of plant hormones, whereas others increase mineral and nitrogen availability in the soil as a way to augment

growth. The isolates could exhibit more than two or three PGP traits, which may promote plant growth directly or indirectly or synergistically (Joseph and Yasmin *et al.*, 2007). The plant growth-promoting rhizobacteria (PGPR), a group of beneficial plant bacteria, as potentially useful for Increased growth and yields of potato, sugar beet, radish and sweet potato (Farzana *et al.*, 2009). Therefore, present investigation conducted to study the inoculation effect of PGPR consortia on N supply, growth and grain yield of wheat.

Materials and Methods

The present investigation conducted during *rabi* season of 2016-17 at Research Farm of ICAR-IISS, Bhopal to study the "Effect of inoculation of PGPR consortia on N supply, Growth and grain yield of wheat crop". The material used and methods adopted during the course of experiment in the field and laboratory are described in brief under following heads.

Media and glasswares sterilization : At 15 psi (1.06 kg/cm²) pressure all media were autoclaved for 20 minutes. The glasswares used were sterilized in hot air oven at 180°C for 2 hours.

Pot study

Chemical characteristics of soil : Soil under study had pH 7.9, Available N 215kg/ha, Phosphorus-110 kg/ha, Potash-390 kg/ha and organic carbon- 0.75%.

Seed Inoculation with potential PGPR isolates : About 50g

Table-1 : Along with PGPR inoculants the effect of different levels of N-fertilizers on agronomic parameters of wheat.

Treatment	Straw wt. (g/pot)	Grain wt. (g/pot)	Root length (cm)	Shoot length (cm)	Root fresh wt. (g/plant)	Shoot fresh wt. (g/plant)	Root dry wt. (g/plant)	Shoot dry wt. (g/plant)
T1	6.74d	5.47d	11.3c	24.4d	1.64c	3.56d	0.32e	1.27c
T2	8.05c	6.58cd	14.4b	27.9d	1.84bc	4.12c	0.36de	1.26c
T3	13.27a	10.28a	16.8b	40.1ab	1.84bc	5.04ab	0.75c	1.85b
T4	10.13b	7.56bc	20.7a	35.0c	2.07ab	4.57bc	0.47d	1.80b
T5	12.22a	8.04b	19.7a	36.6bc	2.29a	4.75b	0.91b	1.65b
T6	13.27a	11.68a	20.5a	41.8a	2.36a	5.34a	1.32a	2.33a
LSD (0.05)	1.29	1.42	2.69	4.26	0.29	0.5	0.11	0.3

wheat seeds were surface sterilized by dipping seed for 30 sec in 70% ethanol solution followed by 2 minutes in HgCl_2 (0. 1%). The seeds were washed thoroughly with sterile distilled water for three times. Inoculums of potential isolate JS1 and MER4 was built in Jensen's broth and Nutrient broth respectively and incubated at $28 \pm 2^\circ\text{C}$, 200 rpm in an incubator shaker for 4 days. Enumeration of viable cell count was done by dilution plating technique. Equal volume of two cultures were mixed in a sterile flask and carboxymethyl cellulose (2%) was added for seed adhesion. The surface sterilized seed were added to this flask and shaken vigorously for seed coating. After seed coating 10 seed were put in 9 ml water blank and the enumeration of organisms adhered to the seed surface was done on Jensen's N free media and nutrient agar media and number of PGPR per seed was calculated.

Experimental set up : *In vivo* study of effect inoculation of PGPR on growth and yield of wheat (*Variety: Malwa Shakti*) was conducted in pot culture. The treatment consisted of:

T₁ : Control (no fertilizer or manure)

T₂ : Consortium of PGPR

T₃: Recommended Dose of Fertilizers (RDF) on Wheat

T₄ : 50%N+full PK + Consortium of PGPR

T₅ : 75% N +full PK+ Consortium of PGPR

T₆: RDF+ Consortium of PGPR

Excepting T1 (control) and T2 (Consortium of PGPR only), graded basal dose of N and full dose of P and K fertilizer calculated for 12 kg soil based on recommended dose of fertilizers for the variety(100:60:40), was added to respective treatment pots. The pots were irrigated to 60% of moisture holding capacity for uniform distribution of fertilizers added and left for one day. Five seeds previously coated with PGPR isolates were sown in each pot. Control and RDF treatment pot were sown with uninoculated surface sterilized seeds. Five replications per treatment were maintained and the pots were kept in

net house. A separate set of same treatment structure was also maintained for destructive plant sampling and measurement of agronomic parameters. Moisture was maintained with regular addition of measured and equal volume of water to each pot. Second split dose of N was added at CRI stage and third at flowering stage. Root length; shoot length; root fresh weight and shoot fresh weight was measured by uprooting five randomly selected plants from each treatment at 80DAS from the pots meant for destructive sampling.

Statistical analysis : Statistical analyses were carried out through one-way analysis of variance (ANOVA) and the mean of treatments were compared according to Fisher's multiple comparison tests. Least significant difference (LSD) was calculated at $p < 0.05$ using statistical package of SAS.

Results and Discussion

Effect of inoculation of PGPR consortia on N supply, growth and yield of Wheat : Three potential isolates (JS1, JS4 and MER4) after evaluation of Nitrogen fixing ability and other PGP attributes, found most promising and hence used for seed inoculation. MER4 was grown in nutrient agar to viable cell count of 3.4×10^8 and JS1 and JS2 in Jensen's N-free broth to viable cell density of 5.6×10^8 , 6.9×10^8 respectively. The wheat seed was treated with PGPR @ 10^3 viable cells/seed of each isolate was sown in pot with graded dose of nitrogen fertilizers as per the defined treatment structure. Plant height, root length, root fresh and dry weight, and shoots fresh and dry weight was recorded at 80 days after sowing.

The highest root length was recorded in T4 (50%N+full PK + Consortium of PGPR) which was statistically at par with T6 and T5. The root length measured for T2 (Consortium of PGPR only) ($p < 0.05$; 14.4cm) was at par with T3 (Recommended Dose of Fertilizers) on Wheat. Lowest root length was recorded in Control treatment ($p < 0.05$; 11.3cm) where no fertilizers, manure or bioinoculum was applied. Shoot length was



Fig-1 : Effect of PGPR inoculation on wheat growth over control.

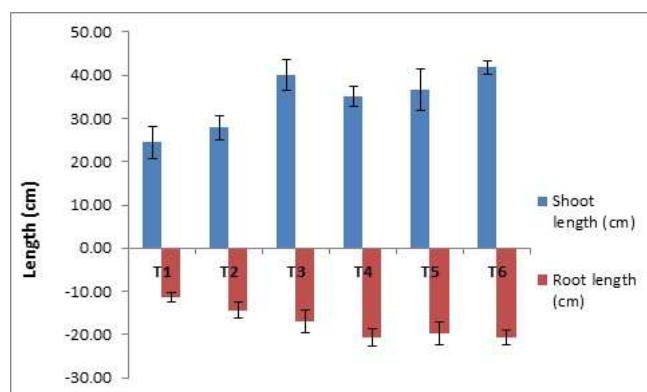


Fig-2 : Root and shoot length at 80 das.

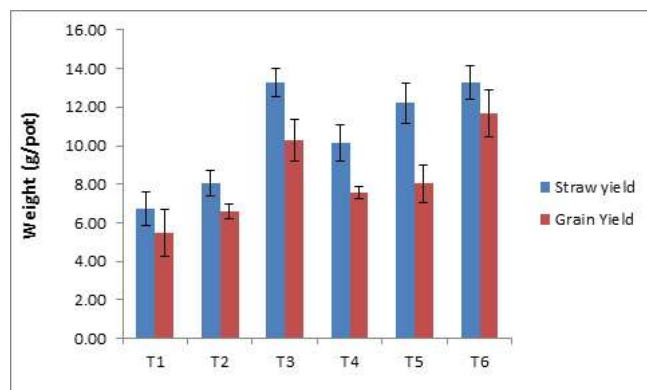


Fig-3 : Wheat grain and straw yield.

recorded highest for the treatment where consortia of PGPR were applied along with recommended dose of fertilizers which was statistically at par with RDF without PGPR. No significant difference in shoot length was observed between T3&T5, T5&T4 and T1&T2 but the shoot length was significantly higher in T3 compared to T4, T2 and T1. The lowest shoot length was observed in control treatment (Table-1).

The lowest root fresh weight per plant was noticed in control (T1) treatment followed by T2 and T3. No significant difference of root fresh weight per plant was observed between T2, T3 and T4 but T4 was significantly higher than T1. The highest root fresh weight was noticed in T6 (RDF+ Consortium of PGPR) treatment which was statistically at par with T5 (75% N +full PK+ Consortium of PGPR) and T4 (50%N+full PK + Consortium of PGPR). Similarly, the highest shoot fresh weight was recorded in T6 i.e. RDF+ Consortium of PGPR which was at par with T3 i.e. Recommended Dose of Fertilizers. No significant difference was observed between T3, T5 and T4. The shoot fresh weight per plant in T4 and T2 was par with each other and was significantly higher than control (T1) (Table-1) (Fig.-1).

Shoot dry weight per plant was recorded significantly higher in T6 compared to T3, T4 and T5 which was statistically at par with each other. No significant difference was recorded in shoot dry weight of T2 and T1 and these recorded the lowest shoot weight per plant. Similarly root dry weight per plant was recorded significantly higher in T6 followed by T5 and T3. No significant difference in root dry weight per plant was noticed between 50% N (T4) and only PGPR (T2) however; T2 was statistically at par with T1 also which recorded lowest root dry weight per plant (Table-1).

Effect of microbial consortia on biomass and grain yield of wheat : The straw yield of wheat was found significantly higher in T6 ($p<0.05$; 13.27g/pot) which was equal to T3 ($p<0.05$; 13.27g/pot) and at par with T5 ($p<0.05$; 12.22g/pot). The straw yield T2 ($p<0.05$; 8.05g/pot) was significantly higher than control ($p<0.05$; 6.74g/pot) but was statistically lower than T4 ($p<0.05$; 10.13g/pot). The grain yield wheat was found numerically higher in T6 ($p<0.05$; 11.68g/pot) but was statistically at par with T3 i.e. RDF treatment ($p<0.05$; 10.28g/pot). The second best performing treatment was T5 ($p<0.05$; 8.04g/pot) which was statistically at par with T4 ($p<0.05$; 7.56g/pot). No significant difference was recorded in wheat grain yield of T4 and T2 ($p<0.05$; 6.58g/pot). The lowest grain yield was recorded in control treatment ($p<0.05$; 5.47g/pot) which was statistically at par with T2 but significantly lower than other treatments (Table 1). Overall the biomass and grain yield was found numerically highest in T6 treatment but was statistically at par with T3. At reduced dose of N fertilizers, compensation in the biomass and grain yield was recorded with application of PGPR bioinoculum.

Three potential isolates (JS1, JS4 and MER4) after evaluation of Nitrogen fixing ability and other PGP attributes used for seed inoculation. These three isolates were evaluated for effect of co-inoculation on wheat at

reduced dose of N fertilizers. Root length of the wheat was found to be significantly higher than control with inoculation of PGPR. The effect on root elongation was more pronounced when the PGPR was applied along with chemical fertilizers. However, the effect of inoculants on shoot elongation was not conspicuous when compared with control and recommended dose of fertilizers. Nevertheless, seed inoculation with PGPR along with recommended dose of fertilizers recorded highest shoot elongation (Fig.-2) Root and shoot weight (both fresh and dry) were found higher when PGPR were applied along with chemical fertilizers. Production of phytohormones especially auxin (IAA) helps in root development (Takahashi, 2013) and thus helps for better establishment of plant but the plant height is mainly governed by genetic factors. Production of phytohormones (IAA) by microbes and improvement in root elongation by microbial inoculants is well documented (Etesami *et al* 2015), Kumar *et al.*, (2014), Masciarelli *et al.*, (2014). Plant biomass (straw yield) was found to be highest where PGPR inoculation was done along with recommended dose of fertilizers, RDF and it was at par with 75% N with PGPR inoculation. There was reduction in grain yield of wheat with reduce dose of N fertilizer compared to RDF but grain yield of wheat was found highest where PGPR inoculation was done along with recommended dose of fertilizers followed by 75% N with PGPR inoculation. No significant difference in yield was recorded at 50%N and 75% N application along with seed inoculation with PGPR (Fig.-3). It is possible that, at reduced dose of nutrients, soil microbes are stress-compelled for synthesis, fixation or mobilization of nutrient from soil and atmosphere to meet its own and associated crop demand. Rath et al, (2014) reported improved growth of wheat with co-inoculation of PGPR with AM Fungi. Amongst PGPRs, *Flavobacterium* gave best response both singly and in combination with AMF. Inoculation with most of the PGPRs gave better response than 60 kg N ha⁻¹ compared to 120N kg ha⁻¹. Swarnalakshmi *et al* (2013) revealed that combined inoculation of mixtures and biofilmed bio-inoculants (*Anabaena torulosa* + *Pseudomonas striata* and/or *Anabaena torulosa* + *Azotobacter-chroococcum*) were superior over single inoculation and chemical fertilizer control in term of plant growth and nutrient uptake. The pot culture study overall revealed improvement in growth and yield of wheat with inoculation of PGPR at recommended dose of fertilizers. Reduction in yield was recorded with limited supply of nitrogen but maximum benefit of PGPR inoculant was observed at lower dose of N fertilizers.

Conclusions

The pot culture study with wheat revealed improvement in

growth and yield of wheat with inoculation of PGPR at recommended dose of fertilizers. Reduction in yield was recorded at lower dose of nitrogen compared to recommended dose but no significant difference in yield was recorded at 50%N and 75% N application along with seed inoculation with PGPR indicating maximum benefit of PGPR inoculants at lower dose of nitrogen fertilizers. Improvement in nitrate reductase activity was noticed with PGPR inoculation. The highest nitrate reductase activity was observed with inoculation of PGPR at recommended dose of N fertilizer compared to all other treatments, indicating favourable effect of bioinoculant on availability of nitrogen.

