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Changes in Micronutrient and Humic Fraction of Different Biodegradable Organic Waste during Vermicomposting by *Eisenia Foetida*

Hemraj Jat and Rajhans Verma

Department of Soil Science and Agricultural Chemistry, SKNAU, Jobner, Jaipur, Rajasthan

*Correspondence Email : hemraj92@gmail.com

Abstract

This study was designed to evaluate the efficacy of earthworm (*Eisenia foetida*) and different biodegradable organic wastes, viz. agricultural waste, vegetable waste, seasonal weed and litter fall with cow dung in various ratios (8:4, 8:5 and 8:6) for micronutrient and humic fraction of vermicompost at 10, 20 and 30 days interval of vermicomposting. The total micronutrient, total humin and total fulvic acid were periodically increased from 10 to 30 days of vermicomposting but total humic acid content decrease from 10 to 30 days of vermicomposting. The highest micronutrient content and humic fraction were found in treatment vegetable waste : cow dung (8:6) whereas treatment vegetable waste : cow dung (8:5) remain statically at par with treatment vegetable waste : cow dung (8:6).

Key words : Organic waste, cow dung, vermicompost, *Eisenia foetida*

Introduction

The term vermicomposting have been coined from the Latin word 'Vermis' meaning to the 'worms'. Vermicomposting refers to composting or natural conversion of bio-degradable garbage into high quality manure with the help of earthworms. So vermicomposting is the process of producing organic fertilizer or the vermicompost from bio-degradable materials by earthworms. So it is an ecofriendly method to degrade the organic waste. Composting with worms avoids the needless disposal of vegetative food wastes and enjoys the benefits of high quality compost. The disposal of wastes has become important for a healthy quality of environment (Senapati and Julka, 1993). The earthworm is one of nature pinnacle "soil scientists". The worms are accountable for a variety of elements including turning common soil into superior quality by breaking down the organic matter into valuable type of fertilizer so they are proving their worth as cost effective farm relief. Many earthworm species convert organic waste into better end product and provide better solution to the problem of waste management. (Nagavallema. K.P. *et al.*, 2004). The processing of waste material through controlled bio-oxidation processes such as vermicomposting reduces the environmental risk by transforming the material into a safer and more stable product suitable for application to soil (Lazcano *et al.*, 2009). The vermicompost itself is beneficial for the land in many ways including as a soil conditioner, as fertilizer, addition of vital humus or humic acids and as a natural pesticide for soil.

Materials and Methods

The experiment was conducted in vermicomposting unit at Agronomy farm, Sri Karan Narendra College of Agriculture, Jobner, Rajasthan. Chopped Agricultural waste, vegetable waste, seasonal weed litter fall and cow dung were used in experiment as substrate. The initial chemical composition of substrate was analyzed.

The experiment was laid out in completely randomized design (CRD) with twelve treatments and three replications. The biodegradable organic wastes were mixed with cow dung in various ratios and form twelve different treatment combinations. The treatment combinations were : T₁ = agricultural waste (8) : cow dung (4), T₂ = agricultural waste (8) : cow dung (5), T₃ = agricultural waste (8) : cow dung (6), T₄ = vegetable waste (8) : cow dung (4), T₅ = vegetable waste (8) : cow dung (5), T₆ = vegetable waste (8) : cow dung (6), T₇ = seasonal weed (8) : cow dung (4), T₈ = seasonal weed (8) : cow dung (5), T₉ = seasonal weed (8) : cow dung (6), T₁₀ = litter fall (8) : cow dung (4), T₁₁ = litter fall (8) : cow dung (5), T₁₂ = litter fall (8) : cow dung (6). The mixture of substrate and cow dung were pre digested for fifteen days. After digestion the pre-digested material was transferred in to cemented vermibed of size 2.5' X 2.5' X 2.5' Ft. Than the vermibed incubated with an epigeic earthworm *Eisenia foetida* and maintained the moisture level up to 70% and kept for 30 days for the process of vermicomposting. The vermicomposting was completed in 45 days and the compost samples were collected at 10, 20, and 30 days intervals from each treatment for laboratory analysis.

Table-1 : Initial chemical composition of substrates.

Sr. No.	Substrate	OC (%)	C:N ratio	Macronutrient (%)			Micronutrient (ppm)			
				N	P	K	Fe	Zn	Mn	Cu
1.	Agriculture waste	35.15	29.29	1.20	0.20	1.50	190.12	60.91	30.21	15.81
2.	Vegetable waste	34.36	22.90	1.50	0.29	1.40	180.43	80.22	47.51	23.47
3.	Seasonal weed	36.12	24.93	1.45	0.20	1.66	185.96	74.34	45.29	14.36
4.	Litter fall	38.25	25.50	1.50	0.12	1.77	150.71	40.43	15.32	7.98
5.	Cow dung	12.16	22.10	0.55	0.11	0.21	170.26	65.37	20.62	8.95

Table-2 : Periodical changes in total iron, zinc, manganese and copper content during vermicomposting.

Treatments	Fe (ppm)			Zn (ppm)			Mn (ppm)			Cu (ppm)		
	Period of sampling (Days)			Period of sampling (Days)			Period of sampling (Days)			Period of sampling (Days)		
	10	20	30	10	20	30	10	20	30	10	20	30
T ₁	122.35	140.26	160.84	7.25	12.54	18.65	30.25	38.54	81.25	1.28	2.09	3.81
T ₂	124.45	142.51	162.89	7.39	12.79	19.21	31.51	39.47	83.24	1.31	2.14	3.88
T ₃	124.95	145.61	163.95	7.74	13.01	19.45	31.85	40.11	84.11	1.33	2.18	3.91
T ₄	126.62	150.25	168.95	9.25	16.11	21.54	35.62	52.58	89.11	1.33	2.68	4.01
T ₅	133.22	161.54	173.65	9.45	16.95	23.58	35.69	55.64	92.68	1.37	2.88	4.15
T ₆	136.59	163.28	179.84	9.95	17.31	24.43	38.61	59.74	96.65	1.39	2.91	4.65
T ₇	119.32	135.62	155.54	6.12	10.85	16.21	27.21	35.15	75.84	1.25	2.05	3.70
T ₈	120.12	138.48	158.51	6.58	11.11	16.95	28.11	36.28	76.95	1.29	2.11	3.72
T ₉	120.45	139.28	159.32	6.98	11.21	17.01	28.75	36.88	77.58	1.31	2.16	3.73
T ₁₀	105.45	121.54	141.28	4.11	8.25	11.24	16.58	15.54	20.15	1.21	1.95	3.22
T ₁₁	106.65	123.65	143.51	4.25	8.95	11.44	17.18	16.11	21.57	1.22	1.97	3.29
T ₁₂	107.21	123.69	144.11	4.34	9.21	11.85	17.35	16.19	22.84	1.24	1.99	3.38
SEm+	3.33	3.67	3.65	0.17	0.23	0.29	0.92	1.05	1.12	0.02	0.05	0.09
CD (P=0.05)	9.76	10.75	10.70	0.49	0.68	0.85	2.70	3.07	3.29	0.06	0.14	0.25

Micronutrients viz., Zn, Cu, Fe, and Mn were extracted with 0.005 M DTPA in aliquot of compost were estimated on Atomic Absorption Spectrophotometer by the method given by (Lindsay and Norvell, (1978). Humic fractions were determined by alkali extraction and separation in to humic fraction given by (Anderson *et al.* (1974)

Results and Discussion

The iron content of vermicompost under various treatment of organic waste was present in increasing trend from 10 to 30 days. The highest total iron content was found under treatment vegetable waste : cow dung (8:6) and that was 136.69, 163.28 and 179.84 ppm for 10, 20 and 30 days, respectively, where, as treatment vegetable waste : cow dung (8:5) was found at par. It was probably due to increased activity of micro-organisms related to nutrient mineralization or ageing of casts enhanced the mineralization process. Similar results were also found by Chowdappa *et al.* (1999) stated that major nutrients N, P, K and micro- nutrients Fe, Mn, Cu, and Zn contents were slightly higher in all vermicompost samples than in normal composts.

The highest total zinc content was found under treatment vegetable waste : cow dung (8:6) that was 9.95,

17.31 and 24.43 ppm for 10, 20 and 30 days, respectively, and lowest zinc content was found under treatment litter fall : cow dung (8:4) was 4.11, 11.21 and 17.21 ppm for 10, 20 and 30 days, respectively. The treatment vegetable waste : cow dung (8:5) remained at par with treatment vegetable waste : cow dung (8:6) for 10,20 and 30 days of vermicomposting. Similar results were also reported by Sannigrahi (2005) reported that increase in earthworm population in compost bed decreased the period of vermicomposting and also increased the total micronutrient content.

The Mn content in vermicompost at various observational periods ranged from 16.58 to 38.61 ppm, 15.54 to 59.34 ppm and 20.16 ppm to 96.55 ppm at 10, 20 and 30 days, respectively. The highest total manganese content was found under treatment vegetable waste : cow dung (8:6) that was 38.61, 59.74 and 96.55 ppm for 10, 20 and 30 days, respectively, where, as treatment vegetable waste : cow dung (8:5) at par with treatment vegetable waste : cow dung (8:6). Nattudurai *et al.* (2014) concluded that during composting micronutrient contents were estimated in vermicompost as well as in control compost. micronutrient values were highly increased in vermicompost. Application of various kind of substrate had positive effect on copper content of vermicompost. The data presented in table 5 show that the copper

Table-3 : Periodical changes in total fulvic acid (per cent) during vermicomposting.

Treatments	Fulvic acid (per cent)			Humic acid (per cent)			Humin (per cent)		
	Period of sampling (Days)			Period of sampling (Days)			Period of sampling (Days)		
	10	20	30	10	20	30	10	20	30
T ₁	19.10	18.97	18.62	44.00	24.31	24.71	24.31	24.71	24.92
T ₂	19.19	19.11	18.71	47.00	24.75	24.88	24.75	24.88	25.05
T ₃	19.33	19.15	18.75	51.00	25.10	24.91	25.10	24.91	25.11
T ₄	20.95	20.25	19.97	63.00	27.61	27.91	27.61	27.91	28.01
T ₅	21.30	20.75	20.15	69.00	28.11	28.68	28.11	28.68	28.75
T ₆	21.55	20.81	20.29	71.00	28.35	29.01	28.35	29.01	29.12
T ₇	18.55	18.39	18.33	37.00	24.11	24.45	24.11	24.45	24.51
T ₈	18.73	18.42	18.39	39.00	24.31	24.59	24.31	24.59	24.59
T ₉	18.75	18.49	18.41	41.00	24.59	24.61	24.59	24.61	24.66
T ₁₀	18.48	18.31	18.23	29.00	23.89	24.05	23.89	24.05	24.15
T ₁₁	18.51	18.37	18.28	31.00	24.01	24.21	24.01	24.21	24.19
T ₁₂	18.52	18.39	18.30	33.00	24.08	24.29	24.08	24.29	24.21
SEm+	0.34	0.47	0.48	1.72	0.23	0.36	0.23	0.36	0.37
CD (P=0.05)	1.00	1.38	1.41	5.04	0.68	1.07	0.68	1.07	1.09

content of vermicompost under various treatment of organic waste was in increasing trend from 10 to 30 days. The highest total copper content was found under treatment (T₆) vegetable waste : cow dung (8:6) that was 1.39, 2.91 and 4.65 ppm for 10, 20 and 30 days, respectively which was at par with treatment vegetable waste : cow dung (8:5). It was due to increased activity of micro-organisms related to nutrient mineralization or ageing of casts enhanced the mineralization process. Similar results were also found by Chowdappa *et al.* (1999) stated that major nutrients N,P,K and micro-nutrients Fe, Mn, Cu, and Zn contents were slightly higher in all vermicompost samples than in normal composts.

The data persented in Table-3 showed that the fulvic acid content of vermicompost under various treatment of organic waste was in decreasing trend from 10 to 30 days. The use of vegetable waste : cow dung (8:6) as substrate for making vermicompost resulted in significant increase in fulvic acid content of vermicompost. The value of fulvic acid was 21.55, 20.81 and 20.29 per cent under treatment vegetable waste : cow dung (8:6) was observed significantly higher over rest of treatments. Similarly, Krishna Murthy *et al.* (2010) reported that low fulvic acid and high humic acid percentage were the indications that the compost has reached an advanced stage of maturity and also observed that the compost quality increased with increasing humic acid percentage.

The highest humic acid content was found under treatment vegetable waste : cow dung (8:6) that was 29.11 ,29.29 and 29.97 per cent for 10, 20 and 30 days respectively where as the treatment vegetable waste : cow dung (8:5) was remained statically at par with this treatment while treatment litter fall : cow dung (8:4) has minimum humic acid content. Similarly, Krishna Murthy *et*

al. (2010) reported that low fulvic acid and high humic acid percentage were the indications that the compost has reached an advanced stage of maturity and also observed that the compost quality increased with increasing humic acid percentage.

The data (Table 3) indicated that humin content of vermicompost under various treatment of organic waste was in increasing trend from 10 to 30 days. The highest humin content was found under treatment vegetable waste : cow dung (8:6) that was 28.35, 29.01 and 29.12 per cent for 10, 20 and 30 days respectively where as the treatment vegetable waste : cow dung (8:5) was remained statically at par with this treatment and lowest humin content was found under treatment litter fall : cow dung (8:4). Similar results were observed by Shirisha (2002) and Xiaowei *et al.* (2010) and observed that increasing levels of humin represent high degree of humification and also stated that humification was found to be dependent on biochemical characteristics and composition of raw material

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Character Association and Path Analysis Study in Single Cut Oat (*Avena sativa* L.)

Ravi Kumar Nechu^{1*}, S.K. Bilaiya¹, Parul Singhal¹ and Manmohan Singh²

¹Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, M.P.-482 004

²Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan-313001

*Corresponding Author Email : ravinechu@jnkvv.org

Abstract

Thirty three genotypes of single cut forage oat (*Avena sativa* L.) green fodder yield and its contributing traits in single cut oat were evaluated to measure the Correlation and Path coefficient analysis during *Rabi* season 2020-2021 under AICRP on Forage Crops, Seed Breeding Farm, JNKVV, Jabalpur. Correlation and path analysis studies suggested that GFY/plant/day and CPY/plant had high direct effect and significant positive correlation, indicating true relationship among them. Hence, selection for these traits will be effective. Correlation coefficient of number of leaves/plant is high but direct effect is negligible hence, indirect selection of characters will be rewarding likewise for leaf stem ratio indirect selection will be rewarding.

Key words : Oat, green fodder yield, correlation and path coefficient analysis.

Introduction

Crop production and animal husbandry go hand in hand and complementary to each other. The growth of livestock sector is about 1.5 times higher than that of crop sector which implies the fodder production is not sufficient to meet the requirements. The present availability of green fodder is 462 million tonnes and dry fodder is 394 million tonnes in the country. It shows a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients. To meet the deficit, green forage supply has to grow at 1.69% annually. (IGFRI, 2013; Kumar, 2018).

Oat is an important versatile *Rabi* cereal crop cultivated for fodder, grain, pasture and crop rotation which is better adapted to cold, moist climate, acidic soil and requires less amount of water as compare to other cereal crop (Murphy and Hoffman, 1992). Because of its high protein content, fat, minerals, dry matter digestibility, palatability and antioxidant property, it is used both for animal feed and human feed (Peterson *et al.*, 2005). It is a self pollinated winter cereal crop native of Mediterranean region and rank sixth in world cereal production. Oat provides huge green fodder at the time when other succulent fodder is scarce (Rajhathy and Thomas, 1974; Kumari *et al.*, 2019; Rana *et al.*, 2019).

The main objective of any crop improvement programme is to enhance yield. Plant breeder always tries to develop new cultivar which is high yielding, better quality and resistant to different abiotic and biotic stresses. For this plant breeder select the desirable genotypes from the available genepool and used them in different breeding methods. As yield is a complex trait and

is the combined result of a number of component traits. Therefore, selection of superior genotypes based on yield alone is not so effective. In order to make it effective one has to focus on the component traits, which contribute to yield in positive directions.

Information on genetic association among components of economic worth is very important in improving the efficiency of selection programme. For this studies on the correlation of traits and their relative direct and indirect effects are important for formulating selection indices. Path coefficient analysis is simply a standardized partial regression coefficient which split the correlation coefficient into the measures of direct and indirect effects. Analysis of path coefficient is based on all simple correlation aiming various characters. It estimates the direct and indirect contribution of various independent characters on a dependent character. It also estimates residual effects. Path analysis helps in determining the yield contributing characters and thus helpful in indirect selection. In the present study 33 lines were analysed for 15 different quantitative characters to judge the variability pattern, association of different characters in term of contribution to yield, classify promising genotypes and identify putative lines for forage yield. These lines were statistically analysed in RCBD and biometrical techniques applied are discussed under the following heads.

Materials and Methods

The experiment was carried out during *Rabi* season 2020-2021 under, All India Coordinated Research Project on Forage Crops, Department of Genetics & Plant Breeding at Seed Breeding Farm, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) at 23°21' North latitude, 79°94' East longitude and

at an altitude of 411.78 meters from the mean sea level. This area as per NBSSLUP (National Bureau of Soil Science and Land Use Planning) of ICAR (Indian Council of Agricultural Research) comes under 10.1 “sub-humid dry eco- sub region” of agro-ecological zone. The crop was grown under normal crop season.

The experimental material consisted of 33 genotypes of single cut (SC) fodder oat. viz. BAUO-103, JHO-20-1, NDO-1902, SKO-244, OL-1980, JO-08-37, OL-1977, HFO-1009, HFO-1003, HFO-1013, BAUO-101, UPO-20-1, OL-1974, OL-1971, HFO-1018, RO-11-4, OL-1874-1, OL-1876-1, RO-11-1-3, JO-06-23, SKO-241, RO-11-1-2, HFO-806, JO-08-41, JO-09-48, OL-1876-9, HFO-904, HFO-906, OL-1960, JO-07-28, SKO-94, JO 1 Check (Zonal) and KENT Check (National).

All genotypes were evaluated in a randomized complete block design (RCBD) with three replications. Each treatment was sown in 3.0 m row length spaced at 25 cm. Observations were recorded from the 5 randomly selected plants, which were true representative of the plot, from each replication of each treatment at 50 per cent flowering.

The observations recorded for fifteen traits viz. Days to maturity, number of tillers/plant, plant height (cm), stem diameter (mm), internodal length (cm), number of leaves/plant, penultimate leaf area (cm²), leaf area index (LAI), leaf stem ratio, green fodder yield (GFY)/plant/day (g), dry matter yield (DMY)/plant (g), DMY/Plant/day (g), crude protein yield (CPY)/Plant (g), CPY/plant/day (g) and GFY/plant (g) were subjected to various statistical and biometrical analyses viz., correlation coefficient analysis (Miller *et al.*, 1958) and path coefficient analysis (Wright, 1921, Dewey and Lu, 1959).

Results and Discussion

Correlation between green fodder yield and its component traits : Correlation studies are important in plant breeding as they show the degree of association between two variables which further used in effective selection of genotype in crop improvement. The interpretation related to correlation has been presented in Table-1.

Correlation coefficients were calculated at genotypic, phenotypic and environmental level to know the effect of environment on expression of a character. However, environmental correlation would not be of much use to the breeder but it give an idea about the extent to which character are influenced by environment irrespective of their genetic control. Phenotypic correlation higher than genotypic correlation coefficient indicates influence of environment on genotypic

expression of a character and vice-versa indicates that there is a strong inherent association among traits. In the present investigations, genotypic correlation coefficients were higher than phenotypic correlation coefficients for most of associated traits which indicates that there is a strong inherent association among traits.

Yield is a complex trait and it is affected by many component traits, hence enhancement in yield is possible by simultaneous improvement in its associated traits. In forage oat, green fodder yield is an important trait hence, in present study GFY/plant was taken as dependent trait and rest of all as independent traits and phenotypic correlation coefficients were studied for all the possible pairs of trait discussed below:

Green fodder yield/plant exhibited highly significant positive correlation with GFY/plant/day, LAI, DMY/plant/day, CPY/plant/day, DMY/plant, number of leaves/plant, CPY/plant, number of tillers/plant, stem diameter, leaf stem ratio and plant height, whereas significant positive correlation with penultimate leaf area. These findings suggest that the simultaneous selection for these traits is possible for improvement of forage yield in oat genotypes.

These results are in accordance with previous researchers Krishna *et al.* (2014) for almost all the traits; Dubey *et al.* (2015) for DMY/plant, number of leaves/plant, and number of tillers/plant; Wagh *et al.* (2018) for CPY/plant, penultimate leaf area, number of tillers/plant, plant height, stem diameter and number of leaves/plant; Sahu and Tiwari (2020) for almost all the traits while these results are in opposite with Krishna *et al.* (2014) for number of leaves/plant and stem diameter; Sahu and Tiwari (2020) for plant height.

Other characters that showed positive correlation were viz., days to maturity had highly significant positive correlation with CPY/plant, DMY/plant, LAI, number of leaves/plant, CPY/plant/day, internodal length and plant height whereas significant positive correlation with leaf stem ratio. Number of tillers/plant exhibited positive and highly significant correlation with number of leaves/plant, GFY/plant, GFY/plant/day, LAI, CPY/plant/day, DMY/plant/day, CPY/plant, DMY/plant and leaf stem ratio whereas significant positive correlation with stem diameter and showed negative and significant correlation with internodal length. Plant height showed highly significant positive correlation with stem diameter, DMY/plant, internodal length, penultimate leaf area, DMY/plant/day, LAI, CPY/plant, CPY/plant/day, GFY/plant and GFY/plant/day whereas significant positive correlation with number of leaves/plant. Stem diameter exhibited highly significant and positive correlation with GFY/plant, GFY/plant/day, LAI, number of

Table-1 : Correlation coefficient analysis for forage yield and its attributing traits.

Characters	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X2	0.074													
X3	0.302**	-0.031												
X4	0.090	0.215*	0.492**											
X5	0.333**	-0.216*	0.420**	0.106										
X6	0.349**	0.846**	0.235*	0.418**	-0.024									
X7	0.114	-0.034	0.412**	0.362**	0.198*	0.068								
X8	0.376**	0.743**	0.409**	0.546**	0.067	0.916**	0.348**							
X9	0.221*	0.460**	0.095	-0.021	0.036	0.420**	0.045	0.411**						
X10	-0.009	0.778**	0.295**	0.566**	-0.201*	0.777**	0.200*	0.807**	0.389**					
X11	0.438**	0.651**	0.429**	0.382**	-0.076	0.743**	0.234*	0.803**	0.456**	0.757**				
X12	0.339**	0.676**	0.412**	0.393**	-0.116	0.740**	0.239*	0.801**	0.450**	0.799**	0.994**			
X13	0.464**	0.666**	0.384**	0.327**	-0.086	0.748**	0.203*	0.788**	0.502**	0.736**	0.985**	0.975**		
X14	0.345**	0.698**	0.359**	0.336**	-0.136	0.745**	0.205*	0.784**	0.498**	0.786**	0.977**	0.982**	0.991**	
X15	0.135	0.786**	0.343**	0.570**	-0.156	0.821**	0.205*	0.853**	0.427**	0.988**	0.823**	0.850**	0.805**	0.837**

Note: X1- Days to maturity, X2-Number of tillers/plant, X3-Plant height, X4-Stem diameter, X5-Internodal length, X6-Number of leaves/plant, X7- Penultimate leaf area, X8- LAI, X9- Leaf-stem ratio, X10-GFY/plant/day, X11-DMY/plant, X12-DMY/plant/day, X13-CPY/plant, X14-CPY/plant/day, X15-GFY/plant.

Note : *indicates significance of correlation at 5% LOS (Level of Significance) while ** indicates significance at 1% LOS

Table-2 : Path analysis for forage yield and its contributing traits.

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14
X1	0.0386	0.004	0.0142	0.004	0.0159	0.0172	0.0058	0.0188	0.0107	-0.0001	0.0198	0.0155	0.021	0.0162
X2	-0.006	-0.053	-0.001	-0.016	0.0153	-0.046	0.0102	-0.041	-0.03	-0.046	-0.04	-0.042	-0.04	-0.042
X3	-0.007	-0.0005	-0.02	-0.011	-0.006	-0.006	-0.014	-0.011	-0.007	-0.007	-0.01	-0.01	-0.01	-0.009
X4	0.0025	0.0072	0.0141	0.0245	0.0013	0.0119	0.0147	0.0166	-0.0008	0.0159	0.0114	0.0117	0.01	0.0104
X5	0.0109	-0.008	0.0084	0.0014	0.0263	-0.003	0.011	0.0004	0.0041	-0.01	-0.004	-0.006	-0.004	-0.006
X6	0.0446	0.0876	0.03	0.0487	-0.011	0.1001	-0.005	0.0924	0.0537	0.0834	0.0873	0.087	0.0865	0.0863
X7	0.002	-0.003	0.0091	0.0078	0.0055	-0.0007	0.0131	0.0045	-0.001	0.0024	0.0032	0.0032	0.0024	0.0024
X8	-0.059	-0.093	-0.064	-0.082	-0.002	-0.111	-0.041	-0.121	-0.069	-0.103	-0.112	-0.111	-0.109	-0.109
X9	0.0056	0.0115	0.0074	-0.0007	0.0032	0.0109	-0.002	0.0116	0.0203	0.0087	0.0121	0.012	0.0129	0.013
X10	-0.002	0.8698	0.3724	0.6512	-0.361	0.8363	0.1843	0.8608	0.4295	1.0036	0.7586	0.8122	0.7309	0.7954
X11	-0.122	-0.179	-0.121	-0.111	0.0331	-0.208	-0.059	-0.221	-0.142	-0.18	-0.239	-0.237	-0.236	-0.234
X12	0.0595	0.1167	0.0713	0.0706	-0.031	0.1287	0.0363	0.1366	0.0877	0.1199	0.147	0.1482	0.1447	0.1463
X13	0.5312	0.7284	0.463	0.3975	-0.139	0.8409	0.1796	0.8834	0.6182	0.7093	0.9642	0.9514	0.9739	0.9635
X14	-0.324	-0.614	-0.346	-0.329	0.1737	-0.667	-0.14	-0.698	-0.493	-0.613	-0.76	-0.764	-0.765	-0.774
X15	0.1747	0.8767	0.437	0.6565	-0.275	0.9045	0.1943	0.9335	0.4815	0.9838	0.84	0.8728	0.8189	0.8599

R SQUARE = 0.9997 RESIDUAL EFFECT = 0.0170

Note: X1- Days to maturity, X2- Number of tillers/plant, X3- Plant height, X4- Stem diameter, X5- Internodal length, X6- Number of leaves/plant, X7- Penultimate leaf area, X8- LAI, X9- Leaf-stem ratio, X10- GFY/plant/day, X11- DMY/plant/day, X12- DMY/plant/day, X13- CPY/plant, X14- CPY/plant/day, X15- GFY/plant.

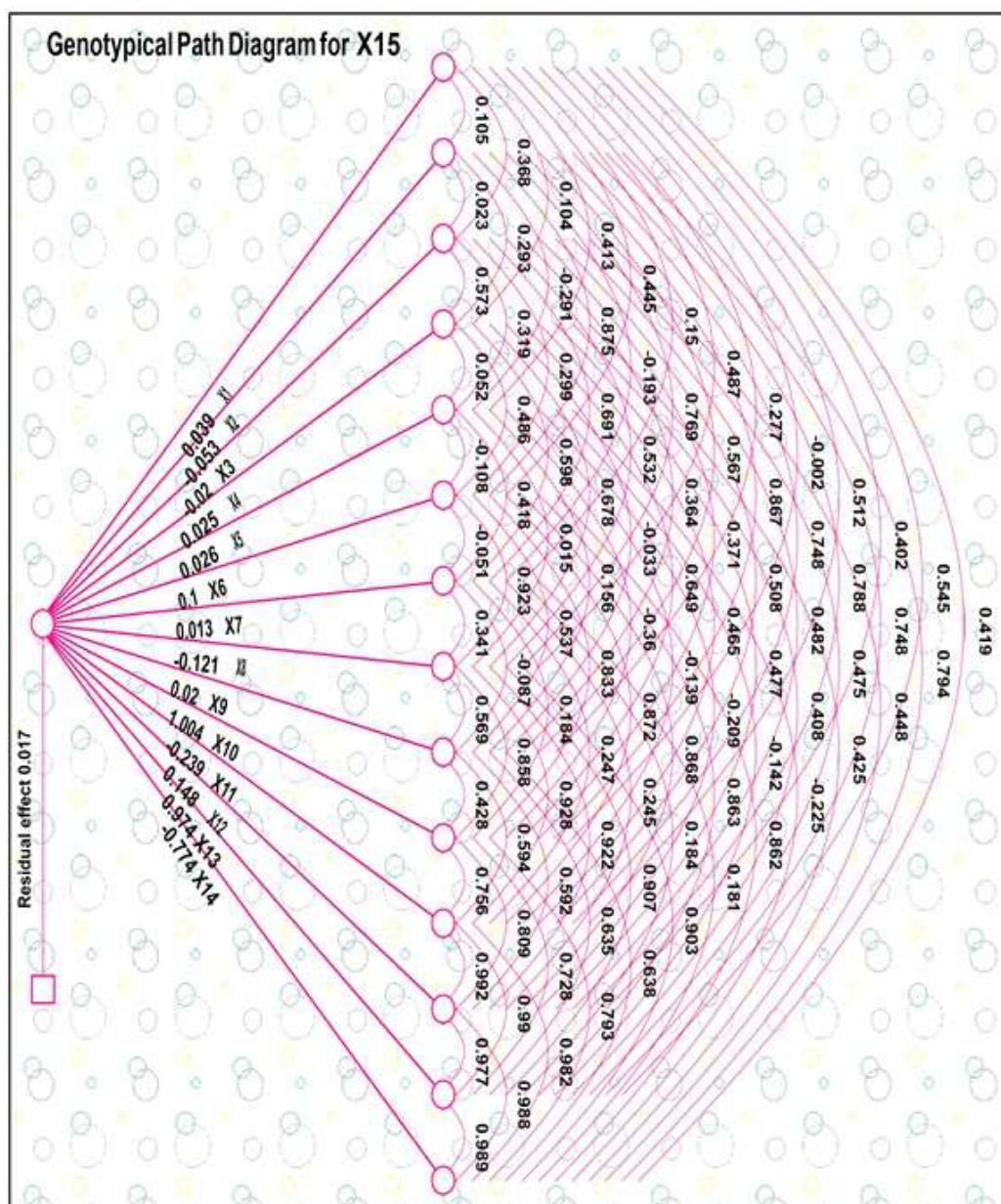


Fig-1 : Genotypic path diagram for green fodder yield.

Note : X1- Days to maturity, X2- Number of tillers/plant, X3- Plant height, X4- Stem diameter, X5- Internodal length, X6- Number of leaves/plant, X7- Penultimate leaf area, X8- LAI, X9- Leaf-stem ratio, X10- GFY/plant/day, X11- DMY/plant, X12- DMY/plant/day, X13- CPY/plant, X14- CPY/plant/day, X15- GFY/plant.

leaves/plant, DMY/plant/day, DMY/plant, penultimate leaf area, CPY/plant/day and CPY/plant. Internodal length was significantly and positively correlated with penultimate leaf area whereas significantly negatively correlated with GFY/plant/day. Number of leaves/plant showed positive and highly significant correlation with LAI, GFY/plant, GFY/plant/day, CPY/plant, CPY/plant/day, DMY/plant, DMY/plant/day and leaf stem ratio. Penultimate leaf area exhibited highly significant and positive correlation with LAI whereas significant positive correlation with DMY/plant/day, DMY/plant, CPY/plant/day, GFY/plant, CPY/plant and GFY/plant/day. Leaf area index showed highly significant positive

correlation with GFY/plant, GFY/plant/day, DMY/plant, DMY/plant/day, CPY/plant, CPY/plant/day and leaf stem ratio. Leaf Stem ratio showed highly significant positive correlation with CPY/plant, CPY/plant/day, DMY/plant, DMY/plant/day, GFY/plant and GFY/plant/day. GFY/plant/day exhibited highly significant positive correlation with GFY/plant, DMY/plant/day, CPY/plant/day, DMY/plant and CPY/plant. DMY/plant showed positive and highly significant correlation with DMY/plant/day, CPY/plant, CPY/plant/day and GFY/plant. DMY/plant/day exhibited highly significant and positive correlation with CPY/plant/day, CPY/plant and GFY/plant. CPY/plant exhibited highly significant and positive correlation with

CPY/plant/day and GFY/plant. CPY/plant/day showed positive and highly significant correlation with GFY/plant. Related results for one or more characters were presented by previous researchers, Ahmed *et al.*(2013); Krishna *et al.*(2014); Poonia *et al.*(2017); Ceri and Acer (2020) and Sahu and Tiwari (2020).

Path coefficient analysis : Path analysis was carried out using GFY/plant as a dependent variable and rest of traits as independent variable. The results of this analysis have been presented in Table 2 and also the path diagram has been shown as Fig.-1 to directly visualize the direct and indirect effects of various traits under study.

Path coefficient analysis was done by using green fodder yield as a dependent character and rest of all as independent. Simple correlation gives an idea about association (positive or negative) between two or more characters but it does not give causal basis of such associations in better ways. It is the path analysis that splits the total correlation coefficients into direct and indirect effects of various independent characters on a dependent character thus specifying the relative contribution of each character.

In the present study, genotypic path coefficient analysis was carried out using GFY/plant as a dependent variable. Results revealed that very positive direct effect on GFY/plant was exerted GFY/plant/day, CPY/plant, DMY/plant/day, number of leaves/plant, days to maturity, internodal length, leaf stem ratio and penultimate leaf area. In contrast, negative direct effect was shown by CPY/plant/day, DMY/plant, LAI, number of tillers/plant and plant height.

Positive direct effect recorded in the study for the characters on GFY are in confirmation with the Krishna *et al.*(2014) for leaf stem ratio; Dubey *et al.*(2015) for number of leaves/plant, CPY/plant, days to maturity and DMY/plant/day; whereas in opposite with Krishna *et al.*(2014) for DMY/plant; Dubey *et al.*(2015) for CPY/plant/day, plant height leaf stem ratio and days to maturity and Ahmed *et al.*(2013) for number of leaves/plant and plant height. Negative direct effect recorded in the study for the characters on GFY are in confirmation with Dubey *et al.*(2015) for number of tillers/plant.

Indirect effects of different characters viz., number of tillers/plant, plant height, stem diameter, number of leaves/plant, LAI, leaf stem ratio, DMY/plant, DMY/plant/day, CPY/plant and CPY/plant/day had high positive indirect effects via GFY/plant/day and days to maturity, number of tillers/plant, plant height, stem diameter, number of leaves/plant, LAI, leaf stem ratio, GFY/plant/day, DMY/plant, DMY/plant/day and

CPY/plant/day had high positive indirect effects via CPY/plant. Internodal length had high negative indirect effect via GFY/plant/day and days to maturity, number of tillers/plant, plant height, stem diameter, number of leaves/plant, LAI, leaf stem ratio, GFY/plant/day, DMY/plant, DMY/plant/day and CPY/plant had high negative indirect effect via CPY/plant/day. Related results for one or more characters presented by previous researchers were, Krishna *et al.*(2014), Gupta and Mehta (2019) and Sahu and Tiwari (2020).

If the correlation between yield and character is due to direct effects of character, it reflects true relationship between them, and simple direct selection will be effective for such a character in order to increase yield, however if correlation is due to indirect effect of character through another component trait, the plant breeder has to select for the later trait through which indirect effect is exerted.

1. GFY/plant/day (1.0036) and CPY/plant (0.9739) had high direct effect and significant positive correlation indicating true relationship among them. Hence, selection for these traits will be effective.

2. Correlation coefficient of number of leaves/plant is high (0.821) but direct effect is negligible (0.1001) hence, indirect selection of characters will be rewarding likewise for leaf stem ratio indirect selection will be rewarding.

Conclusions

Results of correlation and path analysis showed that the characters like GFY/plant/day/, DMY/plant/day, CPY/plant, leaf stem ratio, number of leaves/plant and penultimate leaf area had highly significant positive association and direct effect on GFY/plant. Hence selection based on these traits shall be rewarding and may be used to formulate modal plant.

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A Comprehensive Study on Genetic Divergence for Yield and Quality Traits of Released and pre Released Wheat Genotypes

Parul Singhal, Ravi Kumar Nechu, R.S. Shukla and Suneeta Pandey

Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, M.P., 482004

*Corresponding Author Email : parulsinghal230@gmail.com

Abstract

The present research work comprises of thirty genotypes of wheat, collected from All India Coordinated Research Project on wheat and Barley at Seed Breeding Farm, Department of Plant Breeding and Genetics, JNKVV, Jabalpur. These genotypes were grown in Randomized Complete Block Design with 2 replications during the Rabi season of 2020-21. All genotypes exhibited significant amount of genetic diversity. Genetic divergence among wheat (*Triticum aestivum*) genotypes was evaluated using Mahalanobis D² analysis. Based on nineteen yield attributing traits, genotypes were grouped into 4 distinct clusters. Out of 4 clusters, cluster I being the largest comprises of 20 genotypes and most diversified one followed by cluster III contained 5 genotypes, cluster IV comprised of 4 genotypes and cluster II was monogenotypic. Genotypes grouped in same cluster are less divergent than placed in different cluster. Maximum relative contribution to the total divergence shown by Fe content followed by Mn content, sedimentation value and ear length while number of ears/plant and days to maturity contributed to minimum. The most distant clusters were cluster IV and III (2673.5) and more proximate were cluster I and II (1508.9).