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The Study of Nitrogen Fixing Ability of Soil Isolates and Quantitative Estimation of K Solubilization by Soil and Plant Isolates

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Abstract

The aim of present investigation was to study the nitrogen fixing ability and quantitative estimation of K solubilization by soil isolates, plant and soil isolates respectively. Only JS series (JS1 to JS5) of soil isolates showed vigorous growth on N free media, hence tested for quantitative estimation of nitrogen fixing ability of the cultures by Acetylene reduction activity (ARA) assay. out of five isolates tested, the highest ARA was recorded with JS1 ($p < 0.05$; 47.08 nmole ethylene/mg cell protein/h) which was statistically at par with JS2 ($p < 0.05$; 41.94 nmole ethylene/mg cell protein/h). Isolate JS5 showed the lowest Acetylene reduction activity which was statistically at par with JS3 and JS4. Quantitative estimation of potassium released from mica in broth revealed highest K release by MER 4 ($p < 0.05$; 1.2 $\mu\text{g/ml}$ broth) isolate followed by OS 10 ($p < 0.05$; 0.9 $\mu\text{g/ml}$ broth) which was statistically at par with JS5 ($p < 0.05$; 0.8 $\mu\text{g/ml}$ broth). JS4 and JS1 could release 0.6 and 0.4 $\mu\text{g K/ml}$ broth respectively and were statistically at par to each other. K released by isolate MER 3 was lowest ($p < 0.05$; 0.2 $\mu\text{g/ml}$ broth) and was at par with control.

Key words : Nitrogen fixing ability, K solubilization, ARA, Mica

Introduction

Though a variety of nitrogen fixing bacteria like *Acetobacter*, *Arthrobacter*, *Azoarcus*, *Azospirillum*, *Azotobacter*, *Bacillus*, *Beijerinckia*, *Derxia*, *Enterobacter*, *Herbaspirillum*, *Klebsiella*, *Pseudomonas* and *Zoogloea* have been isolated from the rhizosphere of various crops (Barraquio et al., 2000; James et al., 2000), interest in the beneficial nitrogen fixing growth promoting rhizobacterial-plant association has increased recently due to their potential use as biofertilizers (Vessey, 2003). Plant associated nitrogen-fixing bacteria have been considered as one of the possible alternatives for inorganic nitrogen fertilizer for promoting plant growth and yield (Ladha and Reddy, 2000). A wide range of bacteria namely *Pseudomonas*, *Burkholderia*, *Acidithiobacillus* ferrooxidans, *Bacillus mucilaginosus*, *B. edaphicus*, *B. circulans* and *Paenibacillus* sp. had been reported to release potassium in accessible form potassium-bearing minerals in soils (Sheng, 2006 and Lin et al., 2002). These potassium solubilizing bacteria (KSB) were found to dissolve potassium, silicon and aluminum from insoluble K-bearing minerals such as micas, illite and orthoclases, by excreting organic acids which either directly dissolved rock K or chelated silicon ions to bring K into the solution (Aleksandrov et al., 1967; Ullaman et al., 1996 and Bennett et al., 1998). Inoculation with potassium solubilizing bacteria had been reported to exert beneficial effects on growth of wheat (Sheng and He, 2006).

Similarly, inoculation of maize and wheat plants with *Bacillus mucilaginosus*, *Azotobacter chroococcum* and *Rhizobium* resulted in significant higher mobilization of potassium from waste mica, which in turn acted as a source of potassium for plant growth (Singh et al., 2010). For optimum crop production, soil solution and exchangeable K need to be replenished continually with K releasing by non-exchangeable K through weathering of K resources such as micas and feldspars (Sparks and Huang, 1985) or by addition of K fertilizers. Therefore, the application of K solubilizing bacteria is a promising approach for increasing K availability in soils cultivation of more K demand crops (Zahar et al., 1984; Vandevivaea et al., 1994 and Barker et al., 1998). Hence, the present investigation was undertaken to study the nitrogen fixing ability of diazotrophic soil isolates and quantitative estimation of K solubilization by soil and plant isolates.

Materials and Methods

The present investigation conducted during *rabi* season of 2016-17 at Research Farm of ICAR-IISS, Bhopal to study the "The Study of Nitrogen fixing ability of soil isolates and quantitative estimation of K solubilization by soil and plant isolates". The material used and methods adopted during the course of experimentation in the field and laboratory are described in brief as under following heads.

Glasswares and media Sterilization : All media were autoclaved at 15 psi (1.06 kg/cm²) pressure for 20 minutes. Antibiotics, tryptophan stock were filter sterilized

by using 0.22 μm disposable syringe filters. Glasswares used were sterilized in hot air oven for 2 hours at 180°C.

Isolation of bacteria from soil : For isolation of aerobic nitrogen fixing bacteria, 5 g composite soil sample was added to flask containing 100ml Jensen's N-free broth . The flask was incubated at 30 $\pm$ 2°C in incubator-shaker at 200 rpm for 48 hours. After 48 hours, 10 ml of inoculums was inoculated in fresh 100 ml Jensen's N-free broth and incubated as mentioned above. The process was repeated five times to eliminate all the other microbes not capable of fixing atmospheric nitrogen under aerobic condition. From last transferred flask, serial dilution was prepared up to 10⁻⁷ dilution and 100 μl of inoculum was spread plated on Jensen's N-free Agar media.

Isolation of endophytic bacteria from maize root : Isolation of endophytic bacteria from maize root was done by washing it thoroughly in running water. The excised roots were surface sterilized by placing 10 grams fresh root in 5% sodium hypochlorite for 10 minutes and then in 70% ethanol for 2 minutes. The roots were thoroughly washed with sterile distilled water thrice. Ten ml of sterile water was added to the surface sterilized roots and shaken for 10 minutes vigorously to check the sterility of rhizoplane. From this suspension, 100 μl aliquot was spread plated on nutrient agar media. Further, the surface sterilized roots were crushed with sterilized mortar and pestle in 9 ml physiological saline (0.85% sodium chloride solution). From this sap, serial dilution was prepared and 100 μl inoculum was again spread plated on nutrient agar plates. Three replications were maintained for each dilution and the plates were incubated at 28°C for 48 hours. Morphologically distinct colonies were purified by repeated streaking on nutrient agar media and were used for further study.

Aerobic nitrogen fixation : Nitrogen free Jensen's agar media was used for detection of free living aerobic nitrogen fixers. Media was poured in sterilized petriplates. After solidification, grids were prepared on the lower surface of petriplate. Isolates were washed in physiological saline by centrifugation to remove traces of nitrogen that it could have received from earlier media. All the isolates were spot inoculated in their respective grids and incubated at 28 $\pm$ 2°C for 2 days. Isolate showing growth were further streaked on Jensen's media to conform the nitrogen fixing ability.

Acetylene Reduction Activity (ARA) was used for determination of nitrogen fixing ability of the isolates. Ten ml of Jensen's broth was inoculated with 200 μl of previously grown cultures showing growth on Jensen's agar plate. The inoculated tubes were incubated in an incubator at 28 $\pm$ 2°C for 4 days. After that cotton plugs

were aseptically replaced with sterile subaseals. Ten percent of the airspace in the tube was replaced with acetylene and these were further incubated for 24 hrs. At the end of incubation period, nitrogen fixation ability of the culture was determined by acetylene reduction activity (ARA) by the method of Hardy *et al.*, using a gas chromatograph (Nucon 5765 model) with FID detector having Porapak N column. The carrier gas was Helium. The operating conditions were: Column temperature: 75°C, Injector temperature: 110°C, and Detector temperature: 110°C. Three replications per treatment and appropriate uninoculated controls were maintained. The results were expressed in terms of nmoles of ethylene/mg cell protein/h.

Potassium solubilization by bacterial isolates : For quantitative determination of potassium solubilization from mica, 100 ml of sterilized Aleksandrov media containing mica as mineral potash source were inoculated with 2 ml of bacterial suspension (approx 10⁸ cfu/ml) positive for K solubilization based on plate assay in 250 ml Erlenmeyer flask. The flasks were incubated at 30 $\pm$ 2°C and 200 rpm for 7 days in an incubator-shaker (make - Kuhner). For each isolate three flasks were inoculated. After 7 days, each flask was checked for potassium release by flame photometry. The suspension was centrifuged at 10,000 rpm for 10 min and supernatant was retained. 1ml of supernatant was taken in 25 ml volumetric flask and volume was made to 25 ml with distilled water and mixed thoroughly. After that the solution was fed to flame photometer for estimating K (Hu *et al.*, 2006; Saiyad, *et al.*, 2015).

Statistical analysis : Statistical analyses were carried out through one-way analysis of variance (ANOVA) and the mean of treatments were compared according to Fisher's multiple comparison tests. Least significant difference (LSD) was calculated at p<0.05 using statistical package of SAS. Multivariate analysis of PGP attributes was performed using Principle Component Analysis and clustering of isolates based on Euclidean distance method was calculated with SAS statistical package.

Results and Discussion

Nitrogen fixation : All the 32 isolates were spot inoculated on nitrogen free media in grid prepared on the plates. Except JS series cultures that were obtained through Enrichment Technique on N-free media, only few isolates showed growth on N-free media which upon restreaking on N-free media, failed to grow, indicating inability of these cultures to grow in absence of combined nitrogen (Table-1). Only JS series culture showed vigorous growth on N free media, hence JS series cultures

were tested for quantitative determination of nitrogen fixing ability of the cultures by Acetylene reduction activity (ARA) assay. Out of five isolates tested, the highest ARA was recorded with JS1 ($p < 0.05$; 47.08 nmole ethylene/mg cell protein/h) which was statistically at par with JS2 ($p < 0.05$; 41.94 nmole ethylene/mg cell protein/h). Isolate JS5 showed the lowest Acetylene reduction activity which was statistically at par with JS3 and JS4 (Table-1).



Growth on N-free Jensen's medium

Table-1 : Acetylene reduction activity (ARA) of microbes isolated from soil.

Isolates	ARA (n moles ethylene/mg protein/h)
JS1	47.08a
JS2	41.94a
JS3	22.92b
JS4	26.37b
JS5	20.72b
LSD (0.05)	6.2

Potassium solubilization ability : Quantitative estimation of potassium released from mica in broth revealed highest K release by MER 4 ($p < 0.05$; 1.2 $\mu\text{g/ml}$ broth) isolate followed by OS 10 ($p < 0.05$; 0.9 $\mu\text{g/ml}$ broth) which was statistically at par with JS5 ($p < 0.05$; 0.8 $\mu\text{g/ml}$ broth). JS4 and JS1 could release 0.6 and 0.4 $\mu\text{g K/ml}$ broth respectively and were statistically at par to each other. K released by isolate MER 3 was lowest ($p < 0.05$; 0.2 $\mu\text{g/ml}$ broth) and was at par with control. Decline in pH at the end of incubation period was also recorded with inoculation of isolates in media. The lowest pH was noted with MER4 (4.1) followed by JS4 (4.2), JS1 (4.3), JS5 (4.42), OS10 (4.7) and MER3 (5.32). Control broth could maintain neutral pH (Table-2).

Table-2 : Quantitative estimation of potash solubilization by selected isolates.

Isolates	K released ($\mu\text{g/ml}$ broth)	pH
Control	0.1d	7.2
JS1	0.4c	4.3
JS4	0.6c	4.2
JS5	0.8b	4.42
OS10	0.9b	4.7
MER3	0.2d	5.32
MER4	1.2a	4.1
LSD(0.05)	0.21	

Over all, out of 32 isolates, only five isolates (JS1 to JS5) which was isolated by enrichment techniques were able to fix atmospheric nitrogen. Highest ARA was recorded with JS1 and JS 2 culture (Fig.-1). None of the other isolates were capable of nitrogen fixation. Some microorganisms fix atmospheric nitrogen to ammonia and make it available to the plant. Such microbes are found to possess enzyme nitrogenase for nitrogen fixation. Free living non-symbiotic aerobic nitrogen fixers are widely distributed in arable soils. Though non-symbiotic nitrogen fixation has a great agronomic significance, a major limitation that it faces is the availability of carbon and energy source for the energy intensive nitrogen fixation process (Saharan and Nehra, 2011) particularly under tropical soil which are inherently poor in organic matter content. The use of bio-fertilizer such as N_2 (nitrogen) fixing bacteria and beneficial micro-organism can reduce chemical fertilizer applications and consequently lower production cost.

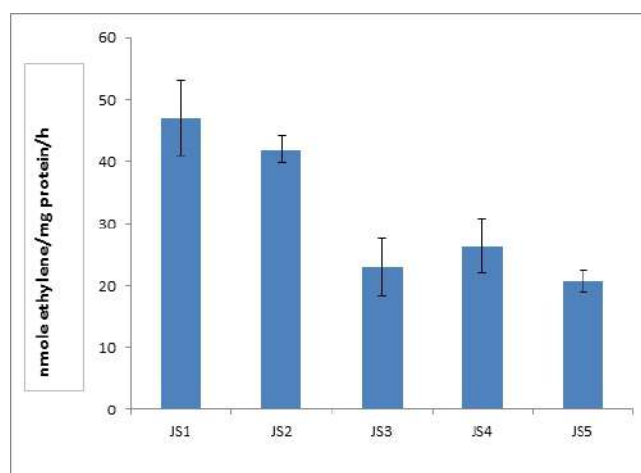


Fig.-1 : Acetylene reduction activity of cultures.

Quantitative estimation also revealed 1.2 $\mu\text{g/ml}$ culture broth (having 10^7 cells/ml) of K released, highest among all the positive isolates (Fig.2). The drop in pH of media was suggestive of possible mechanism of K solubilization by the isolates. A negative correlation (-0.70) between pH and K-released in media was observed indicating production of acids leads to solubilization of mineral and release of K in the media. Production of carboxylic acids like Lactic acid, Acetic acid and Gluconic acid in potash solubilizing media was also reported by Saiyad *et al.* (2015), confirming our findings. In present investigation four endophytic isolates were obtained from maize roots. These isolates were capable of mobilizing potash from mica and 24.227 $\mu\text{g/ml}$ (containing 10^7 cells/ml) in Potassium solubilizing media (MER3).

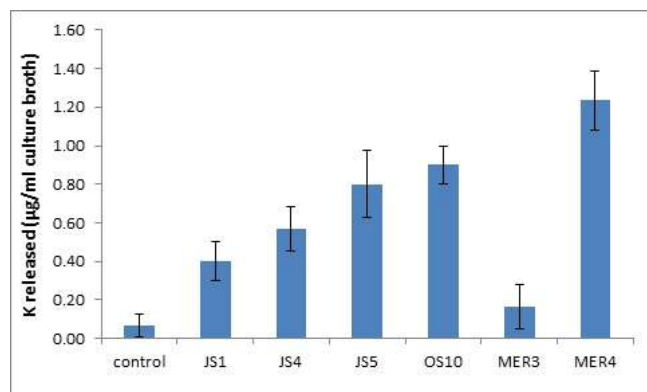


Fig-2 : K released (µg/ml culture broth).

Conclusions

Conducted study concluded that out of five isolates tested, the highest ARA was recorded with JS1 ($p < 0.05$; 47.08 nmole ethylene/mg cell protein/h) which was statistically at par with JS2 ($p < 0.05$; 41.94 nmole ethylene/mg cell protein/h). Quantitative estimation of potassium released from mica in broth revealed highest K release by MER 4 ($p < 0.05$; 1.2 µg/ml broth).

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Effect of Trace Elements, Biofertilizers and FYM on Nodulation and Yield Attributes of Chickpea in Vertisols of Central India

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Abstract

On the basis of present investigation the application of RDF+ Ammonium Molybdate 1g / kg seed + *Rhizobium* + PSB inoculation, RDF + ZnSO₄ @25kg/ha + *Rhizobium* + PSB and RDF+FYM5t/ha + *Rhizobium*+PSB inoculation proved beneficial for better chickpea growth, symbiotic traits, Biological Nitrogen Fixation and its productivity in black soil of M.P. under long term use in Soybean-chickpea sequence. The application of RDF+FYM 5t/ha+ *Rhizobium* +PSB and RDF+ Ammonium Molybdate 1g / kg seed + *Rhizobium* +PSB inoculation significantly influenced the growth attributing parameters viz., plant height, branches, root length, dry weight, number of root nodules and dry weight of root nodules per plant over control (T₁) with highest and comparative better values than the other tested micronutrients treatments of Fe, Mn and B. Maximum net return recorded with the treatment T₄ -RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB as against control followed by with T₃ -RDF + ZnSO₄ @25kg/ha + *Rhizobium* + PSB and with T₈ -RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB. As regards B:C ratio, maximum value of 1: 2.89 was recorded with T₄ -RDF + Ammonium Molybdate (AM) 1 g kg⁻¹ seed + seed inoculation with *Rhizobium*+ PSB followed by with T₃ -RDF + ZnSO₄ 25kg/ha + *Rhizobium* + PSB and with T₈ -RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB.

Key words : *Rhizobium*, ammonium molybdate, biological nitrogen fixation, chickpea.

Introduction

The associative effect of *Rhizobium* and phosphate solubilizing bacteria on the yield and nutrient uptake of chickpea enhanced the growth parameters. Alagawadi and Gaur (1988). Greatest plant height and shoot dry weight of chickpea was obtained with the inoculants plus 1.5 kg Mo/ha. Seed yield per plant increased by 22 % over the control with the same Mo rate. Solaiman (1999) Significant response of foliar spray of 0.1% ammonium molybdate at 50 and 60 days after sowing in kabuli chickpea. Sarawgi *et al.* (1999). Seeds of chickpea inoculated with *Rhizobium* significantly increased the number of seed per pods, pods per plant as well as the seed and straw yield. Patil *et al.* (2001). Seed treated with *Rhizobium* culture significantly increased nitrogen and phosphorus content of chickpea seed. Maurya and Sanoria (1982). *Rhizobium* inoculation had significant positive effect on growth, nitrogen content and uptake in shoot, yield and yield attributes and seed protein content in chickpea. Zaiet *et al.* (1999). The *Rhizobium* inoculation had a significant effect on the seed yield and seed protein content in chickpea. Alam *et al.* (2001). The effect of organics on growth and yield of chickpea (*Cicer arietinum* L.) in vertisols of northern dry zone of Karnataka. Patil *et al.* (2012). Significantly higher B:C ratio (3.34) was recorded with enriched compost 1/3 + vermicompost 1/3 + glyricidia leaf manure 1/3 equivalent

to 100% RDN. Highest net return in chickpea cultivation with the use of RDF+*Rhizobium*+PSB+1g ammonium molybdate/kg seed in black soils. Gupta and Gangwar (2012).

Materials and Methods

The present investigation was carried out during rabi season of 2017-2018 at Research Farm of R.A.K. College of Agriculture, Sehore to study the "effect of trace elements, biofertilizer and fym on nodulation and yield attributes of chickpea in vertisols of central India". The experiment was conducted in R.A.K. College of Agriculture Farm, Sehore, (M.P.) which is situated at Vindhyan plateau in sub-tropical zone at the 27°12'N latitude and 77°05'E longitude at an altitude of 498.77meter above the mean sea level in Madhya Pradesh. The average rainfall varies from 1000 mm to 1100 mm and concentrated mostly from June to September. Experimental site was having the black soils belonging to order vertisol. The experiment was laid out in Randomized block design with 8 treatments *i.e* T1- RDF – (N:P₂O₅:K₂O:S: 20:50:20:20 kg/ha), T2- RDF + Seed inoculation with *Rhizobium* + PSB (Phosphorus Solubilising Bacteria), T3- RDF + ZnSO₄ @25kg/ha + *Rhizobium* + PSB, T4- RDF + 1g Ammonium Molybdate/kg Seed + *Rhizobium* + PSB, T5- RDF + Borax @5g/ha + *Rhizobium* + PSB, T6- RDF+FeSO₄ @10kg/ha + *Rhizobium* + PSB T7- RDF+MnSO₄@25kg/ha +

Rhizobium+ PSB, T₈- RDF + FYM 5t/ha + Seed inoculation with *Rhizobium* + PSB and replicated thrice. Chickpea variety JG 130 is used in the experiment and crop is fertilized with 20:50:20:20, (N:P₂O₅:K₂O:S kg ha⁻¹). Ammonium Molybdate used for experiment contains 54% Mo. Other agronomical practices were followed as per standard package of practice.

Results and Discussion

The results obtained on the growth, yield attributing characters, grain yield, straw yield, in soil after crop harvest of chickpea and economics of various treatments tested during the course of investigation. The results are summarized as follows :

Pre Harvest Studies

Growth attributes

Plant height : Plant height was recorded at 30, 60, 90 days after sowing and at maturity stage and are presented in Chart 1. The results indicates the periodic increase in average plant height and also significant effect of various treatments on plant height at various stages of crop growth.

The data indicates significant increase in plant height due to different treatments at all the stages of crop growth. All the treatments (except T₂) proved significantly superior over T₁ (control). The treatment T₈, viz RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB (46.03cm) recorded highest plant height followed by the treatment T₄ viz. RDF+ Ammonium Molybdate @ 1g/kg seed + *Rhizobium* +PSB(45.60cm).

Number of branches : Application of RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB (T₈) recorded highest branches/ plant (3.63 /pl) followed by with the treatment RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB (3.57/pl) branches/plant (T₄) at all the stages of plant growth.

Root length : The treatment consisting of RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB (T₈) produced significant and highest root length (18.60 cm) followed by (18.40cm) with the treatment RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB (T₄) which were significantly superior over the root length recorded under T₁ and T₂ at maturity stage. Treatments viz. T₃, T₅, T₆ and T₇ consisting of Zn, B, Fe and Mn application were superior over RDF alone (T₁) but were at par with RDF +*Rhizobium*+PSB (T₂) in respect of root length/plant recorded at various stages of crop growth.(chart -1) (Table1).

Symbiotic traits :

Number of root nodules per plant : The data on root

nodules per plant at successive stages under different treatments are presented. The data on nodule per plant at 30, 45 and 60 DAS indicates significant increase under different treatments involving use of *Rhizobium* + PSB as against RDF alone(T₁). Number of nodules/plant found in increasing trend up to 60 DAS. The treatment T₄ (RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB) recorded highest nodules/plant followed by the treatment T₈ (RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB) at different stages of crop growth. These treatments (T₄ and T₈) were superior to control i.e. RDF (N:P₂O₅:K₂O:S: 20:50:20:20 kg/ha) and RDF + seed inoculation with *Rhizobium* + PSB (Phosphorus Solubilising Bacteria). Application of Zn, B, Fe and Mn along with *Rhizobium*+PSB also recorded significantly superior nodules over RDF alone(T₁) but all of these were identical with RDF+*Rhizobium*+PSB (T₂) at most of the stages in respect of root nodules/plant. (Table-2)

Dry weight of root nodules per plant : The data on dry weight of root nodules per plant recorded at 30, 45 and 60 DAS under different treatments are presented in (Table-3). Dry weight of root nodules per plant found in increasing trend up to 60 DAS. The treatment T₄ (RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB) recorded highest dry weight of root nodules per plant followed by the treatment T₈ (RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB) at different stages of crop growth. These treatments (T₄ and T₈) were superior to control i.e. RDF (N:P₂O₅:K₂O:S: 20:50:20:20 kg/ha) and RDF + seed inoculation with *Rhizobium* + PSB (Phosphorus Solubilising Bacteria). (Table-3)

Plant dry weight : The data on Plant dry weight (g/plant) recorded at 30, 45 and 60 DAS under different treatments are presented in Table 4. The maximum dry weight/ plant was recorded with the treatment RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB (T₈) followed by with the treatment viz RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB inoculation (T₄) at all the stage of crop growth. (Table 4)

Post harvest studies:

Yield attributing characters:

Number of pods per plant : The number of pods per plant have direct correlation with seed yield. The observation on this attribute was recorded at maturity. A perusal of data (Table 5) showed that Among different treatments, the maximum number of pods/plant (38.26 pods/pl) was recorded with T₈ (RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB) followed by with T₄ (37.55 pods/pl) i.e. (RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB). These treatments T₄ and T₈

Table-1 : Effect of micronutrient, bio-fertilizers and FYM on root length in chickpea.

S. No.	Treatments	Root length (cm)			
		30 DAS	60 DAS	90 DAS	At maturity
T ₁	RDF-(N:P ₂ O ₅ :K ₂ O:S:20:50:20:20 kg/ha)	12.65	13.90	14.50	14.50
T ₂	RDF + Seed inoculation with <i>Rhizobium</i> + PSB	13.50	15.00	16.10	16.10
T ₃	RDF + ZnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	14.30	16.40	17.33	17.33
T ₄	RDF + 1g Ammonium Molybdate/kg seed + <i>Rhizobium</i> + PSB	15.20	17.20	18.40	18.40
T ₅	RDF+Borax @5kg/ha+ <i>Rhizobium</i> + PSB	14.40	16.00	17.40	17.40
T ₆	RDF+FeSO ₄ @10kg/ha+ <i>Rhizobium</i> + PSB	14.20	16.00	17.10	17.10
T ₇	RDF+MnSO ₄ @25kg/ha+ <i>Rhizobium</i> + PSB	14.17	15.80	17.00	17.00
T ₈	RDF + FYM 5t/ha + Seed inoculation with <i>Rhizobium</i> + PSB	15.40	17.10	18.60	18.60
	CD at 5%	1.47	1.69	1.97	1.97

Table-2 : Effect of micronutrients, bio-fertilizers and FYM on nodules number in chickpea.

S. No.	Treatments	Root nodules/plant		
		30 DAS	45 DAS	90 DAS
T ₁	RDF-(N:P ₂ O ₅ :K ₂ O:S:20:50:20:20 kg/ha)	10.70	18.00	25.10
T ₂	RDF + Seed inoculation with <i>Rhizobium</i> + PSB	14.50	23.13	31.80
T ₃	RDF + ZnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	15.60	27.38	35.50
T ₄	RDF + 1g Ammonium Molybdate/kg seed + <i>Rhizobium</i> + PSB	18.60	33.00	39.10
T ₅	RDF+Borax @5kg/ha+ <i>Rhizobium</i> + PSB	15.00	24.53	32.50
T ₆	RDF+FeSO ₄ @10kg/ha+ <i>Rhizobium</i> + PSB	16.70	26.38	33.10
T ₇	RDF+MnSO ₄ @25kg/ha+ <i>Rhizobium</i> + PSB	15.00	25.36	32.00
T ₈	RDF + FYM 5t/ha + Seed inoculation with <i>Rhizobium</i> + PSB	18.30	30.68	38.50
	CD at 5%	3.64	3.75	6.13

Table-3: Effect of micronutrients, biofertilizers and FYM on dry weight root nodules mg per plant at different growth stages in chickpea.