Key words : Genetic divergence, mahalanobis D² analysis, monogenotypic, wheat.

Introduction

Wheat is a major staple food crop in India as well as in the world in terms of both production and consumption has an important role to play in achieving the food security. Therefore, enhancing grain yield and improving resistance to biotic and abiotic stresses, nowadays end use quality has also become one of the major target of various wheat breeding programmes around the world. More than 30 subspecies of wheat are known and out of which only three are cultivated in the world.

In India, wheat ranks second after paddy both in area and production, occupying 31.76 Mha acreage area (14% of global area) with production of 109.52 Mt (13.64% of world production) and average national productivity of 3440Kg/ha. Madhya Pradesh is the third largest producer of wheat, accounting for 16% of production and 21% of the area under cultivation. In Madhya Pradesh, it is grown in an area of 6.69 Mha with production of 17.58Mt and 2627kg/ha productivity (Anon., 2020-21). It grows best when temperatures are warm, (21° to 24°C), but not too hot. Wheat grows in many types of soil, but it grows well in well-drained loam or clay-loam soils (Britannica, 2021).

Genetic diversity (D² statistics) developed by Mahalanobis (1928) measures the magnitude of divergence between biological population and the relative contribution of each component character to the total divergence (Devesh *et al.*, 2019). Statistical distance

(Mahalanobis D²) between pair of genotypes were obtained as the sum of squares of the difference between the pairs of corresponding uncorrelated value of any two genotypes considered at a time. The results on genetic divergence in the population consists of eighty recombinant inbred lines of wheat, which were assessed using Mahalanobis D² Statistics. The objective of the present study is to estimate the extent of genetic divergence and to identify the putative genotypes for yield and quality traits by using cluster analysis as potential genetic diversity is pre requisite for any breeding programme.

Materials and Methods

Thirty released and pre released wheat genotypes depicted in (Table-1) were collected from All India Coordinated Research Project on wheat and Barley at Seed Breeding Farm, Department of Plant Breeding and Genetics, JNKVV, Jabalpur, evaluated under Randomized Complete Block Design with 2 replications during the Rabi season of 2020-21.

Each plot consists of 6 rows of 6 m length and row to row distance was 20 cm. The experimental area was suitable for good growing and for research purposes also. Jabalpur is situated at 23.18° N latitude and 79.97° E longitude in the agro-climatic zone of Kymore Plateau and Satpura Hills and lies in rice-wheat crop zone of the state. The maximum and minimum temperature in the month of November was 28.7 and 16°C respectively.

Table-1 : List of experimental material.

S. No.	Name of genotypes	S. No.	Name of genotypes	S. No.	Name of genotypes
1.	JW3336	11.	MP1142	21.	MP3545
2.	JW3288	12.	MP1215	22.	MP3382
3.	JW3211	13.	MP1255	23.	JW3465
4.	JW3020	14.	MP1203	24.	WB02
5.	JW3173	15.	C306	25.	Black wheat
6.	JW3469	16.	Sujata	26.	MP3512
7.	JW3523	17.	MP3544	27.	MP3493
8.	JW3527	18.	MP3541	28.	MP3521
9.	JW3535	19.	MP3542	29.	MP4010
10.	JW1201	20.	MP3552	30.	MP3516

Table-2 : Distribution of genotypes in different clusters.

Cluster no.	Number of Genotype	Name of genotypes
I	20	MP3541, MP3542, MP3544, MP3535, MP3545, JW3336, JW3288, JW3211, JW3020, JW3469, JW1201, MP1142, MP1203, C306, SUJATA, MP3382, JW3465, WB02, Black Wheat, MP3512
II	1	MP1215
III	5	MP1255, MP4010, MP3552, MP3516, JW3523
IV	4	JW3527, JW3173, MP3493, MP3521

Observation recorded : Observations were recorded on five randomly selected plants from each plot and from each replication for nineteen traits viz., days to ear emergence, days to maturity, plant height (cm), number of tillers/plant, number of ear/plant, number of spikelets/ear, ear length (cm), ear weight (g), thousand grain weight (g), biological yield/plant (g), harvest index (%) and grain yield/plant (g) protein content (%), starch content (%), sedimentation value (ml), Fe (mg/kg), Cu (mg/kg), Zn (mg/kg) and Mn (mg/kg).

The protein content for each genotype were measured by using micro-Kjeldhal digestion and distillation methods as given by (AOAC, 1980). Starch content were measured with the help of Anthrone reagent (Clegg, 1956). Sedimentation value measures the quality of protein and based on the fact that volume of sediment, formed when flour is suspended in water and treated with lactic acid, consisting of swollen gluten and occluded starch is the sedimentation value and micronutrients were analyzed by Atomic Absorption Spectro-photometer, GBC 902 plus.

Data analysis : The data collected were subjected to multivariate analysis utilizing Mahalanobis D² statistic as suggested by Mahalanobis (1936) and Rao (1952) using MS DOS software.

Results and Discussion

The presence of genetic divergence among the thirty genotypes was evaluated by employing Mahalanobis's D² statistics. The clustering pattern of these genotypes on

the basis of D² analysis has been presented in (Table-2). Total accessions were grouped into five distinct clusters. Cluster I was the largest cluster consisting of 20 genotypes followed by cluster III consisting of five genotypes followed by cluster IV had four genotypes and cluster II had one genotype. It revealed that genotypes placed in a different cluster are more divergent hence selection of such genotypes would be beneficial for starting a judicious breeding programme.

Intra-cluster distance ranged from 0.00 to 2077.47. Maximum Intra-cluster distance was observed for Cluster I (2077.4743), followed by cluster III (560.44), cluster IV (440.64), while lowest was of cluster II (0.00).

The inter cluster distance ranged from 1508.9 to 2673.5. The highest inter cluster distance was observed between genotypes of cluster IV and cluster III (2673.5), followed by cluster IV and I (2555.6), cluster IV and II (2495.6), cluster III and II (2356.5), cluster III and I (2100.5) and lowest inter cluster distance was found between cluster I and II (1508.9).

The percent contribution of individual characters toward the total divergence presented in (Table-3) which showed that Fe content (56.51%) exhibited highest contribution towards total genetic divergence followed by Mn content (20.22%), sedimentation value (9.88%), ear length (9.10%), plant height (6.16%), thousand grain weight (5.14%), biological yield/plant (4.87%), protein content (4.87%), Zn content (2.98%), Cu content (2.52%) and ear weight (1.05%). Other traits viz., number of spikelets/ear, grain yield/plant, starch content, number of tillers/plant, harvest index, days to ear emergence,

Table-3 : Contribution (%) of individual traits towards divergence.

Source	Times ranked 1 st	Relative contribution %
Days to ear emergence	1	0.22%
Days to maturity	-	0.00%
Plant height (cm)	161	6.16%
Number of tillers/plant	11	0.31%
Number of ears/ plant	2	0.02%
Number of spikelets/ear	4	0.91%
Ear length (cm)	281	9.10%
Ear weight (g)	36	1.05%
Thousand grain weight (g)	196	5.14%
Biological yield/ plant (g)	4	4.87%
Harvest index (%)	775	0.23%
Grain yield/ plant(g)	2	0.45%
Protein content (%)	21	4.87%
Sedimentation value (ml)	43	9.88%
Starch content (%)	2	0.45%
Fe (mg/kg)	246	56.51%
Cu (mg/kg)	11	2.52%
Zn (mg/kg)	13	2.98%
Mn (mg/kg)	88	20.22%

number of ears/plant and days to maturity exhibited very low or negligible contribution towards divergence. Singh *et al.* (2005), Devesh *et al.* (2019), Majid *et al.* (2020) observed the formation of clusters representing the availability of wide genetic diversity in wheat genotypes studied.

Conclusions

From the present investigation it was concluded that Fe content (56.51%) exhibited highest contribution towards total genetic divergence followed by Mn content (20.22%) and maximum inter cluster distance was observed between of cluster IV and cluster III (2673.5), followed by cluster IV and I (2555.6).It suggests that the crossing

between genotypes of these clusters may lead to better recombinant and superior segregants for wheat improvement programmes.

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Combining Ability Analysis in Baby Corn (*Zea mays* L.)

Sandeep Kumar Bangarwa*, R.B. Dubey, Divya Chouhan and Heeralal Barupal

Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur-313001

*Corresponding Author Email : sandeepbangarwa123@gmail.com

Abstract

The present investigation consisted of a total of 45 hybrids along with 18 parents (15 inbred lines and 3 testers) and 2 checks. A total of 65 entries were evaluated in randomized block design with three replications over three locations (Two during *Kharif*-2019 and one during *Rabi* 2019-20) at Instructional farm, Rajasthan College of Agriculture, Udaipur, Rajasthan (*Kharif*-2019 and *Rabi* 2019-2020) and Agriculture Research Sub Station, Vallabh Nagar, Udaipur, Rajasthan (*Kharif*-2019). Observations were recorded on eighteen characters for combining ability. The inbred lines viz., EI-Q-103 (2.297), EI-Q-180 (1.534) and EI-1104-1 (1.510) were good general combiners for yield and its contributing characters in all the environments and on pooled analysis. Crosses EI-2177-2 × EI-670-2 (3.25), EI-1104-1 × EI-670-2 (3.41), EI-561-2 × EI-2518-4 (5.08), EI-561-2 × EI-2518-4 (2.15) expressed maximum and significantly (positive) desirable sca effects in E₁, E₂, E₃ and on over the environments, respectively for de-husked cob yield.

Key words : Baby corn, environments, GCA, randomized block design, SCA and yield.

Introduction

Maize (*Zea mays* L.) 2n=20, is the third most important cereal crop after rice and wheat in the world. By origin, maize is native to South America. Baby corn is a delicious, decorative and nutritious vegetable, without cholesterol. It is a low caloric vegetable which is rich in fibre content. One baby corn can be compared with an 'egg' in terms of minerals. Nutritive values of baby corn (per 100 g of edible portion) is Moisture 89.10 %, Carbohydrates 8.20 g, Protein 1.90 g, Calcium 28.00 mg, Phosphorus 86.00 mg, Iron 0.10 mg (1).

Worldwide, Thailand is the leading producer and exporter of baby corn. India is emerging as the potential producer of baby corn due to high demand with less cost of production. In India, baby corn is being cultivated in Meghalaya, Western Uttar Pradesh, Haryana, Maharashtra, Karnataka and Andhra Pradesh. Young cob corn has been used by the Chinese as vegetable for generations, and this practice has spread to other Asian countries. It has nutritive value similar to that of non-legume vegetables such as cauliflower, cabbage, tomato, cucumber. This vegetable has versatile use after cooking and for processing as a canned product. India is emerging as one of the potential baby corn producing country due to low cost of production and high demand within the country. There is a great potential to earn foreign exchange through export of fresh/canned baby corn and its processed products. Another important point is that baby corn is a safe edible vegetable as it is almost free from residual effects of pesticides as the young cob on

plant is wrapped with husk and well protected from insect attack and pathogens.

Baby corn has a short growing period (60-75 days), so that a farmer can grow four or more crops per year in a piece of land under tropical climatic conditions. It has a wide range of adaptation and does not need intensive practices for cultivation. The benefit of reaping with baby corn is that even after its harvest, the total herbage of maize plant can be utilized as green fodder. It generates more nutrition per unit area with the shortest crop duration and has the potential of being an excellent cash crop.

Materials and Methods

The present investigation consisted of a total of 45 hybrids along with 18 parents (15 inbred lines and 3 testers) and 2 checks. A total of 65 entries were evaluated in randomized block design with three replications over three locations (Two during *Kharif*-2019 and one during *Rabi* 2019-20) at Instructional farm, Rajasthan College of Agriculture, Udaipur, Rajasthan (*Kharif*-2019 and *Rabi* 2019-2020) and Agriculture Research Sub Station, Vallabh Nagar, Udaipur, Rajasthan (*Kharif*-2019). Observations were recorded on eighteen characters for combining ability. The experimental material comprised of 15 inbred lines viz., EI-2311-4, EI-2449-2, EI-2403, EI-Q-103, EI-Q-104, EI-1104-1, EI-561-2, EI-2173, EI-2177-2, EI-2509, EI-2518-2, EI-11-3, EI-Q-180, EI-Q-225, EI-Q-235 and 3 testers EI-670-2, EI-2518-4, EI-2156 their 45 F_{1s} and two checks viz., HM-4 and VL Baby Corn-2. These 45 F_{1s} were obtained by crossing 15 inbred lines and 3 testers in line × tester mating design. The combining ability effects for line

Table-1 : Analysis of variance for combining ability on over the environments.

Source of variation	d.f.	Mean squares						
		Days to first cob silking	Days to last cob silking	Days to first cob picking	Days to last cob picking	Days to first and last cob picking interval	Number of cobs per plant	Husked cob weight
Replications (r)	2	0.906	79.055	8.718*	10.476**	0.195	0.11	1.133
Environments (e)	2	12133.4**	21508.6**	13846.34**	27315.1**	2357.662**	5.763**	2662.071**
Rep. x Env.	4	9.939	23.75	4.088	1.83	1.143	0.01	4.796
Crosses	44	22.967**	29.382	14.521**	11.390**	14.859**	0.117**	71.290**
Line (l)	14	30.722	33.009	22.379	15.634	20.134	0.189*	134.611*
Tester (t)	2	12.458	1.819	2.539	26.859	38.866*	0.02	37.616
Line x tester	28	19.840**	29.541	11.449**	8.163**	10.507**	0.087**	47.035**
Environment x Crosses	88	17.98**	37.808*	15.125**	10.666**	13.173**	0.137**	43.711**
Environment x Line effects	28	21.163	57.070*	27.167**	19.554**	22.126**	0.244**	74.234**
Environment x tester effects	4	21.582	22.138	21.691	4.408	20.629	0.025	9.518
Environment x Line x tester effects	56	14.631**	29.296	8.635**	6.669**	8.164**	0.092**	30.891**
Error	264	7.849	27.741	2.386	2.092	2.821	0.026	4.908
Total	404	71.716	136.668	75.065	140.224	18.015	0.088	33.724

Table-1 : Contd....

Source of variation	d.f.	Mean squares						
		Baby corn cob girth	Husked cob yield per plant	De-husked cob yield per plant	De-husked to husked cob yield ratio per plant	Plant height	Moisture content	Crude protein content
Replications (r)	2	0.229	2.921	1.82	0	56.461	2.322	0.432
Environments (e)	2	63.322**	59280.7**	2137.058**	0.001**	18373.51**	95.958**	118.104**
Rep. x Env.	4	0.179	9.187	3.043	0	43.654	1.167	0.167
Crosses	44	0.494**	766.358**	22.093**	0	736.222**	10.102**	2.30**
Line (l)	14	0.686	1373.182**	43.456**	0	1892.390**	16.114*	5.530**
Tester (t)	2	0.889	561.505	10.739	0	41.873	1.852	0.638
Line x tester	28	0.370**	477.578**	12.222**	0	207.735**	7.685**	0.804**
Environment x Crosses	88	0.519**	649.470**	21.175**	0.00**	271.695**	8.282**	3.673**
Environment x Line effects	28	0.857**	941.536*	31.122*	0.00**	629.133**	10.205**	9.498**
Environment x tester effects	4	0.26	86.212	4.472	0	38.254	1.918	0.738
Environment x Line x tester effects	56	0.368**	543.669**	17.394**	0.000*	109.651**	3.755**	0.971**
Error	264	0.146	99.547	4.347	0	42.851	2.119	0.228
Total	404	0.579	583.558	20.477	0	259.035	4.787	1.788

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

x tester mating design was performed as per method suggested by (2) for individual environments as well as over the environments.

Results and Discussion

In the present investigations, Two lines (EI-1104-1 and EI-Q-180) in E_1 , Five lines (EI-2403, EI-Q-103, EI-Q-104, EI-Q-180 and EI-Q-235) in E_2 , four lines (EI-Q-103, EI-1104-1, EI-2173 and EI-11-3) in E_3 and three lines (EI-Q-103, EI-1104-1 and EI-Q-180) on over the environments, exhibited significantly positive gca effects for de-husked cob yield per plant. In E_1 , female line EI-Q-180 (1.88) showed significantly maximum positive desirable gca effects followed by EI-1104-1 (1.64). In E_2 , the female line EI-Q-104 (3.06) expressed maximum positive gca effects followed by EI-Q-235 (2.59) and EI-Q-103 (2.77). In E_3 , the female line EI-Q-103 (3.19) exhibited maximum positive GCA effects followed by EI-1104-1 (2.35) and EI-2173 (1.88). On pooled basis, the female line EI-Q-103 (2.29) indicated maximum positive gca effects followed by EI-Q-180 (1.53) and EI-1104-1 (1.51). None of the male parent in any environment was found with positive significant gca effects for de-husked cob yield per plant. However, male parent viz., EI-2518-4 and EI-2156 were found with desirable significant gca effects for days to last cob picking, days to first and last cob picking interval, husked cob weight and baby corn cob length. The female lines viz., EI-Q-103(2.297), EI-Q-180 (1.534) and EI-1104-1(1.510) were good general combiners for yield and its contributing characters in all the environments and in pooled analysis. Since the gca effects are attributed to the fixable components i.e. additive and additive $\times$ additive gene effects, the above mentioned parents can be used in hybridization programmes for the improvement of respective traits (3,4).

Estimates of sca effects revealed that no cross combination was good for all the characters on over all the environments under study, obviously due to the effect of environments on this parameter. One cross (EI-2177-2 $\times$ EI-670-2) in E_1 , six crosses (EI-2311-4 $\times$ EI-2518-4, EI-2403 $\times$ EI-2156, EI-1104-1 $\times$ EI-670-2, EI-2509 $\times$ EI-670-2, EI-2518-2 $\times$ EI-2518-4 and EI-11-3 $\times$ EI-670-2) in E_2 , five crosses (EI-2311-4 $\times$ EI-2156, EI-561-2 $\times$ EI-2518-4, EI-2173 $\times$ EI-670-2, EI-11-3 $\times$ EI-2156 and EI-Q-235 $\times$ EI-670-2) in E_3 and two crosses (EI-Q-103 $\times$ EI-2156 and EI-561-2 $\times$ EI-2518-4) on pooled analysis, showed significantly positive sca effects for de-husked cob yield per plant. Maximum significantly positive sca effects were depicted by cross EI-2177-2 $\times$ EI-670-2

(3.25) in E_1 . In E_2 , cross EI-1104-1 $\times$ EI-670-2 (3.41) expressed maximum significantly positive desirable sca effects for this trait followed by EI-11-3 $\times$ EI-670-2 (2.59) and EI-2509 $\times$ EI-670-2(2.49). In E_3 , cross EI-561-2 $\times$ EI-2518-4 (5.08) showed maximum significant positive sca effects for this trait followed by EI-2311-4 $\times$ EI-2156 (3.38) and EI-2173 $\times$ EI-670-2(2.81). On pooled basis, cross EI-561-2 $\times$ EI-2518-4 (2.15) indicated maximum significantly positive desirable sca effects followed by EI-Q-103 $\times$ EI-2156 (1.40). Estimates of sca effects revealed that these crosses showed desirable sca effects for other characters also (5,6,7,8).

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Characterization of Single Cut Oat (*Avena sativa* L.) Genotypes for Morphological Traits

Ravi Kumar Nechu^{1*}, S.K. Bilaiya¹, R. Shiv Ramakrishnan², Mrunal Ghogare², A.K. Mehta¹ and Manmohan Singh³

¹Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, M.P.-482004

²Department of Plant Physiology, College of Agriculture, JNKVV, Jabalpur, M.P. 482004

³Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan-313001

*Corresponding Author Email : ravinechu@jnkvv.org

Abstract

Thirty three diverse genotypes of single cut forage oat (*Avena sativa* L.) from different geographic regions were characterized on the basis of observations recorded for ten different qualitative characters viz., plant growth habit, lowest leaf hairiness, Number of tiller/plant, leaf blade hairiness, leaf colour, days to 50 % flowering, ligule shape, stem hairiness of uppermost node, internode length and plant height as per the guidelines for the conduct of test for Distinctiveness, Uniformity and Stability. On the basis of plant growth habit thirty (91%) lines were erect type and three (9%) were semi prostrate type while no one was found prostrate type; twelve (36%) lines did not have lowest leaf sheath hairiness, eleven (33%) lines classified as weak, seven (21%) lines as medium and three (9%) lines had strong lowest leaf sheath hairiness; two (6%) had high number of tillers, five (15%) medium while twenty six (79%) had low number of tillers; twenty eight (85%) lines lacked the leaf blade margin hairiness of pre-penultimate leaf, three (9%) lines grouped into medium and two (6%) lines had strong leaf blade margin hairiness of pre-penultimate leaf; six (18%) lines were classified into light green, twenty (61%) lines grouped into medium green and seven (21%) dark green colour leaf; four (12%) lines were grouped as early, twenty (64%) medium and eight (24%) late lines based on 50 % flowering stage; twenty eight (85%) lines were grouped as pointed type of ligule and five (15%) lines had grouped into broad edge type of ligule; twenty four (73%) lines did not have hairs on node, five (15%) lines were classified as weak, two (2%) lines as medium and two (2%) lines had strong stem hairs on uppermost node; all lines had high length of internode; six (18%) lines had tall plant height, twenty (61%) had medium height while seven (21%) lines were of short height. These parameters are required for the identification and selection of a genotype. The outcome of these traits tells us about the genetic architecture of the genotypes and their interaction within a specified environment for further improvement.

Key words : Oat, DUS, morphological character, Characterization.

Introduction

Crop production and animal husbandry go hand in hand and complementary to each other. The growth of livestock sector is about 1.5 times higher than that of crop sector which implies the fodder production is not sufficient to meet the requirements. The present availability of green fodder is 462 million tonnes and dry fodder is 394 million tonnes in the country. It shows a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients. To meet the deficit, green forage supply has to grow at 1.69% annually (IGFRI, 2013; Kumar, 2018).

Oat is an important versatile *Rabi* cereal crop cultivated for fodder, grain, pasture and crop rotation which is better adapted to cold, moist climate, acidic soil and requires less amount of water as compare to other cereal crop (Murphy and Hoffman, 1992). Because of its high protein content, fat, minerals, dry matter digestibility, palatability and antioxidant property, it is used both for animal feed and human feed (Peterson *et al.*, 2005). It is a

self pollinated winter cereal crop native of Mediterranean region and rank sixth in world cereal production. Oat provides huge green fodder at the time when other succulent fodder is scarce (Rajhathy and Thomas, 1974; Kumari *et al.*, 2019; Rana *et al.*, 2019).

The main objective of any crop improvement programme is to enhance yield. Plant breeder always tries to develop new cultivar which is high yielding, better quality and resistant to different abiotic and biotic stresses. For this plant breeder select the desirable genotypes from the available gene pool based on morphological, physiological and quantitative characteristics.

An agro-morphological character of plant helps in identifying a variety and also helps in desirable genotype selection. In the present study 33 genotypes were analysed for seven morphological traits viz., plant growth habit, lowest leaf hairiness, leaf colour, leaf blade hairiness, ligule shape, stem hairiness of uppermost node and days to 50 % flowering. These traits show huge variations in different lines studied.

Table-1 : List of experimental material.

S. No.	Treatment	Source
1.	BAUO-103	BAU, Sabour
2.	JHO-20-1	HAU, Hissar
3.	NDO-1902	NDAU, Faizabad
4.	SKO-244	SKUAST Kashmir (J&K.)
5.	OL-1980	PAU, Ludhiana
6.	JO-08-37	JNKVV, Jabalpur
7.	OL-1977	PAU, Ludhiana
8.	HFO-1009	HAU, Hissar
9.	HFO-1003	HAU, Hissar
10.	HFO-1013	HAU, Hissar
11.	BAUO-101	BAU, Sabour
12.	UPO-20-1	GBPAU&T ,Pantnagar
13.	OL-1974	PAU, Ludhiana
14.	OL-1971	PAU, Ludhiana
15.	HFO-1018	HAU, Hissar
16.	RO-11-4	MPKV, Rahuri
17.	OL-1874-1	PAU, Ludhiana
18.	OL-1876-1	PAU, Ludhiana
19.	RO-11-1-3	MPKV, Rahuri
20.	JO-06-23	JNKVV, Jabalpur
21.	SKO-241	SKUAST Kashmir (J&K.)
22.	RO-11-1-2	MPKV, Rahuri
23.	HFO-806	HAU, Hissar
24.	JO-08-41	JNKVV, Jabalpur
25.	JO-09- 48	JNKVV, Jabalpur
26.	OL-1876-9	PAU, Ludhiana
27.	HFO-904	HAU, Hissar
28.	HFO-906	HAU, Hissar
29.	OL-1960	PAU, Ludhiana
30.	JO-07-28	JNKVV, Jabalpur
31.	SKO-94	SKUAST Kashmir (J&K.)
32.	JO 1 Check (Zonal)	JNKVV, Jabalpur
33.	KENT Check (National)	PAU, Ludhiana

Materials and Methods

The experiment was carried out during Rabi season 2020-2021 under, All India Coordinated Research Project on Forage Crops, Department of Genetics and Plant Breeding at Seed Breeding Farm, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) at 23°21' North latitude, 79°94' East longitude and at an altitude of 411.78 meters from the mean sea level. This area as per NBSSLUP (National Bureau of Soil Science and Land Use Planning) of ICAR (Indian Council of Agricultural Research) comes under 10.1 "sub-humid dry eco-sub region" of agro-ecological zone. The crop was grown under normal crop season.

The experimental material consisted of 33 genotypes of single cut (SC) fodder oat as shown in Table-1. All genotypes were evaluated in a randomized complete block design (RCBD) with three replications. Each treatment was sown in 3.0 m row length spaced at

25 cm. Observations were recorded from the 5 randomly selected plants, which were true representative of the plot, from each replication of each treatment.

Morphological traits were recorded as per the DUS (Distinctness, Uniformity and Stability) guideline for different categories of a trait, as given in Table-2.

Results and Discussion

The 33 diverse oat lines were classified on the basis of morphological characters. As these characters are governed by oligogenes hence they do not show continuous variation. These variations have been shown in Fig.-1 in form of pie diagram and the detail of agro-morphological characters has been presented in Table-3.

An agro-morphological character of plant helps in identifying a variety and also helps in desirable genotype selection. In the present study 33 genotypes were analysed for ten morphological traits viz., plant growth

Table-2 : Different categories of morphological observations.

Characters	Categories	Symbols
1. Plant Growth habit	1. Erect 2. Semi Prostrate 3. Prostrate	E SP P
2. Lowest leaf hairiness of sheath	1. Absent 2. Weak 3. Medium 4. Strong	A W M S
3. Tillering (No. of tillers/plant)	1. Low (less than 5 tillers) 2. Medium (5-7 tillers) 3. High (more than 7 tillers)	LT MT HT
4. Leaf blade hairiness of margin of leaf	1. Absent 2. Medium 3. Strong	AB ME ST
5. Leaf colour	1. Light Green 2. Medium Green 3. Dark Green	LG MG DG
6. Days to 50 % flowering	1. Early Maturing (<95 days) 2. Medium Maturing (95-110 days) 3. Late Maturing (>110 days)	EM MM LM
7. Ligule shape	1. Pointed 2. Broad edge	PL BL
8. Stem hairiness of uppermost node	1. Absent 2. Weak 3. Medium 4. Strong	AH WH MH SH
9. Internodal length (Between 3rd & 4th node from top)	1. Short (<5 cm length) 2. Medium (5-10 cm) 3. Long (>10 cm length)	SI MI LI
10. Plant height	1. Short height (<125cm) 2. Medium height (125-150cm) 3. Tall height (>150cm)	Tt Tt TT

habit, lowest leaf hairiness, Number of tiller/plant, leaf blade hairiness, leaf colour, days to 50 % flowering, ligule shape, stem hairiness of uppermost node, internode length and plant height. These traits show huge variations in different lines studied.

Plant growth habit of genotype viz., OL-1974, RO-11-1-3 and OL-1960 were found semi-prostrate; while, remaining all genotypes was found erect as shown in Plate-1.

SKO-244, UPO-20-1 and SKO-241 had strong lowest leaf sheath hairiness; JHO-20-1, OL-1980, HFO-1009, RO-11-4, JO-06-23, OL-1960 and OL-1960 had medium lowest leaf sheath hairiness; BAUO-103, JO-08-37, HFO-1003, OL-1971, HFO-1018, HFO-806, JO-08-41, JO-09- 48, HFO-904, HFO-906 and JO-07-28 had weak lowest leaf sheath hairiness while, remaining did not have lowest leaf sheath hairiness as shown in Plate 2. OL-1874-1 and OL-1960 genotypes had high number of tillers, OL-1977, RO-11-1-3, JO-06-23, JO1 and KENT had medium number of tillers while remaining

all had low number of tillers as shown in Plate 3. Likewise, lines SKO-244 and HFO-1013 showed dense leaf blade hairiness and JHO-20-1, UPO-20-1 and OL-1960 shown medium leaf blade hairiness while remaining did not have leaf blade hairs as shown in Plate 4. Genotypes viz., BAUO-103, SKO-244, JO-08-37, HFO-1009, UPO-20-1 and HFO-806 showed light green leaf colour and OL-1980, OL-1977, HFO-1013, HFO-1018, OL-1874-1, RO-11-1-2 and JO-07-28 showed dark colour leaf while, remaining showed green colour leaf as shown in Plate 6. SKO-244, HFO-1009, HFO-1003, JO-09- 48 lines were early maturing; OL-1980, OL-1974, RO-11-4, RO-11-1-2, HFO-806, HFO-906, JO-07-28 and JO1 late maturing while remaining all lines were of medium maturity duration. OL-1971, HFO-1018, RO-11-4, HFO-906 and JO-07-28 had broad edge type of ligule while remaining all lines had pointed type of ligule which can be utilized for identification of varietal diversity in forage and seed production as shown in Plate 5. NDO-1902 and JO-09- 48 lines showed dense stem hairiness of uppermost node;

Table-3 : Agro-Morphological Observations.

Genotypes	Plant growth habit	Lowest Leaf sheath hairiness	No. of tillers per plant	Leaf blade hairiness of margin of leaf	Leaf colour	Days to 50 % flowering	Ligule shape	Stem hairiness of uppermost node	Plant Height
BAUO-103	E	W	LT	AB	LG	MM	PT	AH	Tt
JHO-20-1	E	M	LT	ME	MG	MM	PT	AH	Tt
NDO-1902	E	A	LT	AB	MG	MM	PT	SH	tt
SKO-244	E	S	LT	ST	LG	EM	PT	WH	tt
OL-1980	E	M	LT	AB	DG	LM	PT	AH	tt
JO-08-37	E	W	LT	AB	LG	MM	PT	AH	Tt
OL-1977	E	A	MT	AB	DG	MM	PT	AH	Tt
HFO-1009	E	M	LT	AB	LG	EM	PT	AH	tt
HFO-1003	E	W	LT	AB	MG	EM	PT	AH	Tt
HFO-1013	E	A	LT	ST	DG	MM	PT	AH	Tt
BAUO-101	E	A	LT	AB	MG	MM	PT	WH	Tt
UPO-20-1	E	S	LT	ME	LG	MM	PT	WH	Tt
OL-1974	SP	A	LT	AB	MG	LM	PT	AH	TT
OL-1971	E	W	LT	AB	MG	MM	BB	AH	TT
HFO-1018	E	W	LT	AB	DG	MM	BB	AH	tt
RO-11-4	E	M	LT	AB	MG	LM	BB	AH	Tt
OL-1874-1	P	A	HT	AB	DG	MM	PT	AH	TT
OL-1876-1	E	A	LT	AB	MG	MM	PT	AH	Tt
RO-11-1-3	SP	A	MT	AB	MG	MM	PT	AH	TT
JO-06-23	E	M	MT	AB	MG	MM	PT	AH	tt
SKO-241	E	S	LT	AB	MG	MM	PT	AH	Tt
RO-11-1-2	E	A	LT	AB	DG	LM	PT	AH	Tt
HFO-806	E	W	LT	AB	LG	LM	PT	AH	TT
JO-08-41	E	W	LT	AB	MG	MM	PT	AH	Tt
JO-09- 48	E	W	LT	AB	MG	EM	PT	SH	Tt
OL-1876-9	E	A	LT	AB	MG	MM	PT	AH	Tt
HFO-904	E	W	LT	AB	MG	MM	PT	WH	Tt
HFO-906	E	W	LT	AB	MG	LM	BB	AH	Tt
OL-1960	SP	M	HT	ME	MG	MM	PT	AH	Tt
JO-07-28	E	W	LT	AB	DG	LM	BB	WH	Tt
SKO-94	E	A	LT	AB	MG	MM	PT	AH	Tt
JO1	E	M	MT	AB	MG	LM	PT	MH	Tt
KENT	E	A	MT	AB	MG	MM	PT	MH	tt

Note : E- Erect, SP- Semi Prostrate, W- Weak, M- Medium, S- Strong, A- Absent, LT- Low Tiller, MT- Medium Tiller, HT- High Tiller, AB- Absent, ME- Medium, ST- Strong, LG- Light Green, MG- Medium Green, DG- Dark Green, EM- Early Maturing, MM- Medium Maturing and LM- Late Maturing, PT- Pointed, BB- Broad Base, WH- Weak, MH- Medium, SH- Strong, AH- Absent, tt- Short Height, Tt- Medium Height, TT- Tall Height.

JO1, KENT showed medium; SKO-244, BAUO-101, UPO-20-1, HFO-904 and JO-07-28 showed weak while remaining all lines did not have stem hairiness of uppermost node as shown in Plate 7. All genotypes were found internode having long length; while, none of them were found internode having short and medium length. Lines BAUO-103, OL-1974, OL-1971, OL-1874-1 and RO-11-1-3 were of tall height; RO-11-1-3, SKO-244, OL-1980, HFO-1009, HFO-1018, JO-06-23 and KENT were of medium height; while, remaining all were of medium height.

Arora (2013), Kumari et al. (2018) and Mir et al.(2018) also found similar morphological variations as

found in the present study. Kaziu et al.(2015) distinguished variation in genotype based on lodging due to plant growth habit. Erect plant genotypes were found lodging resistant.

Conclusions

The genotypes studied in the present investigation exhibited a wide range of variation for various traits observed. Evaluation of germplasm is an important step in plant breeding so that the genotypes having inherent ability for different traits can be selected which suggested ample scope of improvement by inclusion of yield and quality characteristics of oat.

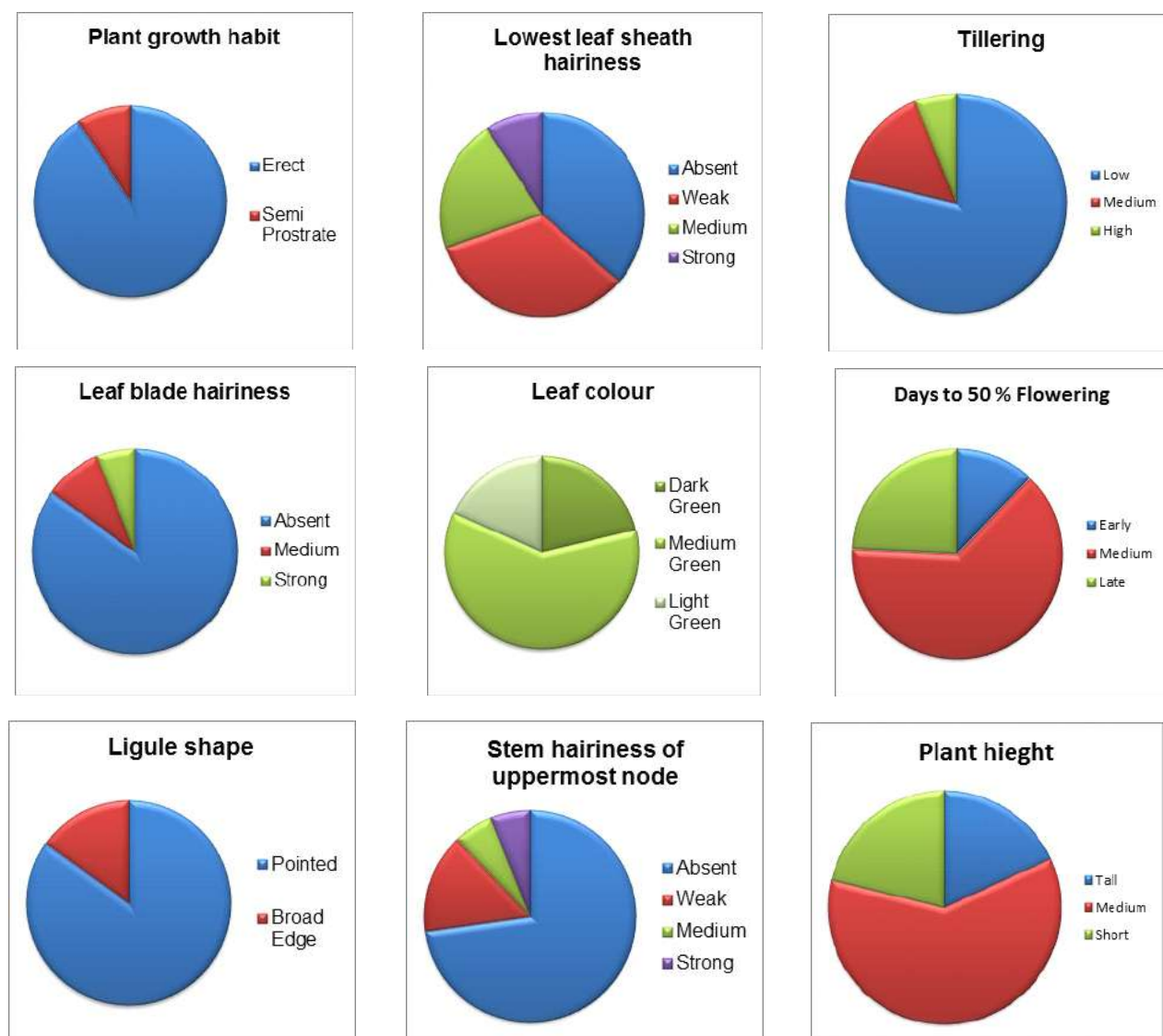


Fig.-1 : Pie diagram showing frequency distribution of Agro-Morphological characters.