S. No.	Treatment	Dry weight of root nodules /plant (mg)		
		30 DAS	45 DAS	60 DAS
T ₁	RDF-(N:P ₂ O ₅ :K ₂ O:S:20:50:20:20 kg/ha)	24.00	60.11	78.67
T ₂	RDF + Seed inoculation with <i>Rhizobium</i> + PSB	25.70	70.80	85.13
T ₃	RDF + ZnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	27.63	71.03	89.70
T ₄	RDF + 1g Ammonium Molybdate/kg seed + <i>Rhizobium</i> + PSB	28.33	77.83	94.20
T ₅	RDF + Borax @5kg/ha + <i>Rhizobium</i> + PSB	27.62	71.96	89.00
T ₆	RDF + FeSO ₄ @10kg/ha + <i>Rhizobium</i> + PSB	27.57	73.26	87.80
T ₇	RDF + MnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	27.73	76.81	86.53
T ₈	RDF + FYM 5t/ha + Seed inoculation with <i>Rhizobium</i> + PSB	30.70	82.16	95.20
	CD at 5%	3.51	5.63	6.73

were significantly superior over T₁ and T₂. Remaining treatments T₃, T₅, T₆ and T₇ were superior over RDF alone (T₁) but were at par with RDF + *Rhizobium* + PSB (T₂). (Table-5).

Seeds per pod : The observation on this attribute was recorded at maturity. The data on seed per pod under different treatments are presented in (Table 5). The data indicates significant increase in seed per pod under various treatments over the control. The maximum seed per pod (1.86) was recorded with the treatment RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB (T₄) followed by seed per pod (1.85) with the treatment viz. RDF + FYM 5t/ha + seed inoculation with *Rhizobium* +

PSB (T₈). These two treatments were identical with each other but were significantly superior T₁ and T₂. (Table-5)

Seed index (100 seed weight) : The data on seed index are presented in (Table 5). The data indicates that the treatments viz. T₈ (RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB) and T₄ (RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB) recorded significantly higher seed index as against RDF alone (T₁) and also against RDF+*Rhizobium*+PSB (T₂). As regards other treatments all the other (except T₂) were significantly superior over RDF alone with better values under RDF + ZnSO₄ @25kg/ha + *Rhizobium* + PSB (T₃) and -RDF+Borax@5Kg/ha+*Rhizobium*+ PSB (T₅). (Table 5)

Table-4 : Effect of micronutrients, bio fertilizers and FYM on dry weight g per plant at different growth stages in chickpea.s

S. No.	Treatment	Dry weight/plant (g)		
		30 DAS	45 DAS	60 DAS
T ₁	RDF-(N:P ₂ O ₅ :K ₂ O:S:20:50:20:20 kg/ha)	0.50	1.44	3.60
T ₂	RDF + Seed inoculation with <i>Rhizobium</i> + PSB	0.62	1.56	4.00
T ₃	RDF + ZnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	0.64	1.65	4.20
T ₄	RDF + 1g Ammonium Molybdate/kg seed + <i>Rhizobium</i> + PSB	0.67	1.84	4.40
T ₅	RDF + Borax @5kg/ha + <i>Rhizobium</i> + PSB	0.62	1.65	4.20
T ₆	RDF + FeSO ₄ @10kg/ha + <i>Rhizobium</i> + PSB	0.63	1.68	4.15
T ₇	RDF + MnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	0.63	1.71	4.10
T ₈	RDF + FYM 5t/ha + Seed inoculation with <i>Rhizobium</i> + PSB	0.68	1.82	4.43
	CD at 5%	0.09	0.10	0.45

Table-5 : Effect of micronutrients, biofertilizers and FYM on pods per plant (no.), seeds per pod (no.), seed yield per plant (gm) and seed index (gm).

S. No.	Treatments	Pods/plant (no)	Seeds/ pod (no)	Seed index (g)
T ₁	RDF-(N:P ₂ O ₅ :K ₂ O:S:20:50:20:20 kg/ha)	27.96	1.40	21.40
T ₂	RDF + Seed inoculation with <i>Rhizobium</i> + PSB	30.18	1.60	23.10
T ₃	RDF + ZnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	31.50	1.70	24.07
T ₄	RDF + 1g Ammonium Molybdate/kg seed + <i>Rhizobium</i> + PSB	37.55	1.86	25.10
T ₅	RDF + Borax @5kg/ha + <i>Rhizobium</i> + PSB	31.53	1.72	24.10
T ₆	RDF + FeSO ₄ @10kg/ha + <i>Rhizobium</i> + PSB	31.67	1.60	23.60
T ₇	RDF + MnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	32.20	1.60	23.67
T ₈	RDF + FYM 5t/ha + Seed inoculation with <i>Rhizobium</i> + PSB	38.26	1.85	25.43
	CD at 5%	3.18	0.11	1.82

Table-6 : Effect of micronutrients, biofertilizers and FYM on seed and straw yield (kg ha⁻¹) and harvest index (%) in Chickpea.

S.No.	Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T ₁	RDF-(N:P ₂ O ₅ :K ₂ O:S:20:50:20:20 kg/ha)	1519.00	1578.00	49.04
T ₂	RDF + Seed inoculation with <i>Rhizobium</i> + PSB	1644.00	1725.00	48.79
T ₃	RDF + ZnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	1728.00	1803.00	48.93
T ₄	RDF + 1g Ammonium Molybdate/kg seed + <i>Rhizobium</i> + PSB	1813.00	1913.00	48.65
T ₅	RDF + Borax @5kg/ha + <i>Rhizobium</i> + PSB	1710.00	1762.00	49.25
T ₆	RDF + FeSO ₄ @10kg/ha + <i>Rhizobium</i> + PSB	1691.00	1765.00	48.92
T ₇	RDF + MnSO ₄ @25kg/ha + <i>Rhizobium</i> + PSB	1670.00	1777.00	48.44
T ₈	RDF + FYM 5t/ha + Seed inoculation with <i>Rhizobium</i> + PSB	1835.00	1943.00	48.57
	CD at 5%	122.38	111.22	NS

Parameters calculated :

Seed yield (kg ha⁻¹) : The data on grain yield (kg/ha) of chickpea as influenced by different treatments are presented in (Table-6). The data indicates significant increase in seed yield of chickpea due to all the treatments over the control T₁ RDF – (N:P₂O₅:K₂O:S: 20:50:20:20 kg ha⁻¹) The treatment T₈ viz. RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB inoculation resulted maximum grain yield (1835 kg/ha) followed by the treatment T₄ viz. RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB, (1813 kg/ha), and the treatment T₃ viz. RDF + ZnSO₄ @25kg/ha + *Rhizobium* + PSB (1728 kg/ha). These treatments were significantly superior to

the control but were identical with each other. Further the treatment T₈ and T₄ were also found significantly superior over T₁ and T₂. (Table 6)..

Straw yield (kg ha⁻¹) : Increase in straw yield is directly related with increase in vegetative growth of the plant and subsequently it's mass. The data on straw yield (kg/ha) of chickpea as influenced by different treatment are presented in (Table 6). The data indicates significant increase in straw yield due to different treatments. The data (Table 6) indicates that the treatment T₈ viz. RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB inoculation resulted maximum straw yield (1943 kg/ha) followed by with the treatment T₄ viz. RDF + 1g

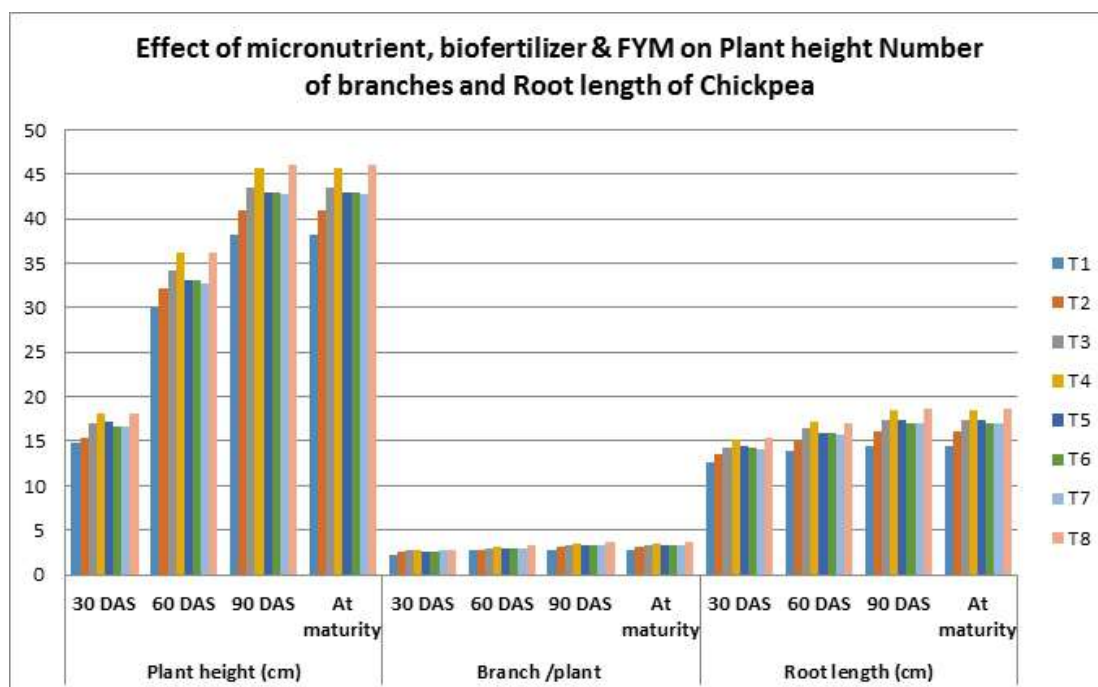


Chart-1

Ammonium Molybdate/kg seed + *Rhizobium* + PSB inoculation, (1913 kg/ha), and the treatment T₃ RDF + ZnSO₄ @25kg/ha + *Rhizobium* + PSB inoculation (1803 kg/ha). These treatments were superior to control but were identical with each other. (Table 6).

Harvest index : The harvest index values as affected by different treatments are presented in (Table 6). The data of (Table 6) indicates significant increase in harvest index and the maximum value of 41.01% was recorded with the treatment RDF+FYM 5t/ha+*Rhizobium* + PSB inoculation (T₈) followed by 40.89% with the treatment viz. RDF+ Ammonium Molybdate @ 1g/kg seed + *Rhizobium* +PSB (T₄). These two treatments were however found identical to each other. (Table 6).

Post harvest studies

Growth attributing characters

Number of pod per plant and seed per pod : The number of pod per plant and seed per pod significantly affected by various treatments over control. Significant and highest number of pods per plant with seed per pod recorded under the treatment RDF + FYM 5t/ha + *Rhizobium* + PSB (T₈) and. RDF+ Ammonium Molybdate @ 1g/kg seed + *Rhizobium* +PSB (T₄) which might be ascribed to favorable effect of application of FYM on soil microbial activity, physical condition and balance nutrition to crop and also due to favorable effect of molybdenum application on nitrogenase activity resulting in enhanced N-fixation, photosynthesis, protein synthesis and there by an increase in the number of pod per plant and seed per

pod. The application of RDF + ZnSO₄ 25 kg/ha + *Rhizobium* +PSB also produced significant and comparatively better pods per plant which might be due to favorable effect of Zinc on several metabolic activities in plant system resulting in better growth, photosynthesis and there by more number of pod/plant. Positive effect of biofertilizers, FYM and micronutrients in chickpea yield attributes has also been reported by Nishita and Joshi. (2010) and Gupta and Namdeo (1997).

Seed and straw yield : Seed and straw yield of chickpea significantly enhanced by most of the treatments over RDF alone. Highest seed yield under RDF+FYM 5t/ha+*Rhizobium* + PSB inoculation might be attributed to better nodulation, growth and development of plants due to improved BNF, balance nutrition provided by the integrated use of organics, Inorganic and biological sources of nutrition. Similarly second best yield due to application of molybdenum as Ammonium Molybdate @ 1g/kg seed + *Rhizobium* +PSB along with RDF might be due to enhanced BNF by increased nitrogenase activity in nodules and nitrate reductase activity inside plant system as mo is an essential constituent of these enzymes.. With the supplementation of Molybdenum along with *Rhizobium* +PSB with seed inoculation this becomes readily available at the site of nodule formation in the vicinity of root zone (rhizosphere) and resulted positive effect in the formation and activity of these enzymes which ultimately resulted in effective nodulation with enhanced BNF, N assimilation and also complementary nutrient uptake with better growth of crop plants. This is also

reflected with the better leghaemoglobin content in nodules, chlorophyll content in leaves and DHA activity in the rhizosphere under molybdenum and FYM treatments. Besides this the better effect of RDF + ZnSO₄ 25 kg/ha + *Rhizobium* +PSB inoculation in increasing seed and straw yield of chickpea might be due to role of Zn in nitrogen metabolism, protein synthesis, chlorophyll formation, carbohydrate and starch formation by its involvement in several enzymatic reaction. Soils of the experimental field were also insufficient in Molybdenum and Zinc which also resulted in good response of the treatments of FYM, Molybdenum and Zinc application. The result of similar kind have also been reported by, Shilet *et al.* (2007), Jain and Singh (2003), Singh *et al.* (2012), Sawires (2001), Johansen *et al.* (2005) and Kanter (2003).

Conclusions

The application of RDF+FYM 5t/ha+ *Rhizobium* +PSB and RDF+ Ammonium Molybdate 1g / kg seed +*Rhizobium* +PSB inoculation significantly influenced the growth attributing parameters viz., plant height, branches, root length, dry weight, number of root nodules and dry weight of root nodules per plant over control (T₁) with highest and comparative better values than the other tested micronutrients treatments of Fe, Mn and B. Application of RDF + FYM 5t/ha + *Rhizobium* + PSB and RDF+ Ammonium Molybdate @ 1g/kg seed + *Rhizobium* +PSB recorded significant and highest pods per plant, seed per pod, seed yield per plant and seed index in chickpea as against RDF alone. Highest and significant seed and straw yield recorded under RDF+FYM 5t/ha+*Rhizobium* + PSB (1835 kg/ha and 1943 kg/ha) followed by with Ammonium Molybdate @ 1g/kg seed + *Rhizobium* +PSB (1813 kg/ha and 1913 kg/ha) and with RDF + ZnSO₄ 25 kg/ha + *Rhizobium* +PSB (1728 kg/ha and 1803 kg/ha) as against RDF alone (1519 and 1578 kg/ha). Maximum net return recorded with the treatment T₄ -RDF + 1g Ammonium Molybdate/kg seed + *Rhizobium* + PSB as against control followed by with T₃ -RDF + ZnSO₄ @25kg/ha + *Rhizobium* + PSB and with T₈ -RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB. As regards B:C ratio, maximum value of 1: 2.89 was recorded with T₄ -RDF + Ammonium Molybdate (AM) 1 g kg⁻¹ seed + seed inoculation with *Rhizobium* + PSB followed by with T₃ -RDF + ZnSO₄ 25kg/ha + *Rhizobium* + PSB and with T₈ -RDF + FYM 5t/ha + seed inoculation with *Rhizobium* + PSB.

On the basis of present investigation, it may be concluded that the application of RDF+ Ammonium Molybdate 1g / kg seed +*Rhizobium* +PSB inoculation, RDF + ZnSO₄ @25kg/ha + *Rhizobium* + PSB

and RDF+FYM5t/ha + *Rhizobium*+PSB inoculation proved beneficial for better chickpea growth, symbiotic traits, Biological Nitrogen Fixation and its productivity in black soil of M.P. under long term use in Soybean-chickpea sequence.

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Spirulina Cultivation : Super Food for All Living Organisms

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Abstract

Spirulina is multi-cellular and filamentous cyano-bacteria that have gained substantial predominance in the health sector, food industry and aquacultures in contemporary times. It has a very high content of macro and micronutrients, essential amino acids, proteins, lipids, vitamins, minerals and anti-oxidants. In recent years, spirulina has garnered enormous attention from research fraternity as well as industries as a boom source of nutraceutical and pharmaceuticals. It is considered a complete food supplement to combat against malnutrition deficiencies. In developing countries like India where malnutrition is a renowned social challenge that can be defeated by the supplement of spirulina products in the diet. The commercial cultivation of spirulina and converting into consumable forms (tablets/granules) can be an economic enterprise in India also. Such agribusiness has been commenced by budding agripreneur. The spirulina agribusiness had a good turnover with low capital investment and also providing employment opportunities to others.

Key words : Super food, spirulina, agribusiness.

Introduction

The progressive lifestyles, dynamic restructuring of micro and macro niches, and unavailability of nutrition sources contribute to the expansion of incidence of malnourishment and additional health risks. In such a circumstance, it is imperative to examine other alternatives for supplementing the diet that will boost the health status of individuals (Ravi *et al.*, 2010). Therefore, it is indispensable to create a means to provide cost-effective nutrition and dietary supplements. One supplement source, with ease of production, processing, distribution along with a wide range of macro and micronutrients of human health benefits is the cultivation of spirulina and its consumption.

Spirulina – a kind of blue-green algae contains several nutrients, including B-vitamins, α -carotene, and vitamin-E and also comprises antioxidants, minerals, chlorophyll, and phyco-cyanobilin. It was first discovered by Spanish scientist Hernando Cortez and Conquistadors in 1519. Now, modern lifestyle personalities endorse Spirulina as a secret, potent 'super-food or a miracle from the sea' (Fathima and Salma, 2001; Dillon, 2014). The United Nations world at food conference declared that Spirulina as the best food for the future, and it is gaining popularity nowadays among the wide population (Pulz & Gross, 2004). The nutritional profile of Spirulina powder (composition by 100 g) is shown in Table-1.

The spirulina has also multiple applications for clinical practices - allergy, rhinitis, and immuno-modulation; antiviral applications; cholesterol-lowering

effects and effects on diabetes, anticancer effects; chronic arsenic poisoning; and antioxidant effects (Karkos *et al.*, 2011). Therefore, the demand for this supplementary diet is picking up in many countries to suffice the nutritional requirements of its population.

Antioxidant effects, better food stability, modified rheological and anti-staling properties can be observed in Spirulina incorporated food. So, *S. platensis* revealed to be a good ingredient, with good color stability over time. Adults resistant to the acceptance of novel microalgae incorporated food due to the traditional moral and social factors.

Cultivation Process :

Cultivation of Spirulina

Spirulina is one among various algal species discovered growing in natural freshwaters. These are observed in natural habitats such as soil marshes, seawater, and brackish waters where alkaline waters subsist. It can withstand low temperatures 15°C during nights and 40°C for a few hours in the daytime also. In natural habitats, their growth cycles depend on the limited supply of nutrients. In Japan, large scale cultivation of microalgae of chlorella (early 1960s) followed by Spirulina commenced in the early 1970s. Today, there are more than 22 countries that cultivate Spirulina commercially on a large-scale (Ravi *et al.*, 2010). The distinct stages for commercial cultivation of spirulina as practiced by the agripreneurs.

Species selection : It is a very crucial stage in spirulina cultivation. The two species which are most commonly

Table-1 : Nutritional profile of Spirulina Powder (composition by 100 g).

Macronutrients		Vitamins	
Calories	373Kcal	Vitamin A (as β -carotene)	352.0 IU
Total fat	4.3g	Vitamin K	1090 mcg
Total carbohydrate	17.8g	Thiamine HCL (Vitamin B1)	0.5 mg
Essential amino acids	21.9g	Riboflavin (Vitamin B2)	4.53 mg
Non-essential amino acids	35.4g	Niacin (Vitamin B3)	14.9 mg
		Pyridox HCL (Vitamin B6)	0.96 mg
		Vitamin B12	162 mcg
Minerals		Phyto-nutrients	
Calcium	468 mg	Phycocyanin (mean)	17.2%
Iron	87.4 mg	Chlorophyll (mean)	1.2%
Phosphorus	961 mg	Superoxide dismutase (SOD)	531,000 IU
Iodine	142 mcg	linolenic acid (GLA)	1080 mg
		Total carotenoids (mean)	504 mg
		β -carotene (mean)	211 mg
		Zeaxanthin	101 mg
Magnesium	319 mg		
Zinc	1.45 mg		
Selenium	25.5 mcg		
Copper	0.47 mg		
Manganese	3.26 mg		
Chromium	< mcg		
Potassium	1660 mg		
Sodium	641 mg		

(Source: Salmeán *et al.*, 2015; mcg= microgram, mg= milligram, IU=international unit)

utilized are *Spirulina platensis* and *Spirulina maxima* (De Smet, 1997) due to its valuable components, positive effects, and being a supplement which is nontoxic for human well-being. The agripreneur, Shri M. Vamshi Krishna, is growing *Spirulina platensis* species for producing commercial products.

Open Raceway Pond : A raceway pond is a shallow artificial pond utilized for the cultivation of algae. The cultivation of *Spirulina* can be done in open systems like ponds, lakes or lagoons or a closed system (Singh and Sharma, 2012). The open ponds are utilized commercially to produce high value spirulina products, which may be shallow big ponds, circular ponds, tanks and raceway ponds. The cultivation is usually carried out in two ways: a) concrete ponds and, b) pits lined with PVC or other plastic sheets. The agripreneur had constructed concrete ponds for its cultivation (Figure 3). The installation of single or multiple ponds can be arranged with each pond size of 50 m long, 2-3 m wide, and with 20 to 30 cm depth are ideal pond conditions but the length of the ponds can be of any length depending on the land availability (Karthikeyan *et al.*, 2016). With such infrastructures, *Spirulina* biomass yield of 35 tonnes/ hectare/yr has been reported in a commercial open mass cultivation pond at Siam Algae, Bangkok (Habib *et al.*, 2008).

Growth conditions : *Spirulina* growth conditions are similar to terrestrial plants but they utilize resources very efficiently to increase biomass productivity with comparatively less water use (Sudhakar *et al.*, 2014; Lucie *et al.*, 2016). *Spirulina* cultivation for commercial and large-scale production has to be executed in given regions with suitable climatic conditions. The tropical and sub-tropical regions are well-suited places for its cultivation. It requires sunshine throughout the year. The growth rate and production of *Spirulina* depend on numerous factors such as wind, rain, temperature fluctuation, and solar radiations.

***S. Platensis* microalgae as food supplement :** It was that *S. platensis* has several applications as fertilizer, colouring agent, feed, pollution control and cosmetics. Also this microalgae has been applied in human nutrition. *Spirulina* is often used for human consumption in form of powder, tablets, capsules and extracts, but the functional features of *S. platensis* led to be used in processing usual foods. Antioxidant effects, better food stability, modified rheological and anti-staling properties can be observed in *Spirulina* incorporated food. So, *S. platensis* revealed to be a good ingredient, with good color stability over time. Adults resistant to the acceptance of novel microalgae incorporated food due to the habitual moral and social

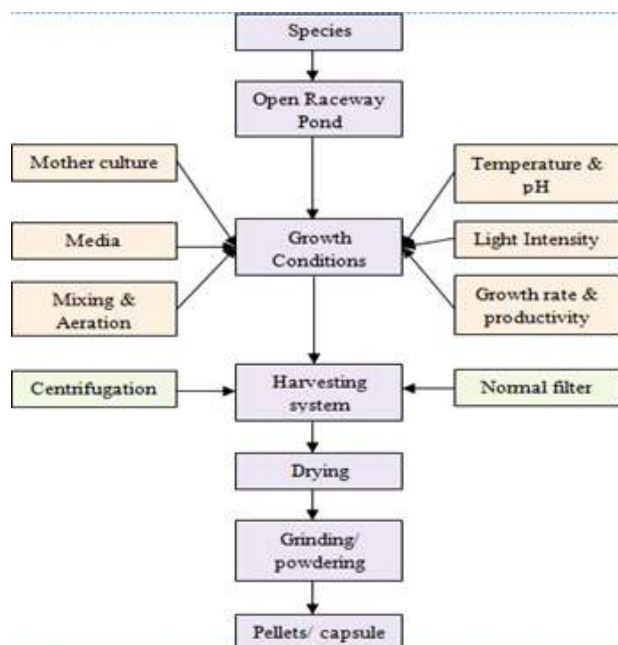


Fig.-1 : Phases of Spirulina Cultivation.

factors. But acceptance of children is easier due to their trend for unusual preparing of foods with good-looking color and taste.

Beverages : It added to many drinks including health drink, sour milk and green tea in order to enhance their nutritional value. To keep the clear color and homogeneity of these drinks, Spirulina must be used in the form of extract or phycobilisyanin. Tea, especially green tea, is a health drink due to its high content of vitamin C. Spirulina and Chlorella have small amount of vitamin C but, containing large amounts of protein, chlorophyll II, carotenoids, polyunsaturated fatty acids, polysaccharides and microelements. Mixture of tea and microalgae have complete nutrient compounds with modified the properties of green tea powder e.g. good foam.

Bakery Products : The powder can be added to improve the nutritional value of bread. Microalgae bread has color and flavor of algae and higher amounts of vitamins, microelements, especially the active biological material. Microalgae improved the water holding in the bread and cause to the long-term shelf time of product .

Among the typical applications of micro-algae in processed foods, the highest rate of consumption is in the noodles. Addition of Chlorella and Spirulina to noodles nutritional and organoleptic (color, odor & taste) properties with strong elasticity. In order to produce light-colored noodles 0.1-1% Spirulina powder should be added to flour.

Cookies are one kind of bakery products which due to the taste, appearance, texture, ease of preparation and



Fig.-2 : Open Race-way pond.

storage have an important place in people's eating habits and are used widely. So they can act as carriers for important nutrients. The use of *S. platensis* microalgae in the cookie can provide nutrients with a modified color and functional features such as antioxidant activity [40]. Salehifar *et al.* investigated the effects of *S. platensis* microalgae used in production of traditional Iranian cookies (0.5, 1.0 and 1.5% w/w) on nutritional value, color and texture properties. The results indicated the possibility of production of fortified cookies (1.0-1.5%) *S. platensis* with desirable nutritional and sensory characteristics.

Candy : *Spirulina* candy is produced with granular sugar, pectin, spirulina powder, peanuts, and agar - agar.

Water in oil emulsions : Oil in water emulsion formulation by using natural ingredients such as Spirulina is a desirable field for research due to novelty in creation of attractive and stable colors. Most natural pigments can be improved oil oxidation resistance due to antioxidant characteristics. This is an important advantage in high fat products such as emulsion.

Gel Desserts : Addition of *S. Maxima* and *Diacronema vlikianum* at 0.1- 1% w/w levels in the vegetable gel desserts created a novel product rich in polyunsaturated fatty acids (such EPA,DHA and γ -linolenic acid) along with the improved features of tissue.

Dairy Products : Spirulina is a promising dietary supplement for the enhancement of cow milk with health-associated unsaturated fatty acids. The growth, acid production and survival of probiotic dairy starters during manufacture and subsequent refrigerated storage of fermented milks can be improved, by addition 0.3% (w/v) of the dried biomass of *S. platensis*. The stimulatory or protective effect of Spirulina is effective for *Bifidobacterium* spp. because of its poor growth in milk and survival rates in conventional fermented dairy foods. Also *S. platensis* improved the nutritional and sensory

properties of the final products, and also it had antifungal effects on spoilage yeasts and molds. Phycocyanin extracted from *Spirulina* mainly used as a food colorant, as an edible dye in ice creams. However, as the pigment was light sensitive, special care must be taken in protecting it from bleaching.

Conclusions

Spirulina has the potential for being a 'wonder food supplement' and various leading organizations have recommended its salubrious effects on human well-being. In developing countries like India can be very suitably utilized as a diet supplement to overcome the challenge of social malnutrition. Unlike a company set up for *spirulina* production in other countries, the commercial cultivation of *spirulina* can be an agribusiness in India to supply *spirulina* products to a large population of the country. It has good turnover with low capital investment, and also providing employment opportunities to others.

WHO (world health organization) also suggest that adding the daily diet will naturally boost the immune system of your body. *Spirulina* is contributed animal feed as mainly on ornamental fish farming for increasing the colour pattern of fish. So proper training and technology to the cultivation of such nutritious algae can be lead to make a good profit and improve the unemployed and rural livelihood opportunities in the society.