Plate 1: Variation in plant growth habit

Plant Growth Habit

1. Semi- Prostrate
2. Prostrate



Plate 2: Variation in lowest leaf sheath hairiness



Plate-3 : Variation in number of tillers/plant.

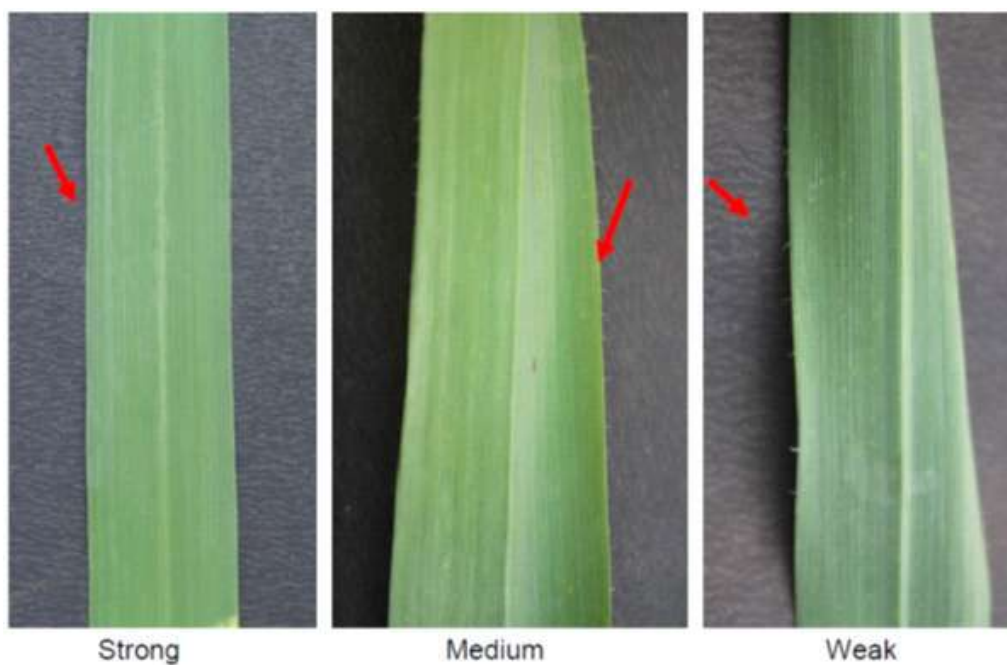


Plate 4: Variation in hairiness of leaf blade margin



Plate-5 : Variation in ligule shape.



Plate-6 : Variation in leaf colour.

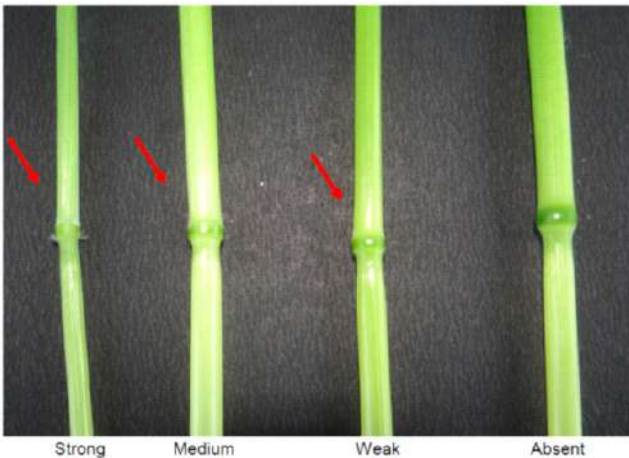


Plate-7 : Variation in stem hairiness of uppermost node.

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Extent of Mechanical Methods and Easiness of Adoption of Paddy Straw Management Techniques among Farmers of Punjab State

Anil Kumar Choudhary¹, R.K. Dhaliwal², Divyata Joshi¹ and Naveen Kumar³

¹Department of Extension Education, Punjab Agricultural University, Ludhiana, Punjab

²Punjab Agricultural University, Ludhiana-141004, Punjab

³Department of Agronomy, Mata Gujri College, Fatehgarh Sahib

Corresponding Author Email : iamanil.ak@gmail.com

Abstract

To feed the burgeoning population the intensive cultivation is being followed with rice and wheat being the chief crops grown. Due to monoculture and intensive cultivation, along with crops, large amount of crop residue which is estimated around 600 million tons is produced out of which 70 per cent accounts from cereals. This amount further increases with increasing population as there is a need to increase production and area under cereals. The study comprised of two types of respondents i.e. adopted villages and non-adopted villages. One district of Punjab having large area under *kharif* rice was selected purposively. Further from one district 6 villages were selected from which three villages were selected randomly which was not adopted by any institution and three villages were selected purposively which was adopted by any institution. From each village 20 farmers were selected randomly, thus comprising sample of 60 farmers from adopted and 60 farmers from non-adopted villages, making the total sample size of 120. On the basis of easiness of adoption of paddy straw management techniques the study found that most of the respondents of adopted villages found easy to moderately difficult and in non-adopted villages it was moderately difficult to difficult in adoption of different paddy straw management techniques. The study found that extent of adoption of mechanical paddy straw management techniques have been gradually increasing year after year. In case of happy seeder extent of adoption showed significant increment from 2.36 per cent in 2015-16 to 22.60 per cent in 2019 in adopted villages and 1.96 to 18.60 in non-adopted villages. Similar trend was found in case of Super SMS, Zero till drill, Rotavator. Whereas MB plough and mulcher showed increment in initial three years and decline afterwards decline in trend over the years in adopted villages. Similar trends were shown in case of mulcher but MB plough showed significant increase in extent of adoption in non-adopted villages.

Key words : Mechanical methods, conventional methods, adopters, non-adopters, PSM machinery, easiness in adoption

Introduction

The level and extent of adoption was measured by taking different measurements i.e. Technology used for paddy straw management (Mechanical and conventional), Easiness of adoption of different paddy straw management techniques, Extent of adoption of different paddy straw management techniques in different years in adopted and non-adopted villages, extent of adoption of different paddy straw management techniques at the initial year of adoption in adopted and non-adopted villages.

Distribution of respondents on the basis of mechanical method used for paddy straw management : In table-1 it was seen that mechanical methods i.e. Happy seeder, rotavator, MB plough, Mulcher etc. for in-situ management and baler for ex-situ management were used for paddy straw management founded medium to high extent of adoption in adopted villages and low to medium in non-adopted villages. The result recorded in adopted villages was 11.66 per cent and

in non-adopted villages 33.33 per cent of the respondents were in low category (0-33 %) of extent of adoption. 40 per cent of the respondents of adopted villages were in medium category (34-66%) whereas 36.66 per cent of the respondents of the non-adopted were found in same category and 48.33 per cent of the respondents of adopted villages were found in high category (67- 100%) whereas in non-adopted villages it was found that 30 per cent of the respondents were under this category of extent of adoption.

Distribution of respondents on the basis of conventional method used for paddy straw management : In table-2 it was seen that conventional methods i.e. Burning of paddy straw, composting, animal fodder etc. were used for paddy straw management founded low to medium extent of adoption in adopted villages and high to medium in non-adopted villages. The result recorded that 58.33 per cent respondents of adopted villages and 28.33 per cent were in low category (0-33%). In medium category (34-66%) there were 36.66 per cent respondents of adopted villages and 41.66 per

Table-1 : Distribution of respondents on the basis of mechanical method used for paddy straw management.

S. No.	Extent of adoption (%) (Mechanical methods)	Adopted villages (n=60)	Non-adopted villages (n=60)
		f (%)	f (%)
1.	Low (0-33)	7 (11.66)	20 (33.33)
2.	Medium (34-66)	24 (40)	22 (36.66)
3.	High (67-100)	29 (48.33)	18 (30)

Table-2 : Distribution of respondents on the basis of conventional method used for paddy straw management.

S. No.	Extent of adoption (%) (Conventional methods)	Adopted villages (n=60)	Non adopted villages (n=60)
		f (%)	f (%)
1.	Low (0-33)	35 (58.33)	17 (28.33)
2.	Medium (34-66)	22 (36.66)	25 (41.66)
3.	High (67-100)	3 (5)	18 (30)

Table-3 : Distribution of respondents on the basis of easiness of the adoption of paddy straw management methods.

Sr. No.	Easiness of adoption	Adopted villages (n=60)	Non-adopted villages (n=60)	Z-value
		f (%)	f (%)	
1.	Easy	37 (61.66)	19 (31.66)	3.67**
2.	Moderately difficult	18 (30)	26 (43.33)	
3.	Difficult	5 (8.33)	15 (25)	

**Significant at 0.01 level

cent of non-adopted villages. It was also founded that only 5 per cent of the respondents from adopted villages and 30 per cent of the respondents from non-adopted villages were under the high category (0.67-1%) of extent of adoption.

Thus adopted villages were more prominent in adoption of mechanical methods for paddy straw management whereas non-adopted villages were high in adoption of conventional methods.

Distribution of respondents on the basis of easiness of the adoption of paddy straw management methods : In table-3 the tables depicted that easiness of extent of adoption in adopted villages was found easy to moderately difficult and in non-adopted villages it was moderately difficult to difficult level in case of paddy straw management techniques. In adopted villages individuals who pursued easy extent of adoption were found to 61.66 per cent whereas in non-adopted villages it was 31.66 per cent. The respondents perceived adoption of paddy straw management as moderately difficult was found 30 percent in adopted and 43.33 percent in non-adopted villages. Whereas respondents who perceived adoption of paddy straw management as difficult was 8.33 percent in adopted and 25 percent in non-adopted villages. The result from Z-value (3.67) showed that there was a significant difference in easiness of adoption of paddy straw management techniques in adopted and non-adopted villages.

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Correlation and Regression Study under the Influence of Weed Control Methods in Pearl Millet [*Pennisetum glaucum* (L.) R. Br. Emend Stuntz]

B.C. Dhayal¹, S.S. Yadav¹, M.L. Jat², Reema¹ and S. Kumar³

¹Department of Agronomy, S.K.N. College of Agriculture (SKNAU) Jobner, Rajasthan-303329

²MAF, Agriculture University, Kota-324001

³Department of Agronomy, College of Agriculture (AU) Jodhpur, Rajasthan-342301

Email : dhayalbhadgchand45@gmail.com

Abstract

A field experiment was conducted under loamy sand soil during Kharif, 2016 at Agronomy farm, S.K.N. College of Agriculture, Jobner. The treatments comprising nine weed control measures [Weedy check, one HW at 20 DAS, two HW at 20 and 40 DAS, atrazine at 0.5 kg/ha (PE), atrazine at 0.5 kg/ha + one HW at 20 DAS, alachlor at 1.0 kg/ha (PE), alachlor at 1.0 kg/ha + one HW at 20 DAS, oxyfluorfen at 200 g/ha (PE) and oxyfluorfen at 200 g/ha + one HW at 20 DAS] were replicated thrice in Randomized Block Design. Pearl millet variety 'RHB-173' was used as a test crop. Results showed that significant and positive correlation between crop dry matter, total tillers/plant, effective tillers/plant, grains/ear and N, P and K uptake with grain yield ($r = 0.992^{**}$, 0.996^{**} , 0.989^{**} , 0.967^{**} , 0.814^{**} , 0.991^{**} , 0.990^{**} and 0.997^{**}) and significant and negative correlation between weed dry matter and N, P and K depletion by weeds with grain yield ($r = -0.761^{**}$, -0.765^{**} , -0.762^{**} and -0.764^{**}). The regression studies showed that a unit decrease of 1.0 kg in weed dry matter or N, P and K depletion by weeds increased the grain yield of pearl millet by 0.46, 20.98, 105.69 and 22.63 kg/ha, respectively.

Key words : Correlation coefficients, regression, WCE, HI, weed infestation, weed index

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz], also known as candle millet, cattail millet, bulrush millet or bajra, is one of an important millet crops of India. India is the largest producer of pearl millet in the world occupying 7.38mha with annual production of 9.13 million tonnes and average productivity of 1237 kg ha^{-1} (Anonymous, 2017-18). Pearl millet is a warm weather coarse cereal grown in semi-arid and arid climate of tropical and subtropical regions, as it is endowed with greater ability to withstand harsh environment. It is nutritionally better than many cereals as it is a good source of carbohydrate (67%), protein (12.6%), fat (5%) and minerals 2.8%. The energy level of 361 K cal is the highest among grain cereals or millets (Anonymous, 2012). It is also rich in vitamins A and B, thiamin, riboflavin and imparts substantial energy to the body digestibility. Apart from grain, the stover for animal feed and fuel is an important secondary product for resource poor farmers (Arshewar, 2018). Like other rainy season crops, pearl millet too faces severe weed competition in the initial stages leading to reduction in grain yield to the tune of 20-30%, however, under humid rainy season and extremely weedy situations, the loss may be as high as 55% (Banga et al. 2000) and 72% (Das and Yaduraju, 1995). Hence, the crop should be kept free from

weeds at least for the initial 25-30 DAS after which it picks up growth, start tillering and become more competitive against weeds. .

The predominant methods of weed management are inter-culturing and hand weeding in pearl millet crop. The use of herbicides has revolutionized weed management and reduces the cost of cultivation. Though lot of research has been conducted on the use of herbicides across crops but research and adoption of the same for effective weed control in Pearl millet is meager. On the other hand, benefits of mechanical measures viz. loosening of soil, root aeration, deep root penetration, moisture conservation etc. cannot be ignored. Hence, integrated weed management are effective and workable practices that may be used ecologically and economically viable to the farmers. Unavailability of adequate labour during peak period of weeding and difficulty in use of mechanical weeding in heavy rains create problem for effective weed management in crops (Nainwal et al, 2010). Therefore, integrated approaches for weed management using chemical and manual methods were evaluated for efficient weed management and economic benefits in pearl millet.

Materials and Methods

Field experiment was conducted under loamy sand soil during Kharif, 2016 at Agronomy farm, S.K.N. College of Agriculture, Jobner. Jobner is situated 45 km west of

Table-1 : Correlation coefficients and linear regression equations showing relationship between grain yield (kg/ha) and independent variables (X).

S. No.	Independent variable (X)	Correlation coefficients (r)	Regression equations (Y= a + byx.X)
1.	Weed dry matter at harvest (kg/ha)	-0.761**	$Y = 1659.13 + -0.461 X_1$
2.	N depletion by weeds at harvest (kg/ha)	-0.765**	$Y = 1707.72 + -33.87 X_2$
3.	P depletion by weeds at harvest (kg/ha)	-0.762**	$Y = 1688.27 + -233.94 X_3$
4.	K depletion by weed at harvest (kg/ha)	-0.764**	$Y = 1702.98 + -35.49 X_4$
5.	Crop dry matter at harvest (kg/ha)	0.992**	$Y = -53.02 + 4.12 X_5$
6.	Total tillers/plant	0.996**	$Y = -66.45 + 483.48 X_6$
7.	Effective tillers/plant	0.989**	$Y = -36.45 + 652.98 X_7$
8.	Number of grains/ear	0.814**	$Y = -634.79 + 1.566 X_8$
9.	N uptake by crop (kg/ha)	0.991**	$Y = 437.12 + 20.98 X_9$
10.	P uptake by crop (kg/ha)	0.990**	$Y = 432.98 + 105.69 X_{10}$
11.	K uptake by crop (kg/ha)	0.997**	$Y = 277.33 + 22.63 X_{11}$

** Significant at 1% level of significance.

Jaipur at 26° 05' N- latitude and 75° 28' E- longitudes and at an altitude of 427 metres above mean sea level in Jaipur district of Rajasthan. The region falls in Agroclimatic zone III-A (Semi-arid Eastern Plain). The average annual rainfall of this tract varies from 450 mm to 500 mm most of which is received during the period of July to September. The soil of the experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon with low available nitrogen and sulphur and medium in available phosphorus and potash. The treatments comprising nine weed control measures [Weedy check, one HW at 20 DAS, two HW at 20 and 40 DAS, atrazine at 0.5 kg/ha (PE), atrazine at 0.5 kg/ha + one HW at 20 DAS, alachlor at 1.0 kg/ha (PE), alachlor at 1.0 kg/ha + one HW at 20 DAS, oxyfluorfen at 200 g/ha (PE) and oxyfluorfen at 200 g/ha + one HW at 20 DAS] were replicated thrice in Randomized Block Design. Pearl millet variety 'RHB-173' was used as a test crop. The application of Atrazine, alachlor, and oxyfluorfen were applied through aatrex 50 WP, lasso 50 EC, and rota 23.5 EC, respectively through a knap-sack hydraulic sprayer was used for spraying the herbicides using a spray volume of 800 litres/ha. Atrazine, alachlor, and oxyfluorfen were applied as pre emergence treatment to the respective plots one day after sowing of pearl millet. In the plots earmarked for hand weeding, the operation was done at 20 and 40 days after sowing (DAS) as per treatment. Data on correlation coefficients and regression equations were calculated as per the standard procedures.

Results and Discussion

Correlation coefficients and regression equations were worked out to study the relationship of grain yield with

weed dry matter, nutrient depletion by weeds, crop dry matter, yield attributes and nutrient uptake by crop which is summarized in table-1. The results of correlation coefficients indicated that grain yield of pearl millet was significantly and negatively correlated with weed dry matter at harvest ($r = -0.761$) and N, P and K depletion by weeds ($r = -0.765$, -0.762 and -0.764) and significantly and positively correlated with crop dry matter at harvest ($r = 0.992$), number of total tillers/plant ($r = 0.996$), effective tillers/plant ($r = 0.989$), number of grains/ear ($r = 0.814$) and N, P and K uptake by crop ($r = 0.991$, 0.990 and 0.997). Linear relationship appeared to exist between grain yield and independent variables. The regression equations (Table 4.20) showed that every unit increase in weed dry matter and N, P and K depletion by weeds at harvest stage decreased the grain yield of pearl millet by 0.461, 33.87, 233.94 and 35.49 kg/ha, respectively. On the other hand, every unit increase in crop dry matter at harvest, number of total tillers/plant, number of effective tillers/plant, number of grains/ear, and N, P and K uptake by crop substantially increased the grain yield by 4.12, 483.48, 652.98, 1.566, 20.98, 105.69 and 22.63 kg/ha, respectively. The most severe competition throughout the crop season due to unrestricted weed growth under weedy check plots increased the depletion and moisture by weeds, thus adversely affecting the crop growth and ultimately the lowest yield of crop. These results are strongly supported with the findings of Kaur and Singh (2006), Kiroriwal *et al.* (2012) and Munde *et al.* (2013) in pearl millet.

Conclusions

Based on one year experimentation, it may be concluded that correlation coefficients indicated that grain yield of

pearl millet was significantly and negatively correlated with weed dry matter and nutrient depletion by weeds and significantly positively correlated with crop dry matter, number of total tillers/plant, effective tillers/plant, number of grains/ear and nutrient uptake by crop. Linear relationship appeared to exist between grain yield and independent variables. The regression equations showed that every unit increase in weed dry matter and nutrient depletion by weeds decreased the grain yield of pearl millet. On the other hand, every unit increase in crop dry matter, number of total tillers/plant, number of effective tillers/plant, number of grains/ear, and nutrient uptake by crop substantially increased the grain yield.

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Characterization of Grain Nutritional Quality of Released and Pre Released Wheat (*Triticum aestivum* L.) Genotypes

Parul Singhal*, Ravi Kumar Nechu, R.S. Shukla and Suneeta Pandey

Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, M.P, 482 004

*Corresponding Author Email : parulsinghal230@gmail.com

Abstract

The present research work comprises of thirty genotypes of wheat, collected from All India Coordinated Research Project on wheat and Barley at Seed Breeding Farm, Department of Plant Breeding and Genetics, JNKVV, Jabalpur. These genotypes were grown in Randomized Complete Block Design with 2 replications during the Rabi season of 2020-21. Genotypes were characterized for seven qualitative parameters viz., protein content, starch content, sedimentation value, Fe, Cu, Zn, and Mn content. Highest protein content was found in MP1215. MP3382 possess highest Zn and Mn content. Black wheat contain highest Fe content. The findings of this study concludes that on the basis of overall nutritional status, these genotypes can be selected for future breeding programmes to combat hidden hunger.

Key words : sedimentation value, protein, starch, qualitative, combat.

Introduction

Wheat is a major staple food crop in India as well as in the world in terms of both production and consumption. World nutrition mostly depends on wheat and wheat products viz. chapati, bread, biscuit, pasta and fermented products, as the people all over the world consume wheat products in one of these forms (Agrawal and Gupta 2006). Wheat (*Triticum aestivum* L.) is one of the major food crops of the world and has an important role to play in achieving the food security. Therefore, enhancing grain yield and improving resistance to biotic and abiotic stresses, nowadays end use quality has also become one of the major target of various wheat breeding programmes around the world. In India, wheat ranks second after paddy both in area and production, occupying 31.76 Mha acreage area (14% of global area) with production of 109.52 Mt (13.64% of world production) and average national productivity of 3440Kg/ha. Madhya Pradesh is the third largest producer of wheat, accounting for 16% of production and 21% of the area under cultivation. In Madhya Pradesh, it is grown in an area of 6.69 Mha with production of 17.58 Mt and 2627kg/ha productivity (Anon., 2020-21).

Around three billion people throughout the world face problem of malnutrition due to micronutrient deficiency (Anon., 2000). So, emphasis is being given to improve wheat grain nutritional quality to meet the challenge of world malnutrition. Therefore, along with optimal level of starch and protein, adequate level of essential elements like iron and zinc are needed to fight against world malnutrition. High protein and starch are

important for growth and energy. Per annum problems are becoming more fierce thereby highlighting the need to focus research on area like quality production. Despite of the increase in production of wheat, India ranks 94th out of the 107 countries in the 2020 Global Hunger Index. As per the study, roughly 14 % of the country's population remains undernourished. It also showed the country recorded a 37.4% stunting rate among children under five.

The objectives of this research work were to estimate various genetic parameters to identify superior genotypes having good quality traits and micronutrient composition (High in Fe, Zn, Mn, Cu) for future breeding programs. The major breeding objective at the present is to increase the production as well as to enhance the nutritional value of a particular crop species.

Materials and Methods

The present investigation was carried to assess the genetic diversity for yield and quality traits in Thirty released and pre released wheat genotypes depicted in (Table-1) were collected from All India Coordinated Research Project on wheat and Barley at Seed Breeding Farm, Department of Plant Breeding and Genetics, JNKVV, Jabalpur, evaluated under Randomized Complete Block Design with 2 replications during the Rabi season of 2020-21.

Each plot consists of 6 rows of 6 m length and row to row distance was 20 cm. The experimental area was suitable for good growing and for research purposes also. Jabalpur is situated at 23.18° N latitude and 79.97° E longitudes in the agro-climatic zone of Kymore Plateau and Satpura Hills and lies in rice-wheat crop zone of the

Table-1 : List of experimental material.

S. No.	Name of genotypes	S. No.	Name of genotypes	S. No.	Name of genotypes
1.	JW3336	11.	MP1142	21.	MP3545
2.	JW3288	12.	MP1215	22.	MP3382
3.	JW3211	13.	MP1255	23.	JW3465
4.	JW3020	14.	MP1203	24.	WB02
5.	JW3173	15.	C306	25.	Black wheat
6.	JW3469	16.	Sujata	26.	MP3512
7.	JW3523	17.	MP3544	27.	MP3493
8.	JW3527	18.	MP3541	28.	MP3521
9.	JW3535	19.	MP3542	29.	MP4010
10.	JW1201	20.	MP3552	30.	MP3516

Table-2 : Grain nutritional quality parameters for different wheat genotypes.

S. No.	Variety	Protein content (%)	Starch content (%)	Sedimentation value (ml)	Fe (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)
1.	JW3336	12.7	63.8	36.6	55.3	6.1	28.6	57.6
2.	JW3288	12.0	61.8	49.9	57.7	5.5	19.8	57.4
3.	JW3211	11.7	65.1	35.5	49.2	5.7	30.3	53.6
4.	JW3020	10.3	64.6	54.8	52.2	5.3	30.6	51.1
5.	JW3173	10.5	64.9	43.4	56.7	5.9	18.6	55.7
6.	JW3469	12.8	64.5	41.0	62.6	5.9	25.5	58.9
7.	JW3523	11.9	61.9	41.8	58.4	4.7	28.4	49.9
8.	JW3527	10.2	65.6	36.0	57.8	4.9	24.8	51.6
9.	JW3535	11.9	67.7	43.0	54.1	6.3	20.6	37.9
10.	JW1201	12.5	63.7	44.0	67.0	5.3	28.4	58.9
11.	MP1142	12.8	62.1	42.6	68.0	6.1	26.8	49.6
12.	MP1215	30.0	62.1	32.9	77.0	4.5	35.0	33.5
13.	MP1203	14.1	62.2	39.2	70.0	4.4	28.0	39.0
14.	C306	12.5	63.7	41.0	68.4	5.5	27.1	53.6
15.	Sujata	12.3	63.1	42.8	68.4	5.1	27.5	48.7
16.	MP3544	12.8	62.6	37.0	49.2	5.2	21.0	38.4
17.	MP1255	10.3	67.0	44.9	39.0	4.4	15.9	37.9
18.	MP3541	11.2	66.9	45.0	48.5	5.2	18.9	38.1
19.	MP3542	11.4	64.3	44.2	47.0	4.3	18.5	37.2
20.	MP3552	9.9	65.6	49.0	28.6	3.9	17.9	33.3
21.	MP3545	9.8	65.1	41.0	30.2	2.6	18.0	34.0
22.	MP3382	13.1	64.2	41.7	77.6	6.6	37.6	59.7
23.	JW3465	9.6	65.8	48.2	28.2	5.6	17.1	55.1
24.	WB02	12.2	64.4	53.6	77.1	4.4	36.9	53.6
25.	Black wheat	11.3	60.2	28.1	78.0	5.4	24.5	56.4
26.	MP3512	11.4	65.4	33.5	45.5	6.0	26.6	50.1
27.	MP3493	9.7	66.8	49.2	35.4	2.8	20.8	47.4
28.	MP3521	8.5	69.4	41.0	30.2	5.7	15.1	55.3
29.	MP4010	11.5	62.0	50.1	49.3	2.0	25.1	36.3
30.	MP3516	11.7	65.4	49.0	41.0	3.1	24.4	47.4
Mean		12.0	64.4	41.6	54.7	4.9	24.7	47.9
Min		8.1	60.0	11.7	28.0	2.0	15.1	32.1
Max		30.0	69.0	55.1	78.0	6.6	37.6	59.7
CD (p=0.05)		0.2222	0.3483	0.4809	0.4364	0.1877	0.417	0.5782

state. The maximum and minimum temperature in the month of November was 28.7 and 16°C respectively.

Seven qualitative parameters were analysed to characterize the genotypes viz., protein content (%), starch content (%), sedimentation value (ml), Fe content (mg/kg), Cu content (mg/kg), Zn content (mg/kg) and Mn content (mg/kg).

Protein content were estimated by calculating total nitrogen content of seed at maturity stage by Palican Equipment Kel-Plus which is based on the Microkjeldhal digestion and distillation methods as given by (AOAC,1980).

Nitrogen and protein % was calculated by the following formula :

$$\text{Nitrogen (per cent)} = \frac{14 \text{ Normality of H}_2\text{SO}_4 \times \text{Volume of H}_2\text{SO}_4}{\text{Weight of sample} \times 1000} \times 100$$

Protein % in the sample was estimated multiplying nitrogen % of sample by factor 6.5.

$$\text{Protein (per cent)} = \text{Nitrogen \%} \times 6.5$$

Starch content was estimated by a colorimetric method using Anthrone reagent and taking readings at 690 nm in spectrophotometer. Results for the starch content of these materials show a standard deviation of 2.2 % of the mean value. (Clegg, 1956). Sedimentation value measures the quality of protein and based on the fact that volume of sediment, formed when flour is suspended in water and treated with lactic acid, consisting of swollen gluten and occluded starch is the sedimentation value and micronutrients were analyzed by Atomic Absorption Spectro-photometer, GBC 902 plus.

All measurements were drawn on grounded samples drawn in duplicates. The data were analysed by analysis of variance (ANOVA) (Singh and Chaudhary, 1985) and CD was calculated at $p = 0.05$.

Results and Discussion

Grain quality parameters for all the genotypes are shown in table-2. Protein content was ranged from 8.1 % (MP3521) to 30.0 % (MP1215) with a mean value of 12.0 %. Protein content was found highest for MP1215 (30%), followed by MP1203 (14.1%), MP3382 (13.1%) and MP3544 (12.7%). Protein is as essential component for bread/ or chapati making quality of wheat. High protein was reported to improve nutritional as well as quality status of food. Gluten protein of wheat is a complex mixture of glutenin (Glu) and gliadin (Gld). Starch content was ranged from 60.0 % (MP1215) to 69.0 % (MP3521) with a mean value of 64.4%. MP 3521 contained highest

starch content (69.0%), followed by MP3535 (67.7%), MP1255 (67.0%) and MP3541 (66.9%) are potential candidates for bakery industry. Sedimentation value was ranged from 11.7 ml (MP1215) to 55.1 ml (JW3020) with a mean value of 41.6 ml. Genotypes viz., JW3288, JW3020, JW3173, JW3523, JW3535, JW1201, Sujata, MP1255, MP3541, MP3542, MP3552, MP3382, MP3465, WB02, MP3493, MP4010 and MP3516 had relatively higher sedimentation value than overall average hence it revealed that these genotypes possess good chapati making qualities and rheological properties.

Besides enough calories and quantity/quality of protein, a balanced level of micronutrients is essential for proper growth and development. Table 2 depicts that Fe content was ranged from 28.0 mg/kg (MP3521) to 78.0 mg/kg (Black wheat) with mean value of 54.7 mg/kg. Black wheat had maximum iron content followed by MP3382. Copper content was ranged 2.0 mg/kg (MP4010) to 6.6 mg/kg (JW3382) with a mean value of 4.9 mg/kg. Lowest Cu content was found in MP3545, MP3493 and MP3516. Zn content was ranged from 15.1 mg/kg (MP3521) to 37.6 mg/kg (JW3382) with a mean value of 24.7 mg/kg. Highest Zn content was found in MP3382 followed by MP1215 and JW3211. Mn content was ranged from 32.1 mg/kg (MP1215) to 59.7 mg/kg (MP3382) with mean value of 47.9 mg/kg. Manganese content was found highest in MP3382 followed by MP3469, MP1201 and JW3336. Similar results were reported by (Rajput, 2019) and (Baye et al., 2020).

From the given result it is found that these nutritionally rich genotypes can be considered for future quality breeding programmes.

Conclusions

Out of thirty genotypes evaluated for quality parameters suggested that JW3382 contained high protein content and sedimentation value and maximum zinc and manganese content whereas black wheat contain highest iron content among all genotypes. Therefore JW3382 is considered the most nutritionally efficient genotypes that can be used in the breeding programme and processing industry for consumer.

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Heterosis Studies in Baby Corn (*Zea mays* L.) for Yield and Yield Contributing Traits

Sandeep Kumar Bangarwa*, R.B. Dubey, Divya Chouhan and Manmohan Singh

Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur-313001

*Corresponding Author Email : sandeepbangarwa123@gmail.com

Abstract

The present investigation consisted of a total of 45 hybrids along with 18 parents (15 inbred lines and 3 testers) and 2 checks. A total of 65 entries were evaluated in randomized block design with three replications over three locations (Two during *Kharif*-2019 and one during *Rabi* 2019-20) at Instructional farm, Rajasthan College of Agriculture, Udaipur, Rajasthan (*Kharif*-2019 and *Rabi* 2019-2020) and Agriculture Research Sub Station, Vallabh Nagar, Udaipur, Rajasthan (*Kharif*-2019). Observations were recorded on eighteen characters for estimates of the extent of standard heterosis. The perusal of estimates of standard heterosis for de-husked cob yield and its contributing characters revealed that on pooled basis, maximum and significantly desirable economic heterosis was depicted by cross EI-Q-103 × EI-2156 (13.51). The cross combinations viz., EI-Q-103 × EI-2156 (13.51), EI-Q-180 × EI-2156 (16.02), EI-Q-103 × EI-2156 (10.54), EI-Q-103 × EI-2156 (17.26), EI-Q-180 × EI-2156 (9.46) were identified suitable for yield and yield contributing traits.

Key words : Baby corn, environments, heterosis, randomized block design and yield.

Introduction

Maize (*Zea mays* L.) $2n=20$, is the third most important cereal crop after rice and wheat in the world. By origin, maize is native to South America. It is grown during rainy (*Kharif*), winter *Rabi* and spring seasons, but major production is in the *Kharif* rainy season. It has diversified uses as food for humans, feed for livestock and raw material for industries. It has immense potential, and is, therefore, called the “miracle crop”. Maize being a C4 plant, is an efficient converter of absorbed nutrients into food. Globally, maize is known as ‘queen of cereals’ because of its highest genetic yield potential. It is the only food cereals crop that can be grown in diverse seasons, ecologies and uses. Beside this maize have many types like normal yellow/white grain, sweet corn, baby corn, popcorn, waxy corn, high amylose corn, high oil corn, quality protein maize etc. Apart from this, maize is an important industrial raw material and provides large opportunity for value addition. A recent trend is of growing maize for vegetable purpose, which is commonly known as ‘Baby corn’. Baby corn is a young finger like unfertilized cob of maize harvested early within 1-3 days of silk emergence. Baby corn is a good option for crop diversification (1) and it suits to periurban agriculture. Baby corn is a delicious, decorative and nutritious vegetable, without cholesterol. It is a low caloric vegetable which is rich in fibre content. One baby corn can be compared with an ‘egg’ in terms of minerals. Nutritive values of baby corn (per 100 g of edible portion) is Moisture 89.10 %, Carbohydrates 8.20 g, Protein 1.90 g, Calcium 28.00 mg, Phosphorus 86.00 mg, Iron 0.10 mg. (2).

Worldwide, Thailand is the leading producer and exporter of baby corn. India is emerging as the potential producer of baby corn due to high demand with less cost of production. In India, baby corn is being cultivated in Meghalaya, Western Uttar Pradesh, Haryana, Maharashtra, Karnataka and Andhra Pradesh.

Heterosis, the measure of the average superiority of a hybrid over its parental inbred lines is an important consideration in the development of hybrid varieties. Diversity among inbred source populations is an important factor in determining combining ability among inbred lines and heterosis revealed by hybrids, where a more diverse combination is expected to produce more superior hybrids (3).

Despite manifold uses of baby corn, very little information is so far available on standard heterosis in baby corn. In view of the above facts, the present investigation is employed to derive information on heterosis.

Materials and Methods

The present investigation consisted of a total of 45 hybrids along with 18 parents (15 inbred lines and 3 testers) and 2 checks. A total of 65 entries were evaluated in randomized block design with three replications over three locations (Two during *Kharif*-2019 and one during *Rabi* 2019-20) at Instructional farm, Rajasthan College of Agriculture, Udaipur, Rajasthan (*Kharif*-2019 and *Rabi* 2019-2020) and Agriculture Research Sub Station, Vallabh Nagar, Udaipur, Rajasthan (*Kharif*-2019). Observations were recorded on eighteen characters for estimates of the extent of standard heterosis. The experimental material

Table-1 : Analysis of variance on over the environments.