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Livelihood Security of Small and Marginal Farmers from IFS Model in Middle Indo-Gangetic Plains

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Abstract

An experiment was conducted Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya during 2018-19 to 2020-21. The operational area of IFS model is 1.01 ha. The productivity of various farm enterprises in terms of rice grain yield equivalent (RGEY t/ha/annum). On an average, system productivity of crop unit (10.45 t/yr), dairy unit (3.44 t/yr), horticulture unit (1.22 t/yr), Fish unit (2.95 t/yr) and Vermicompost (0.56 t/yr) was recorded in terms of rice grain equivalent yield, respectively. The economics showed that Rs. 232193 was obtained as total net return against the expenditure of Rs. 210405. A progressive increase in benefit cost ratio was observed due to integration of various components of farming system. The maximum benefit cost ratio (3.02) was obtained from vermicompost component followed by fish unit (2.12), while minimum B: C ratio (0.42) was recorded from dairy enterprises. The total annual man-days (489/year) were generated out of various component in IFS model.

Key words : IFS, productivity, resource conservation, sustainability and employment generation.

Introduction

The agricultural sector, which employs around 60% of the workforce directly, is the backbone of the Indian economy. Small and marginal farmers make up 86% of all Indian farmers, despite possessing only 44% of the nation's arable land (GOI, 2014). The main focus of marginal and small farmers in India is producing crops based on cereals, which are vulnerable to natural disasters like droughts and floods. The Indian government has taken an interest in IFS in terms of mixed farming systems for the farming community's growth, and various programs were developed to bring livelihood security to small and marginal farmers as well as to advance agriculture and animal production (Mahapatra and Behera, 2011). In India, there is a decrease in the number of active farm holdings, with almost 85 million out of 105 million holdings being smaller than one hectare. On the other side, the nation will need to boost food production by more than 32% of current levels in order to feed almost 1.6 billion people by 2050 (Ngachan and Das, 2018).

In addition to being unable to provide income and jobs in a sustainable manner, India's intensive agricultural systems fail to meet farm-level targets for food, environmental, and energy security. Thus, single-property farmers—such as those in a typical monoculture system—are not able to sustain themselves. The integration of crops, livestock, and fishery components

that ensure food and nutritional security with regular and periodic income to farmers is essential to overcoming the challenges faced by specialized, input-driven agriculture (Gill *et al.*, 2009). Marginal, small, and medium-sized farmers who cultivate less than one hectare are showing a revived interest in integrated farming systems (IFS), which combine livestock, crop industries and many more (Behera & France, 2016). The agricultural production system needs to be changed so that it is both profitable and environment friendly rather than only profit-oriented. Additionally, integrated agricultural systems in semi-arid and dry locations created more job prospects than single-farming systems, according to Rathore *et al.*, (2019). Consequently, the IFS model helped in resolving the issue of farm families' unemployment.

Materials and Methods

A study on Integrated Farming System was during 2016-17 to 2018-19 at Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya. The operational area of IFS model is 1.01 ha. The IFS model comprises with five combination of cropping sequences (0.70 ha) viz., rice-wheat-sudanchari (0.22 ha), rice-mustard-blackgram (0.12 ha), rice-potato-greengram (0.12 ha), rice-lentil-maize + cowpea (0.12 ha) and desichari-berseem-cowpea (0.12 ha), horticultural crops (0.20 ha) viz. main fruit trees aonla and filler fruit trees guava, fishery (0.10 ha) and dairy (0.01 ha) and

Table-1 : System productivity of different components of IFS model developed on 1.01 ha land (mean data of 3 years).

S. No.	Component of IFS Model	Total farm production (REY tonnes/year)
1.	Crops	10.45
2.	Horticulture (fruit trees + Boundary plantation)	1.22
3.	Dairy (3 buffaloes)	3.44
4.	Fish pond	2.95
5.	Vermicompost	0.56
6.	Total IFS area (1.01 ha)	18.62

Table-2 : Economics of different components of IFS model developed on 1.01 ha land (mean data of 3 years).

S. No.	Component of IFS Model	Gross return (Rs/year)	Net return (Rs/year)	Cost of production (Rs/year)	B:C Ratio
1.	Crops	198876	127606	71270	1.79
2.	Horticulture (fruit trees + Boundary plantation)	21650	13532	8118	1.67
3.	Dairy	158722	47432	111290	0.42
4.	Fish pond	56650	37838	17812	2.12
5.	Vermicompost	7700	5785	1915	3.02
6.	Total IFS area (1.01 ha)	443598	232193	210405	1.10

Table-3 : Employment generation of different components of IFS model developed on 1.01 ha land (mean data of 3 years).

S. No.	Component of IFS Model	Component-wise man-days generated/year
1.	Crops	208
2.	Horticulture (fruit trees + Boundary plantation)	32
3.	Dairy (3 buffaloes)	215
4.	Fish pond	24
5.	Vermicompost	10
6.	Total IFS area (1.01 ha)	489

vermicompost unit in the IFS model. The different component of the model is dependent upon complementary and supplementary interaction with each other's.

Results and Discussion

Productivity : The irrigated agro-ecosystem in the eastern plain zone of Uttar Pradesh has many cropping sequences, and among them are cereals, pulses, oilseeds, and vegetables. Conversely, only dominant crops and cropping sequences were included in the model in order to preserve crop component productivity, profitability, and sustainability. Rice yield equivalent (REY) t/ha/annum was used to calculate the productivity of several agricultural enterprises, including the crop, fish, dairy, horticulture and vermicompost enterprises. In terms of rice grain equivalent yield, the average system productivity for IFS model was 18.62 t/yr. The highest REY was crop unit (10.45 t/yr) followed by dairy unit (3.44 t/yr), fish unit (2.95 t/yr), horticulture unit (1.22 t/yr), and vermicompost (0.56 t/yr) was reported.

Economics : Data obtained after three years of farming shows that the adoption of integrated farming with the stated components has increased net returns (210405

Rs./1.01 ha) and decreased input purchases overall (443598 Rs./1.01 ha). The IFS model's crop component reported gross income of 198876 rupees and net return of 127606 rupees; the horticulture component reported gross income of 21650 rupees and net return of 13532 rupees; the dairy component reported gross income of 158722 rupees and net return of 47432 rupees; the fish pond component reported gross income of 56650 rupees and net return of 37838 rupees; and finally, the vermicompost component recorded gross income of 7700 rupees and net return of 5785 rupees. Similarly, B: C ratio under different IFS components was dissimilar and the highest benefit: cost ratio was fetched from the vermicompost unit (3.02) then followed by fish unit (2.12), crop unit (1.79), horticulture unit (1.67) and dairy unit (0.42). These results are in accordance with the findings of Reddy *et al.* (2018).

Employment generation : Due to more enterprises than the cropping system alone, the IFS has increased the number of working hours in the system. Each year, the model produced 489 man-days/1.01 hectares. Crops produced 208 man-days, horticulture produced 32, dairy produced 215, fish pond produced 24 and vermicompost produced 10 man-days. Because more personnel are

involved in the IFS model than is needed for any one system module, employment opportunities have been available all year long. A number of job opportunities were created by the diversification of farming, which included the many operations of many businesses involved in the IFS model. Families that still included farming were able to maintain year-round work in this industry.

Conclusions

The sustainable provision of farmers with a satisfactory degree of income, employment, and livelihood security depends on the efficient management of resources at the farm level, which can only be achieved through the implementation of an integrated farming system. Adding organic residue in the form of plant and animal wastes can also result in increased soil health and productivity over a longer duration with fewer environmental dangers. The effective recycling of nutrients resulted in decreased production costs and an increased cost-benefit ratio. Selecting businesses can help them become less reliant on outside resources and foster partnerships amongst them.

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Formulation and Quality Evaluation of Little Millet Bar Based on Consumer Study

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Abstract

Millets, the Nutri – cereals which are highly nutritious and non-glutinous foods. The consumption of millets was decreasing day to day because of unavailability, inconvenience to cook & low palatability etc. Hence, this study aimed to develop a millet bar based on Online consumer study on consumption of millets. The consumer study says that the preference of little millets by the consumers is very low, inspite of its high nutritional value. Compared to other millets, the little millets are high in fat content, high in Zn & Cr. And also there is wide requirement of a product which can instantly supply the nutritional requirement of individual in this busy life. The change in life style, eating habits, fast life is making us far apart from the millets. Keeping this in view, we decided to develop a Millet based bar which can supply high nutrition along with micronutrients based on consumer study. So, a millet bar was prepared with little millets (which was least preferred by consumers) in different amounts in addition with (0%,15%, 20%, 25%), rolled oats, nuts (almonds, cashews) & seeds (flax seeds, sunflower seeds, pumpkin seeds). The developed bar was evaluated for sensory attributes and physico-chemical attributes with standardized methods. The organoleptic evaluation showed significant difference between the variations and the highly accepted product was chosen (20%). Under the physico-chemical analysis, the moisture content of 25% millet bar has less, compared to other variations, hardness is more for sample V25 and there is an increased deviation (ΔE^*) of color along with increased millet proportions.

Key words : Millets, nutri bar, market survey.

Introduction

Millets, the Nutri-cereals which are high in nutrition and dietary fibre. They serve as good source of protein, micronutrients and phytochemicals. The millets contain 7-12% protein, 2-5% fat, 65-75% carbohydrates and 15-20% dietary fiber. The essential amino acid profile of the millet protein is better than various cereals such as maize. Millets contain fewer cross-linked prolamins, which may be an additional factor contributing to higher digestibility of the millet proteins.

Similar to cereal proteins, the millet proteins are poor sources of lysine, but they complement well with lysine - rich vegetables (leguminous) and animal proteins which form nutritionally balanced composites of high biological value. Small millets are good source of phosphorous and iron.

The millet grain contains about 65% carbohydrate, a high proportion of which is in the form of non-starchy polysaccharides and dietary fibre which help in prevention of constipation, lowering of blood cholesterol and slow release of glucose to the blood stream during digestion. Lower incidence of cardiovascular diseases, duodenal ulcer and hyperglycemia (diabetes) are reported among regular millet consumers. Millet grains are also rich in important vitamins viz., Thiamine, riboflavin, folic acid and niacin. Millets vary largely in composition of carbohydrates

as proportion of amylose (16-28%) and amylopectin (72-84%).

Kodo millet and little millet were also reported to have 37% to 38% of dietary fiber respectively, which was once considered as 'anti-nutrient' and is now termed as a nutraceutical and highest among cereals;. Thus, it makes millets a complete food ingredient suitable for large scale utilization as processed products, snacks, baby foods etc., and also play a major role in propagating food security among under developed and developing countries. The new cooking recipes from minor millets have great potential as protein and minerals rich supplementary foods to alleviate Protein Calories Malnutrition (PCM) and mineral deficiency diseases prevalent among school going children .

In India, production and consumption of millets is declined due to various reasons. Despite of their superior nutritional qualities and climate resilience, cultivation of small millets in India declined from 7.22 million hectares to 2.29 million hectares from 1961–2009. , harvested area and the consumption of millets in India gradually decreased in an alternative year of 2005-2008 & 2009 onwards it was increased but, in the year of 2012, onwards it came to falling. Low productivity, high labour intensity, drudgery of agricultural operations and lack of alternative farm gate prices, easy availability of rice and wheat through public distribution system, inadequate

investment in product development and commercialization, inadequate availability of small millets in local markets and high prices, inadequate policy support for small millets when compared to crops like rice and wheat, were the reason for decline of millets. Value added products from millets have the potential to add value to business and has a large potential growth for food industries and consumers believe that millets and millet-based foods contribute good health.

Hence, keeping these aspects in view the objective of this study is to develop Millet Based Bar. Consumer Study & to conduct Sensory Analysis for developed Millet Based Bar and to analyse Physico-chemical properties for Millet Based Bar.

Materials and Methods

3.1 Development of Questionnaire : Questionnaire was developed to know the consumer preferences on consumption of millets. It is developed in two parts i.e on demographic profile & consumer preferences. Under demographic profile, age, gender, occupation, educational qualification & annual income are included. Under consumer preferences, functional aspects & pleasure aspects are asked. The data was collected using the questionnaire, which is circulated through online using Google Forms.

3.2 Raw materials

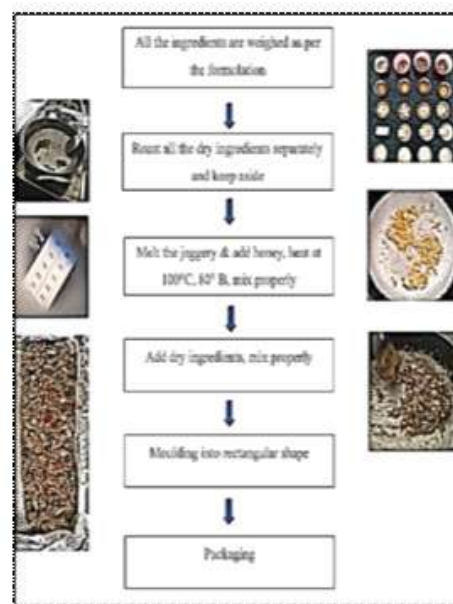
3.2.1 Millets : Little millets were collected from the local market which are already cleaned & dehusked.

3.2.2 Other materials : Cane sugar jaggery, was procured from local market.

Table-1 : Formulation of Millet based bar.