Source of variation	df	Mean sum of squares						
		Days to first cob silking	Days to last cob silking	Days to first cob picking	Days to last cob picking	Days to first and last cob picking interval	Number of cobs per plant	Husked cob weight
Environments	2	15990.87**	29353.3**	18747.19**	36933.13**	3189.23**	12.22**	2371.73**
Treatments	62	20.2**	26.13	13.45**	11.19**	12.18**	0.2**	202.84**
Treatments x Environments	124	16.9**	31.49**	14.4**	11.78**	12.26**	0.13**	48.99**
Error	378	6.07	21.03	2.19	2.22	2.59	0.03	5.75
SEm(g) +		0.82	1.53	0.49	0.5	0.54	0.06	0.8
CD(5%)		2.28	4.25	1.37	1.38	1.49	0.16	2.22
SEm(gxe) +		1.42	2.65	0.85	0.86	0.93	0.1	1.38
CD(5%)		3.96	7.36	2.38	2.39	2.58	0.28	3.85
CV		4.14	6.89	2.38	2.14	21.66	6.51	5.37
GM		59.49	66.53	62.13	69.55	7.43	2.66	44.69
								8.49
								8.51

*** indicates significant at 5% and 1%, respectively.

Table-1 : Contd...

Source of variation	df	Mean sum of squares						
		Baby corn cob girth	Husked cob yield per plant	De-husked cob yield per plant	De-husked husked cob yield ratio per plant	Plant height	Moisture content	Crude protein content
Environments	2	78.99**	74304.18**	2655.61**	0.0115**	20306.23**	178.8**	184.63**
Treatments	62	1.01**	2643.67**	72.44**	0.0003**	-9966.19	9.34**	3.26**
Treatments x Environments	124	0.52**	580.91**	18.78**	0.0002**	2729.29**	7.72**	2.86**
Error	378	0.14	102.76	4.13	0.0001	51.93	1.92	0.24
SEm(g) +		0.12	3.38	0.68	0	2.4	0.46	0.16
CD(5%)		0.35	9.4	1.88	0.01	6.68	1.28	0.45
SEm(gxe) +		0.22	5.85	1.17	0.01	4.16	0.8	0.28
CD(5%)		0.6	16.27	3.26	0.02	11.57	2.22	0.79
CV		8.28	8.46	8.94	5.25	4.62	1.86	6.18
GM		4.52	119.8	22.73	0.19	155.97	74.64	7.93
								8.27
								337.63

*** indicates significant at 5% and 1%, respectively.

1.41

3.35**

3.7**

0.59

0.26

0.71

0.44

1.23

8.37

9.17

131281.29**

94230.54**

16694.54**

779.5

9.31

25.88

16.12

44.82

comprised of 15 inbred lines viz., EI-2311-4, EI-2449-2, EI-2403, EI-103, EI-104, EI-1104-1, EI-561-2, EI-2173, EI-2177-2, EI-2509, EI-2518-2, EI-11-3, EI-180, EI-225, EI-235 and 3 testers EI-670-2, EI-2518-4, EI-2156 their 45 F_{1s} and two checks viz., HM-4 and VL Baby Corn-2. These 45 F_{1s} were obtained by crossing 15 inbred lines and 3 testers in line $\times$ tester mating design.

Heterosis, heterobeltiosis and economic heterosis were calculated according to the method suggested by Shull (4), Fonseca and Patterson (5) and Meredith and Bridge (6), respectively for individual as well as over the environments.

$$\text{Heterosis (\%)} = \frac{\bar{F}_1 - \overline{MP}}{\overline{MP}} \times 100$$

It's significance was tested by using student "t" test.

$$t_{EDP} = \frac{\bar{F}_1 - \overline{MP}}{SE(\bar{F}_1 - \overline{MP})}$$

$$SE(\bar{F}_1 - \overline{MP}) = \sqrt{\frac{3MSE}{2n}}$$

Heterobeltiosis :

$$\text{Heterobeltiosis (\%)} = \frac{(\bar{F}_1 - \overline{BP})}{\overline{BP}} \times 100$$

It's significance was tested by using student "t" test.

$$t_{EDP} = \frac{\bar{F}_1 - \overline{BP}}{SE(\bar{F}_1 - \overline{BP})}$$

$$SE(\bar{F}_1 - \overline{BP}) = \sqrt{\frac{2MSE}{n}}$$

Economic heterosis :

$$\text{Economic heterosis (\%)} = \frac{(\bar{F}_1 - \overline{BC})}{\overline{BC}} \times 100$$

It's significance was tested by using student "t" test.

$$t_{EDP} = \frac{\bar{F}_1 - \overline{BC}}{SE(\bar{F}_1 - \overline{BC})}$$

$$SE(\bar{F}_1 - \overline{BC}) = \sqrt{\frac{2MSE}{n}}$$

Where,

- F1 = Mean value of hybrid
 MP = Mean of two parents of corresponding F1
 i.e. $(P_1 + P_2)/2$
 BP = Mean value of better parent
 BC = Mean value of best checks

- n = Divisor in respective conditions i.e. r in case of individual environment and rs in over the environments.
 r,s = Number of replications and environments respectively.
 MSE = Error mean square from (Table 3.7 and 3.8) for individual and over the environments, respectively.
 t_{EDF} = Student's 't' at error degree of freedom

Results and Discussion

The cross combinations viz., EI-103 $\times$ EI-2156 (13.51) for de-husked cob yield per plant, EI-180 $\times$ EI-2156 (16.02), EI-103 $\times$ EI-2156 (10.54) and EI-180 $\times$ EI-2518-4 (9.84) for husked cob weight, EI-103 $\times$ EI-2156 (17.26) for husked cob yield per plant, EI-180 $\times$ EI-2156 (16.68) for husked cob yield per plant were identified suitable for yield and yield contributing traits. Twenty one crosses in E_1 , twenty four crosses in E_2 , twenty six crosses in E_3 and thirty seven crosses on pooled over the environments, expressed significantly positive heterosis for de-husked cob yield per plant. On pooled basis, cross EI-103 $\times$ EI-2156 (40.81) expressed significantly positive desirable heterosis for de-husked cob yield per plant followed by EI-11-3 $\times$ EI-2156 (32.57) and EI-103 $\times$ EI-670-2 (28.18). These crosses depicted significant heterosis for yield contributing traits also. Ten crosses in E_2 , fourteen crosses in E_3 and nine crosses on pooled basis, possessed significantly positive heterobeltiosis for de-husked cob yield per plant. All those crosses that depicted significant heterosis on pooled basis also depicted significant heterobeltiosis on pooled basis. The cross EI-103 $\times$ EI-2156 (22.55) expressed maximum significantly positive heterobeltiosis for de-husked cob yield followed by EI-180 $\times$ EI-2156 (18.06) and EI-1104-1 $\times$ EI-2156 (13.27) on pooled analysis. Other significant crosses were EI-11-3 $\times$ EI-2156 (12.23) and EI-2177-2 $\times$ EI-2518-4 (8.95). All these crosses depicted significant heterosis for yield contributing traits also (7).

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Milk Production and Fertility Performance of Crossbred Cows Supplemented with Shatavari (*Asparagus racemosus*) Root Powder

Hitesh Muwal^{1*}, D.C. Rai¹ and V. Bhateshwar²

¹Department of Dairy Science and Food Technology, Institute of Agricultural Science, BHU, Varanasi-221005, U.P.

²Department of Agriculture, Vivekananda Global University, Jaipur-303012, Rajasthan

*Email : hiteshmuwal230@gmail.com

Abstract

The aim of the present study was to demonstrate the milk production and fertility performance of crossbred cows supplemented with Shatavari (*Asparagus racemosus*) root powder. Twenty healthy lactating crossbred cows with a close date of calving were randomly divided into two equal groups for control group (CG; n = 10) and supplemented group: Shatavari root powder 50 gm/cow/d (SG; n = 12) from 7 days post partum until 90 post partum. Statistically analyzed data revealed that fortnightly milk production significantly ($P < 0.005$) increased from 45 to 90 dpp was found in the SG (9.80 to 10.54 kg/day) compare to the CG (9.80 to 10.54 kg/day). Occurrence of first post partum estrus decreased ($P < 0.005$) in supplemented Shatavari group (SG: 52 dpp) cows compared to control group (CG: 77 dpp) cows. In this study, it was observed that the overall conception rate was higher ($P < 0.005$) in SG: 60% and lesser in the CG: 20%. The results of this study indicated that supplemented with Shatavari (*Asparagus racemosus*) root powder increased the milk production and improved fertility of crossbred cows.

Key words : Crossbred cows, fertility, shatavari root powder, milk production

Introduction

India, a developing country is a land of villages and more than 70% of the human population still depends upon agriculture and livestock sector for their livelihood. Livestock sector plays a critical role in the welfare of India's rural population. India is the highest milk producer in the world and with increase in number of milch animals (in-milk and dry) in cows and buffaloes has increased from 111.09 million to 118.59 million, an increase of 6.75% [1]. The growth is on account of both improvements in productivity and shift in priorities towards buffalo and crossbred cattle. Yet, the productivity is low compared to the potential and world average. Out of the total 190.90 million cattle present in India, 39.73 million are crossbred cattle [1]. Contribution of crossbred cattle to the 44% of the total cattle milk production was 16% [2] 6.75 vs. 1.98 lit/day [3]. They are more prone to environmental stress, diseases and infertility and sub-fertility due to sub-estrous, anoestrus, repeat breeding and longer post partum interval (PPI) days open and service per conception.

Sahiwal cow a zebu breed of cattle has all the desirable characteristics for an efficient dairy animal in addition to high milk yields viz. heat tolerance, tick and parasite resistance, ease of calving, bloat tolerant, good temperament and disease resistance which are perfectly suited for arid and tropical climatic condition. There is a need for agents to alleviate environmental stressors for improving productivity in this breed of cattle. Sahiwal is

the heaviest milker of all zebu breeds and display a well-developed udder.

The ancient history of India is very rich in herbal medicine. Ayurveda, one of the oldest surviving systems of health care in the world is totally based on herbs. There are several herbs which have been described in the Ayurveda to improve the general well beings, milk production and reproduction of both human and animals. Among them, Shatavari (*Asparagus racemosus*) needs a special mention. Ayurveda described that Shatavari overcomes all reproduction related complications and improves overall physiological system so called pillars of health including digestion, energy metabolism, immune and reproductive system. Shatavari is a creeper grown in all the tropical countries which is an important medicinal plant of tropical and subtropical India since prehistoric times. The genus *Asparagus* includes about 300 species around the world. Out of these, 22 species of *Asparagus* are found in India; In Sanskrit, the meaning of Shatavari is described as "able to have one hundred husbands" and in Ayurveda this amazing herb is known as the "queen of herbs". In Ayurveda, Shatavari has been described as absolutely safe for long term use, even during pregnancy and lactation. So it is recommended during last and first trimester of pregnancy to restore the mother's energy, boosts the immunity of both mother and foetus, promote quality breast milk and promote digestion (Maasaanumaasi kapathya, Garbhini Paricharya, Prasuthi Tantra, Ayurveda).

Table-1 : Feeding schedule of lactating Sahiwal crossbred cows.

S. No.	Feed and fodders	Quantity of feed and fodders
1.	Wheat straw	8.0 kg offered and fed ad lib.
2.	Concentrate mixture	2.0 kg for maintenance ration/animal and @ 1.0 kg/2.5 litre milk production for production ration
3.	Green Lucerne	5.0 kg/head/day
4.	Shatavari root powder	@ 50 g/head/day was offered

Table-2 : Effect of Shatavari (*Asparagus racemosus*) root powder on fortnightly milk production (Kg) of crossbred cows.

Days	Treatments	
	CG	SG
0	9.41 ± 0.35	9.62 ± 0.44
15	9.53 ± 0.56	9.78 ± 0.58
30	9.65 ± 0.48	10.15 ± 0.24
45	9.80 ± 0.26	10.73* ± 0.15
60	10.00 ± 0.20	11.54* ± 0.10
75	10.28 ± 0.11	11.92* ± 0.23
90	10.54 ± 0.26	12.39* ± 0.19
Overall mean	9.88 ± 0.15	10.87* ± 0.41

*(P<0.005)

Materials and Methods

Twenty healthy lactating crossbreed cows with the beginning date of calving were randomly allotted into two equal groups: control group (CG; n = 10; Milk production = 9.41±0.35 kg/d) and supplemented group (SG; n = 10; Milk production = 9.62 ± 0.44 kg/d). The experimental groups received a basal diet twice daily containing wheat straw (*Triticum aestivum*) ad lib, green lucerne (*Medicago sativa*) as a green fodder and concentrate mixture in a mixed-ration (Table-1). Diets of lactating cows were formulated as per the nutritional requirements of [4]. Only the SG-cows were orally supplemented with Shatavari root powder (50 gm/cow/d) during the entire experimental period, which lasted from 7 days after calving to 90 dpp. Cows were milked twice daily by hand milking according at (05:00 AM and 04:00 PM). Productions of milk were measured using an automatically (Electric digital scale weighing balance machine) and individual cow's milk productions (kg/d) were recorded every day, however, only milk production data from the last 15 days of each period (dpp on 0, 15, 30, 45, 60, 75 and 90).

Detection of estrus was performed twice daily, in the morning and evening, for at least 30 minutes. In addition, during the remainder of the day, any cows that showed estrus behaviour were reported to the inseminators by the farm workers.

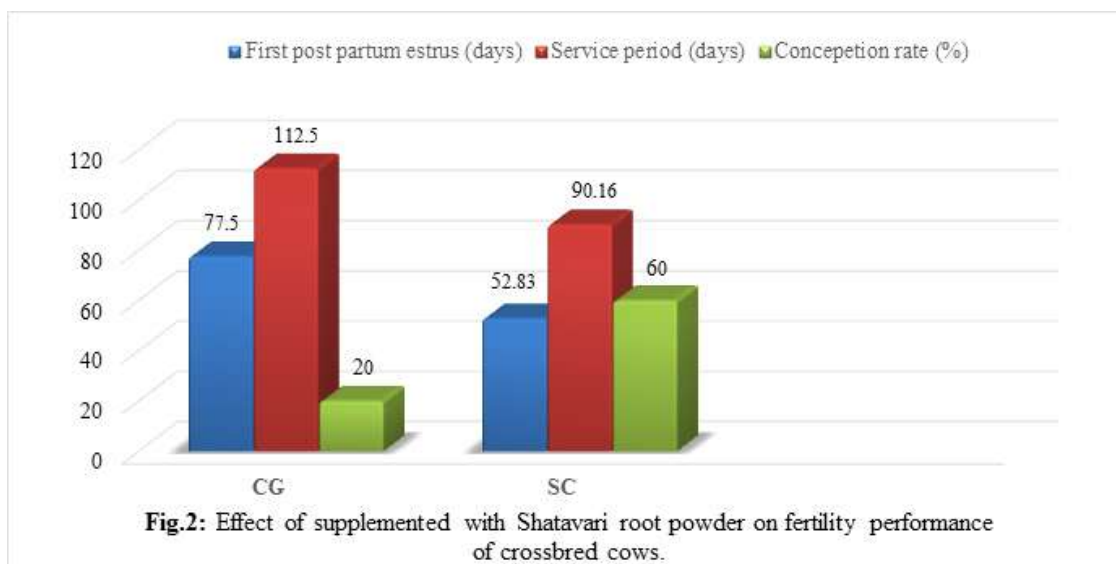
Data related to milk production and fertility performance were statistically analyzed using the one-way analysis of variance (SPSS version 21.0) for completely randomized design. All statement of significant differences was based on the 0.005 probability level. Significant differences among treatment, within the

experiment, were analyzed using the SPSS statistical software program.

Results and Discussion

The results (Table-2) showed that the fortnightly milk production were similar from 0 to 30 dpp in cows of both groups CG (9.41 to 9.65 kg/d) and SG (9.62 to 10.15 kg/d). However, from 45 to 90 dpp in SG cows which provides additional Shatavari root powder were significantly (P<0.005) higher in fortnightly milk production (10.73 to 12.39 kg/day) which over than CG cows (9.80 to 10.54 kg/day) respectively. The similar result also found by [5] evaluated significant improvement in overall milk production were increased 1.06±0.17 kg (11.47%) daily and average milk production in buffaloes and cows were increased 0.8±0.34 kg (9.0%), 1.32±0.15 kg (12.72%) respectively as compared to their previous production. Shatavari significantly (P<0.05) increased milk production during supplementation by 20 percent in treatment group (23.40 kg) over control group (19.50 kg) [6]. Polyherbal supplementation containing Shatavari @ 200 mg/kg BW, significantly increased the milk production by 12.24, 15.01 and 10.50% during supplementation, residual and post residual periods [7]. The milk production was increased 0.60±0.27 kg (9.67%) daily respectively as compared to their previous production supplementation of 50 gm powder of shatavari roots in concentrates [8].

Fig.-1 showed that the mean of first post partum estrus was 77.50±2.50 and 52.83±1.27 in the CG and SG respectively. The first post partum estrus day was significantly less in SG than CG. However, statistical analysis showed that there was significantly (P<0.005) differences among the CG and SG groups. The means of



service period (days) in CG and SG was 112.50 ± 2.50 and 90.16 ± 1.44 , respectively (Fig.-1). The statistical analysis indicated that the service period in SG was significantly reduced ($P < 0.005$) than that of CG group, which might be due to stage of lactation and initiation of supplementation of *Asparagus racemosus*. The present findings were in agreement with the effect of supplementation of *Asparagus racemosus* root powder weight at postpartum (up to 90 days), significantly ($P < 0.05$) lowered service period, service per conception and but significantly ($P < 0.05$) increased conception rate in treatment group than control [6]. Reproduction performance as indicated by lesser days to postpartum oestrus, first service, number of services/conception, lower service period and higher conception rate in polyherbal supplementation fed groups was better than control [7]. In the similar way the effect of Shatavari root powder found significant ($P < 0.05$) reduction in service period and service/conception in experimental group than control group [9, 10].

Conclusions

The results of this study indicated that supplemented with Shatavari root powder increased the milk production and improved fertility rate over cows with non-supplemented group from calving up to 90 days post partum. These results are only indicative and require further experimentation to arrive at some more consistent conclusion.

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Principal Component Analysis for Evaluation of Single Cut Forage Oat (*Avena sativa* L.) Germplasm Accessions

Ravi Kumar Nechu^{*1}, S.K. Bilaiya¹, A.K. Mehta¹, Manmohan Singh² and Parul Singhal¹

¹Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, M.P.-482004

²Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan-313001

*Corresponding Author Email : ravinechu@jnkvv.org

Abstract

Thirty three genotypes including two checks of single cut forage oat (*Avena sativa* L.) green fodder yield and its contributing traits in single cut oat were evaluated to assess genetic diversity for green fodder yield and yield contributing traits during Rabi season 2020-2021 under AICRP on Forage Crops, Seed Breeding Farm, JNKVV, Jabalpur. The traits were studied through principal component analysis (PCA). Out of 15 Principal components (PC) three principal components have eigen values higher than one and overall explained 83.66% of the total included variability. The PC1 (first principal component) explained 58.6 % of the total variation. The PC2 and PC3 explained 14.96, and 10.11% of the total variability respectively. The data revealed that the PC1 comprised most of the variability for different traits viz., number of tillers/plant, stem diameter, number of leaves/plant, LAI, leaf stem ratio, GFY/plant/day, DMY/plant, DMY/plant/day, CPY/plant, CPY/plant/day and GFY/plant. PC2 dominated with plant height, internodal length and penultimate leaf area while PC3 with days to maturity and stem diameter. On the basis of PC scores genotypes BAUO-103, RO-11-4 and OL-1971 are the major source of variation among oat population and this information would be useful for selecting these lines for future oat improvement programme.

Key words : Oat, green fodder yield, PCA, genetic diversity, eigen value.

Introduction

Crop production and animal husbandry go hand in hand and complementary to each other. The growth of livestock sector is about 1.5 times higher than that of crop sector which implies the fodder production is not sufficient to meet the requirements. The present availability of green fodder is 462 million tonnes and dry fodder is 394 million tonnes in the country. It shows a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients. To meet the deficit, green forage supply has to grow at 1.69% annually. (IGFRI, 2013; Kumar, 2018).

Oat is an important versatile *Rabi* cereal crop cultivated for fodder, grain, pasture and crop rotation which is better adapted to cold, moist climate, acidic soil and requires less amount of water as compare to other cereal crop (Murphy and Hoffman, 1992). Because of its high protein content, fat, minerals, dry matter digestibility, palatability and antioxidant property, it is used both for animal feed and human feed (Peterson *et al.*, 2005). It is a self pollinated winter cereal crop native of Mediterranean region and rank sixth in world cereal production. Oat provides huge green fodder at the time when other succulent fodder is scarce (Rajhathy and Thomas, 1974; Kumari *et al.*, 2019; Rana *et al.*, 2019).

The main objective of any crop improvement programme is to enhance yield. Plant breeder always

tries to develop new cultivar which is high yielding, better quality and resistant to different abiotic and biotic stresses. For this plant breeder select the desirable genotypes from the available genepool and used them in different breeding methods. As yield is a complex trait and is the combined result of a number of component traits. Therefore, selection of superior genotypes based on yield alone is not so effective. In order to make it effective one has to focus on the component traits, which contribute to yield in positive directions.

Principal Component Analysis is a standard tool in modern data analysis. It reduces the dimensionality of the data while retaining most of the variation in the data set by identifying directions, called principal components, along which the variation in the data is maximal. It is valuable tool for assessment of germplasm lines as it simultaneously describes the relationships between sets of variables. It helps to diminish the dimension of multivariate data by eliminating inter-correlation between variables and agree to a multi-dimensional relationship to be plotted on two or three principle axis. As a result, PCA allow to show the differences among the individuals, identification of possible groups and finding relationships among individuals and variables.

Materials and Methods

The experiment was carried out during *Rabi* season 2020-2021 under, All India Coordinated Research Project

Table-1 : Eigen values and total variability explained by different PCs.

Principal component (PC)	Eigen value	Variability explained (%)	Cumulative variability explained (%)
PC1	8.7895	58.5964	58.5964
PC2	2.2434	14.9559	73.5523
PC3	1.5167	10.1115	83.6637
PC4	0.7480	4.9866	88.6504
PC5	0.7185	4.7898	93.4401
PC6	0.4162	2.7745	96.2147
PC7	0.2399	1.5995	97.8142
PC8	0.1711	1.1407	98.9549
PC9	0.0753	0.5022	99.4571
PC10	0.0485	0.3233	99.7804
PC11	0.0193	0.1284	99.9089
PC12	0.0128	0.0853	99.9942
PC13	0.0007	0.0044	99.9985
PC14	0.0002	0.0013	99.9998
PC15	0.00002	0.0002	100.0000

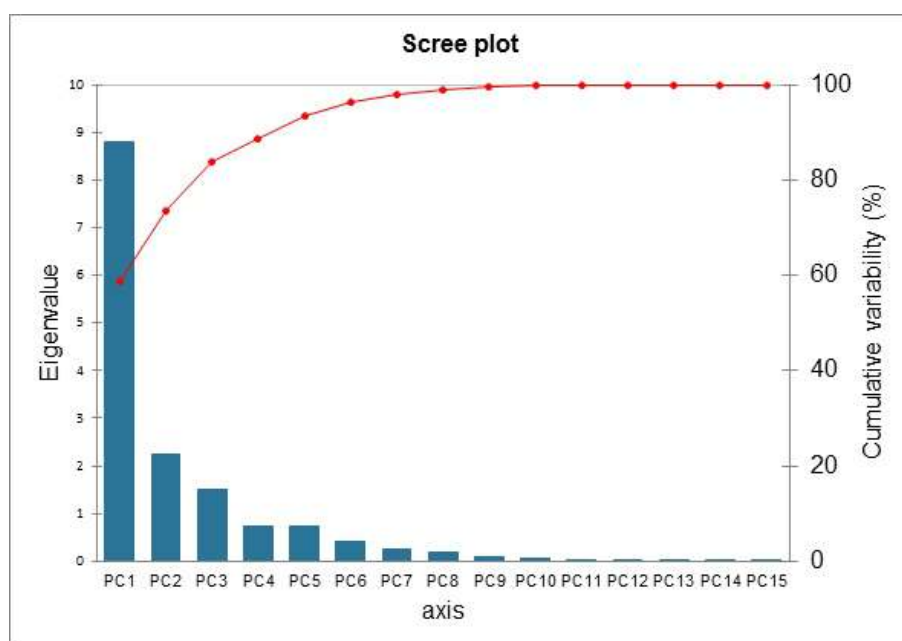


Fig.-1 : Scree plot diagram of eigen values and PCs.

on Forage Crops, Department of Genetics & Plant Breeding at Seed Breeding Farm, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) at 23°21' North latitude, 79°94' East longitude and at an altitude of 411.78 meters from the mean sea level. This area as per NBSSLUP (National Bureau of Soil Science and Land Use Planning) of ICAR (Indian Council of Agricultural Research) comes under 10.1 "sub-humid dry eco- sub region" of agro-ecological zone. The crop was grown under normal crop season.

The experimental material consisted of 33 genotypes of single cut (SC) fodder oat. viz. BAUO-103, JHO-20-1, NDO-1902, SKO-244, OL-1980, JO-08-37, OL-1977, HFO-1009, HFO-1003, HFO-1013, BAUO-101,

UPO-20-1, OL-1974, OL-1971, HFO-1018, RO-11-4, OL-1874-1, OL-1876-1, RO-11-1-3, JO-06-23, SKO-241, RO-11-1-2, HFO-806, JO-08-41, JO-09- 48, OL-1876-9, HFO-904, HFO-906, OL-1960, JO-07-28, SKO-94, JO 1 Check (Zonal) and KENT Check (National).

All genotypes were evaluated in a randomized complete block design (RCBD) with three replications. Each treatment was sown in 3.0 m row length spaced at 25 cm. Observations were recorded from the 5 randomly selected plants, which were true representative of the plot, from each replication of each treatment at 50 per cent flowering.

The observations recorded for fifteen traits viz. Days to maturity, number of tillers/plant, plant height (cm), stem

Table-2 : Factor loading of different traits.

Character	Rotated Component Matrix		
	PC1	PC2	PC3
Days to maturity	0.393	0.427	-0.640
Number of tillers/plant	0.804	-0.465	-0.011
Plant height	0.483	0.705	0.096
Stem diameter	0.553	0.391	0.590
Internodal length	-0.092	0.740	-0.353
Number of leaves/plant	0.905	-0.152	-0.088
Penultimate leaf area	0.254	0.732	0.358
LAI	0.955	0.120	0.028
Leaf-stem ratio	0.571	-0.097	-0.475
GFY/plant/day	0.883	-0.198	0.363
DMY/plant	0.957	0.023	-0.130
DMY/plant/day	0.964	-0.028	-0.046
CPY/plant	0.947	-0.013	-0.201
CPY/plant/day	0.954	-0.080	-0.107
GFY/plant	0.941	-0.130	0.245

Table-3 : Interpretation of rotated component matrix for the traits having PF value > ± 0.5 .

PC1		PC2		PC3	
Character	Number of tillers/plant	Plant height	Days to maturity		
	Stem diameter	Internodal length	Stem diameter		
	Number of leaves/plant	Penultimate leaf area			
	LAI				
	Leaf-stem ratio				
	GFY/plant/day				
	DMY/plant				
	DMY/plant/day				
	CPY/plant				
	CPY/plant/day				
	GFY/plant				

diameter (mm), internodal length (cm), number of leaves/plant, penultimate leaf area (cm²), leaf area index (LAI), leaf stem ratio, green fodder yield (GFY)/plant/day (g), dry matter yield (DMY)/plant (g), DMY/Plant/day (g), crude protein yield (CPY)/Plant (g), CPY/plant/day (g) and GFY/plant (g) were subjected to various statistical and biometrical analyses viz., Principal Component Analysis (Massey, 1965 and Jolliffe, 1986)

Results and Discussion

Principal Component Analysis (PCA) is basically a technique for data reducing, firstly explained by Pearson (1901) and later on evolved by Hotelling (1933) that provide solution to the complex problem of bigger and uncontrollable data through transforming the original set of variables into a smaller set that explain for majority of the variability of the original data. Principal component analysis helps in identifying the most relevant characters and presents them in easy and more visualized dimensions through linear combinations of variables that accounts for most of the variation presents in original set of variables.

In this experiment, principal components with eigen values higher than one were selected for interpretation hence three principal components had eigen values greater than one and overall explained 83.66% of the total included variability as shown in Table 1 and screen plot diagram in fig.-1. The PC1 (first principal component) explained 58.6 % of the total variation. The PC2 and PC3 explained 14.96, and 10.11% of the total variability respectively. Sood *et al.* (2020) also obtained three PCs having eigen values higher than one.

Principal factor analysis was carried out because PCA does not provide a complete picture of components. In principal factor analysis each observed variable reflects linearly in terms of a common factor and a unique factor. The common factors contribute for the correlation among the variables whereas each unique factor contributes for the residual variance (error variance) of that variable. In PCA, the total variation present in a set of variables is measured, while in principal factor analysis measures that part of variance which is shared by the common factors. Also in contrast to principal component analysis, here the

Table-4 : PC scores for different genotypes of single cut oat.

Genotype	PC1	PC2	PC3
BAUO-103	2.859	1.930	1.358
JHO-20-1	-1.225	-1.342	0.175
NDO-1902	-2.740	-1.362	-0.229
SKO-244	-3.402	-2.668	1.075
OL-1980	-2.801	-0.590	-1.086
JO-08-37	1.564	0.897	-0.306
OL-1977	1.253	0.738	0.586
HFO-1009	-2.082	-2.552	0.936
HFO-1003	-1.569	0.119	1.564
HFO-1013	-1.094	1.199	0.591
BAUO-101	-1.275	0.959	0.265
UPO-20-1	-0.919	0.743	-0.385
OL-1974	0.169	1.765	-2.547
OL-1971	0.579	2.105	2.044
HFO-1018	-2.281	-1.162	-1.601
RO-11-4	2.723	1.111	-0.578
OL-1874-1	8.828	-0.156	0.553
OL-1876-1	-3.061	-0.682	1.328
RO-11-1-3	6.287	-0.154	0.792
JO-06-23	-0.187	-2.268	1.686
SKO-241	-0.085	1.011	-1.371
RO-11-1-2	-1.852	-0.709	-2.650
HFO-806	-0.006	2.211	-0.370
JO-08-41	-2.032	-0.226	0.342
JO-09-48	-1.563	-0.655	2.187
OL-1876-9	-1.401	1.284	-1.127
HFO-904	-2.022	1.047	0.560
HFO-906	-1.549	2.956	0.182
OL-1960	7.952	-2.526	-0.100
JO-07-28	-0.178	0.703	-0.312
SKO-94	-2.707	0.098	0.084
JO1 (C)	3.087	-1.762	-1.971
KENT (C)	0.732	-2.062	-1.675

Note : Bold fonts were used to group genotypes with > 1 positive PC scores.

variables axes are allowed to interrelate resulting in distortion of mutual orthogonality.

Without rotation the principal factor analysis did not derive the exact picture of interaction among the characters. This did not give accurate model regarding the idea of character association with respective principal factor as some factors had very high loading of variable and some have none. To select the prominent characters in various PFs (Principal Factors), the correlation values (> (± 0.5)) were considered as appropriate for that principal factor. Factor loading of various characters with varimax rotation have been presented in Table-2.

Data presented in Table-2 and Table-3 revealed that the PC1 comprised most of the variability for different traits viz., number of tillers/plant, stem diameter, number of leaves/plant, LAI, leaf-stem ratio, GFY/plant/day,

Table-5 : List of advanced lines of single cut oat with >1 PC scores.

S. No.	Genotypes	PC1	PC2	PC3
1.	BAUO-103	2.859	1.93	1.358
2.	JHO-20-1			
3.	NDO-1902			
4.	SKO-244			1.075
5..	OL-1980			
6.	JO-08-37	1.564		
7.	OL-1977	1.253		
8.	HFO-1009			
9.	HFO-1003			1.564
10.	HFO-1013		1.199	
11.	BAUO-101			
12.	UPO-20-1			
13.	OL-1974		1.765	
14.	OL-1971		2.105	2.044
15.	HFO-1018			
16.	RO-11-4	2.723	1.111	
17.	OL-1874-1	8.828		
18.	OL-1876-1			1.328
19.	RO-11-1-3	6.287		
20.	JO-06-23			1.686
21.	SKO-241		1.011	
22.	RO-11-1-2			
23.	HFO-806		2.211	
24.	JO-08-41			
25.	JO-09- 48			2.187
26.	OL-1876-9		1.284	
27.	HFO-904		1.047	
28.	HFO-906		2.956	
29.	OL-1960	7.952		
30.	JO-07-28			
31.	SKO-94			
32.	JO1 (C)	3.087		
33.	KENT (C)			

1 PC common 2 PC common 3 PC common

DMY/plant, DMY/plant/day, CPY/plant, CPY/plant/day and GFY/plant. PC2 dominated with plant height, internodal length and penultimate leaf area while PC3 with days to maturity and stem diameter. The results obtained are in close proximity with the earlier researchers, Kumar *et al.*(2006), Kujur *et al.*(2017), Kumari *et al.*(2019) and Sood *et al.* (2020).

The first three PCs are consisting maximum variability (83.66%) using rotated component matrix. Hence, the traits in these three PCs may be given due importance in oat improvement programme.

PC scores of oat lines : In 31 advanced lines and two checks of oat, high PC score for all the traits were estimated in these three components and are presented in Table-4 and Table-5. These scores can be utilized to

propose precise selection indices whose intensity can be decided by variability explained by each of principal component. High PC score for a particular line in a particular component denotes high values for the variables in that particular genotype.

The lines which exhibited higher PC1 scores BAUO-103 (2.859), JO-08-37 (1.564), OL-1977 (1.253), RO-11-4 (2.723), OL-1874-1 (8.828), RO-11-1-3 (6.287), OL-1960 (7.952) and JO1 (3.087). The high score for PC2 was observed for genotypes viz., BAUO-103 (1.93), HFO-1013 (1.199), OL-1974 (1.765), OL-1971 (2.105), RO-11-4 (1.111), SKO-241 (1.011), HFO-806 (2.211), OL-1876-9 (1.284), HFO-904 (1.047) and HFO-906 (2.956) whereas high score for PC3 was observed for genotypes; BAUO-103 (1.358), SKO-244 (1.075), HFO-1003 (1.564), OL-1971 (2.044), OL-1876-1 (1.328), JO-06-23 (1.686) and JO-09-48 (2.187).

Conclusions

The results clearly indicated that PC1 was constituted by most of the fodder yield attributing traits, an intensive selection procedure can be designed to bring out rapid improvement of dependent traits *i.e.*, yield by selecting the lines from PC1. PC scores suggests that the genotypes BAUO-103, RO-11-4 and OL-1971 are the major source of variation among oat population and this information would be useful for selecting these lines for future oat improvement programme.

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Character Association and Path Analysis Study in Chickpea (*Cicer arietinum* L.)

Manmohan Singh^{1*}, P.B. Singh¹ and Ravi Kumar Nechu²

¹Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan-313001

²Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, M.P.-482004

*Corresponding Author Email : mannkaswan101@gmail.com

Abstract

The present investigation was conducted in chickpea (*Cicer arietinum* L.) Genotypes during *rabi*, 2019-20. In the experiment twenty five diverse genotypes including three checks viz., PC-1, JG-16 and JG-315 of chickpea, were grown at the instructional farm, CTAE, MPUAT, Udaipur. This experiment was conducted in RBD with three replications. The correlation studies showed that the seed yield per plant was exhibited significantly and positively correlated with number of secondary branches per plant, biological yield per plant and harvest index at genotypic level. Harvest index, number of secondary branches per plant and biological yield per plant were showed positively and significantly correlated with seed yield per plant at phenotypic level. These associations indicated that improvement in seed yield can be achieved by improving the above characters. Path coefficient analysis revealed that maximum positive direct effect was observed for harvest index followed by days to maturity, plant height, number of seeds per pod, number of primary branches per plant, days to 50% flowering, protein content and number of secondary branches per plant on seed yield per plant. Plant height had considerable positive indirect effect on seed yield per plant via harvest index. Thus these characters can be used for yield improvement in chickpea.

Key words : Chickpea, correlation, path coefficient analysis.

Introduction

Chickpea (*Cicer arietinum* L.) belonging to the family Fabaceae, sub-family Fabioidea. It is a self pollinated leguminous crop with chromosome no. $2n=14$. It is native crop of India. Chickpea is also known as Gram, Bengal gram, Garbanzo, Garbanzo bean and Egyptian pea.

The root system in chickpea is tap root with root nodules. Roots are robust and make its major portion up to 60cm, although as deep as 2 m. The stem is generally 0.2-1m tall, herbaceous, may be shrubby and erect or spreading with much branching. The stem may be of dark green, bluish green or olive color and has glandular pubescence. Leaves are stipulate, alternate, imparipinnate, glandular, pubescent with 3-8 pairs of leaflets and a top leaflet (rachis ending in a leaflet) pinnately compound and have pulvinate leaf base; leaflets ovate to elliptic. The flower of chickpea is complete, bisexual, zygomorphic, hypogynous, pentamerous solitary, axillary and polypetalous standard aestivation. Calyx is gamosepalous, lanceolate and densely covered with hairs. Corolla is polypetalous, papilionaceous having five petals, odd petal posterior, consisting of a posterior standard two lateral wings, two anterior ones forming a keel (enclosing stamens and pistil), vexillary aestivation. Stamens are ten in number in diadelphous (9 anthers are fused + 1 anther is free), condition of ovary is superior, sessile, inflated and pubescent. Majority of buds commence opening between 8.00 a.m. to 11.00 a.m. After fertilization, pod formation

starts in 5-6 days. Fruits (pods) known as Legume. Pods are rhomboid ellipsoid, containing one/two or rarely three seeds and inflated, glandular-pubescent. Seed colour cream, yellow, brown, black, or green, rounded to angular, seed coat smooth or wrinkled. It is largely grown as rainfed but can also be grown as irrigated crop.

Chickpea is one of the major pulses cultivated and consumed in India. It is an important food legume providing protein in human diet. It is also a major and cheap source of protein compared to animal protein. It contains 21-24 per cent protein, 2.2 per cent fat, 62 per cent carbohydrates. It also contains 190 mg/100g calcium, 280 mg/100g phosphorous and 90.5 mg/100g iron and high percentage of other mineral nutrients and unsaturated oleic and linoleic acid. Among pulses, chickpea has relatively lower protein content but of higher biological value and protein digestibility. The granular hair of leaves and pods secretes two acids in liquid forms Malic acid (90-96%) and Oxalic acid (4-10%).

The trend of production of top 5 states of India is Madhya Pradesh followed by Rajasthan followed by Maharashtra followed by Karnataka followed by Uttar Pradesh while Telangana have highest productivity i.e., 1.54 t ha^{-1} . The total area, production and yield are 2463029 ha, 2660934 tonnes and 1080 kg ha^{-1} respectively in Rajasthan. Large variation is seen in terms of area (ha), production (tonnes), yield/productivity (kg ha^{-1}) in Rajasthan. Top 5 districts in terms of area (ha) for chickpea production are Churu followed by

[illegible]

Table-2 : Genotypic path coefficients for seed yield per plant in chickpea.

S. No.	Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches per plant	No. of pods per plant	No. of seeds per pod	100 Seed weight(g)	Harvest index (%)	Protein content (%)	r with seed yield per plant
1.	Days to 50% flowering	0.1066	-0.1491	-0.1492	0.0855	0.0040	-0.0410	-0.0576	-0.0067	-0.0715	-0.0238	-0.3027
2.	Days to maturity	-0.0278	0.5709	-0.0434	0.0616	-0.0132	-0.1673	-0.0932	-0.0956	-0.2035	0.0078	-0.0038
3.	Plant height (cm)	-0.0309	-0.0482	0.5143	-0.0767	0.0135	0.0510	0.0380	0.0981	-0.4145	-0.0069	0.1377
4.	No. of primary branches per plant	0.0346	0.1333	-0.1496	0.2638	0.0086	-0.1512	-0.1243	-0.0955	0.2301	0.0022	0.1518
5.	No. of secondary branches per plant	0.0089	-0.1566	0.1447	0.0469	0.0481	0.0334	-0.0286	0.0239	0.2596	-0.0164	0.3639
6.	No. of pods per plant	0.0126	0.2760	-0.0758	0.1152	-0.0046	-0.3462	-0.0400	-0.0039	0.0667	-0.0105	-0.0106
7.	No. of seeds per pod	-0.0214	-0.1851	0.0680	-0.1141	-0.0048	0.0482	0.2875	0.1237	-0.2540	0.0007	-0.0513
8.	100 Seed weight(g)	0.0027	0.2087	-0.1929	0.0963	-0.0044	-0.0051	-0.1359	-0.2616	0.3640	0.0277	0.0995
9.	Harvest index (%)	-0.0068	-0.1038	-0.1904	0.0542	0.0112	-0.0206	-0.0652	-0.0851	1.1195	0.0016	0.7146**
10.	Protein content (%)	-0.0344	0.0602	-0.0481	0.0078	-0.0107	0.0492	0.0028	-0.0981	0.0238	0.0739	0.0264

Residual = 0.3758, **, Significant correlation with dependent char at 5% and 1% respectively.

Hanumangarh, Bikaner, Ajmer and Jaisalmer while production trend is different Ajmer followed by Bikaner, Jaipur, Tonk, Hanumangarh and the trend of productivity so much different from this *i.e.*, Chittorgarh followed by Sawaimadhopur, Baran, Rajsamand and Bundi (1).

The main objective of any crop improvement programme is to enhance yield. Plant breeder always tries to develop new cultivar which is high yielding, better quality and resistant to different abiotic and biotic stresses. For this plant breeder select the desirable genotypes from the available genepool and used them in different breeding methods. As yield is a complex trait and is the combined result of a number of component traits. Therefore, selection of superior genotypes based on yield alone is not so effective. In order to make it effective one has to focus on the component traits, which contribute to yield in positive directions.

Information on genetic association among components of economic worth is very important in improving the efficiency of selection programme. For this studies on the correlation of traits and their relative direct and indirect effects are important for formulating selection indices. Path coefficient analysis is simply a standardized partial regression coefficient which split the correlation coefficient into the measures of direct and indirect effects. Analysis of path coefficient is based on all simple correlation aiming various characters. It estimates the direct and indirect contribution of various independent characters on a dependent character. It also estimates residual effects. Path analysis helps in determining the yield contributing characters and thus helpful in indirect selection. In the present study 25 genotypes were analysed for twelve diverse quantitative characters to judge the variability pattern, association of different characters in term of contribution to yield, classify promising genotypes and identify putative genotypes for higher yield.

Materials and Methods

The present investigation was carried out during *Rabi* 2019-2020 at the instructional farm CTAE, MPUAT, Udaipur. The 25 genotypes along with 3 checks of chickpea were evaluated for genetic variability, correlation and path analysis for 12 economically important traits during *Rabi* 2019-2020. Udaipur is situated at an elevation of 579.5 meters above mean sea level, latitude of 24°35' North and longitude of 73°42' East.

The experimental material used in the present investigation was consisted of the 25 diverse chickpea genotypes viz., PBC-511, PBC-512, PBC-514, PBC-515, PBC-517, PBC-518, PBC-519, PBC-520, PBC-521, PBC-522, PBC-527, PBC-530, PBC-531, PBC-532,

PBC-1103, PC-1, JG-16 and JG-315 representing diversity in adaptability and geographical origin. The experimental material was evaluated for genetic variability, correlation analysis and path analysis for 12 economically important traits during *Rabi 2019-2020*. The experimental materials consisting of twenty five diverse genotypes of chickpea were sown in randomized block design in three replications. Each entry was planted in a plot size of 4 x 1.50 m² accommodating 5 rows of 4 m length, keeping row to row and plant to plant distance of 30 cm and 10 cm, respectively. All the recommended package of practices was followed to raise a good and healthy crop.

Five competitive plants for each entry were randomly selected for recording observations for all the quantitative characters in each replication except days to 50 per cent flowering and days to maturity, where observations were recorded on plot basis.

The data were subjected to various statistical and biometrical analyses viz., Correlation analysis as per the procedure described by Singh and Choudhary (1979), The estimates of direct and indirect effects were calculated by the path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

Results and Discussion

Correlation coefficient analysis : Correlation coefficient at phenotypic and genotypic levels were estimated using twelve characters in twenty five genotypes of chickpea to study the degree of mutual relationship between yields and its component traits. The estimates are present in Table 1. Perusal of the results revealed that the estimates of genotypic correlation coefficients were higher in magnitude than their corresponding correlation coefficient at phenotypic level. This indicated that how much of phenotypic correlation coefficient are influenced by environment.

Days to maturity exhibited positive and significant correlation coefficient with number of pods per plant ($rg = 0.48^{**}$ and $rp = 0.42^{**}$) at both genotypic and phenotypic levels while it showed positive and significant correlations with 100-seed weight ($rg = 0.37^{*}$) at genotypic level only. Plant height established positive and significant correlation coefficient with biological yield per plant ($rg = 0.53^{**}$ and $rp = 0.45^{**}$) at both genotypic and phenotypic level while it showed negative and significant correlation with 100-seed weight ($rg = -0.37^{*}$ and $rp = -0.36^{*}$) at both genotypic and phenotypic levels. Number of primary branches per plant had positive and significant correlation with number of pods per plant ($rg = 0.44^{*}$ and $rp = 0.31^{*}$) and 100-seed weight ($rg = 0.37^{*}$ and $rp = 0.34^{*}$) at both

genotypic and phenotypic level while it exhibited negative and significant correlation coefficient with number of seeds per pod ($rg = -0.43^{*}$ and $rp = -0.31^{*}$) at both genotypic and phenotypic level. Number of secondary branches per plant exhibited positive and significant correlations coefficient with seed yield per plant ($rg = 0.36^{*}$ and $rp = 0.34^{*}$) at both genotypic and phenotypic levels. Number of seeds per pod exhibited negative and significant correlations coefficient with 100-seed weight ($rg = -0.47^{*}$ and $rp = -0.30^{*}$) at both genotypic and phenotypic levels. 100-seed weight had positive and significant correlation with protein content ($rg = 0.37^{*}$) at genotypic level only. Biological yield per plant exhibited positive and significant correlations coefficient with seed yield per plant ($rg = 0.70^{**}$ and $rp = 0.64^{**}$) at both genotypic and phenotypic levels. Harvest index exhibited positive and significant correlations coefficient with seed yield per plant ($rg = 0.71^{**}$ and $rp = 0.71^{**}$) at both genotypic and phenotypic levels.

The seed yield per plant had positive and significant correlation with number of secondary branches per plant, biological yield per plant and harvest index at both genotypic and phenotypic levels. Similar results also reported by Jivani *et al.* (2013), Aarif *et al.* (2014), Malik *et al.* (2014), Joshi and Yasin (2015), Chopdar *et al.* (2017) Dhuria and Babbar (2017) and Priyadarsini *et al.* (2017).

Path analysis : Path coefficient analysis was conducted to assess the magnitude of contribution of various yield contributing traits to yield in the form of cause and effect. Seed yield per plant was taken as dependent variable and days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, 100-seed weight, harvest index and protein content were treated as independent variables. It revealed whether the association of these independent characters with yield is due to their direct effect on yield or is consequence of their indirect effect *via* other component characters. The estimates of path coefficient analysis using genotypic and phenotypic correlation are presented in Table 2.

Direct Effect : The influence of characters can be judged by magnitude of direct effect and irrespective of its direction. The maximum direct positive effect on seed yield per plant was observed in harvest index (1.12) followed by days to maturity (0.57), plant height (0.51), number of seeds per pod (0.29), number of primary branches per plant (0.26), days to 50% flowering (0.11), protein content (0.07) and number of secondary branches per plant (0.05). Maximum negative direct effect on seed yield per plant was observed from number of pods per plant (-0.35) followed by 100-seed weight (-0.26).

Indirect Effect : The indirect effects on seed yield per plant at genotypic level accessed *via* different characters are presents in Table-2. The highest positive indirect effect was observed from 100-seed weight through harvest index (0.36) followed by number of pods per plant *via* days to maturity (0.28), number of secondary branches per plant *via* harvest index (0.26), number of primary branches per plant *via* harvest index (0.23) and 100-seed weight through days to maturity (0.21).

The maximum negative indirect effect was observed by plant height *via* harvest index (-0.41) followed by number of seeds per pod through harvest index (-0.25), days to maturity *via* harvest index (-0.20), 100-seed weight *via* plant height (-0.19) and harvest index *via* plant height (-0.19).

Path analysis was demonstrated at the genotypic level for seed yield per plant for 10 traits, out of these trait only harvest index showed positive and significant correlation coefficient toward seed yield per plant, so only above trait which showed significant correlation coefficient to seed yield per plant is explained.

The harvest index showed a positive direct effect (1.12) on seed yield per plant. It revealed positive indirect effect *via* number of primary branches per plant (0.05) and number of secondary branches per plant (0.01). Negative indirect effect was observed *via* days to maturity (-0.10), plant height (-0.19), number of pods per plant (-0.02), number of seeds per pod (-0.07) and 100-seed weight (-0.09).

Residual Effect : The residual effect $R = 0.3758$ indicated that 62.42 per cent variability was explained by the traits considered for path study and low residual effect indicated that characters for path analysis were adequate and appropriate.

These findings are in consonance to the results obtained by Bhavani *et al.* (2008) for number of secondary branches per plant, followed by days to maturity, days to 50 per cent flowering and harvest index, Borate and Dalvi (2010), Usman *et al.* (2012) and Jivani *et al.* (2013) were observed maximum positive direct effect for harvest index, followed by biological yield per plant, number of pods per plant and 100-seed weight towards seed yield and were considered to be the most promising traits for selection for higher seed yield in chickpea.

Conclusions

Association studies revealed that harvest index, number of secondary branches per plant and biological yield per plant are important traits due to their high magnitude of significant correlation coefficient that can be used for

further selection to improve seed yield in chickpea. It is concluded from the path analysis study that seed yield in chickpea can be improved by focusing on characters harvest index, days to maturity, plant height, number of seeds per pod, number of primary branches per plant, days to 50% flowering, protein content and number of secondary branches per plant.

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Effect of Gibberellic Acid (GA₃) and Growing Media on Seed Germination Parameters of Papaya (*Carica papaya* L.) cv. Pusa Nanha

Ramesh Chand Choudhary^{1*}, Jyoti Kanwar¹ and Hitesh Agarwal²

¹Department of Fruit Science, K.N.K. College of Horticulture, Mandsaur, RVSKVV, Gwalior, M.P.

²Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

*Corresponding Author Email : bajyaramesh9738@gmail.com

Abstract

The experiment was carried out to investigate "Effect of gibberellic acid (GA₃) and growing media on seed germination parameters of papaya (*Carica papaya* L.) cv. Pusa Nanha". This experiment was revealed that the treatments comprised combinations of soil, FYM and vermicompost with varying levels of GA₃. The finding results indicated that GA₃ 200 ppm was found the most effective for better germination of papaya seedlings. Among different growing media the treatment combination of soil + FYM + vermicompost (1:1:1) was recorded higher values of germination parameters that are germination percentage (%), germination period (days), seed vigour (%) and germination index. The treatment combination of GA₃ 200 ppm and growing media of soil: FYM: vermicompost (1:1:1) was found most suitable for growing of papaya nursery.

Key words : Gibberellic acid, vermicompost, FYM, growing media.

Introduction

Papaya is botanically known as *Carica papaya* L. and belongs to the family Caricaceae. It is originated from tropical America [1] and introduced in India during 16th century from Malacca [2]. It occupies about 2.0% area of total fruit cropped area and 5.3% of total fruit production in India. It occupies a cultivated area of 126.0 thousand ha with an annual production of 5508.0 thousand MT has average productivity of 43.7 MT/ha [3]. Papaya is generally propagated by seed [4] and it is interested by the researchers due to the presence of gelatinous sarco-testa preventing germination and dormancy. Gibberellins act in the mobilization of seed reserves during the germination process. Therefore, GA₃ considered as an important germination promoter which increased the seed germination of papaya [5]. Growing media plays an important role in seed germination and subsequent vegetative growth of seedlings [6]. Media not only acts as a growing place but also as a source of nutrients for plant growth. The soil is usually used as a basic medium because it is cheapest and easy to procure [7]. Vermicompost provides sufficient levels of oxygen to roots, adequate storage of water and nutrient for the plants. FYM is having good water holding capacity as well as sufficient porosity which help in good growth and development of plants.

Materials and Methods

The experiment was carried out at Shade net house, Department of Fruit Science, K.N.K. College of Horticulture, Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during the year

2016-2017. The experiment was laid out in Factorial Complete Randomized Block Design. The experiment comprised of sixteen treatments with combination of GA₃ and growing medias. Gibberellic acid (GA₃) is used as presoaking solution in which seeds of papaya soaked for 12 hours with three concentrations i.e. GA₃ 100 ppm, 150 ppm, 200 ppm and Control as water and different growing media used in different ratio i.e. Soil as control, Soil: FYM (1:1), Soil: Vermicompost (1:1) and Soil: FYM: Vermicompost (1:1:1).

Results and Discussion

Effect of gibberellic acid (GA₃) : The data presented in Table-1 have shows results that the maximum seed germination (78.33 %) was observed in treatment GA₃ 200 ppm as compare to control (55.00 %). The shortest germination period (10.75 days) was observed in treatment GA₃ 200 ppm where as longest germination period (15.58 days) was found in control. Similarly, the highest seed vigour (84.17 %) was observed in treatment GA₃ 200 ppm as compare to control (67.17 %). The promising effect of gibberellic acid (GA₃), when it used as pre-sowing treatment to the seeds that replaced the dormancy mechanism of the seeds resulting in early germination [8]. Gibberellic acid acts on the embryo and causes synthesis of hydrolyzing enzymes particularly α -amylase and protease. This hydrolyzed food is utilized for growth of embryo and thereby germination enhanced [9] and reduced number of days until germination [10]. Similar results were reported [11] in aonla and papaya [12]. The result of germination index was observed non-significant.

Table-1 : Effect of gibberellic acid, Growing media and Interaction effect on Germination period, Seed vigour and Germination index.

Treatment	Treatment details	Germination percentage (%)	Germination period (days)	Seed vigour (%)	Germination index
G0	Untreated seed	55.00 (47.91)	15.58	67.17 (55.25)	1.17
G1	GA ₃ -100 ppm	57.50 (49.33)	12.67	67.83 (55.49)	1.19
G2	GA ₃ -150 ppm	71.25 (57.64)	11.75	73.67 (59.15)	1.22
G3	GA ₃ -200 ppm	78.33 (63.02)	10.75	84.17 (66.70)	1.34
SE(m)		1.82	0.30	1.26	0.07
C.D. at 5%		5.26	0.89	3.64	NS
M0	Soil	57.92 (49.64)	13.75	68.00 (55.85)	1.14
M1	Soil + FYM (1:1)	62.92 (52.59)	13.00	71.83 (58.17)	1.18
M2	Soil + Vermicompost (1:1)	69.17 (56.89)	12.50	74.50 (59.95)	1.29
M3	Soil + Vermicompost + FYM (1:1:1)	72.08 (58.77)	11.50	78.50 (62.63)	1.32
SE(m)		1.82	0.30	1.26	0.07
C.D. at 5%		5.26	0.89	3.64	NS
G0M0	Untreated seeds + Soil	43.33 (41.14)	17.00	53.33 (46.90)	1.05
G0M1	Untreated seeds + Soil + FYM (1:1)	56.67 (48.83)	15.67	64.67 (53.53)	1.09
G0M2	Untreated seeds + Soil + Vermicompost (1:1)	56.67 (48.91)	15.33	72.33 (58.29)	1.26
G0M3	Untreated seeds + Soil + Vermicompost + FYM (1:1:1)	63.33 (52.75)	14.33	78.33 (62.26)	1.27
G1M0	GA ₃ -100 ppm + Soil	53.33 (46.90)	14.00	64.67 (53.53)	1.06
G1M1	GA ₃ -100 ppm + Soil + FYM (1:1)	56.67 (48.83)	13.00	67.00 (54.92)	1.17
G1M2	GA ₃ -100 ppm + Soil + Vermicompost (1:1)	60.00 (50.83)	12.67	67.33 (55.21)	1.18
G1M3	GA ₃ -100 ppm + Soil + Vermicompost +FYM (1:1:1)	60.00 (50.75)	11.00	72.33 (58.29)	1.34
G2M0	GA ₃ -150 ppm + Soil	66.67 (54.76)	12.67	72.33 (58.29)	1.16
G2M1	GA ₃ -150 ppm + Soil + FYM (1:1)	70.00 (56.77)	12.33	72.33 (58.29)	1.17
G2M2	GA ₃ -150 ppm + Soil + Vermicompost (1:1)	73.33 (58.98)	11.33	73.33 (58.91)	1.33
G2M3	GA ₃ -150 ppm + Soil + Vermicompost +FYM (1:1:1)	75.00 (60.05)	10.67	76.67 (61.12)	1.22
G3M0	GA ₃ -200 ppm + Soil	68.33 (55.75)	11.33	81.67 (64.67)	1.29
G3M1	GA ₃ -200 ppm + Soil + FYM (1:1)	68.33 (55.95)	11.00	83.33 (65.93)	1.28
G3M2	GA ₃ -200 ppm + Soil + Vermicompost (1:1)	86.67 (68.83)	10.67	85.00 (67.38)	1.37
G3M3	GA ₃ -200 ppm + Soil + Vermicompost +FYM (1:1:1)	90.00 (71.54)	10.00	86.67 (68.83)	1.43
SE(m)		3.65	0.61	2.53	0.15
C.D. at 5%		NS	NS	7.29	NS

Growing media : Among different growing media treatment M₃ [Soil + FYM + vermicompost (1:1:1)] has significantly affect to the germination parameters. The treatment M₃ [Soil + FYM + vermicompost (1:1:1)] had maximum germination percentage (72.08 %) followed by M₂ [Soil + vermicompost (1:1)] (69.17 %) and minimum (57.92 %) in M₀ (Soil). The shortest germination period (11.50 days) was observed in treatment M₃ [Soil + Vermicompost + FYM (1:1:1)] and longest germination period (13.75 days) found in M₀ (control). Similarly, highest seed vigour (78.50 %) was recorded in treatment M₃ [Soil + Vermicompost + FYM (1:1:1)] and lowest (68.00 %) in M₀ (control). The promising effect of M₃ on seed germination might be due to its appropriate cation exchange capacity for retention of nutrients and having the properties of good water holding capacity as well as

sufficient porous, so that permitting adequate moisture and exchange of gasses between the germination growth media and the embryo, that is essential for rapid and uniform germination of seeds reported in Aonla [13] and Mango [14]. The effect of media on germination index was recorded non-significant.

Interaction effect : According the finding results interaction effect of G₃M₃ [Soil + Vermicompost + FYM (1:1:1) + GA₃ – 200 ppm] recorded highest seed vigour (86.67 %) followed by G₃M₂ (85.00 %), G₃M₁ (83.33 %) and G₃M₀ (81.67 %). Lowest seed vigour (53.33 %) was recorded in G₀M₀. The promising effect of GA₃ on seed germination might be due to its participation in the activity of alpha-amylase, which catalyzes the starch conversion in to simple carbohydrates and chemical energy is liberated which used in the activation of embryo resulting

effective germination [15]. The growing media also increase beneficial effect of all components in improving physical, biological and chemical properties of media as soil provides natural support, FYM provides proper aeration, vermicompost gives warm condition and high water holding capacity while FYM as organic manure provided better nutrition to the germinating of seedlings. Further the vermicompost also provides a uniform physical structure which ensures close contact between seed and media, increases steady moisture supply, facilitates root respiration and encourages overall plant growth. It exhibits a beneficial effect on soil health and all these attributes might enhance the seed germination and seedling growth of Moringa at the initial stage [16]. However, the other observation parameters like germination percentage (%), germination period (days) and germination index affected non-significantly by interaction of gibberellic acid (GA_3) and growing media.

Conclusions

It is concluded that the gibberellic acid (GA_3 -200 ppm) has enhance the seed germination which also increase the germination percentage, seed vigour (%) and reduce the germination period (days) and the media combination of Soil + Vermicompost + FYM (1:1:1) found also same affect on these parameters. The interaction of G_3M_3 [Soil + Vermicompost + FYM (1:1:1) + GA_3 – 200 ppm] has found significant only seed vigour (%).

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Studies of Genetic Variability Parameters for Forage Yield and its Contributing Traits in Single Cut Oat (*Avena sativa* L.)

Ravi Kumar Nechu^{1*}, S.K. Bilaiya¹, Manmohan Singh² and Parul Singhal¹

¹Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, M.P.-482 004

²Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan-313001

*Corresponding Author Email : ravinechu@jnkvv.org

Abstract

Genetic variability, heritability, genetic advance and genetic advance as per cent of mean for green fodder yield and its contributing traits in single cut oat (*Avena sativa* L.) were studied for 33 genotypes during Rabi season 2020-2021 under AICRP on Forage Crops, Seed Breeding Farm, JNKVV, Jabalpur. Analysis of variance studied showed that there is a significant difference among the genotypes for all the traits. This signifies that there is a huge scope for the improvement of germplasm through selection and other breeding methods. Highest genotypic and phenotypic coefficient of variation was observed for DMY/plant, DMY/plant/day, GFY/plant, LAI, CPY/plant, GFY/plant/day, CPY/plant/day, number of leaves/plant, number of tillers/plant and leaf stem ratio, hence selection for these traits will be rewarding. DMY/plant, DMY/plant/day, CPY/plant and CPY/plant/day had comparatively higher estimates of GCV, heritability and genetic advance as per cent of mean indicated that the predominance of additive gene action in expression of these traits therefore for these traits direct selection will be effective and profitable. Based on the per se performance and PCA, genotype viz., BAUO-103, OL-1971, RO-11-4, OL-1874-1, OL-1960 and RO-11-1-3 were found superior among all the genotypes and shall be selected for future crop improvement program.

Key words : Variability, heritability, genetic advance, PCV, GCV, Green fodder yield and oat.

Introduction

Crop production and animal husbandry go hand in hand and complementary to each other. The growth of livestock sector is about 1.5 times higher than that of crop sector which implies the fodder production is not sufficient to meet the requirements. The present availability of green fodder is 462 million tonnes and dry fodder is 394 million tonnes in the country. It shows a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients. To meet the deficit, green forage supply has to grow at 1.69% annually. (IGFRI, 2013; Kumar, 2018).

Oat is an important versatile *Rabi* cereal crop cultivated for fodder, grain, pasture and crop rotation which is better adapted to cold, moist climate, acidic soil and requires less amount of water as compare to other cereal crop (Murphy and Hoffman, 1992). Because of its high protein content, fat, minerals, dry matter digestibility, palatability and antioxidant property, it is used both for animal feed and human feed (Peterson *et al.*, 2005). It is a self pollinated winter cereal crop native of Mediterranean region and rank sixth in world cereal production. Oat provides huge green fodder at the time when other succulent fodder is scare (Rajhathy and Thomas, 1974; Kumari *et al.*, 2019; Rana *et al.*, 2019).

The foremost step in breeding programme is to

assess the amount of variation present in plant population and also find their heritability for the effective selection of superior genotypes that is used for the crop improvement. Analysis of the genetic variability can be obtained using morphological measurements and phenotypic characterization (Greene *et al.*, 2008). The heritability measurement together with genotypic coefficient of variation would give an accurate idea about the extent of genetic advance that would be expected through simple selection (Burton, 1952). Knowledge of genetics of forage yield, its components and the most heritable components showing high expected selection for the characters will be useful to manage the appropriate breeding methodology. In the present study 33 lines were analysed for 15 different quantitative characters to judge the variability pattern, association of different characters in term of contribution to yield, classify promising genotypes and identify putative lines for forage yield. These lines were statistically analysed in RCBD and biometrical techniques applied are discussed under the following heads.

Materials and Methods : The experiment was carried out during *Rabi* season 2020-2021 under, All India Coordinated Research Project on Forage Crops, Department of Genetics & Plant Breeding at Seed Breeding Farm, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) at 23°21' North

Table-1 : Parameters of genetic variability for fodder yield and its contributing traits in single cut oat.

S. No.	Character	Mean	Range		Genotypic Coefficient of Variations	Phenotypic Coefficient of Variations	Heritability (h ²) %	Genetic Advance as % of mean
			Minimum	Maximum				
1.	Days to maturity	103.40	85.09	114.33	7.42	7.45	99.06	15.21
2.	Number of tillers/plant	4.19	2.44	8.22	30.31	38.22	62.89	49.52
3.	Plant Height (cm)	126.60	105.78	153.78	9.40	11.55	66.25	15.77
4.	Stem diameter (mm)	5.12	3.33	6.78	14.60	18.36	63.21	23.91
5.	Internodal length (cm)	18.22	13.89	22.67	12.38	15.30	65.49	20.64
6.	Number of leaves/plant	29.75	16.11	58.11	32.30	40.28	64.31	53.36
7.	Penultimate leaf area (cm ²)	114.74	78.39	152.16	12.59	16.17	60.63	20.19
8.	LAI	5.84	2.38	12.41	37.86	48.20	61.71	61.27
9.	Leaf-stem ratio	0.53	0.32	0.86	19.83	25.36	61.16	31.95
10.	GFY/plant/day (g)	0.91	0.53	1.99	35.88	45.43	62.37	58.37
11.	DMY/plant (g)	22.53	12.05	52.79	42.85	49.61	74.63	76.26
12.	DMY/Plant/day (g)	0.22	0.11	0.49	39.00	46.07	71.64	67.99
13.	CPY/Plant (g)	1.93	1.07	4.01	36.71	42.73	73.80	64.96
14.	CPY/plant/day (g)	0.019	0.012	0.037	32.82	39.22	70.02	56.57
15.	GFY/plant (g)	94.38	57.88	212.89	37.91	47.16	64.61	62.77

latitude, 79°94' East longitude and at an altitude of 411.78 meters from the mean sea level.

The experimental material consisted of 33 genotypes of single cut (SC) fodder oat. viz. BAUO-103, JHO-20-1, NDO-1902, SKO-244, OL-1980, JO-08-37, OL-1977, HFO-1009, HFO-1003, HFO-1013, BAUO-101, UPO-20-1, OL-1974, OL-1971, HFO-1018, RO-11-4, OL-1874-1, OL-1876-1, RO-11-1-3, JO-06-23, SKO-241, RO-11-1-2, HFO-806, JO-08-41, JO-09-48, OL-1876-9, HFO-904, HFO-906, OL-1960, JO-07-28, SKO-94, JO 1 Check (Zonal) and KENT Check (National).

All genotypes were evaluated in a randomized complete block design (RCBD) with three replications. Each treatment was sown in 3.0 m row length spaced at 25 cm. Observations were recorded from the 5 randomly selected plants, which were true representative of the plot, from each replication of each treatment at 50 per cent flowering.

The observations recorded for fifteen traits viz. Days to maturity, number of tillers/plant, plant height (cm), stem diameter (mm), internodal length (cm), number of leaves/plant, penultimate leaf area (cm²), leaf area index (LAI), leaf stem ratio, green fodder yield (GFY)/plant/day (g), dry matter yield (DMY)/plant (g), DMY/Plant/day (g), crude protein yield (CPY)/Plant (g), CPY/plant/day (g) and GFY/plant (g) were subjected to various statistical and biometrical analyses viz., Analysis of Variance (Burton, 1952), Heritability (Hanson *et al.*, 1956) and Genetic Advance (Johnson *et al.*, 1955).

Results and Discussion

The parameters of genetic variability viz., mean performance and range, GCV and PCV (%), heritability in broad sense (%), and genetic advance as percentage of

mean for all the 15 traits under study were analyzed and has been presented in Table-1.

Analysis of variance for all the traits studied showed that there is significant differences among the genotypes for all the traits viz. Days to maturity, number of tillers/plant, plant height (cm), stem diameter (mm), internodal length (cm), number of leaves/plant, penultimate leaf area (cm²), LAI, leaf stem ratio, GFY/plant/day (g), DMY/plant (g), DMY/Plant/day (g), CPY/Plant (g), CPY/plant/day (g) and GFY/plant (g) as shown in Table-2.1 and Table-2.2. This signifies that there is a huge scope for the improvement of germplasm through selection and other breeding methods. Jaipal and Shekhawat (2016) and Sood *et al.* (2020) also found the significant variance for all the traits studied. This infers a greater scope for selection and exploitation to improve these traits in commercial genotypes.

Among green fodder yield and its component characters GFY/plant possessed the highest range followed by penultimate leaf area, number of leaves/plant and DMY/plant. Considering the green fodder yield genotypes with highest yield was OL-1960 followed by OL-1874-1 while for Dry matter yield OL-1874-1 and OL-1960. The high variability for green fodder yield/plant, ranged from 57.88 g (SKO-244) to 212.89 g (OL-1960). Hence, genotypes OL-1960 and OL-1874-1 found superior in term of GFY/plant and DMY/plant respectively. The genotypes showed better results for GFY/plant were OL-1960, OL-1874-1, RO-11-1-3, JO-06-23, JA, RO-11-4, OL-1971 and OL-1977, also found superior than standard check. This was in accordance with the previous researchers Surje *et al.* (2015) and Poonia *et al.* (2017).

The values of PCV were higher than that of GCV for all the traits studied showing the effects of environment in

Table-2.1 : Analysis of variance for GFY and its contributing traits in single cut oat genotypes.

Sources of variation	Degree of freedom	Mean Sum of Squares							
		Days to maturity	Number of tillers/plant	Plant height (cm)	Stem diameter (mm)	Internode length (cm)	Number of leaves/plant	Penultimate leaf area (cm ²)	Leaf Area Index (LAI)
Replication	2	7.848	0.76	46.234	0.303	0.257	67.527	3.62	1.261
Treatment	32	177.009**	5.777**	497.328**	2.000**	17.95**	328.438**	761.22**	17.725**
Error	64	0.557	0.949	72.192	0.325	2.681	51.290	135.440	3.038

Table-2.2 : Analysis of variance for GFY and its contributing traits in single cut oat genotypes.

Sources of variation	Degree of freedom	Mean Sum of Squares						
		Leaf-stem ratio	GFY/plant /day (g)	DMY /plant (g)	DFY/Plant /day (g)	CPY /Plant (g)	CPY/plant /day (g)	GFY /plant (g)
Replication	2	0.001	0.051	21.584	0.002	0.115	0.011	545.096
Treatment	32	0.040**	0.387**	311.286**	0.024**	1.687**	0.126**	4,541.624**
Error	64	0.007	0.065	31.689	0.003	0.178	0.016	701.157

the expression of these characters. Bind *et al.* (2016) and Revathi *et al.* (2016) also reported the same results. The difference of PCV and GCV is very less for days to maturity, plant height, internodal length, penultimate leaf area and stem diameter, this indicates less influence of environment on the expression of these traits. Ahmed *et al.* (2013) also reported the same results for days to maturity and plant height. The highest value of PCV was recorded for DMY/plant followed by LAI, GFY/plant, DMY/plant/day, GFY/plant/day, CPY/plant, number of leaves/plant, CPY/plant/day, number of tillers/plant and leaf stem ratio. The moderate value of PCV was observed for stem diameter, penultimate leaf area, internodal length and plant height. The lowest value of PCV was recorded for days to maturity. These are in accordance with the findings of Kumari *et al.* (2017) for days to maturity; Wagh *et al.* (2018) for leaf stem ratio and GFY/plant; Chauhan and Singh (2019) for number of leaves/plant, number of tillers/plant, leaf stem ratio and GFY/plant; Gupta and Mehta (2020) for DMY/plant followed by CPY/plant/day, number of tillers/plant and CPY/plant.

The highest value of GCV was recorded for DMY/plant followed by DMY/plant/day, GFY/plant, LAI, CPY/plant, GFY/plant/day, CPY/plant/day, number of leaves/plant and number of tillers/plant. The moderate value was observed for leaf stem ratio, stem diameter, penultimate leaf area and internodal length. The lowest value of GCV was recorded for plant height and days to maturity. These are in accordance with the findings of Bind *et al.* (2016) for DMY/plant and GFY/plant; Kumari *et al.* (2017) for days to maturity and plant height; Singh *et al.* (2017) got the highest GCV for DMY/plant; Wagh *et al.* (2018) for leaf stem ratio and GFY/plant; Chauhan and Singh (2019) for number of leaves/plant, number of tillers/plant and GFY/plant; Gupta and Mehta (2020) for CPY/plant/day and number of tillers/plant. Thus the magnitude of GCV and PCV is high for DMY/plant followed by DMY/plant/day, GFY/plant, LAI, CPY/plant,

GFY/plant/day, CPY/plant/day, number of leaves/plant and number of tillers/plant. Hence, selection for these traits would be effective for the improvement of yield in oat.

The parameters such as GCV, PCV, heritability and genetic advance are helpful in deciding the method of selection for improvement of a specific trait. High heritability along with high genetic advance signifies that there are additive genetic effects and simple selection is effective for the improvement of that character. But, it is always not obligatory for high heritability to be related with high genetic advance as in present study finding shows. High heritability with low genetic advance shows predominance of non additive genetic effects while low heritability indicates the more influence of character by environment. Selection of such characters may not be fruitful. The results for heritability and genetic advance percentage of mean shows that medium to high heritability and genetic advance for all the character studied. Days to maturity has highest heritability and lowest genetic advance as percentage of mean. The highest value of heritability was recorded for days to maturity followed by DMY/plant, CPY/plant, DMY/plant/day and CPY/plant/day and moderate value of heritability was observed for plant height, internodal length, GFY/plant, number of leaves/plant, stem diameter, number of tillers/plant, GFY/plant/day, LAI, leaf stem ratio and penultimate leaf area. These findings are in accordance with Bind *et al.* (2016); Kumari *et al.* (2017); Singh *et al.* (2017); Sahu and Tiwari (2020) for DMY/plant.