S.No.	Ingredients	Standard	Variation 1	Variation 2	Variation 3
1.	Cane sugar Jaggery	25	25	25	25
2.	Honey	20	20	20	20
3.	Rolled oats	10	10	10	10
4.	Almonds	5	5	5	5
5.	Raisins	5	5	5	5
6.	Flax seeds	5	5	5	5
7.	Sunflower seeds	5	5	5	5
8.	Pumpkin seeds	5	5	5	5
9.	Cashew nuts	5	5	5	5
10.	Little Millets	0	15	20	25

3.3 Preparation of Millet Based Bar :



All the seeds, nuts & millets are roasted separately until the raw aroma disappears and keep them aside. Melt the jaggery at 100°C and add the honey and check for until the 80°B reading and put off the flame. Immediately add all the roasted ingredients and mix properly. Mould the mixture into greased rectangular mould. Keep aside in room temperature for about 20 min. After it sets, cut into bars with dimensions 8cm*3cm*1.5cm. Pack the bars in LDPE pouches.

3.4 Physico-chemical Properties

3.4.1 Colour : The colour was measured using Hunter Lab Colorimeter (Hunter Lab Color Flex EZ).

3.4.2 Texture profile analysis : The texture measurements of Millet based Bar samples were performed at room temperature using Texture Profile Analyser (Texture Pro CT V1.4 Build 17), Brookfield Engineering Labs, Inc. The texture profile analysis was performed to each sample (2*2*1 cm), which were compressed twice to half of the height of the sample with a cylindrical probe TA4/1000. A time of 2sec was allowed to elapse between two compression cycles. The cross head moved at a constant speed of 1mm/s. From the resulting curve, hardness was determined.

3.4.2 Chemical properties

3.4.2.1 Moisture : Moisture of the fresh pulp and the products was measured by using standard AOAC method.

3.4.2.2 Total ash : Total ash content was estimated by AOAC method (2005).

3.5 Sensory Analysis : The sensory evaluation of developed products i.e Millet based bar was carried out by using 9- point hedonic scale with semi- trained panel members from College of Food Science & Technology, Pulivendula. Judgement was made through rating products on a 9- point Hedonic scale with corresponding descriptive terms ranging from point 9 'like extremely' to 1 'dislike extremely'. Millet based bar were scored for different quality attributes like as color, flavor, taste, texture, appearance and overall acceptability.

Results and Discussion

The present research work deals with the study of Millet based bar. The main purpose for introducing millets in the bar is to provide the nutritional values of the millets in Ready to eat snack. The Millet based bars prepared by using little millets along with nuts, seeds & dry fruits for complete package of nutrition. In order to evaluate the quality and acceptability of Millet based bar, the Chemical analysis as well as Organoleptic evaluation was done in the present investigation. In this study, we took three samples V15, V20 & V25 with 15%, 20% & 25% of little millets and control sample 0% respectively. The results were tabulated and discussed keeping in the view the various objectives of study. The Millet based bars were analyzed for Physical, Chemical and Sensory qualities.

4.1 Market Survey :

4.1.1 Demographic Characteristics of the Respondents : Out of 265 respondents, age group of 11-20 are 58 (21.9%), 21-30 are 195 (73.6%), 31-40 are 8 (3%), 41-50 are 3 (1.1%), 51-60 are 1 (0.4%) and 61-70 are 0. It is shown that majority of the respondents are young generation of age 21-30 (fig: 4.1).

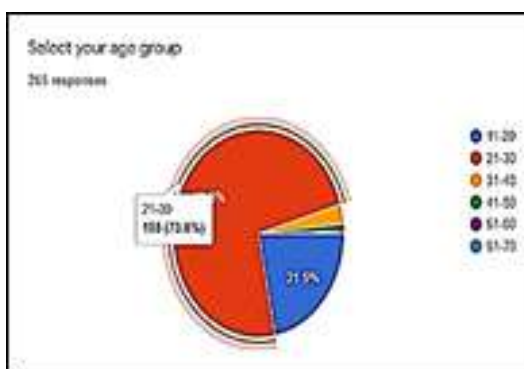


Fig.-4.1. Results of demographic character (age) of the respondents.

Out of 265 respondents, females are of 160 (60.4%) and males are of 103 (38.9%), respondents who prefer not to say are of 2 (0.7%). It is shown that majority of the respondents are females in the study (fig: 4.2).

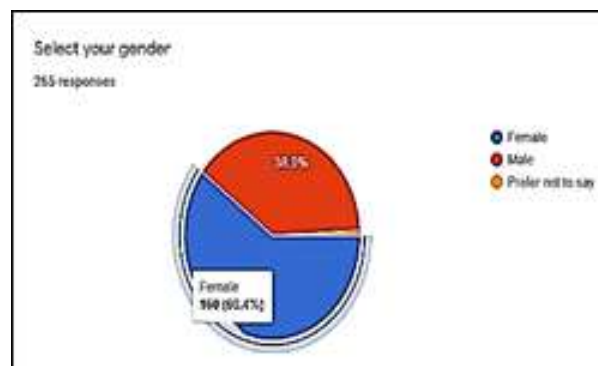


Fig.-4.2. Results of demographic character (gender) of the respondents

All the respondents varied in educational qualifications like BTech, MSc, PG etc., which shows that respondents are most qualified (fig: 4.3).

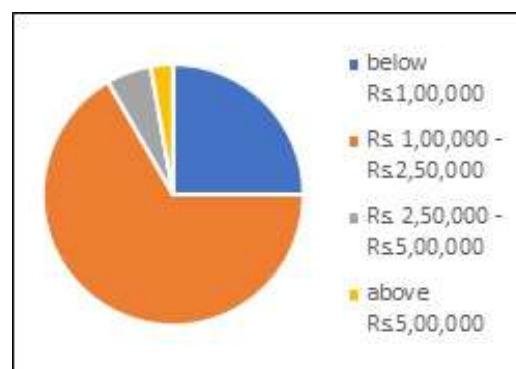


Fig.-4.3. Results of demographic character (annual income) of the respondents

All the respondents reside from various districts of Andhra Pradesh & Hyderabad (fig: 4.4).

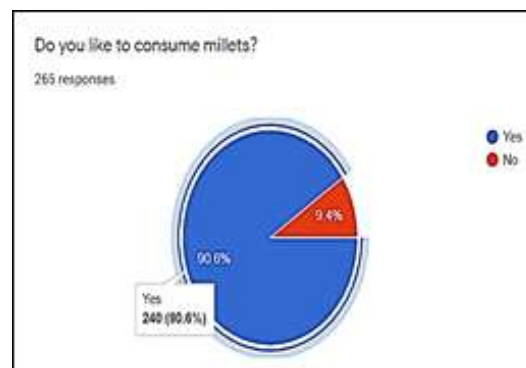


Fig.-4.6 : Preference towards millets consumption.

Out of 180 respondents, 45 respondents annual income is below Rs.1,00,000 (24.7%), 120 respondents annual income is between Rs.1,00,000 – Rs.2,50,000 (67%), 10 respondents annual income is between Rs.2,50,000 to Rs.5,00,000 (5.5%) and 5 respondents annual income is above Rs.5,00,000 (2.7%). It is shown that majority respondents are having annual income

between Rs. 1,00,000 to Rs. 2,50,000. This observation evidently indicated that respondents are from middle class (fig: 4.5).

4.1.2 Preference towards Millets Consumption : Out of 265 respondents, majority of the respondents i.e.240 (90.6%) liked to consume millets and remaining 25(9.4%) disliked the millets (Fig: 4.6). This observation evidently indicated preference towards the consumption of millets.

4.2 Results of Physico-Chemical Properties:

4.2.1 Results of Color : It is observed that the color deviation increased from sample V15 to V25. This results that there is high color deviation for V25 because of high millet content (Table-4.1).

Table-4.1 : Results of E* of millet based bars.

S. No.	Sample	Color Deviation from the standard (E*)
1.	V15	8.66
2.	V20	8.88
3.	V25	8.96

4.2.2 Results for Texture profile Analysis

Table-4.2 : Results for Texture profile analysis of millet based bars.

S. No.	Sample	Hardness (N)
1.	Standard	6.6
2.	V15	7.3
3.	V20	7.6
4.	V25	8.2

It is observed that hardness increased from standard to V25. This results that the sample V25 has more hardness and low hardness for the standard sample due to millet content (Table-4.2).

4.2.3 Results for Proximate content

Table-4.3 : Results for proximate content of millet based bars.

S.No.	Sample	Standard	V15	V20	V25
1.	Moisture	7.5	7.3	7.3	7.2
2.	Total Ash	2.83	3.0	3.1	3.1

It is observed that there is a decrease in moisture content from standard to V25. This results that this decrease is due to increase in millet content (Table-4.3). Less moisture content for sample V25 may have a long shelf life due to less microbial activity.

It is observed that there is an increase in ash content from which increase in the concentration of little millets. This results that there is high total ash content for sample V25 which shows high mineral content.

4.3 Results of sensory analysis : By considering all the three variations with control overall acceptability of Millet

based bar of V20 with 20% of little millets rated high than other samples (Table-4.4).

Table-4.4 : Results of sensory analysis.

	Standard	V15	V20	V25
Color	7.5±1.02	7.04±1.03	7.52±1.1	7.66±1.13
Texture	7.40±1.26	7.30±1.27	7.46±1.18	7.22±1.27
Appearance	7.58±1.29	6.79±1.53	7.43±1.46	7.42±1.23
Flavor	7.34±1.31	5.84±1.27	7.03±1.89	6.85±1.28
Taste	7.29±1.14	5.99±1.34	7.08±1.11	6.89±1.15
Overall acceptability	7.19±0.91	6.47±0.94	7.33±1.20	7.12±0.11

Conclusions

The research study titled Development of Millet based bar based on consumer study was carried out with the objectives of successfully developing the product by consumer study and assessing the acceptability of the product developed. By the consumer survey there is very low consumption of little millets is observed. Little millets are rich in nutrition. To increase the consumption of little millets the millet based bar is designed with 0%, 15%, 20% & 25% along with dry fruits & nuts. It can be concluded that the developed millet based bar with 20% of little millet is more accepted by the consumers.

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Effect of Plastic Low Tunnel on Flowering and Fruiting Behaviour During Off Season of Summer Squash (*Cucurbita pepo* L.)

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Abstract

During the winter seasons of 2009-10 and 2010-11, an experiment was conducted to investigate the impact of low tunnels on the flowering and fruiting patterns of summer squash variety "Australian Green" at the Bihar Agricultural College in Sabour, Bhagalpur. The study followed a randomized block design with seven distinct treatments, each replicated three times. These treatments encompassed seven different sowing dates: November 30th in open field, December 15th in open field, December 30th under tunnel, January 15th under tunnel, January 30th under tunnel, February 15th in open field, and February 28th in open field. The results demonstrated significant effects on the flowering and fruiting behavior of summer squash during the off-season. Specifically, the lowest number of days required for the first appearance of a female flower (48.50 days) and the first fruit harvest (55.50 days) were recorded. Moreover, attributes such as fruit length (36.20 cm), fruit girth (7.81 cm), number of fruits per plant (8.0), individual fruit weight (0.970 kg), and yield per hectare (4.25 quintal) were maximized when sowing was conducted on December 30th under the low tunnel conditions (T3). It was observed that the use of plastic low tunnels induced early flowering during the off-season.

Key words : Low tunnel flower, fruits, date of sowing, summer squash

Introduction

Cucurbits are primarily warm-season crops that thrive in tropical and subtropical regions. However, summer squash, a member of the cucurbit family, can tolerate lower temperatures, although it typically flourishes in the range of 15-25°C. Vegetable markets are often flooded with various cucurbits during their main growing season, and at times, growers struggle to cover their production costs. Yet, the prices of these vegetables tend to be substantially higher during their off-season availability. Currently, some farmers in northern India are attempting to cultivate cucurbits in riverbeds (diara land) after water has receded by digging deep trenches. However, the potential of this practice is limited and could be further extended. Protected cultivation, particularly through the use of low-cost structures like plastic low tunnels, offers an effective method for off-season cultivation of cucurbits, especially in northern parts of India. Plastic houses, predominantly covered with polyvinyl chloride or polyethylene sheets, commonly referred to as polytunnels, have gained popularity in recent years. They provide protection against frost damage during flowering and fruiting stages. This technique is becoming increasingly important in mitigating the adverse effects of climate change on fruit production (Carlen and Kruger,

2009). Production under high or low tunnels can enhance fruit precocity, allowing growers to fetch premium prices that are typically available early in the harvest season (Demchak, 2009). Shielding crops with plastic (polyethylene), whether through high tunnels or greenhouses, leads to alterations in environmental conditions such as light, temperature, and relative humidity, which can impact the plant's productivity and physiological responses (Li *et al.*, 2012). Studies indicate that the air temperature inside the tunnel is 3 to 20°C higher, and soil temperature is 2-5°C higher compared to open fields (Ogden and Van Iersel, 2009; Zhao *et al.*, 2014). Research in tomatoes and strawberries suggests that the temperature increase in high tunnels directly influences fruit precocity, resulting in a harvest starting 7 to 21 days earlier than in open fields (Wien, 2009; Singh *et al.*, 2012; Crown *et al.*, 2014; Zhao *et al.*, 2014). Temperature and relative humidity significantly impact leaf stomatal conductance (gs), affecting transpiration rates and photosynthesis in plants (Righi *et al.*, 2012). Commonly used polyethylene film for covering greenhouses or tunnels can reduce the transmission of photosynthetically active radiation (PAR) by 20% to 30% compared to open conditions (Cowan *et al.*, 2014). A decrease in PAR availability can negatively impact crop production under plastic by reducing photosynthetic rates,

which in turn affects yield and quality (Sandri *et al.*, 2003). Low tunnels not only warm the soil but also protect plants from hail, cold winds, injuries, and promote earlier crop advancement compared to the normal growing season, especially since temperatures can drop below 8°C for 30-40 days during the winter season in the plains of northern India. Fruits are available from April to November, causing market oversupply and subsequent price crashes during the main season (Kumar *et al.*, 2015). However, the produce commands a high premium value during off-season availability, especially when employing season-forcing techniques like greenhouses, polyhouses, net houses, and low tunnels (Enoch and Enoch, 1999). The installation of these structures can be costly and may be unaffordable for small and marginal farmers. Among these techniques, low tunnels have proven to be highly effective for non-woody species, including ornamental and vegetable crops (Zhao *et al.*, 2014). They provide warmth to the soil, protect plants from hail and cold winds, and expedite crop growth, especially considering that temperatures can drop below 8°C for 30-40 days during the winter season in the plains of northern India. In light of these considerations, this study was designed to determine the optimal sowing date and growing conditions to achieve early flowering and fruiting in bottle gourd, ultimately leading to higher market prices.