The highest genetic advance as percentage of mean was recorded for DMY/plant followed by DMY/plant/day, CPY/plant, GFY/plant, LAI, GFY/plant/day, CPY/plant/day, number of leaves/plant, number of tillers/plant, leaf stem ratio, stem diameter, internodal length and penultimate leaf area. The moderate genetic advance as percentage of mean was observed for plant height and days to maturity. These findings are in accordance with

Bind *et al.* (2016); Sahu and Tiwari (2020); for DMY/plant and GFY/plant; Jaipal and Shekhawat (2016) for GFY/plant and number of tillers/plant; Kumari *et al.* (2017) GFY/plant, DMY/plant and number of tillers/plant; Singh *et al.* (2017; Singh *et al.* (2017) for DMY/plant followed by number of leaves/plant and number of tillers/plant; Wagh *et al.* (2018) for number of tillers/plant, leaf stem ratio, stem diameter, penultimate leaf area and GFY/plant; Chauhan and Singh (2019) for number of leaves/plant, number of tillers/plant, stem diameter, penultimate leaf area and GFY/plant.

It is interpreted that DMY/plant, DMY/plant/day, CPY/plant and CPY/plant/day have comparatively higher estimates of GCV, heritability and genetic advance as per cent of mean which is indicative of predominance of additive gene action in expression of these traits therefore, for these traits direct selection will be effective and profitable.

Conclusions

Based on the *per se* performance and PCA, genotype viz., BAUO-103, OL-1971, RO-11-4, OL-1874-1, OL-1960 and RO-11-1-3 were found superior among all the genotypes and also from both of checks.

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Fertility Rate of Sirohi Goats Supplemented with Concentrate Feed

Vinod Bhateshwar^{1,2*}, M. Datt¹, D.C. Rai³ and Hitesh Muwal⁴

¹Department of Livestock Production Management, Sri Karan Narendra Agriculture University, Jobner-303329

²Department of Agriculture, Vivekananda Global University, Jaipur-303012

³Department of Dairy Science and Food Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005

⁴Department of Animal Production, Maharana Pratap University of Agriculture and Technology, Udaipur-313001

*Email : vinodbhu0883@gmail.com

Abstract

A study was conducted to assess the fertility rate of Sirohi goats supplemented with concentrate feed at different levels (@ 0, 100, 200 and 300 gm/goat/day). Twenty-four healthy Sirohi goats with approximately similar body weight (36.2 ± 0.7 kg) were selected. The goats were randomly divided into four equal groups containing six goats in each group. In this study, it was observed that the overall conception rate was found to be 16.67%, 33.33%, 33.33% and 50.00% at first conception and 33.33%, 33.33%, 33.33% and 33.33% at second conception in all goats of SG-1, SG-2, SG-3 and SG-4. In this study, the overall conception rate was higher ($P < 0.005$) in SG-4: 83.33% (goats pregnant: 5/6) and lesser in the SG-1: 50.00% (goats pregnant: 3/6). The lactation length of goats recorded non-significant ($P > 0.005$) as 150.83 ± 1.40 days in SG-1, 154.66 ± 2.41 days in SG-2, 157.16 ± 3.92 days in SG-3 and 154.33 ± 2.41 days in SG-4 respectively. The average lactation length of all group goats was found of 154.33 ± 1.34 (range from 150-157 days) which was similar in all groups. The results of this study indicated that supplemented with concentrate feed improved fertility rate over goats with non-supplemented goats during the experiment.

Key words : Concentrate feed, Fertility rate, Sirohi goats.

Introduction

Nutritional demands are increased in animals during lactation period and gestation period due to higher requirement of nutrients. [2]. Generally, goats are depending on forage as their primary source of feed in the arid and semi-arid environments which often resulting in the forage supply falls and availability of fibrous and low protein diet [2]. The traditional goat production system in India is largely based on pasture farming, which did not have enough biomass to meet the nutritional needs of goats and however, goat farmers do not offer concentrates due to economic situation and lack of awareness of the benefits of supplementation [3]. However, supplementing concentrates in addition to traditional feeding and management can improve goat productive and reproductive performance. Keeping in view, the problems of traditional feeding of goats, the aim of the present experiment was to demonstrate the benefits of an optimize level of supplemented concentrate feed in the diet of Sirohi goats for better fertility performance.

Materials and Methods

The present research trial was conducted at the Sirohi Goat Farm, College of Agriculture, Sri Karan Narendra Agriculture University, Jobner, Rajasthan. Twenty-four healthy Sirohi goats with approximately similar body weight (36.2 ± 0.7 kg) were selected. The goats were

randomly divided into four equal groups containing six goats in each group maintained in a semi-intensive rearing system. Goats of SG-1 (control group) were maintained on grazing only, while goats of treatment group SG-2 (@ 100 gm concentrate mixture/goat/day), group SG-3 (@ 200 gm concentrate mixture/goat/day) and group SG-4 (@ 300 gm concentrate mixture/ goat/day) were supplemented after grazing (12:30 pm). Concentrate mixture contained 18-20% crude protein (minimum), 12% crude fiber (maximum) and 75% total digestible nutrients. All experimental groups received a basal diet twice containing dry leaves of *Prosopis cineraria* (Khejri) as a dry fodder *ad libitum* in daily (10:00 am and 3:30 pm) along with free access to water and shaded areas. During the study, data related to post partum estrus period was calculated as the interval from the day of kidding to the day of first expression of symptoms of estrus (post partum estrus) and expressed in days. Estrus detection was being carried out by making one of the bucks as teaser which was used twice a day (morning and evening) for identifying does in estrus. Teaser buck was used after one month of kidding. White paint was used on dorsal side of teaser buck to identify doe that was coming into estrus. It was noted down that does showing impressions of paint near of tail/back were considered does in estrus. Estrus was also detected also by visualizing various estrus behaviour signs. The estrus signs like bleating, frequent micturition, mucus discharge,

Table-1 : Effect of concentrate mixture supplementation on reproductive performance in lactating Sirohi goats.

Treatment groups	No. of animals treated	Conception rate			
		Interval from kidding to first conception	At first conception	At second conception	Overall
		d	% of goats pregnant		
SG-1 (Grazing alone)	6	99.83	(1/6) 16.67	(2/6) 33.33	(3/6) 50.00
SG-2 (100 gm conc. mix./goat/d)	6	97.50	(2/6) 33.33	(2/6) 33.33	(4/6) 66.67
SG-3 (200 gm conc. mix./goat/d)	6	94.00	(2/6) 33.33	(2/6) 33.33	(4/6) 66.67
SG-4 (300 gm conc. mix./goat/d)	6	88.18*	(3/6) 50.00*	(2/6) 33.33	(5/6) 83.33*
Overall	24		(8/24) 33.33	(8/24) 33.33	(16/24) 66.77

*P<0.005, d = Day, SG = Sirohi goat.

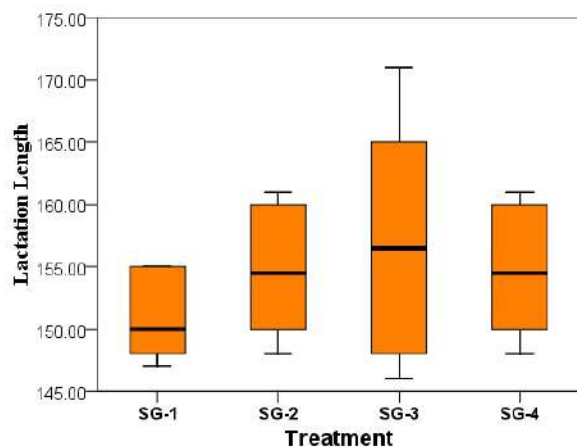


Fig.-1 : Effect of supplementation of concentrate feed on lactation length of Sirohi goats.

wagging of tail and stand to be mounted were noted in goats induced to estrus. Lactation length was recorded from 15 days after kidding until daily milk yield dropped to below 0.20 lit. Lactation length data was recorded of each doe on separate proforma specially designed for this purpose.

Statistically, data was analyzed by using the one-way analysis of variance (SAS system 'Local', W32-7PRO) for a completely randomized design. Significant differences ($P < 0.05$) among treatment, within the experiment, were analyzed using Duncan's multiple range test.

Results and Discussion

In the current investigation the signs of first post partum estrus interval from kidding to first conception were noted in all group goats but the observable signs i.e. rosy clear discharge and standing while mounting by other animals etc. were more pronounced in SG-4 goats. Supplementation of concentrate feed to diet decreased the first post partum estrus interval from kidding to first

conception about 11 days was noted in SG-4. Variation in the interval of calving to first conception from 88 to 99 dpp was less ($P < 0.005$) for goats in the SG-4 than that for goats in the SG-1 during the experimental period (Table. 1). The overall conception rate was found to be 16.67%, 33.33%, 33.33% and 50.00% at first conception and 33.33%, 33.33%, 33.33% and 33.33% at second conception in all goats of SG-1, SG-2, SG-3 and SG-4 (Table 1). In this study, the overall conception rate was higher ($P < 0.001$) in SG-4 (83.33%) compared to the goats in SG-1 (50.00%), SG-2 (66.67%) and SG-3 (66.67%) respectively. These results are in agreement with [4] who reported lesser values of average service period 62.27 ± 0.14 days in Keonjhar goat breed of Orissa and 68.21 ± 0.46 days in Kamohri breed of goat reported by [5]. Whereas, the higher values of average service period in Sirohi goats was no significant difference in the post partum estrus interval for does giving birth to different number of off spring [6]. Management is one of the important factors that affect period of post partum estrus in lactating animals. Poor management of goats after kidding may lead to higher period of post partum in goats.

The data related to lactation length of Sirohi goats graphically summaries in (Fig.-1) In the present investigation it was observed that the lactation length of Sirohi goats recorded non-significantly ($P > 0.005$) as 150.83 ± 1.40 days in SG-1, 154.66 ± 2.41 days in SG-2, 157.16 ± 3.92 days in SG-3 and 154.33 ± 2.41 days in SG-4 respectively. The average lactation length all groups of Sirohi goats was found of 154.33 ± 1.34 (range from 150-157 days) which was similar in all groups. The results of present investigations are in close agreement to those reported by [7] the average lactation length of Jakhrana goats was 143.0 ± 3.2 days in semi intensive system and 118.0 ± 2.3 days in extensive system of management. The higher length of lactation when goat was stall fed (150.2 ± 3.83 days) than extensive system (92.5 ± 1.12 days) [8]. Similar results in Pantja breed of goat that was identified in the Himalayan basin (156.0 ± 2.5 days) [9]. The differentiation in lactation length will be variation in

breeds or variation in nutrition provided to lactating does. Nutrition is one of the most important factors that directly influence the lactation period in goats.

Conclusions

It was concluded that the effect of supplemented concentrate feed @ 300 gm/goat/day coupled with grazing in SG-4 group was significantly improved fertility rate of Sirohi goats. Whereas the lactation length of all groups Sirohi goats did not influenced with supplemented concentrate feed. Considering the fact, Sirohi goat is a unique small ruminant livestock species in Rajasthan, supplementation with 300 gm concentrate mixture with *ad-libitum* dry leaves of *Prosopis cineraria* (Khejri) as dry roughage per day per goat may be recommended for optimum performance under arid and semi-arid environmental conditions.

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Impact of Grass-Based Cropping Systems on Improvement in Particle Size Distribution and Aggregate Size

Bheru Lal Kumhar, K.K. Agrawal, H.K. Rai, S.R. Jakhar, Badal Verma, Vijay Kumar and A.K. Jha

College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalyaya, Jabalpur-482004

Email : prajapatiagro09@gmail.com

Abstract

The present investigation was conducted during two consecutive years of 2018-19 and 2019-20 entitled "impact of grass-based cropping systems on improvement in particle size distribution and aggregate size". Mean weight diameter (MWD) of soil aggregates under different grass based cropping systems ranged from 1.43 - 1.63 mm with maximum (1.63) in PN hybrid in paired rows + ricebean - egyptian clover and minimum (1.43) in guinea grass (GG) sole crop. Data related to sand, silt and clay contents in soil under different grass based cropping system was ranged from 37.17 to 37.48, 20.30 to 21.26 and 41.26 to 41.446 %, respectively. Different size fractions (>5.0, 2.0-1.0, 1.0-0.5, 0.5-0.25, 0.25-0.10 and <0.10 mm) of water stable soil aggregates are non significantly affected by different grass based cropping systems. Maximum (3.24 %) water stable soil aggregates of size >5.0 mm found in gg in paired rows + ricebean - egyptian clover.

Key words : Aggregate size, grass-based cropping systems and particle size distribution.

Introduction

Grass based cropping system (GBCS) provides a quick way to numerous benefits viz. stabilization of soil aggregates, food for beneficial organisms, slow-release source of nutrients, increased water holding capacity, increase in nutrient holding capacity by improving cation exchange capacity, binding of toxic material build carbon for several reasons viz. where perennial species growing continually rather than seasonally, minimal disturbance relative to cropping, no erosion, if well managed [1]. GBSCS help in increasing the fodder yield and resource use efficiency through their vegetation cover, greater root production ability especially in the top 15 cm soil profile thus bind soil particles, help in soil conservation, sustainable fodder production, adapting to mitigating global climate change, improving water quality, availability and ensuring food security [2-3]. Reduced soil disturbance and increased organic matter inputs in forage production systems may improve soil quality and crop production through their effects on soil organic matter (SOM) dynamics and nutrient cycling. Perennial forage crops are known to increase soil microbial substrate quality, availability and diversity and to augment root biomass carbon and nitrogen accumulation and thereby improve soil organic carbon (SOC) storage. In addition, most of the forage grasses are of multi-cut type and they serve as vegetative mulch conditions for a longer period depending on the soil fertility and availability of water. Inclusion of perennial species in farming systems seems to be a feasible option to help mitigate the extensive impacts of these threats. To increase the production of biomass and maintain soil fertility. The cultivation of cover

crops throughout the year like forages is also reported to improve aggregate size in soils [4]. The data served as a base to determine carbon credit for forage crops which may offer benefits to the farmers besides sustaining soil fertility and environmental safety [5]. Comprehensive information on aggregate size in fodder crops is meager and compilation of scientific information on this burning issue is a great challenge. Hence, looking to information as above the present study has been undertaken.

Materials and Methods

Field experiment was conducted at Research Farm, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalyaya, Jabalpur, Madhya Pradesh during two consecutive years 2018-19 and 2019-20 with eight grass based cropping systems viz. pearl millet napier (PN) hybrid sole crop (T_1), guinea grass sole crop (T_2), PN hybrid in paired rows + rice bean (*kharif*) - Egyptian clover (*rabi*) (T_3), PN hybrid in paired rows + *Desmanthus* (T_4), PN hybrid in paired rows + *Sesbania grandiflora* (T_5), guinea grass in paired rows + rice bean (*kharif*) - Egyptian clover (*rabi*) (T_6), guinea grass in paired rows + *Desmanthus* (T_7) and guinea grass in paired rows + *Sesbania grandiflora* (T_8). The experiment was laid out in three replications under randomized block design (RBD). The various soil physico-chemical characteristics of experimental soil are elaborated in table No. 1. Recommended dose of 150 kg N, 80 kg P_2O_5 and 40 kg K_2O ha^{-1} was applied through urea, single super phosphate and muriate of potash. All the observations were recorded and recommended package of practices

Table-1 : Physico-chemical properties of the experimental field.

S. No.	Particulars	Value
A. Mechanical composition		
1.	Sand (%)	37.3
2.	Silt (%)	21.1
3.	Clay (%)	41.6
4.	Bulk Density (mg m^{-3})	1.38
B. Chemical composition		
5.	Organic carbon (g kg^{-1})	6.5
6.	Available nitrogen (kg ha^{-1})	190.0
7.	Available phosphorus (kg ha^{-1})	19.50
8.	Available potassium (kg ha^{-1})	275.5
9.	Soil pH (1:2.5 suspension)	7.02
10.	Electrical conductivity (ds m^{-2})	0.20

as adopted in Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, were followed to raise the crops.

Particle size distribution (Soil texture) : Particle size analysis was done using hydrometer method as described by Bouyoucos [6]. For the determination of primary soil particles 40 g of air-dried soil sample was transferred to a 600 ml beaker then 100 ml of calgon solution and 400 ml of distilled water was added and content in beaker allowed to soak for 10 minutes. Content in the beaker was transferred to the sedimentation cylinder and made the volume to 1000 ml with distilled water. Suspension was mixed thoroughly with the plunger then time and temperature of suspension recorded. Hydrometer was lowered into the suspension slowly and the reading on the hydrometer scale noted just after 40 seconds and thereafter hydrometer removed from suspension rinsed and dried with the help of tissue paper. Further, without mixing the suspension, hydrometer was lowered into the suspension and reading on the hydrometer scale and thermometer recorded at 120 minute.

Determination of aggregate size : The procedure used for aggregate size analysis was modified Yoder's sieving method [7]. Soil samples from each treatment were collected from 0-15, 15-30 and 30-45 cm depths. At the time of sampling, soil samples were broken gently with cleavage and air dried in the laboratory. Air dried samples were passed through 8 mm sieve. The samples were cleaned by removing roots, lime concretion *etc.* The nest of six sieves having 5.0, 2.0, 1.0, 0.5, 0.25, 0.1 mm openings was mounted on sieve holders in the Yoder's type wet sieving machine. Air dried triplicate soil samples were used for the analysis. Out of them, one sample was kept for moisture content estimation and the remaining two were used for aggregate analysis. Soil sample was placed on 5.0 mm sieve of the sieve set and was moist by a mist of water. Then sieve set was placed in Yoder's type

wet sieving machine. Immediately prior to sieving water level was raised rapidly to a point where it fairly covered the sample when the sieves were in their highest position. Subsequently, the Yoder's wet sieving procedure was followed [8].

Mean weight diameter (MWD) : Aggregate stability was estimated by the MWD. MWD is a comprehensive indicator for the evaluation of aggregate stability, Greater values of MWD indicate higher aggregate stability [9]. Aggregate separation was done by using wet sieving apparatus [7]. MWD gives an estimate of weight per cent of average size of all aggregate. The mean diameter of any particular size range of aggregates (X_i) is multiplied by the weight of the aggregates in that size range as a fraction of the total dry weight of the sample analyzed (W_i). The sum of the products gives the MWD in mm.

$$\text{MWD (mm)} = \sum X_i W_i$$

Results and Discussion

Particle size : Texture is the relative proportions of primary particles (sand, silt and clay) of soil. The data pertaining to primary soil particles of the different grass based cropping system at soil depth are given in Table-2. Data clearly indicate that contents of sand, silt and clay in soils were not affected significantly by the different grass based cropping system. Data revealed that sand, silt and clay contents in soil under different grass based cropping system was ranged from 37.17 to 37.48, 20.30 to 21.26 and 41.26 to 41.446 %, respectively. Data further indicated that sand content in soil at 0-15 cm depth (37.48 %) was non significantly higher than those obtained at 15-30 cm (37.68 %) and 30-45 cm (37.49 %) soil depths. It was also noted that sand content at 15-30 cm depth was significantly higher than those found at 30-45 cm and 45-60 cm depths which were statistically at par among themselves. Data also indicates that silt content in soil at different depth varied from 21.26 - 21.32 per cent with highest value at 0-15 cm depth. The changes in silt content at different depths were not significant. The clay content in soil at different depths ranged from 41.26 to 42.33 per cent with highest value (42.33 %) at 15-30 cm and lowest (41.26 %) at 0-15 cm depth. Data also showed that clay content in soil was statistically on significant at various soil depths during experimentation. Results showed that different treatments of grass based cropping systems did not affect the proportion primary soil particles in soil significantly. Similar finding was also reported by [10]]. Results revealed that increase in per cent clay with increasing soil depth with maximum clay content at 30-45 cm and minimum at 0-15 cm. It was might be because of downward movement of clay from upper horizons. The findings are in good agreement of those reported by [11]]

Table-2 : Soil texture as influenced by different grass based cropping system at various soil depth.

Cropping Systems		0-15 cm			15-30 cm			30-45 cm		
Name of treatment		Sand	Silt	Clay	Sand	Silt	Clay	Sand	Silt	Clay
T ₁	Pearlmillet Napier (PN) hybrid sole crop	37.38	21.24	41.38	37.61	20.87	41.52	37.2	20.74	42.06
T ₂	Guinea grass (GG) sole crop	37.38	21.26	41.36	37.43	21.11	41.46	37.18	20.79	42.03
T ₃	PN hybrid in paired rows + Ricebean - Egyptian clover	37.28	21.32	41.4	37.34	21.19	41.47	37.23	20.86	41.91
T ₄	PN hybrid in paired rows + <i>Desmanthus</i>	37.17	21.3	41.53	37.27	21.04	41.69	37.24	20.64	42.12
T ₅	PN hybrid in paired rows + <i>Sesbania grandiflora</i>	37.31	21.24	41.45	37.47	21	41.53	37.34	20.66	42.00
T ₆	GG in paired rows + Ricebean - Egyptian clover	37.48	21.26	41.26	37.68	21.01	41.31	37.49	20.67	41.84
T ₇	GG in paired rows + <i>Desmanthus</i>	37.36	21.32	41.32	37.42	21.08	41.5	37.36	20.31	42.33
T ₈	GG in paired rows + <i>Sesbania grandiflora</i>	37.26	21.3	41.44	37.38	20.97	41.65	37.33	20.52	42.15
SEm ±		0.06	0.32	0.16	0.44	0.50	0.31	0.43	0.53	0.76
CD (p=0.05)		NS	NS	NS	NS	NS	NS	NS	NS	NS

Table-3 : Soil aggregation of different size (%) at 0-15 cm. depth as influenced by different grass based cropping system.

Cropping Systems		>2.0 mm	2.0-1.0 mm	1.0-0.50 mm	0.50-0.25 mm	0.25-0.10 mm	<0.10 mm
T ₁	Pearlmillet Napier (PN) hybrid sole crop	2.49	20.55	34.11	20.67	10.99	11.19
T ₂	Guinea grass (GG) sole crop	2.42	20.67	34.01	20.55	11.67	10.68
T ₃	PN hybrid in paired rows + Ricebean - Egyptian clover	3.24	20.99	35.11	21.04	11.00	8.75
T ₄	PN hybrid in paired rows + <i>Desmanthus</i>	2.91	20.81	35.04	20.93	12.10	8.21
T ₅	PN hybrid in paired rows + <i>Sesbania grandiflora</i>	2.80	20.77	34.48	20.81	11.33	9.59
T ₆	GG in paired rows + Ricebean - Egyptian clover	3.00	20.86	35.08	20.99	11.33	8.83
T ₇	GG in paired rows + <i>Desmanthus</i>	2.83	21.04	34.92	20.86	10.95	9.40
T ₈	GG in paired rows + <i>Sesbania grandiflora</i>	2.5	20.93	34.13	20.77	10.60	11.07
SEm ±		0.27	0.41	1.37	0.99	0.49	1.09
CD (p=0.05)		NS	NS	NS	NS	NS	NS

Table-4 : Soil aggregation of different size (%) at 15-30 cm. depth as influenced by different grass based cropping system.

Cropping Systems		>2.0 mm	2.0-1.0 mm	1.0-0.50 mm	0.50-0.25 mm	0.25-0.10 mm	<0.10 mm
T ₁	Pearlmillet Napier (PN) hybrid sole crop	1.82	19.86	32.63	17.74	15.06	12.89
T ₂	Guinea grass (GG) sole crop	1.71	19.54	32.43	18.07	14.25	14.00
T ₃	PN hybrid in paired rows + Ricebean - Egyptian clover	2.16	20.25	34.08	18.08	11.19	14.24
T ₄	PN hybrid in paired rows + <i>Desmanthus</i>	2.02	20.22	33.43	18.08	13.30	12.95
T ₅	PN hybrid in paired rows + <i>Sesbania grandiflora</i>	1.93	19.97	32.93	18.45	13.04	13.68
T ₆	GG in paired rows + Ricebean - Egyptian clover	2.03	20.23	34.07	18.08	12.72	12.87
T ₇	GG in paired rows + <i>Desmanthus</i>	1.97	19.97	33.08	18.42	13.09	13.47
T ₈	GG in paired rows + <i>Sesbania grandiflora</i>	1.88	19.94	32.85	18.43	12.70	14.20
SEm ±		0.21	0.25	0.82	0.77	0.49	1.09
CD (p=0.05)		NS	NS	NS	NS	NS	NS

who also reported increased clay content with increasing soil depth.

Water stable aggregates : Data pertaining to effect of different grass based cropping systems on different size fractions (>5.0, 2.0-1.0, 1.0-0.5, 0.5-0.25, 0.25-0.10 and <0.10 mm) of water stable soil aggregates are presented in Table 3, 4 and 5. Data clearly revealed that different size fractions of water stable soil aggregates were differences non significantly under different grass based cropping systems at various soil depths. Data shows different size of water stable soil aggregates were non significantly affected by different grass based cropping systems. Maximum (3.24 %) water stable soil aggregates

of size >5.0 mm found in GG in paired rows + Ricebean - Egyptian clover which were non significantly higher than other grass based cropping systems and minimum (3.00 %) recorded PN hybrid in paired rows + *Desmanthus*. Data further showed that medium size (2.0 – 0.1 mm) water stable soil aggregates were highest (20.99 %) in GG in paired rows + Ricebean - Egyptian clover and lowest (20.55 %) under pearlmillet napier hybrid sole crop While, smaller size (<0.1 mm) water stable soil aggregates were maximum (11.19 %) in pearlmillet napier hybrid sole crop over (8.21 %) under PN hybrid in paired rows + *Desmanthus*. Data further revealed that different size of water stable soil aggregates were non significantly altered

Table-5 : Soil aggregation of different size (%) at 30-45 cm. depth as influenced by different grass based cropping system.

Cropping Systems		>2.0 mm	2.0-1.0 mm	1.0-0.50 mm	0.50-0.25 mm	0.25-0.10 mm	<0.10 mm
T ₁	Pearlmillet Napier (PN) hybrid sole crop	1.45	19.04	33.00	16.74	11.5	18.27
T ₂	Guinea grass (GG) sole crop	1.44	18.70	33.00	17.41	10.97	18.48
T ₃	PN hybrid in paired rows + Ricebean - Egyptian clover	1.58	19.10	33.68	16.41	10.12	19.11
T ₄	PN hybrid in paired rows + <i>Desmanthus</i>	1.52	19.05	33.33	17.74	10.70	17.66
T ₅	PN hybrid in paired rows + <i>Sesbania grandiflora</i>	1.50	19.04	33.31	16.78	10.29	19.08
T ₆	GG in paired rows + Ricebean – Egyptian clover	1.55	19.05	33.35	17.42	10.92	17.71
T ₇	GG in paired rows + <i>Desmanthus</i>	1.51	19.05	33.32	17.75	11.34	17.03
T ₈	GG in paired rows + <i>Sesbania grandiflora</i>	1.46	19.04	33.30	17.43	11.03	17.74
SEm ±		0.14	0.18	0.73	0.65	0.38	0.82
CD (p=0.05)		NS	NS	NS	NS	NS	NS

Table-6 : Mean weight diameter as influenced by different grass based cropping system at various soil depth.

Cropping Systems		0-15 cm	15-30 cm	30-45 cm
T ₁	Pearlmillet napier (PN) hybrid sole crop	1.57	1.49	1.43
T ₂	Guinea grass (GG) sole crop	1.57	1.47	1.43
T ₃	PN hybrid in paired rows + ricebean – egyptian clover	1.63	1.53	1.45
T ₄	PN hybrid in paired rows + <i>Desmanthus</i>	1.62	1.52	1.45
T ₅	PN hybrid in paired rows + <i>Sesbania grandiflora</i>	1.61	1.50	1.44
T ₆	GG in paired rows + ricebean – egyptian clover	1.62	1.53	1.45
T ₇	GG in paired rows + <i>Desmanthus</i>	1.62	1.50	1.45
T ₈	GG in paired rows + <i>Sesbania grandiflora</i>	1.58	1.49	1.44
SEm ±		0.14	0.13	0.12
CD (p=0.05)		NS	NS	NS

by grass based cropping system at various soil depth. Highest (2.16, 20.25 and 34.08 %) amount of larger size (>5.0, 2-1 and 1-0.5 mm) respectively soil aggregates found at 15- 30 cm depth and similar trends found at 30-45 cm soil depth. Data shows that amount of (2.0 - 0.50 mm) water stable soil aggregates a non significantly decreased with increasing soil depth. Pearlmillet napier hybrid in paired rows + ricebean - egyptian clover produced higher amount of larger water stable aggregates and also the proportion of larger aggregates were more at 0-15 cm depth as compare to lower depths. It may be because of higher organic carbon content in soil which acts as cementing material for promoting formation of larger aggregates. [12-13] also reported a decrease in aggregate size with increasing soil depth and an increase in fraction of larger aggregates with inclusion of legume in perennial grass based cropping system. Soil aggregation is an important mechanism which contributes to soil fertility through reducing soil erosion, mediating air permeability, infiltration and nutrient cycling. Soil aggregates play an important role in retention of soil organic carbon and protection against decomposition from various decomposing agents thereby help in long term stabilization of soil organic carbon (SOC) by physical encapsulation. Similar results were reported by [14, 15, 16, 11 and 17].

Mean weight diameter : Mean weight diameter (MWD) estimates the weighted percentage of average size of all the aggregates. The data pertaining to effect of different

grass based cropping systems on mean weight diameter of soil aggregates are given in Table 6. It is evident from the data that MWD of soil aggregates under different grass based cropping systems ranged from 1.43 - 1.63 mm with maximum (1.63) in PN hybrid in paired rows + ricebean - egyptian clover and minimum (1.43) in guinea grass (GG) sole crop. Data further revealed that effect of grass based cropping systems at various soil depth on mean weight diameter of soil aggregates was not significant. It was also noted that values of MWD of soil aggregates decreased significantly with increasing the soil depth. Largest (1.63 mm) MWD of soil aggregates was obtained at 0-15 cm soil depth and was not significantly greater than those found at 15-30 cm and 30-45 cm. Non significant effect of grass based cropping system on mean weight diameter (MWD) of soil aggregates was recorded. Higher MWD of soil aggregates was obtained in pearlmillet napier hybrid in paired rows + ricebean - egyptian clover. It was might be due to larger proportions of bigger size aggregates under this treatment. [18] reported that mean weight diameter of soil aggregates is very crucial for movement of air, water and temperature and ultimately for flourishing the root system of crops. [19] also reported that well aggregated soil, having higher values of MWD and improved aggregation leads to continuity of soil pores and pore size distribution facilitating water infiltration resulting in greater. Similar results were reported by [10 and 13].

Conclusions

On the basis of present study, it can be concluded that among the different grass based cropping systems sand, silt and clay contents in soil under different grass based cropping system was varied from 37.17 to 37.48, 20.30 to 21.26 and 41.26 to 41.446 %, respectively. PN hybrid in paired rows + ricebean - egyptian clover is best cropping system in terms of soil texture, aggregate size and mean weight diameter in Jabalpur.

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Genetic Divergence of Brown Spot Disease Components in Rice Germplasm (*Oryza sativa* L.) under Aerobic Condition

Monika Shahani, Rajesh Kumar, Nilanjaya, Ashutosh Kumar, Abhishek Mishra and Subhash Bijarania*

Department of Plant Breeding and Genetics, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar-848125

Abstract

The present investigation was carried out with 150 rice genotypes and three check varieties namely Rajshree, Pankaj and Rajendra Neelam with the view of screening these varieties for brown spot resistance under the aerobic condition. These genotypes were evaluated for brown spot incidence and yield potential by recording observation for 11 quantitative traits by using augmented randomized complete block design at Rice research farm of RPCAU, Pusa, Bihar, during *Kharif* season of 2019. All the 153 genotypes (including checks) were grouped into 17 clusters using D^2 statistics. The maximum inter cluster distance was chronicled among cluster VII and cluster XVI. Cluster XVI holds the desirable mean value for the traits like the highest mean value for the number of tillers per plant (18.66) and grain yield per plant and the lowest mean value for the PDI and AUDPC which are necessary to develop the varieties required for the resistance from the brown spot

Introduction

Rice (*Oryza sativa* L.) is an annual monocotyledonous cereal grass encompassed within the genus *oryza* and the family *Gramineae*. The genus *Oryza* comprises of the twenty wild species and 2 cultivated species i.e. *oryza sativa* (cultivated around the world) and *oryza glaberrima* (mainly cultivated in Africa). Around the world, rice fill in as the staple nourishment for more than 2.5 billion individuals and it likewise fills in as day to day calorie intake upto 50 to 80%. The demand for rice will grow by 2.5% per year in the upcoming decades. Based on the hydrological condition, soil status and water control the typical value of usage of water in low-lying rice cultivation is around 1,500-2,000 mm. Water is becoming scare for agriculture at present situation. It is envisioned that by the era of 2025, out of seventy five million hectare, the 15 million hectare of Asia's crop cultivation relying on the flooded irrigated system will prone to face the deprivation of water which will results in the certain extent of water deprivation condition in 15-20 million hectares of irrigated rice. Hence due to impeding water crisis and water exhaustive nature of the rice farming drives the need to search an alternative approach that increases the water productivity of rice. Thus, one such forthcoming approach of rice cultivation is aerobic rice cultivation which reduces the water demand in rice production and increases the water use efficiency. Experiments on aerobic rice has shown that water requirement in aerobic rice were 50% lower (470-650mm) and water productivity were 64-88% higher than lowland rice (Suryavanshi *et al.*, 2013). In aerobic rice system, crop is established by direct seeding under non-puddled, non-flooded soil and field remain unsaturated throughout the season. In addition to coping with water scarcity this form of cultivation also reduces labour requirements and

decreases greenhouse gas emissions. Aerobic rice cultivar is developed by combining the features of drought resistance of upland cultivar along with high yielding traits of lowland cultivar. In the aerobic cultivation the anticipated yields of rice are although to a certain extent lower than the yield attained through low-lying flood irrigated cultivation however, it can be promising option for the resource poor farmers who are entirely relying on the rainfall for crop production. Therefore aerobic cultivation of rice is slowly gaining momentum among farmers and research workers in order to achieve both higher productivity and efficient use of water. Genetic diversity is deliberated as the basis for crop improvisations as well as survival in nature. The ample amount of genetic diversity found in germplasm material generate right set of circumstances for the researchers to evolve a new and better-quality accessions with appropriate attributes. The existence of the genetic diversity between and within the crop allows the plant breeder to either directly select superior genotype as a new variety or use it as a parent in the hybridization programme. Genetic diversity between two parents is an indispensable criterion that should be taken into consideration to gain the heterotic combination and to obtain desirable segregants. Genetic diversity in the germplasm assists the researchers to breed the varieties intended for the characteristics like quality enhancement and tolerance for the various abiotic and biotic stress factors

Materials and Methods

The present investigation was executed at the research farm, of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar during the *Kharif* season of 2019. The experimental material used in this

Table-1 : Disease rating scale of standard evaluation system of Rice published by IRRI (2013) for assessment of brown spot incidence.

Scale	% Foliar infected	Host response
0	No incidence	Immune
1	Less than 1%	Highly Resistant
2	1-3%	Resistant
3	4-5%	Resistant
4	6-10%	Moderately Resistant
5	11-15%	Moderately Resistant
6	16-25%	Moderately Susceptible
7	26-50%	Susceptible
8	51-75%	Susceptible
9	76-100%	Highly susceptible

The one fifty three genotypes were assigned into different clusters by Tocher's method.

study include 150 rice genotypes along with the 3 check varieties named Rajshree, Pankaj and R. Neelam. Out of these three checks Rajshree was used as moderately resistant check and Neelam was used as resistant check while Pankaj was used as susceptible check. Eleven parameters viz., panicle length days to 50% flowering, plant height, disease intensity % (PDI), area under disease progress curve (AUDPC), days to maturity, number of panicles per plant, test weight, filled grains per panicle, number of tillers per plant, grain yield per plant. For the estimation of PDI and AUDPC, an epiphytotic condition for the brown spot was created by artificial inoculation by using the inoculum collected from Department of Plant Pathology, RPCAU, Pusa, Bihar after 65 days after sowing by using an aerosol sprayer. The PDI was estimated by carrying out the field scoring for three times during the entire cropping period, i.e. 20th October, 5th November, 20th November. Screening for brown spot resistance consists of visual scoring of affected plants following disease rating scale of Standard Evaluation System of Rice published by IRRI (2013) presented in table1. During scoring the tagged plants inside each plot was visually assessed for percent foliar affected area at fifteen days span. Disease intensity % (PDI) was calculated using the following formula :

Disease intensity %

$$= \frac{\text{Sum of all numerical ratings}}{\text{Number of plants observed}} \times \frac{100}{\text{Maximum rating}}$$

The percent disease intensity (PDI) was estimated by carrying out the field scoring for three times during the entire cropping period, i.e. 20th October 2019, 5th November 2019, 20th November 2019. Then the integration of PDI readings (disease severity) recorded from the rice variety estimated the values of AUDPC. AUDPC also summarizes the level of disease intensity

along a period which is computed using the following formula as given by "Campbell and Madden (1990)".

$$AUDP = \sum_{i=1}^{n-1} (Y_i - Y_{i+1}) 0.5 (T_{i+1} - T_i)$$

Where,

Y_i = PDI on i^{th} date

T_i = date of scoring of the disease

n = numbers of dates on which disease was scored.

Results and Discussion

Mahalanobis's D^2 statistics is one of the most important biometrical techniques that assesses a large number of genotypes for the degree of diversification and also defines the contribution of every component trait to the overall divergence. The genotypes placed within the cluster will exhibit a lesser amount of genetic diversity than those which are retained in the different clusters. The cluster which possesses greater statistical distance exhibits maximum divergence.

D^2 analysis conducted in the present investigation has grouped the 153 rice genotypes into seventeen clusters.

The distribution pattern of the rice cultivars, cluster mean of the traits, intracluster, and inter-cluster divergence (D^2) and contribution percentage of traits towards genetic divergence were structured within the Table-1,2,3, and 4. D^2 analysis conducted in the present investigation has grouped the 153 rice genotypes into seventeen clusters. reflecting the presence of the greater amount of heterogeneity among the genotypes used in the present investigation. The maximum number of genotypes are encompassed under cluster I (62) subsequently by cluster II (34), cluster IV (23), cluster VIII (16), cluster IV (6) while the remaining clusters comprised of only a single genotype. Comparable clustering pattern premised on the D^2 Mahalanobis was chronicled by Chauhan and Singh (2), Sankar *et al.* (3), Banumathy *et al.* (4), Tripathi *et al.* (5). The maximum inter cluster distance was chronicled among cluster VII and cluster XVI, subsequently followed by cluster III and XVI, cluster XIV and cluster XVI inferring that the crossing of the genotypes grouped within these clusters would be useful in procuring the heterotic combination and transgressive segregants. Cluster XVI holds the desirable mean value for the traits like the highest mean value for the number of tillers per plant (18.66) and grain yield per plant and the lowest mean value for the PDI and AUDPC which are necessary to develop the varieties required for the resistance from the brown spot. Towards the genetic divergence, the maximum percentage contribution was attributed by PDI subsequently followed by filled grains

Table-1 : Assignment of 153 rice genotypes into seventeen clusters as per the D² statistics.

Cluster No.	No. of genotype within the cluster	Name of genotype
I	62	Red Triveni, Samyakhala, Rhylo White, Gopalbhok, Sakha, K-393-29-1, Danteshwari, Radhi, HR5829-73-3-23, Pora Meunya, IR-1386, Bhagyabati, RCPL-1-13C, Rosho,teviirii,mima, MILYANG46, Ratnagiri 1, Palghar2, Nonglwai, GR 7, Golaka, IRCTN-91-5, GR 11, Bhalum-3, Dullo, IRCTN-11-94, Bardhan, Ratnagiri4, Himalaya2216, Khandagiri, Badami, Dandi, Pusa Sughandh-2, GR103, Daya, GR4, Pusa 834, GNR 3, Kuhusoi-ri-sareku, CO48, Vinhatsa, Teinem Ruisheng Maa, VL Dhan209, Channapaddy, Saraswati, Pantdhan4, Ringui Maa, GAR 2, Khamong, RR-8588, Nami, JR 353, Vaisak, RCPL-1-5C, Kalinga-3, HPR2143, Santhi, Rajendra Dhan 102, VL Dhan61, Saponyo, Maigothi
II	34	DRR Dhan 39, Amker, SARSA, Narendra-1, Karjat-7, IR64, Srabani, ASD14, IR72, Pantdhan-12, BUD110, Tara, BR -72, Udyagiri, CO-49, Sahabhagi Dhan, CSR35, Pusa Sughandh -5, Sarju 52, PS3, Karanti, CSR27, PS-4, Sasyashree, Vld16, Jyati, Sukhardhan, JR503, Sebati, Satabdi, NDR-97, SKL6, Purnandu, Kutchigisim
III	1	Abhaya
IV	23	Zielum, Arunachal Pradesh-1,Varsa, RCPL-1-9C, Nedu, Hatibandha, BD-202, NCW11, Indrabans, Dzuluore, Raga- Binni (Sticky Rice), GR 12, Taramon, Hazor Kecho, Kelhrie Cha,varun Dhan, Pyari, Kongkoi, Taker AM, Ngobanyo Red Clover,sarathi, PR113, Luna Sankhi
V	1	Sirarakhong meryon maa
VI	6	Pant sughandh dhan21, Kalanamak101, Haryana Basmati, GR 64, R. Neelam, BVS1
VII	1	Sirarakhong manui
VIII	16	Annada, Bhoi,Govinda, SYE1, Kuki, Jahagisim, Sirarakhong Ashangn Maa, Minil Gisim, Sanwal Basmati, Pankaj, Ratnagiri711, Himalaya1, Pantdhan19, Kasalath, Jyotimayee, IRCTN-91-78
IX	1	ASD18
X	1	Jahagipok
XI	1	Mandakini
XII	1	VLD221
XIII	1	GAR-13
XIV	1	Kala jira jaha
XV	1	Rajshree
XVI	1	Khira
XVII	1	Ayaar

Table-2 : Cluster mean of seventeen clusters for different quantitative traits of rice.

Cluster no	DFF	DM	PH (cm)	PL (cm)	NTP	NPP	FGP	TW (g)	GYP	PDI	AUDPC
I	85.16	114.53	122.3	22.44	9.21	6.88	68.93	24.98	20.67	79.46	1386.65
II	85.62	113.65	102.53	21.63	10.17	7.47	64.53	28.32	33.99	28.64	584.49
III	65	96	103.2	20.4	6.33	6	49.66	24.24	20.19	89.35	1570.14
IV	88.74	118.78	121.43	22.4	11.98	8.3	85.94	27.22	22.64	73.83	1293.66
V	91	121	159	24.8	6.66	6	59	25	25.32	62.96	1125.38
VI	94.17	122.33	113.63	21.87	8.66	6.33	84.89	17.94	32.75	26.58	517.33
VII	89	123	157.4	26	7.66	5.66	76.33	31.4	14.39	85.19	1660.98
VIII	86.63	115.5	116.43	22.36	9.27	6.18	53.85	22.76	21.65	74.59	1342.09
IX	105	132	125.8	22.4	8	6.33	143	18.36	20.29	78.23	1410.39
X	90	121	136.2	22.8	18	10	48.66	20.3	19.21	85.19	1460.23
XI	77	106	91	21.2	13.66	9.33	35.33	22.04	35.26	27.42	597.25
XII	82	111	121	22	13.33	12.66	70	31.8	29.56	33.45	702.52
XIII	96	130	116.8	23.2	17.66	12.66	92.33	24	21.2	75.23	1327.75
XIV	123	151	136.6	21	8	6.66	109	12.52	17.23	81.48	1504.08
XV	105	135	117.6	21.6	15	10.33	64	28.48	15.96	30.2	604.82
XVI	93	116	100.2	16.2	18.66	8	68	37.52	35.42	20.31	455.42
XVII	80	108	165.2	27	9	7.33	71	48.44	20.44	80.65	1438.91

Table-3 : Average intra & inter-cluster distances among seventeen clusters of rice genotypes studied under aerobic condition.

Cluster no	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
I	70.90	351.94	104.65	133.17	106.30	419.43	116.21	134.33	268.63	232.87	454.12	401.60	311.17	195.72	375.20	635.54	235.32
II	80.10	80.10	502.66	316.13	254.40	154.26	575.04	376.75	556.49	490.62	125.66	163.58	439.74	539.63	218.45	207.36	560.74
III			0.00	251.22	173.71	604.18	146.65	152.03	428.90	357.21	589.52	611.08	534.53	334.16	615.04	900.00	294.81
IV				125.22	187.69	388.48	217.56	217.27	253.76	216.97	408.85	290.70	192.38	224.40	287.64	484.44	285.27
V					0.00	288.66	123.65	150.80	318.62	338.19	391.64	371.72	444.37	230.13	356.83	603.68	220.52
VI						134.33	641.10	448.59	451.56	619.01	250.27	304.15	539.17	443.52	317.55	369.41	749.12
VII							0.00	205.06	287.64	369.02	783.44	639.58	486.20	222.90	570.73	930.86	110.04
VIII								183.60	400.80	279.56	441.84	465.26	412.09	290.02	417.79	663.06	342.62
IX									0.00	575.52	834.63	637.56	417.79	67.40	610.58	882.09	511.66
X										0.00	383.77	341.88	121.00	399.60	262.12	536.39	468.29
XI											0.00	131.33	405.62	731.70	185.50	173.71	778.41
XII												0.00	205.06	612.56	102.01	182.52	541.96
XIII														362.14	206.78	431.39	526.70
XIV														0.00	509.40	882.68	509.86
XV															0.00	201.07	574.56
XVI																0.00	792.42
XVII																	0.00

Table-4 : Contribution percentage of eleven traits towards divergence of rice genotypes.

Source	Times ranked 1 st	Contribution %
DFF	261	2.24%
DM	4	0.03%
PH (cm)	466	4.01%
PL (cm)	94	0.81%
NTP	1552	13.35%
NPP	1061	9.12%
FGP	1758	15.12%
TW	1100	9.46%
GYP (g)	296	2.55%
PDI	3931	33.81%
AUDPC	1105	9.50%

per panicle, number of tillers per plant, AUDPC suggesting that the selection of desirable genotypes may be beneficial for the further use in the breeding programme. Comparable findings were likewise reported by Banumathy *et al.* (4), Thomas *et al.* (6), Ready *et al.* (7).

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Relationship of Photosynthetic, Vegetative Growth, Soil Physico-Chemical and Leaf Nutrient Parameters of Kinnow Mandarin

Pawan Kumar Pareek^{1*}, P. Bhatnaga¹, Atma Ram meena² R.K. Meena³, P.S. Gujar³ and Sheetal Tak¹

¹College of Horticulture and Forestry, Jhalawar, AU, Kota, Rajasthan

²Deptt. of Horticulture, COA, SK RAU, Bikaner

³ICAR-Central Institute of Arid Horticulture, Bikaner, Rajasthan

*Corresponding author presently YP-II (DUS-date palm), ICAR-CIAH, Bikaner, Email : pawanpareek001@gmail.com

Abstract

Correlation among photosynthetic, growth, soil physico-chemical and leaf nutrient status parameter of kinnow mandarin in vertisols of Jhalawar district was studied at the Fruit Research Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar (Rajasthan). The experimental plants were 4 years old and at vegetative growth phase. Plant growth was directly influenced with soil properties and leaf nutrient status that parameter's positive association accelerates the photosynthetic parameters. The study revealed that the correlation between plant growth and soil parameters available organic carbon and nitrogen, phosphorus and potassium were significant and positively related except soil pH, EC and CaCO₃ content i.e. negatively correlated. Similarly, leaf nutrient status positive correlated with photosynthetic parameters except vpd. In conclusion, better combination of nutrients supplementation or improvement in soil fertility might lead to severe soil and leaf nutrient balance and better photosynthetic efficiency, eventually enhancing the fruit yield attributing parameters and yield of kinnow orchard.

Key words : Correlation, kinnow, soil physico-chemical parameters, leaf nutrient status.

Introduction

Among citrus fruits, mandarin (*Citrus reticulata* Blanco) is placed at first with respect to area and production followed by sweet oranges and limes. Kinnow (*Citrus nobilis* × *Citrus deliciosa*) is a hybrid between 'King' and 'Willow leaf' mandarin. It is extensively cultivated in Punjab and Sri Ganganagar districts of Rajasthan. Kinnow plant has vigorous and drooping growth habit and produces heavy yield under favourable growing conditions. It has attractive fruit colour, size and good eating quality. Its fruits are nutritious, juicy and have bright and deep colour. The fruit is a rich source of minerals and also contains carotene and vitamin C. Kinnow fruit production is intended for fresh fruit market.

The total production of mandarin in India is 6368.0 thousand tonnes from an area of 480.0 thousand hectares with the productivity of 13.0 MT/ha [1]. In Rajasthan, Kinnow mandarin covers 11.09 thousand hectares area with a total production of 2.64 lac MT/ha [2]. However, Jhalawar district is blessed with Nagpur mandarin where it is grown over 23,900 ha area and the production is 4.78 lac tonnes [2]. In India, the average yield of citrus is about 13 MT/ha, which is quite less than the citrus yield (20-25 t/ha) in other countries like Brazil, Spain, USA, Japan, China and Mexico. The low productivity is probably due to nutritional imbalance, poor

orchard management and general negligence of citrus orchard [3].

Determining the yield and quality of any crop, various components play a vital role viz., edaphic, plant growth behavior, nutrient status of soil and plant as well as photosynthetic parameters etc. For improving fertility status of soil principle sources are manure and fertilizers that directly influence the tree vigor and nutrient content in soil and plant. Kinnow is high productive citrus crop that require judicious supplementation of nutrient for better growth and development of tree [4 &5]. Keeping in view of all these facts, to find out relationship effect (positive or negative) among the parameters (growth, soil physico-chemical, leaf nutrients and photosynthetic) were undertaken that information would be further use in targeted yield prediction model establishment [6].

Materials and Methods

The experiment was carried out at the Fruit research farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalapatan, Jhalawar. The plant growth (plant spread, plant height, canopy volume, shoot length, shoot diameter, relative water content in leaves, and number of leaves per shoot). Observation on photosynthetic parameters (photosynthetic rate ($\mu\text{molm}^{-2}\text{s}^{-1}$), transpiration rate ($\text{mmolm}^{-2}\text{s}^{-1}$), stomatal conductance ($\text{mmolm}^{-2}\text{s}^{-1}$), photosynthetic active radiation ($\text{mmolm}^{-2}\text{s}^{-1}$), internal CO₂ concentration (ppm), vapour

pressure deficit (mb), leaf temperature (OC) and relative humidity (%) by CIRAS-2 PP system (Portable Photosynthesis system), USA, vegetative plant growth (spread, height, canopy volume, shoot length, shoot diameter, relative water content in leaves, and number of leaves per shoot), soil physico- chemical (pH, electrical conductivity by Jackson, 1973 [7], Soil organic carbon by Walkley and Black's, 1934 [8], available nitrogen by Subbiah and Asija 1956 [9], phosphorus by Olsen et al., 1954 [10], potassium by Meston, 1956 [11] and leaf nutrient status (N, P, K, Fe, Mn, Zn, Cu) were recorded as per standard methodology. Specific formulae using for calculation of relative water content of leaves and canopy volume of tree as mentioned under :

$$RWC (\%) = \frac{FW - DW}{TW - DW} \times 100$$

Where: FW = fresh weight of leaves, DW = Dry weight of leaves, TW = Turgid weight of leaves.

$$\text{Canopy volume (m}^3\text{)} = \frac{(E \times W \times N \times S)^2}{4} \times \frac{1}{2}$$

Plant height 4.19

Pearson correlation coefficient matrix between the above mentioned parameters were established between the plant growth –soil, photosynthesis-leaf nutrient, soil properties- leaf nutrient status and plant growth with leaf and soil physico-chemical parameters.

Results and Discussion

Photosynthesis with growth and soil parameter : The data elucidated in Table-1 reveals the correlation of photosynthesis parameter with growth parameters and soil parameter of Kinnow mandarin during growth period (October to March).

The photosynthetic rate showed significantly positive correlation with E-W spread (0.882**), N-S spread, collar girth, plant height, canopy volume, shoot length, number of leaves per shoot, relative water content, shoot diameter, organic carbon, available N, P, K, and highly significant and negative correlation with soil pH (-0.881**), electrical conductivity (-0.897**) and CaCO₃ content (-0.788**). Similarly, photosynthetic active radiation showed significantly positive correlation with N-S spread (0.871**), collar girth (0.840**), plant height (0.861**), canopy volume (0.874**), shoot length (0.938**), number of leaves per shoot (0.532*), relative water content (0.985**), shoot diameter (0.929**), organic carbon % (0.770**), available N (0.770**), available K (0.677**), and highly significant and negative correlation with E-W spread (-0.903**), soil pH (-0.894**), electrical conductivity (-0.955**) and CaCO₃ content (-0.916**) and non-significant correlation with available P.

The present study growth of the plant and photosynthesis and PAR value had close and positive association.

The stomatal conductance indicates significantly positive correlation with shoot length (0.493*), relative water content (0.637**), shoot diameter (0.552**) and highly significant and negative correlation with E-W spread (-0.888**), electrical conductivity (-0.615*) and non-significant correlation with other growth parameters and soil parameter. The leaf temperature and internal CO₂ concentration showed significantly positive correlation with spread, collar girth, plant height, canopy volume, shoot length, number of leaves per shoot, relative water content, shoot diameter, organic carbon, available N P K and highly significant and negative correlation with soil pH, electrical conductivity and CaCO₃ content. The relative humidity showed significantly positive correlation with E-W spread (0.965**), N-S spread (0.946**), collar girth (0.901**), plant height (0.975**), canopy volume (0.974**), shoot length (0.990**), number of leaves per shoot (0.740**), relative water content (0.939**), shoot diameter (0.954**), organic carbon % (0.892**), available N (0.892**), available P (0.491*), available K (0.712**), and highly significant and negative correlation with soil pH (-0.918**), electrical conductivity (-0.920**) and CaCO₃ content (-0.986**). The transpiration rate showed significantly positive correlation with plant spread, collar girth, plant height, canopy volume, shoot number of leaves per shoot, relative water content, shoot diameter organic carbon, available N K and non-significant correlation with available P. The vapour pressure deficit significantly positive and maximum correlation with soil pH (0.707**) and highly significant and negative correlation with E-W spread (-0.718**), relative water content (-0.707*), shoot diameter (-0.707**), organic carbon % (-0.752**), available N (-0.752**), K (-0.628**) and non-significant correlation with available P and plant height. The water use efficiency showed significantly positive correlation with E-W spread (0.879**), N-S spread (0.865**), collar girth (0.830**), plant height (0.881**), canopy volume (0.900**), shoot length (0.811**), number of leaves per shoot (0.926**), relative water content (0.669**), shoot diameter (0.821**), organic carbon % (0.821**), available N (0.821**), available P (0.612**), available K (0.712**), and highly significant and negative correlation with soil pH (-0.799**), electrical conductivity (-0.735**) and CaCO₃ content (-0.809**).

Photosynthesis parameters with leaf nutrient content

: The photosynthetic rate showed significantly positive correlation with leaf N content (0.506*), leaf P content (0.823**), leaf K content (0.718**), leaf Fe content (0.784**), leaf Mn content (0.881**), leaf Zn content (0.839**) and leaf Cu content (0.867**). The photosynthetic rate showed significantly positive

Table-1 : Correlation of photosynthetic parameter with growth parameters and soil parameter.

Parameters	Pn	PAR	gs	t. leaf	RH	ci.	E	vpd	WUE
E-W spread	0.882**	-0.903**	-0.888**	0.945**	0.965**	0.955**	0.965**	-0.718*	0.879**
N-S spread	0.834**	0.871**	0.403	0.901**	0.946**	0.925**	0.955**	-0.650**	0.865**
Collar girth	0.838**	0.840**	0.456	0.885**	0.901**	0.880**	0.904**	-0.638**	0.830**
Plant height	0.824**	0.861**	0.367	0.975**	0.975**	0.959**	0.948**	-0.599	0.881**
Canopy volume	0.836**	0.874**	0.367	0.926**	0.974**	0.961**	0.965**	-0.636**	0.900**
Shoot length	0.864**	0.938**	0.493*	0.902**	0.990**	0.980**	0.972**	-0.671*	0.811**
Number of leaves/shoot	0.641**	0.532*	0.066	0.835**	0.740**	0.739**	0.739**	-0.459*	0.926**
RWC	0.868**	0.985**	0.637**	0.873**	0.939**	0.916**	0.944**	-0.707*	0.669**
Shoot diameter	0.904**	0.929**	0.552*	0.915**	0.954**	0.930**	0.946**	-0.707**	0.821**
Soil pH	-0.881**	-0.894**	-0.536	-0.947**	-0.918**	-0.917**	-0.942**	0.724**	-0.799**
EC	-0.897**	-0.955**	-0.615*	-0.902**	-0.920**	-0.908**	-0.940**	-0.752**	-0.735**
Organic carbon %	0.836**	0.770**	0.460	0.898**	0.892**	0.916**	0.849**	-0.752**	0.821**
Available N	0.836**	0.770**	0.460	0.898**	0.892**	0.916**	0.849**	-0.752**	0.821**
Available P	0.496*	0.344	0.168	0.506*	0.491*	0.515*	0.464	-0.240	0.612**
Available K	0.736**	0.677**	0.377	0.705**	0.712**	0.715**	0.679**	0.628**	0.712**
CaCO ₃ %	-0.788**	-0.916**	-0.376	-0.883**	-0.986**	-0.988**	-0.976	0.627**	-0.809*

*Significant at 5% level of significance

**Significant at 1% level of significance

Table-2 : Correlation of photosynthetic parameter with leaf nutrient status.

Parameters	Pn	PAR	gs	t. leaf	RH	ci.	E	vpd	WUE
Leaf N	0.506*	0.330	-0.488	0.721**	0.575*	0.579*	0.575*	-0.348	0.879**
Leaf P	0.823**	0.842**	0.361	0.912**	0.935**	0.920**	0.921**	-0.620*	0.884**
Leaf K	0.718**	0.836**	0.280	0.836**	0.959**	0.977**	0.923**	-0.597*	0.798**
Leaf Fe	0.784**	0.901**	0.374	0.867**	0.989**	0.992**	0.963**	-0.620*	0.805**
Leaf Mn	0.881**	0.972**	0.556*	0.911**	0.977**	0.969**	0.971**	-0.730**	0.772**
Leaf Zn	0.839**	0.915**	0.439	0.908**	0.991**	0.987**	0.972**	-0.660**	0.826**
Leaf Cu	0.876**	0.898**	0.450	0.934**	0.989**	0.985**	0.975**	-0.694	0.860**

Pn = Photosynthetic rate, PAR = Photosynthetic active radiation, gs = Stomatal conductance, t.leaf = Leaf temperature, RH = Relative humidity, ci :- Internal CO₂ concentration, E = Transpiration rate, vpd = Vapour pressure deficit, WUE = Water use efficiency, RWC = Relative water content.

correlation with leaf P content (0.842**), leaf K content (0.836**), leaf Fe content (0.901**), leaf Mn content (0.972**), leaf Zn content (0.915**), leaf Cu content (0.898**) and non-significant correlation with leaf P. The stomatal conductance indicates significantly positive correlation only with leaf Mn content (0.556*), and non-significant correlation with other leaf nutrient like N, P, K, Fe, Zn and Cu content.

The leaf temperature showed significantly positive correlation with leaf N content (0.721**), leaf P content (0.912**), leaf K content (0.836**), leaf Fe content (0.867**), leaf Mn content (0.911**), leaf Zn content (0.908**) and leaf Cu content (0.934**). The relative humidity showed significantly positive correlation with leaf N content (0.575*), leaf P content (0.935**), leaf K content (0.959**), leaf Fe content (0.989**), leaf Mn content (0.977**), leaf Zn content (0.991**) and leaf Cu content (0.989**). The internal CO₂ concentration showed significantly positive correlation with leaf N content

(0.579*), leaf P content (0.920**), leaf K content (0.977**), leaf Fe content (0.992**), leaf Mn content (0.969**), leaf Zn content (0.987**) and leaf Cu content (0.985**). The transpiration rate showed significantly positive correlation with leaf N content (0.575*), leaf P content (0.921**), leaf K content (0.923**), leaf Fe content (0.963**), leaf Mn content (0.971**), leaf Zn content (0.972**) and leaf Cu content (0.957**). The vapour pressure deficit showed significant and negative correlation with leaf P content (-0.620*), leaf K content (-0.597*), leaf Fe content (-0.620*), leaf Mn content (-0.730**), leaf Zn content (-0.660**) and leaf Cu content (-0.694**) and non-significant correlation with leaf N. The water use efficiency showed significantly positive correlation with leaf N content (0.879**), leaf P content (0.884**), leaf K content (0.798**), leaf Fe content (0.805**), leaf Mn content (0.772**), leaf Zn content (0.826**) and leaf Cu content (0.860**).

Soil parameters with leaf nutrient content : The soil pH

Table-3 : Correlation of soil parameter with leaf nutrient status.

Parameters	pH	EC	Organic Carbon %	Available N	Available P	Available K	CaCO ₃ %
Leaf N	-0.856**	-0.765**	0.854**	0.854**	0.530*	0.576*	-0.895**
Leaf P	-0.891**	-0.876**	0.844**	0.844**	0.509*	0.716**	-0.919**
Leaf K	-0.868**	-0.857**	0.860**	0.859**	0.470	0.676**	-0.980**
Leaf Fe	-0.906**	-0.906**	0.872**	0.872**	0.496*	0.706**	-0.996**
Leaf Mn	-0.939**	-0.965**	0.878**	0.878**	0.474	0.739**	-0.969**
Leaf Zn	-0.938**	-0.940**	0.889**	0.889**	0.476	0.695**	-0.992**
Leaf Cu	-0.936**	-0.928**	0.914**	0.914**	0.508*	0.723**	-0.979**

EC = Electrical conductive, N = Nitrogen, P = Phosphorous, K = Potassium, Fe = Iron, Mn = Manganese, Zn = Zinc, Cu = Copper

Table-4 : Correlation of growth parameter with leaf nutrient content and soil parameter.

Parameters	E-W spread	N-S spread	Collar girth	Plant height	Canopy volume	Shoot length	Number of leaves/shoot	RWC %	Shoot diameter
Leaf N	0.876**	0.879**	0.794**	0.918**	0.903**	0.876**	0.844**	0.755**	0.782**
Leaf P	0.957**	0.953**	0.894**	0.960**	0.972**	0.931**	0.846**	0.875**	0.951**
Leaf K	0.925**	0.909**	0.818**	0.937**	0.937**	0.945**	0.748**	0.846**	0.850**
Leaf Fe	0.955**	0.937**	0.864**	0.964**	0.964**	0.982**	0.738**	0.910**	0.912**
Leaf Mn	0.962**	0.922**	0.890**	0.936**	0.945**	0.985**	0.669**	0.977**	0.966**
Leaf Zn	0.973**	0.958**	0.899**	0.977**	0.977**	0.989**	0.765**	0.932**	0.939**
Leaf Cu	0.978**	0.957**	0.911**	0.981**	0.982**	0.983**	0.800**	0.921**	0.952**
Soil pH	-0.949**	-0.913**	-0.886**	-0.927**	-0.929**	-0.936**	-0.744*	-0.930**	-0.911**
EC	-0.923**	-0.890**	-0.863**	-0.891**	-0.897**	-0.939**	-0.623**	-0.961**	-0.925**
Organic carbon %	0.891**	0.848**	0.873**	0.879**	0.887**	0.883**	0.769**	0.811**	0.889**
Available N	0.891**	0.848**	0.873**	0.879**	0.887**	0.883**	0.769**	0.811**	0.889**
Available P	0.541*	0.497*	0.440	0.538*	0.549*	0.537*	0.557*	0.378	0.539*
Available K	0.756**	0.672**	0.525*	0.695**	0.717**	0.752**	0.533*	0.668**	0.794**
CaCO ₃ %	-0.959**	-0.944**	-0.875**	-0.962**	-0.966**	-0.980**	-0.742**	-0.923**	-0.920**

*Significant at 5% level of significance. **Significant at 1% level of significance.

of soil showed significant and negative correlation with leaf N content (-0.856**), leaf P content (-0.891**), leaf K content (-0.868**), leaf Fe content (-0.906**), leaf Mn content (-0.939**), leaf Zn content (-0.938**) and leaf Cu content (-0.936**). The electrical conductivity of soil showed significant and negative correlation with leaf N content (-0.765**), leaf P content (-0.876**), leaf K content (-0.857**), leaf Fe content (-0.906**), leaf Mn content (-0.965**), leaf Zn content (-0.940**) and leaf Cu content (-0.928**). The organic carbon per cent of soil showed significantly positive correlation with leaf N content (0.854**), leaf P content (0.844**), leaf K content (0.860**), leaf Fe content (0.872**), leaf Mn content (0.878**), leaf Zn content (0.889**) and leaf Cu content (0.914**). The available N content of soil showed significantly positive correlation with leaf N content (0.854**), leaf P content (0.844**), leaf K content (0.859**), leaf Fe content (0.872**), leaf Mn content (0.878**), leaf Zn content (0.889**) and leaf Cu content (0.914**). The available P content of soil showed significantly positive correlation with leaf N content

(0.530*), leaf P content (0.509*), leaf Fe content (0.496*), Cu content (0.508*) and non-significant correlation with leaf K, leaf Mn and leaf Zn content. The available K content of soil showed significantly positive correlation with leaf N content (0.576*), leaf P content (0.716**), leaf K content (0.676**), leaf Fe content (0.706**), leaf Mn content (0.739**), leaf Zn content (0.695**) and leaf Cu content (0.723**). The CaCO₃ content of soil showed significant and negative correlation with leaf N content (-0.895**), leaf P content (-0.919**), leaf K content (-0.980**), leaf Fe content (-0.996**), leaf Mn content (-0.969**), leaf Zn content (-0.992**) and leaf Cu content (-0.979**).

Growth parameters with leaf nutrient content and soil parameters : The data elucidated in Table-4 reveals the correlation of growth parameter with leaf nutrient content and soil parameters of Kinnow mandarin during growth period (October to March).

The plant spread showed significantly positive correlation with leaf N, P, K, Fe, Mn, Zn and Cu content,

organic carbon, available N, P, K and highly significant and negative correlation with soil pH (-0.949**), electrical conductivity (-0.923**) and CaCO_3 content (-0.959**) and highly significant and negative correlation with soil pH (-0.913**), electrical conductivity (-0.890**) and CaCO_3 content (-0.944**). The collar girth and shoot diameter of Kinnow plant showed significantly positive correlation with leaf N P K Fe Mn Zn and Cu content, organic carbon, available NK and highly significant and negative correlation with soil pH, electrical conductivity and CaCO_3 content however leaf P was non-significant. The plant height showed significantly positive correlation with leaf N (0.918**), P (0.960**), K (0.937**), Fe (0.964**), Mn (0.936**), Zn (0.977**) and Cu content (0.981**) and highly significant and negative correlation with soil pH (-0.927**), electrical conductivity (-0.891**) and CaCO_3 content (-0.962**). The canopy volume showed significantly positive correlation with leaf N content (0.903**), leaf P content (0.972**), leaf K content (0.937**), leaf Fe content (0.964**), leaf Mn content (0.945**), leaf Zn content (0.977**) and leaf Cu content (0.982**), organic carbon % (0.887**), available N (0.887**), available P (0.549*), available K (0.717**), and highly significant and negative correlation with soil pH (-0.929**), electrical conductivity (-0.897**) and CaCO_3 content (-0.966**). The shoot length showed significantly positive correlation with leaf N content (0.876**), leaf P content (0.931**), leaf K content (0.945**), leaf Fe content (0.982**), leaf Mn content (0.985**), leaf Zn content (0.986**) and leaf Cu content (0.983**), organic carbon % (0.883**), available N (0.883**), available P (0.537*), available K (0.752**), and highly significant and negative correlation with soil pH (-0.936**), electrical conductivity (-0.939**) and CaCO_3 content (-0.980**). The number of leaves per shoot showed significantly positive correlation with leaf N content (0.844**), leaf P content (0.846**), leaf K content (0.748**), leaf Fe content (0.738**), leaf Mn content (0.669**), leaf Zn content (0.765**) and leaf Cu content (0.800**), organic carbon % (0.769**), available N (0.769**), available P (0.557*), available K (0.533**), and highly significant and negative correlation with soil pH (-0.744*), electrical conductivity (-0.623**) and CaCO_3 content (-0.742**). The relative water content of Kinnow leaves showed significantly positive correlation with leaf N content (0.755**), leaf P content (0.875**), leaf K content (0.846**), leaf Fe content (0.910**), leaf Mn content (0.977**), leaf Zn content (0.932**) and leaf Cu content (0.921**), organic carbon % (0.811**), available N (0.811**), available K (0.668**), and highly significant and negative correlation with soil pH (-0.930**), electrical

conductivity (-0.961**) and CaCO_3 content (-0.923**) however leaf P was non-significant.

Thus, plant growth with PAR, vpd is negatively correlated whereas rest parameters are positively correlated as well as highly association registered with leaf temperature, relative humidity and WUE with canopy volume. Further soil properties with regards to pH, EC and CaCO_3 negatively correlated with photosynthetic and soil parameters and organic carbon, N, P, K parameters showed positive with plant growth and soil physico-chemical parameters. Leaf nutrient and photosynthesis (PAR, RH, WUE) was positive except vpd and leaf P & canopy volume, leaf Mn & Zn with shoot length were established highly positive relationship among each other.

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Effect of Different Levels of NPK and Rhizobium on Growth and Yield of Cowpea (*Vigna unguiculata* L.) Var. Pusa Komal

Dinesh Kumar Sharma^{1*}, Tarence Thomas¹, Shankar Lal Yadav², Rohan Serawat¹, Ajit Kumar Meena³, Jaipal Yadav³

¹Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj-211007, U.P.

²Department of Soil Science and Agricultural Chemistry, RVSKVV, Gwalior, M.P.

³Department of Soil Science and Agricultural Chemistry, MPUAT, Udaipur, Rajasthan

*Corresponding Author Email : dineshsharma115781@gmail.com

Abstract

A field study was conducted on the “Effect of different levels of NPK and Rhizobium on Physico-Chemical properties of soil in Cowpea (*Vigna unguiculata* L.)” var. PusaKomal” at the Soil Science & Agricultural Chemistry Research Farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during Kharif season 2018. The soil of experimental area falls in order Inceptisol and soil texture was sandy loam treatment combination $T_8-N_2R_2$ [@ 100% NPK ha⁻¹+ 100% Rhizobium ha⁻¹] combined use of NPK resulted in significant increase on enrichment of soil fertility status. The design applied was 3x3 factorial randomized block design having three factors with three levels of NPK @ 0, 50 and 100 % ha⁻¹, three levels of Rhizobium @ 0, 50 and 100% ha⁻¹ respectively. The result obtained with treatment $T_8 - N_2R_2$ [@ 100% NPK ha⁻¹+ 100% Rhizobium ha⁻¹] that showed the highest yield regarding, gave the best results with respect to plant height 193.30 cm, number of leaves plant⁻¹ 45.40, No. of branches 14.74, it gave highest yield 21.95 q ha⁻¹ as compared to T_0 (control).

Key words : Cowpea, NPK, rhizobium, growth and yield of cowpea.

Introduction

Pulses are the main source of protein particularly for vegetarians and contribute about 14% of the total protein of average Indian diet. Production of pulses in the country is far below the requirement to meet even the minimum level per capita consumption. The per capita availability of pulses in India has been continuously decreasing which is 32.52 g day⁻¹ against the minimum requirement of 80 g day⁻¹ per capita prescribed by Indian Council of Medical Research (ICMR). Therefore, it is necessary for agricultural scientists to evolve strategy to increasing production of pulses to meet the protein requirements of increasing population of the country. Cowpea (*Vigna unguiculata* L.) is a self-pollinated leguminous crop which is grown during kharif as well as summer seasons in arid and semi-arid regions of India. It is tolerant to drought and can be grown successfully on drained loamy to sandy loam soil in areas of erratic rainfall. Cowpea is primarily a rainy season crop but with the development of early maturing varieties, it has also proved to be an ideal crop for spring and summer season. It has protein content about 24.6 % and rich source of calcium and iron. Cowpea production in Rajasthan is about 11644 tonnes from an area about 124407 hectare.

Cowpea [*Vigna unguiculata* L.] is also known as black eye pea, southern pea and crowder pea. It is an important legume vegetable crop. The crop is used for

variety of ways, as vegetable it is grown for its long tender green pods which are used as a vegetable. Mature but green seeds are also used as a vegetable purpose. Commonly it is used for soil fertility improvement through biological nitrogen fixation, green manuring, forage yield, production of high quality hay and silage, synthesis of nutritional products, suppression of weeds, food, and a source of protein and income generation.

Materials and Methods

The investigation on “Effect of different levels of NPK and Rhizobium on Physico-Chemical properties of soil in Cowpea (*Vigna unguiculata* L.) var. PusaKomal” comprise of a field experiment which was carried out at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during kharif season 2018-19. The details about the experiment site, soil and climate is described in this chapter together with the experimental design, layout plan, culture practice, particulars of treatments, planting material and techniques employed for the parameters.