Materials and Methods

The field experiment was carried out during the winter seasons of 2009-10 and 2010-11 at the vegetable research farm of Bihar Agricultural College, Sabour, Bhagalpur, Bihar. Bhagalpur is situated in the Ganga basin at an elevation of 141 feet above sea level, with coordinates of 25° 15' 12.20"N latitude and 86° 59' 20.61"E longitude. The experimental site experiences a subtropical climate, with temperatures ranging from 4°C to 28°C during the winter. The soil is characterized as sandy loam, well-drained, with a pH of 7.22, organic carbon content of 0.41%, available nitrogen at 228.15 kg/ha, available phosphorus at 49.25 kg/ha, and available potassium at 363.78 kg/ha. The experiment followed a randomized block design with three replications, comprising seven different sowing dates: November 30th under open field, December 15th under open field, December 30th under tunnel, January 15th under tunnel, January 30th under tunnel, February 15th under open field, and February 28th under open field. Seedlings of bottle gourd variety "Narendra Reshmi" were transplanted with a spacing of 3 m x 0.5 m. To create plastic low tunnels, 60 cm wide, 50 cm high, and 50-micron transparent plastic sheets were used. Immature bamboo sticks were placed on both sides of the water channel to

support the tunnels. The tunnels were oriented in a north-south direction, with vents on the east side. All necessary cultural practices were implemented according to recommended protocols during the crop's growth period. Plastic covering was removed from the beds in the second week of February each year. Five plants were randomly selected in each treatment for recording various plant growth parameters and yield metrics. Mean values of different characteristics were used for statistical analysis. Data were collected on vine length (cm), primary branches, first appearance of female flower, first picking, fruit length (cm), fruit girth (cm), and number of fruits per plant. Artificial soil media, consisting of cocopeat, vermiculite, and perlite in a 3:1:1 (V/V) ratio, was predominantly used for cultivating healthy and vigorous vegetable seedlings in plastic pro-trays. These trays were ready for transplanting in approximately 20-25 days. Vine length was measured from the base of each plant to the growing point of the main vine. The total number of fruiting branches emerging from the main stem was counted at the time of the final picking to determine primary branches per plant. Fruit length was measured in centimeters, and fruit diameter was recorded at the middle periphery of the fruit using Vernier calipers. Data collected across both growing seasons were combined for statistical analysis (Panse and Sukhatme, 1978).

Results and Discussion

The possible consequences of climate change on agriculture and food security are of great concern. The use of protective structures such as low tunnels can be a critical factor in reducing the impact of temperature shifts, unpredictable rainfall patterns, and the risk of diseases and pests (Singh and Satpathy, 2005). These analyses play a vital role in informing regional policies that seek to enhance the resilience of the agricultural sector to climate change. Here, we summarize the main discoveries and discussions from the current research covering various parameters :

Parameters related to flowering : The number of days taken for the first female flower to appear and for the first harvest were notably affected by both the sowing date and the growing conditions. The minimum duration for the appearance of the first female flower and the first harvest was observed when sowing was conducted on December 30th under the low tunnel conditions (T3), surpassing other sowing dates under the low tunnel. The early onset of flowering leads to an early fruiting process. The data concerning the timing of first flowering and fruit harvest was attributed to the consistently higher air temperatures recorded inside the tunnels compared to outside. The temperature differential was as high as 10 degrees

Table-1 : Effect of sowing and growing condition on growth and yield attributing parameters of summer squash.

Treatments	Female flower	First picking	Fruit length (cm)	Fruit girth (cm)	Fruits/plant
T1=30 th Nov. Open field	62.50	64.50	26.80	6.87	3.00
T2=15 th Dec. Open field	54.00	65.50	19.60	5.11	2.65
T3=30 th Dec. under tunnel	48.50	55.50	36.20	7.81	8.00
T4=15 th Jan. Under tunnel	56.50	69.50	32.60	6.61	3.45
T5=30 th Jan. tunnel	62.00	76.00	30.75	5.69	3.50
T6=15 th Feb. Open field	56.00	66.00	11.18	3.41	3.60
T7=28 th Feb. Open field	56.00	64.00	9.25	3.08	2.60
SD	1.64	1.99	1.13	0.33	0.29
CD at 5%	3.33	4.05	2.47	0.77	0.65

Table-2 : Effect of sowing and growing condition on growth and yield attributing parameters of summer squash.

Treatments	Fruits/plant	Fruit weight (kg)	Yield/plant	Yield/ha
T1=30 th Nov. Open field	3.00	0.749	2.24	138.88
T2=15 th Dec. Open field	2.65	0.335	0.88	54.86
T3=30 th Dec. under tunnel	8.00	0.970	4.25	258.09
T4=15 th Jan. Under tunnel	3.45	0.815	2.081	173.72
T5=30 th Jan. tunnel	3.50	0.625	2.020	136.09
T6=15 th Feb. Open field	3.60	0.152	0.55	33.79
T7=28 th Feb. Open field	2.60	0.137	0.35	21.70
SD	0.29	19.70	0.11	7.76
CD at 5%	0.55	40.14	0.25	16.91

Celsius between the inside and outside environments. The favorable impact of low tunnels on flowering and harvest timing is likely due to the conducive microclimate conditions created, which result in earlier flowering and fruit ripening, as well as enhanced fruit precocity production. Ogden and van Iersel (2009) have also noted that low tunnels bring about modifications in climatic conditions, thus promoting earlier flowering and fruit ripening, as well as the precocious production of fruits. A similar study by Ibarra et al. in 2001 observed that muskmelon crops grown under plastic covers flowered 24 days earlier than their uncovered counterparts.

Fruiting parameters : Upon reviewing the data presented in Table-1, it becomes evident that fruit length, fruit girth, fruit weight, yield per plant, and yield per hectare were significantly affected by the sowing date and growing conditions. The maximum values for fruit length, fruit girth, fruit weight, yield per plant, fruit per plant, and yield per hectare were achieved when the sowing was carried out on December 30th under the low tunnel condition (T3), surpassing other sowing dates under the low tunnel. This enhanced performance is likely attributed to the favorable growth and development conditions provided by the low tunnel, leading to increased net photosynthesis and the production of more assimilates available for individual plant growth. Similar results were reported in earlier studies by Singh and Kumar in 2009, where the variety

“Australian Green” exhibited a shorter time to the first harvest (58 days after transplanting), along with the highest fruit yield per plant (5.90 kg/plant) and the highest total fruit yield (696.0 quintals/ha) among five summer squash varieties evaluated for off-season cultivation under plastic low tunnels during the winter period. Consistently, enhanced vegetative growth was observed in plants within the tunnel, benefiting from the more favorable thermal conditions, resulting in the highest total marketable yield under the poly tunnel, as reported by Siwek and Capecka in 1999. It's worth noting that there were no significant differences observed in fruit weight between crops grown in tunnels and those in open fields.

Economics : The adoption of low tunnel technology for off-season flowering and fruiting significantly impacts net income and cost-benefit ratio. The highest net income and cost-benefit ratio were observed when the crop was sown on December 30th under the tunnel. This can be attributed to the increased market value of the produce during the off-season. Growers commonly expressed contentment with the implementation of this technology..

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A Study on Constraints Faced by Cauliflower Growers in Cauliflower Cultivation in Nalanda District of Bihar, India

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Abstract

The primary vegetables cultivated in India include tomato, onion, brinjal, cabbage, cauliflower, okra, peas, etc. India holds a significant position in global vegetable production, contributing about 13% of the total. Specifically, it ranks first in cauliflower production, second in onion, and third in cabbage worldwide. This study, conducted during the 2021-22 period in Bihar's Nalanda district, involved 80 respondents selected through proportional random sampling. Personal interviews were conducted to collect data. The findings indicated that a substantial majority (81.66%) of cauliflower growers faced significant challenges due to the supply of inferior quality seeds by input dealers, hampering cauliflower production. Farmers encountered various problems in the production of cauliflower. A structured schedule was developed to align with the study's objectives and variables, and respondents were personally contacted for data collection. This study provides valuable insights into the constraints faced by cauliflower farmers, highlighting the need to disseminate this knowledge to farmers in other states.

Key words : *Cauliflower growers and constraints.*

Introduction

India holds the second position globally in vegetable production, following China. In the 2013-14 period, India produced 162,896.9 thousand metric tons of vegetables from an area of 9,205.2 thousand hectares, achieving a productivity of 17.70 MT/ha (National Horticulture Board, 2013-14). Vegetables thrive in diverse agro-climatic and soil conditions across the country, encompassing plains and hilly regions. Currently, India cultivates approximately 70 different varieties of leafy, fruity, and starchy tuber vegetables, with over 40 types belonging to various groups such as solanaceous, cucurbitaceous, leguminous, cruciferous (cole crops), root crops, and leafy vegetables. Key vegetables grown in India include tomato, onion, brinjal, cabbage, cauliflower, okra, and peas. India contributes around 13% to the world's total vegetable production, securing the first position in cauliflower, second in onion, and third in cabbage globally. The extensive production base provides India with significant opportunities for export. In the 2014-15 period, India exported vegetables valued at Rs. 4,702.78 crores. China leads in cauliflower production, producing 8,067,917 metric tons annually from 450 hectares, while India produces 7,887 metric tons of cauliflower each year from an area of 402 hectares. Among Indian states, West Bengal is a prominent contributor to cauliflower production, followed by Uttar Pradesh.

Materials and Methods

The investigation was carried out in Nalanda district during the 2020-21 period. Nalanda district consists of 20 blocks, with two blocks, namely Noorsarai and Nagarnausa, purposefully chosen for the study. From these blocks, four villages were deliberately selected, and a total of 80 cauliflower growers were chosen from all the selected villages, constituting the entire sample size for the study. The data collection process involved personal interviews conducted with the assistance of a pre-structured schedule. Subsequently, the collected data were analyzed to determine percentages and rank orders.

Results and Discussion

Limitations encountered by growers of cauliflower in the production of the crop The information shown in Table 1 indicates that the main input constraint, as viewed by growers, was the input dealers' provision of low-quality seeds for cauliflower cultivation. Its mean percent score value was 81.66, placing it #1, followed by the inability to get high-quality seed when it was time to sow. It came in second place with a mean percent score of 78.75. Expensive pesticides, fertilizers, and seeds for hybrid crops. It came in third place with a mean percent score of 78.33. Fertilizer and micronutrients are not available at the appropriate time. With a mean percent score of 75.83,

it came in fourth place. Decreased fertility of the soil as a result of using more chemical fertilizers. With a mean percent score of 74.16, it came in sixth. Lack of access to high-quality plant protection agents. With a mean percent score value of 71.25, it was rated sixth. not having enough money to buy the necessities. The second table of limitations relating to technical limits as viewed by cauliflower farmers was that application of technology is extremely technical in cauliflower production. With a mean percent score value of 68.75, it placed eighth. Its mean percent score value of 80 placed it top, followed by operational difficulties resulting from a lack of labor in the deployment of technical instruments. It was placed second with a mean percent score value of 79.58. inadequate technology. It came in third place with a mean percent score of 77.08. Because of ignorance, using plant protection measures is dangerous. With a mean percent score of 76.25, it came in fourth place. ignorance about the IPNM principle and balanced fertilizers. It came in fifth place with a mean percent score of 75.41. Lack of technically competent labor. It came in sixth place with a mean percent score of 75. Insufficient understanding of planting distance. It was placed eighth with a mean percent score of 73.33. ignorance of the regulators of plant development. With a mean percent score value of 72.50, it was rated eighth. Insufficient understanding of plant protection protocols. It came in ninth place with a mean percent score of 71.25. ignorance about the suggested bundle of procedures. It was placed tenth with a mean percent score of 70.41. Table 3 presents the socio-psychological obstacles that cauliflower producers perceived, including poor motivation and inadequate knowledge about cauliflower growing. It was scored highest with a mean percent score of 80, followed by Cauliflower business is quite dangerous. It came in second place with a mean percent score of 79.16. Inadequate communication between the recipients. With a mean percent score of 76.66, it came in third. absence of influential local leaders. With a mean percent score of 72.50, it came in fourth. To cover the designated territories, field functionaries must go through procedures. With a mean percent score value of 71.25, it was rated sixth. The government department executed inadequate extension initiatives. Sixth place was achieved with a mean percent score of 70.83. Less interest in the initiative

is shown by local officials. With a mean percent score of 70.41, it came in seventh place. Concerning general restrictions, as observed by farmers of cauliflower, the fourth table's constraints were Department's lack of training in vegetable growing. With a mean percent score of 80.83, it was placed first, ahead of inadequate demonstrations at farmers' fields. With a mean percent score of 78.75, it was rated second. There are no credit options available for growing vegetables. With a mean percent score of 78.33, it came in third. Labor costs are high and labor is unavailable during prime time. With a mean percent score of 75, it came in fourth place. There are no facilities for storage. It was placed seventh with a mean score of 74.58. Accurate and timely agricultural information is not readily available. It came in sixth place with a mean percent score of 74.16. Vegetables with a short shelf life after harvest. It came in seventh place with a mean percent score of 71.66. There is a delay in the availability of timely and new information. It was placed eighth with a mean percent score of 69.58. inadequate transportation infrastructure. It came in tenth place with a mean percent score of 47.91. high watering costs. It was rated in the top ten with a mean percent score of 45.

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