It is situated at 25°24'23" N latitude, 81°50'38" longitude and at the altitude of 98 meter above the sea level. The area of Prayagraj 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.

Experiment will be laid out in 3x3 factorial randomized block design with three levels of NPK and Rhizobium plot size was 2x2 m² for crop seed rate is 15-20 kg ha⁻¹ (*Vigna unguiculata L.*) var. Pusa Komal. Cowpea sowing was done on in 21th July 2018 and the source of NPK and Rhizobium were Urea, SSP, MOP and Rhizobium respectively. Dose of fertilizer was applied in respective plots according to treatment allocation uniform furrows opened by about 5 cm. All the agronomic practices were carried out uniformly to raise the crop. The crop was harvested on October 2018.

Results and Discussion

Plant Height (cm) : The data presented in table-1 and depicted in fig.-1 clearly shows the response of plant height of Cowpea recorded at 30 DAS, 45 DAS and 60 DAS as influenced by different levels NPK and Rhizobium. The plant height of Cowpea was found to be increased significantly with the increase in levels of NPK and Rhizobium. The maximum plant height was recorded as 65.35 cm, 181.44 cm and 193.30 cm in T₈ (@100%NPK+100% Rhizobium) at 30 DAS, 45 DAS and 60 DAS respectively and the minimum plant height was recorded as 51.10 cm, 143.50 cm and 169.02 cm in T₀ (control) at 30 DAS, 45 DAS and 60 DAS respectively. Increase in plant height due to increase in NPK and Rhizobium fertilizers may be due to adequate supply of nutrients which in turn helps in vigorous vegetative growth of plants and subsequently increase the plant through cell

Table-1 : Effect of different levels of NPK and Rhizobium on the Plant height (cm) 30, 45 and 60 DAS.

Treatment	Plant height (cm)		
	30 Days	45 Days	60 Days
T ₀	51.10	143.50	169.02
T ₁	52.22	149.92	172.32
T ₂	55.28	158.22	176.32
T ₃	56.30	170.01	181.92
T ₄	57.93	171.15	184.62
T ₅	60.40	173.70	186.68
T ₆	61.20	174.52	188.02
T ₇	62.42	177.22	189.70
T ₈	65.35	181.44	193.30
F-test	S	S	S
S. Em+	0.12	0.21	0.02
C.D. (P= 0.05)	0.37	0.62	0.05

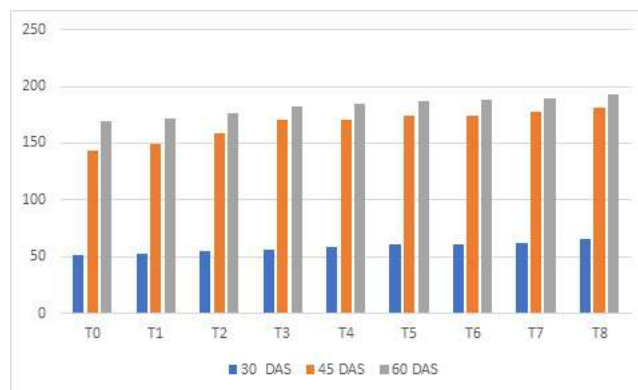


Fig.-1 : Effect of different levels of NPK and Rhizobium on the Plant height (cm) 30, 45 and 60 DAS.

elongation, cell division, photosynthesis and turbidity of plant cell. The increase in nodulation and nitrogen fixation leads to more plant height. Similar findings were reported by Sharma and Dayal, (2005).

Number of Leaves plant per plant : The data presented in table-2 and depicted in fig.-2 clearly shows the response of number of leaves plant⁻¹ of Cowpea recorded at 30 DAS, 45 DAS and 60 DAS as influenced by different levels NPK and Rhizobium. The number of leaves plant⁻¹ of cowpea was found to be increased significantly with the increase in levels of NPK and Rhizobium. The maximum number of leaves was recorded as 18.19, 32.70 and 45.40 in T₈ (@100%NPK+100% Rhizobium) at 30 DAS, 45 DAS and 60 DAS respectively and the minimum number of leaves were recorded as 8.30, 19.40 and 28.50 in T₀

Table-2 : Effect of different levels of NPK and Rhizobium the number of Leaves plant⁻¹ at 30, 45 and 60 DAS.

Treatment	No. of leaves per plant		
	30 Days	45 Days	60 Days
T ₀	8.30	19.40	28.50
T ₁	10.62	21.31	30.42
T ₂	11.51	22.00	32.30
T ₃	12.42	22.20	33.92
T ₄	14.20	24.42	35.52
T ₅	14.82	26.52	37.50
T ₆	15.73	28.95	41.43
T ₇	17.90	32.30	43.09
T ₈	18.19	32.70	45.40
F-test	S	S	S
S. Em+	0.01	0.39	0.01
C.D. (P= 0.05)	0.04	1.16	0.04

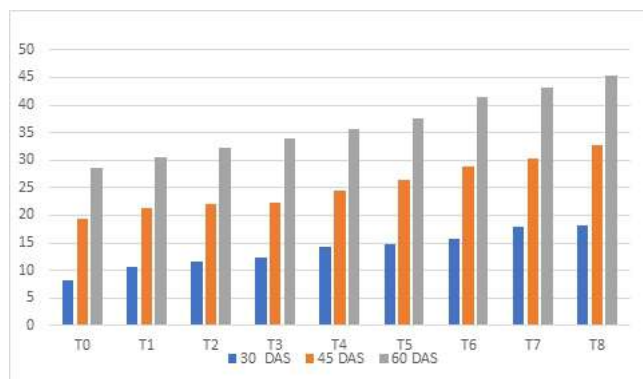


Fig.-2 : Effect of different levels of NPK and Rhizobium the number of Leaves plant⁻¹ at 30, 45 and 60 DAS.

(control) at 30 DAS, 45 DAS and 60 DAS respectively. 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 Shete *et al.* (2010).

Number of Branches per plant : The data presented in table-3 and depicted in fig.-3 clearly shows the response of number of branches plant⁻¹ of Cowpea recorded at 30 DAS, 45 DAS and 60 DAS as influenced by different levels NPK and Rhizobium. The number of branches plant⁻¹ of Cowpea was found to be increased significantly with the increase in levels of NPK and Rhizobium. The maximum number of branches was recorded as 7.21, 13.50 and 14.74 in T₈ (@ 100%NPK+100% Rhizobium) at 30 DAS, 45 DAS and 60 DAS respectively that was higher than any other treatment combination. Increase in number of branches due to increasing in adequate supply of NPK

Table-3 : Effect of different levels of NPK and Rhizobium the number of branches plant⁻¹ at 30, 45 and 60 DAS.

Treatment	No. of Branches per plant		
	30 Days	45 Days	60 Days
T ₀	3.30	5.74	7.74
T ₁	3.30	6.09	8.40
T ₂	3.33	6.50	9.52
T ₃	4.20	7.00	10.30
T ₄	4.52	7.41	10.62
T ₅	5.43	9.08	11.41
T ₆	5.98	10.83	12.82
T ₇	6.50	12.51	13.53
T ₈	7.21	13.50	14.74
F-test	S	S	S
S. Em+	0.03	0.38	0.02
C.D. (P= 0.05)	0.08	1.15	0.06

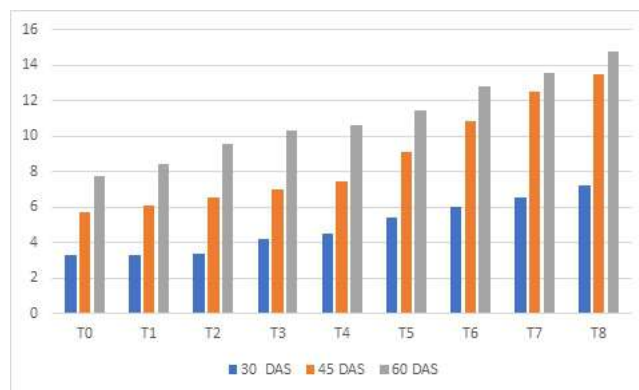


Fig.-3 : Effect of different levels of NPK and Rhizobium the number of Branches plant⁻¹ at 30, 45 and 60 DAS.

and Rhizobium fertilizers which in turn help in vigorous vegetative growth of plants and subsequently increase the number of branches through cell elongation, cell expansion, cell division, photosynthesis and turbidity of plant cell. Similar findings were also reported by Aslam (2010) and Bhaskara (2015).

Number of Pods per plant : The data presented in table-4 and depicted in fig.-4 clearly shows the response of number of pods plant⁻¹ of Cowpea recorded as influenced by different levels NPK and Rhizobium. The number of pods plant⁻¹ of Cowpea was found to be increased significantly with the increase in levels of NPK and Rhizobium. The maximum number of pods was

Table-4 : Effect of different levels of NPK and Rhizobium the number of Pods/plant.

Treatment	No. of pod per plant
T ₀	12.30
T ₁	12.95
T ₂	13.97
T ₃	14.31
T ₄	14.62
T ₅	15.64
T ₆	17.00
T ₇	17.95
T ₈	18.00
F-test	S
S. Em+	0.39
C.D. (P= 0.05)	1.18

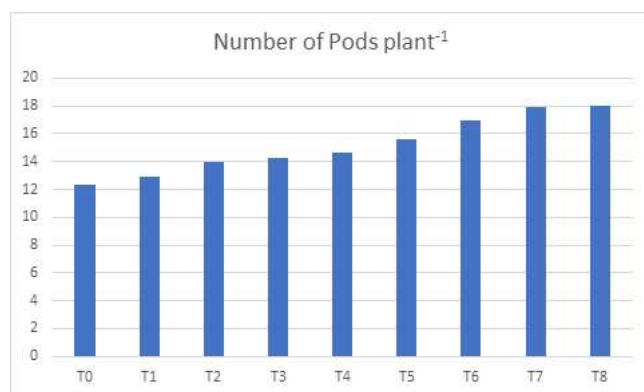


Fig.-4 : Effect of different levels of NPK and Rhizobium the number of Pods/plant.

recorded as 18.00 in T₈ (@100%NPK+100% Rhizobium) and the minimum number of pods were recorded as 12.30 in T₀ (control). 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 Patel *et al.*, (2013) and Kumawat *et al.*, (2010).

Total Grain yield (q/ha) : The data presented in table-5 and depicted in fig.-5 clearly shows the response of total seed yield of Cowpea recorded as influenced by different levels NPK and Rhizobium. The grain yield of Cowpea

Table-5 : Effect of different levels of NPK and rhizobium the total grain yield (q/ha).

Treatment	Total Grain Yield q ha ⁻¹
T ₀	15.95
T ₁	17.05
T ₂	17.60
T ₃	18.38
T ₄	18.77
T ₅	19.40
T ₆	19.85
T ₇	21.15
T ₈	21.90
F-test	S
S. Em+	0.02
C.D. (P= 0.05)	0.05

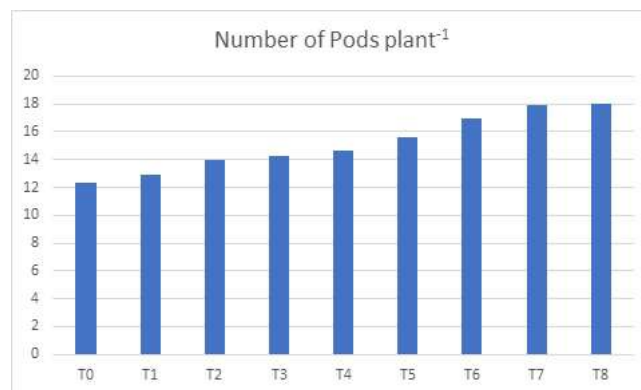


Fig.-5 : Effect of different levels of NPK and rhizobium on the total grain yield (q/ha).

was found to be increased significantly with the increase in levels of NPK and Rhizobium. The maximum grain yield was recorded as 21.95 (q ha⁻¹) T₈ (@ 100% NPK + 100% Rhizobium) which was higher than any other treatment combination and the minimum grain yield was recorded as 15.95 (q ha⁻¹) in T₀(control). Similar results were also reported by Patel *et al.*, (2013).

Conclusions

It was concluded from trail that the effect of different levels in the experiment, the best treatment was T₈ [@ 100% NPK +100% Rhizobium] that showed the highest yield regarding, gave the best results with respect to plant height 193.30 cm, number of leaves plant⁻¹ 45.40, number of branches plant⁻¹, number of pod plant⁻¹ 18.00, it gave highest yield 21.90 q ha⁻¹.

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Genetic Divergence Analysis in Bread Wheat (*Triticum aestivum* L.)

Sohan Lal Kajla¹, A.K. Sharma², Hoshiyar Singh², Mukesh Bhakal³, Moti Ram Natwaria¹ and Shravan Kumar Sharma¹

¹Department of Genetics and Plant Breeding, College of Agriculture, SKRAU, Bikaner, Rajasthan

²Department of Plant Breeding and Genetics, Rajasthan Agriculture Research Institute, Durgapura, Jaipur, Rajasthan

³Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner, Rajasthan

*Corresponding Author Email : kajlasikar@gmail.com

Abstract

The study was conducted during Rabi 2017-18 at the Research Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner to assess the genetic diversity among 55 genotypes of bread wheat. The genetic diversity analysis revealed the formation of sixteen clusters suggesting the presence of wide genetic diversity. The clustering pattern indicated that geographic diversity was not associated with genetic diversity. The analysis of per cent contribution of various characters towards the expression of total genetic divergence indicated that biological yield per plant followed by number of effective tillers per plant, spike length, 1000-seed weight, harvest index, number of grains per spike, days to heading, plant height and days to maturity contributed maximum towards total genetic divergence. Based on the maximum genetic distance, it is advisable to attempt cluster XIII with V and XII would be useful for inducing variability in respective attributes and their rational improvement for increasing the grain yield in bread wheat.

Key words : Bread wheat, genetic divergence, D^2 statistic.

Introduction

Wheat (*Triticum aestivum* L.) is the most widely grown crop and an essential component of the global food security mosaic, providing one-fifth of the total calories for the world's population. India is second largest producer of wheat in the world. It is grown in all the regions of the country and the states, namely, Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Maharashtra, Gujarat, West Bengal, Uttarakhand and Himachal Pradesh together contribute about 98% to the total wheat production of the country and play an important role of supplying carbohydrate and protein (Tewari *et al.*, 2015).

Genetic diversity and relationship among genotypes is a prerequisite for any successful breeding programme. Genetic diversity of plants determines their potential for improved efficiency and hence their use for breeding, which eventually may result in enhanced food production. Evaluation of genetic diversity levels among adapted, elite germplasm can provide predictive estimates of genetic variation among segregating progeny for pure-line cultivar development. Genetic similarity or dissimilarity can be compared by genetic distance between different individuals. Genetic distance can be used to measure the genetic divergence between different sub-species or different varieties of a species. The parents having more genetic distant relationship result into higher heterotic expression in F_1 and greater

amount of genetic variability in segregating populations (Shekhawat *et al.*, 2001). The genetic diversity of genotypes is not always based on factors such as geographical diversity, place of release and ploidy level etc. Hence characterization of genotypes should be based on statistical procedures. Different statistical methods have been developed to assess the genetic diversity such as D^2 -statistics and hierarchical cluster analysis. These methods determine the genetic divergence using the similarity or dissimilarity based on aggregate effect of different economic important traits. Some appropriate methods, cluster analysis, PCA and factor analysis, for genetic diversity identification, parental selection, tracing the pathway to evolution of crops, centre of origin and diversity, and study interaction between the environment are currently available (Bhatt, 1970; Carves *et al.*, 1987; Mohammadi and Prasanna, 2003). Precise information on nature and degree of genetic divergence helps the plant breeder in selecting the genetically diverse parents for the purposeful hybridization (Arunachalam, 1981). Genetic improvement of yield especially in self-pollinated crops depends on nature and amount of genetic diversity (Joshi and Dhawan, 1966).

Materials and Methods

The study was conducted during rabi 2017-18 at the Research Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner to assess the genetic diversity among 55 genotypes of bread

Table-1 : Grouping of 55 genotypes of bread wheat in various clusters on the basis of D² statistic.

Cluster	No. of genotypes	Name of genotypes
I	16	Raj 4238 x Raj 4079, Raj 3777 x DBW 90, HD 3086, Raj 4079 x Raj 3777, Raj 1482, Raj 3077 x DBW 90, Raj 4238 x Raj 3077, DBW 90, WH 1021 x DBW 90, Raj 4238 x DBW 90, Raj 4079 x HD 3086, Raj 1482 x PBW 550, Raj 4238, Raj 3765 x PBW 550, PBW 550 x HD 3086, Raj 4238 x Raj 3777
II	7	Raj 4079 x WH 1021, Raj 3777 x PBW 550, Raj 3765 x Raj 3777, Raj 4238 x PBW 550, Raj 3077 x HD 3086, DBW 90 x HD 3086, Raj 4238 x Raj 3765
III	1	Raj 3077
IV	1	Raj 3765 x Raj 1482
V	6	Raj 3077 x Raj 3777, DBW 90 x PBW 550, Raj 4238 x WH 1021, Raj 3777 x HD 3086, Raj 3765 x HD 3086, WH 1021 x PBW 550
VI	14	Raj 3765, Raj 3765 x WH 1021, Raj 3077 x PBW 550, Raj 3077 x Raj 1482, Raj 3777, Raj 4238 x HD 3086, Raj 1482 x WH 1021, Raj 3777 x WH 1021, Raj 1482 x DBW 90, PBW 550, Raj 4079 x PBW 550, Raj 1482 x Raj 3777, Raj 4238 x Raj 1482, Raj 4079 x DBW 90
VII	1	Raj 4079 x Raj 1482
VIII	1	Raj 4079 x Raj 3077
IX	1	WH 1021 x HD 3086
X	1	Raj 4079 x Raj 3765
XI	1	Raj 4079
XII	1	Raj 3765 x DBW 90
XIII	1	Raj 3765 x Raj 3077
XIV	1	Raj 3077 x WH 1021
XV	1	WH 1021
XVI	1	Raj 1482 x HD 3086

wheat (*Triticum aestivum* L.). Fifty five genotypes were evaluated in a Randomized Block Design in three environments viz., three different dates of sowing 15 Nov. (timely sown), 1 Dec. (late sown) and 15 Dec. (very late sown) with 3 replications. Row length was 4 meter. Row to row and plant to plant distance was kept 22.5 cm and 10 cm, respectively. Observations were recorded on 12 different characters viz., days to heading, days to maturity, grain filling period, plant height, flag leaf area, number of effective tillers per plant, spike length, number of grains per spike, 1000-seed weight, biological yield per plant, harvest index and grain yield per plant. The data were analysed as per the multivariate analysis of genetic divergence using Mahalanobis (1936) D² statistics described by Rao (1952). The genotypes were grouped into different clusters following the Tocher's method (Rao, 1952).

Results and Discussion

The results of genetic divergence revealed that D² statistic estimated on 55 genotypes of bread wheat for 12 characters showed that the generalized distance (D="D₂) between two populations varied from 4.95 to 30.43, which was an indicator of considerable diversity available in the material evaluated (Table-2). On the basis of D² values,

16 clusters were formed from 55 genotypes (Table-1). The clustering pattern of genotypes showed that the genotypes of different origins were clubbed into one cluster, whereas the genotypes belonging to same state or origin were grouped into different clusters indicating that the geographic distribution was not the sole criterion of genetic diversity. The results obtained in the present study are in accordance to the findings of Dhakar *et al.* (2012), Verma *et al.* (2013), Kumar *et al.* (2014b), Singh *et al.* (2014), Arya *et al.* (2017) and Singh *et al.* (2019) who also reported that there was no parallelism between geographic distribution and genetic diversity.

The cluster I contained 16, cluster VI contained 14, cluster II contained seven and cluster V contained six genotypes from different origins. On the other hand, the clusters III, IV, VII, VIII, IX, X, XI, XII, XIII, XIV, XV and XVI possessed only one genotype in each cluster (Table 1). In general, intra-cluster distance values were lower than the inter-cluster distances (Table 2). Thus, the genotypes included within a cluster tended to diverse less from each other. The lowest intra-cluster distance was in cluster II (D=5.20), whereas the highest intra-cluster distance was in cluster VI (D=7.04). The maximum inter-cluster distance (D) was observed between clusters II and XIII

Table-2 : Average inter and intra-cluster distance ($D="D^2"$) values for 55 genotypes of bread wheat.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
I	5.39	12.75	6.85	6.51	14.18	7.16	6.88	7.38	7.49	7.69	6.56	7.41	20.35	6.46	7.32	7.60
II		5.20	12.73	13.12	24.53	16.12	11.59	12.17	8.44	13.34	9.98	10.54	30.43	12.04	11.68	9.88
III			0.00	6.84	13.73	8.60	4.98	7.49	8.67	4.95	7.82	5.14	19.19	8.48	7.36	8.36
IV				0.00	13.90	7.55	6.55	8.51	8.86	6.81	7.70	7.88	19.23	5.61	7.82	7.23
V					5.94	11.95	15.73	15.61	18.22	14.25	16.76	16.28	8.32	16.56	15.67	17.30
VI						7.04	9.10	9.85	10.62	9.15	9.31	10.12	17.66	6.63	9.30	9.58
VII							0.00	7.99	8.55	6.98	7.83	7.06	21.40	5.56	9.70	8.26
VIII								0.00	6.68	7.99	7.92	6.00	21.89	8.59	8.76	10.16
IX									0.00	8.87	5.03	6.96	24.45	8.95	6.64	6.19
X										0.00	10.05	6.67	19.68	9.17	7.79	7.70
XI											0.00	7.21	22.74	7.61	5.89	6.78
XII												0.00	22.16	8.53	7.63	7.97
XIII													0.00	22.58	21.21	22.79
XIV														0.00	10.00	8.81
XV															0.00	5.91

Table-3 : Cluster mean for 12 different characters in 55 genotypes of bread wheat.

Cluster	Days to heading	Days to maturity	Grain filling period	Plant height	Flag leaf area	No. of effective tillers per plant	Spike length	No. of grains per spike	1000-seed weight	Biological yield per plant	Harvest index	Grain yield per plant
I	73.14	112.96	39.12	74.37	21.49	6.50	9.85	41.09	34.26	39.08	37.87	14.96
II	73.43	112.43	39.00	74.75	21.66	5.00	9.35	33.96	30.56	27.20	37.56	10.25
III	71.45	109.89	38.44	75.45	23.62	7.61	11.42	42.39	32.36	35.07	42.04	14.76
IV	77.56	117.44	39.89	77.63	16.63	7.34	10.97	39.88	34.87	37.48	39.78	15.11
V	71.94	110.39	38.45	81.60	21.41	8.36	12.01	50.33	38.50	48.91	47.00	23.03
VI	73.17	112.03	38.86	77.93	20.85	6.76	10.69	41.84	35.25	42.51	37.22	15.93
VII	76.33	107.33	31.00	76.12	23.03	7.80	10.11	39.37	32.02	35.04	36.50	12.92
VIII	71.11	111.45	40.33	78.88	19.75	6.97	8.28	41.83	38.29	34.46	44.82	15.52
IX	73.67	112.00	38.33	78.05	21.55	5.10	9.08	42.09	33.49	34.12	42.63	14.73
X	72.55	115.55	43.00	80.32	20.09	7.95	10.85	44.69	27.77	36.06	42.30	15.24
XI	74.33	108.44	34.11	71.72	20.62	5.04	10.26	40.39	36.79	35.17	40.28	14.38
XII	70.44	112.22	41.78	71.61	21.69	6.63	10.19	37.99	33.19	34.60	49.38	17.15
XIII	72.67	110.67	38.00	87.01	20.51	9.44	14.47	54.06	39.60	52.23	49.83	26.08
XIV	77.89	111.11	33.22	71.26	17.07	7.20	9.07	36.08	34.14	37.58	34.53	13.03
XV	70.56	113.56	43.00	76.44	17.87	5.39	11.64	44.62	32.49	34.96	39.12	13.80
XVI	75.22	115.44	40.22	80.14	21.63	5.29	11.64	39.86	28.48	36.49	38.16	13.96
Times Ranked 1 st	55	13	0	14	5	185	147	61	90	829	86	0
Contribution %	3.70	0.88	0.00	0.94	0.34	12.46	9.90	4.11	6.06	55.82	5.79	0.00

(D=30.43) followed by clusters II and V (D=24.53) and IX and XIII (D=24.45). The minimum inter-cluster distance (D=4.95) was found between clusters III and X. The genotypes belonging to different clusters separated by high statistical distance could be used in hybridization program for obtaining a wide spectrum of variation among the segregates. A wide range of variation for several characters among single as well as multi-genotype clusters was observed. However, the differences were clear for number of effective tillers per plant, spike length, number of grains per spike, biological yield per plant, harvest index and grain yield per plant. The present findings are in conformity with those reported earlier in wheat by Singh *et al.* (2010), Arya *et al.* (2017) and Singh *et al.* (2019). The clustering pattern could be utilized in selecting the parents and the cross combinations which may generate the highest possible variability for various traits.

The clustering pattern could be utilized in selecting the parents and deciding the cross combinations which may generate the highest possible variability for various traits. The genotypes with high values of any cluster can be used in hybridization program for further selection and improvement. In the present study, cluster XIII indicated high cluster mean values for number of effective tillers per plant, number of grains per spike, 1000-seed weight, biological yield per plant and grain yield per plant (Table 3). Cluster XIII showed highest cluster mean values 26.08 followed by cluster V (23.03) and cluster XII (17.15). Cluster XII and cluster XV exhibited lowest cluster mean values for days to heading. Cluster V expressed the highest cluster mean values for spike length and 1000-seed weight. Therefore, intercrossing of genotypes involved in these cluster would be useful for inducing variability in respective characters and their rational improvement for increasing the grain yield. High cluster means for various characters were also reported by Kumar *et al.* (2013), Kumar *et al.* (2014a), Arya *et al.* (2017) and Singh *et al.* (2019).

The analysis of per cent contribution of various characters towards the expression of total genetic divergence indicated that biological yield per plant followed by number of effective tillers per plant, spike length, 1000-seed weight, harvest index, number of grains per spike, days to heading, plant height and days to maturity contributed maximum towards total genetic divergence in the current study (Table 3). The present finding are supported with earlier reports of Kolakar *et al.* (2014), Kumar *et al.* (2014a), Arya *et al.* (2017), Santosh *et al.* (2017) and Singh *et al.* (2019). These attributes accounted for more than 99 per cent of total divergence in the present material studied.

From the above results and discussion, it can be concluded that genotypes from cluster XIII with V and XII would be useful for inducing variability in respective attributes and their rational improvement for increasing the grain yield in bread wheat.

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Water Productivity of American Cotton (*Gossypium hirsutum* L.) Influenced as Different Irrigation Levels and Mulches

Shri Rakesh, S.R. Bhunia, N.K. Pareek, Pramendra Singh and Akshika Bhawariya

Department of Agronomy, College of Agriculture, Bikaner, SKRAU, Bikaner, Rajasthan-334006

Email : shrirakeshchoudhary108@gmail.com

Abstract

A field experiments were conducted consecutively for two years during kharif season of 2019 and 2020 at Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner to study the effect of irrigation levels and mulches on growth, yield and water productivity of American cotton (*Gossypium hirsutum* L.) in Arid Western Rajasthan. The experiment comprising total 20 treatment combinations; five level of irrigation (0.30 PE, 0.45 PE, 0.60 PE, 0.75 PE and 0.75 IW/CPE ratio) and four mulches (no mulch, dust mulch, straw mulch and polythene mulch) in split plot design with three replications. Results of the investigation revealed that crop irrigated at 0.60 PE through drip irrigation recorded significantly higher physical and economical water productivity as compared to irrigation level of 0.30, 0.45 PE through drip irrigation and 0.75 IW/CPE ratio (Surface irrigation), it was at par with drip irrigation level of 0.75 PE during both the years and pooled result basis. Among mulch treatments, straw mulch proved effective in terms of physical and economical water productivity over no mulch, dust mulch and polythene mulch. Further, interactive effect showed that irrigation level of 0.45 PE along with straw mulch gave maximum physical and economical water productivity which was significantly superior over rest of treatments.

Key words : Cotton, drip irrigation, surface irrigation, mulch, water productivity.

Introduction

Cotton, the white gold is the world's leading fibre crop plays important role in economics of the world and also considered as the fourth most important oilseed. Cotton production, processing and trade provide livelihood and employment to several millions of people. Export of raw cotton, yarn, textile, garments, cotton seed cake, earns valuable foreign exchange. Cotton fibre is preferred in apparel textiles and garments because of its hydrophilic properties and hence despite severe competition from synthetic fibre, cotton continues to enjoy a place of pride in textile industries. Besides fibre, cotton is also valued for its oil and cotton seed cake and several other by-products. Globally cotton production is 118.5 million bales in 2018-19 (USDA, 2019). India is the second largest producer after china in the world. In India, it is cultivated in 13.37 million hectares with an annual production of 35.49 million bales and productivity of 386 kg ha⁻¹ in 2019-20 (Anonymous, 2020a). It is mostly cultivated in the states of Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu. In Rajasthan, Sri Ganganagar, Hanumangarh, Bhilwara, Banswara, Nagaur, Jodhpur, Alwar, Bikaner and Ajmer are major cotton growing districts. The crop occupied 7.60 lakh hectares area and produced 27.87 lakh bales with the productivity 623 kg ha⁻¹ in 2019-20 (Anonymous, 2020b).

Low yield of cotton in arid western Rajasthan associated with cultivation of cotton on light soils with low

in organic matter, available nutrient status, low water holding capacity and high evaporation. Under such conditions, proper management of available irrigation water through introduction of drip system along with along with mulch can be effective intervention in enhancing water productivity. For achieving maximum crop growth and productivity per unit of applied water has become more critical as increasing cost of water and ever decreasing availability of water for crops.

Irrigation is the most important parameter for enhancing crop growth and productivity. However, water supply is uneven and inadequate because of the increased human needs (Wu and Cosgrove, 2000). With increasing concerns over the utilization of scarce water resources, there has been a renewed interest in improving water productivity (Tennakoon and Milroy, 2003). Increasing irrigation efficiency would improve irrigation water management (Hou *et al.*, 2007). Among irrigation methods drip irrigation is becoming more popular worldwide due to the controlled irrigation rate that fulfills the requirement of a crop during all crop growth stages (Mmolawa 2000). Adoption of drip irrigation technology in combination of mulch also has the potential for soil water-conservation and increased crop yields (Luo *et al.*, 2013). Mulching is a practice for conservation of soil water by reducing evaporation; moderation of soil temperature and control of weed growth. Soil temperature is one of the important soil factor affecting growth and development of cotton. Mauney (1986) suggested that all

processes squaring, blossoming and boll initiation, maturation and boll opening are temperature dependent. High temperature results in delayed crop growth and fruiting abortion. An optimum temperature for cotton ranges from 20 to 30°C (Reddy *et al.* 1991), but cotton is successfully grown at temperatures even in excess of 40°C. Prolonged extreme temperature is harmful for crop growth. Thus, mulching has a scope to moderate soil temperature, enhancing crop growth, productivity and soil water conservation. There is an urgent need to follow management practices for efficient use of limited irrigation water. The present studies were, therefore, under taken to evaluate the effect of irrigation levels mulches on water productivity of cotton.

Materials and Methods

The field experiments were conducted at Instructional Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan, India (28° 01'N latitude and 73° 22'E longitude at an altitude of 235 meters above mean sea level) during *kharif* season of 2019 and 2020. The soil of experimental field was loamy-sand, alkaline in reaction (pH 8.4 and 8.5) having 103.5 and 101.3 kg/ha available N (Alkaline permanganate method, Subbiah and Asija, 1956), low level of available phosphorus of 15.1 and 15.4 kg/ha (Olsen's method, Olsen *et al.*, 1954) and medium in available potassium of 173.7 and 172.5 kg/ha (Flame photometric method, Metson, 1956) in 0-15 cm soil depth at the start of the both experiments. The experiment comprising total 20 treatment combinations; five level of irrigation (0.30 PE, 0.45 PE, 0.60 PE, 0.75 PE through drip irrigation on alternative day and 0.75 IW/CPE ratio through surface irrigation) and four mulches (no mulch, dust mulch, straw mulch and polythene mulch) in split plot design with three replications. Cotton variety 'RCH-650 BG-II' was sown on 23.05.2019 and 24.05.2020 with using 1.8 kg seed ha⁻¹ at the spacing of 100 × 60 cm. All the recommended package of practices was followed to raise the crop.

Water productivity : It is used to define the relationship between crop produced and the amount of water involved in crop production, expressed as crop production per unit volume of water. Crop production may be expressed in terms of seed cotton yield. Crop yield also transformed into monetary units. It is expressed as kg m⁻³ or m⁻³.

$$\text{PWP (kg ha}^{-1} \text{ mm}^{-1}) = \frac{\text{Seed cotton yield (kg ha}^{-1})}{\text{Water used (mm)}}$$

$$\text{EWP (₹ kg m}^{-3} \text{ of water)} = \frac{\text{Gross returns (₹ ha}^{-1})}{\text{Water used (m}^3\text{)}}$$

Experimental data recorded in various

observations were statistically analyzed with the help of Fisher's analysis of variance technique (Fisher, 1950). The analysis of data of the various treatments was compared together using CD at 5% significant levels.

Results and Discussion

Water use (field) : Data regarding water use in field presented in table-1 showed that in 2019, 2020 as well as on pooled mean basis, highest water use of 1232.0, 1096.5 and 1164.3 mm was recorded with 0.75 PE and lowest water use of 658.9, 571.9 and 615.4 mm was recorded with irrigation level of 0.30 PE, respectively.

Physical water productivity

Effect of irrigation levels and mulches : The analysis of the data showed that the physical water productivity affected as irrigation levels and mulches in 2019, 2020 as well as on pooled basis (Table-1). Significantly higher physical water productivity (3.30, 3.67 and 3.49 kg ha⁻¹ mm) in 2019, 2020 as well as on pooled basis was observed with irrigation level of 0.60 PE, which was statistically at par with 0.45 PE level of irrigation as compared to 0.30, 0.75 PE and 0.75 IW/CPE ratio, respectively. The physical water productivity decreased with increase in irrigation levels from 0.60 to 0.75 PE. Increased physical water productivity might be due to reduced water losses through the soil, controlled deep percolation loss, elimination of runoff and irrigation to smaller portion of soil volume and more efficient plant use coupled with higher productivity. The highest physical water productivity at 0.60 PE irrigation level indicated most efficient utilization of water for growth and development of plants. The decrease in physical water productivity with increase in irrigation level from 0.60 and 0.75 PE indicated that production of seed cotton per mm of water utilized decreased with increase in irrigation water supply. Physical water productivity clearly indicated that when water quantity is limited, irrigation scheduling should be adjusted in accordance with, to maximize water productivity rather than maximum yield per unit area of land as opined by scientists working for efficient management of irrigation water. Nalayini *et al.* (2006) found the best results for WUE with 80% ET_c, which corroborated the results of these research findings. Among mulch treatments, mulches were found to be effective in increasing the physical water productivity of cotton. Results revealed that straw mulched plot found highest physical water productivity (3.43, 3.85 and 3.64 kg ha⁻¹ mm) which was higher by 25.64, 22.06 and 9.94 per cent in 2019, 25.82, 24.60 and 8.76 per cent in 2020 and 25.95, 23.39 and 9.31 per cent on pooled data basis over no mulch, dust mulch and polythene mulch, respectively. Straw mulching is well-known for preserving soil moisture and increasing physical water productivity. Mulch

Table-1 : Effect of irrigation levels and mulches on water use and physical water productivity of cotton.

Treatments	Water use in field (mm)			Physical water productivity (kg ha ⁻¹ mm)			Economical water productivity (₹ m ⁻³)		
	2019	2020	Mean	2019	2020	Pooled	2019	2020	Pooled
Irrigation levels									
0.30 PE	658.9	571.9	615.4	2.85	3.24	3.05	15.00	17.04	16.02
0.45 PE	850.1	746.8	798.5	3.24	3.62	3.43	17.04	19.04	18.04
0.60 PE	1041.2	921.6	981.4	3.30	3.67	3.49	17.36	19.28	18.32
0.75 PE	1232.0	1096.5	1164.3	2.88	3.18	3.03	15.16	16.70	15.93
0.75 IW/CPE ratio	1046.6	922.1	984.4	2.84	3.21	3.02	14.90	16.85	15.88
SEm±	-	-	-	0.08	0.10	0.06	0.41	0.50	0.32
CD at 5 %	-	-	-	0.25	0.31	0.18	1.34	1.64	0.97
Mulches									
No mulch	965.8	851.8	908.8	2.73	3.06	2.89	14.35	16.07	15.21
Dust mulch	965.8	851.8	908.8	2.81	3.09	2.95	14.78	16.22	15.50
Straw mulch	965.8	851.8	908.8	3.43	3.85	3.64	18.03	20.21	19.12
Polythene mulch	965.8	851.8	908.8	3.12	3.54	3.33	16.40	18.62	17.51
SEm±	-	-	-	0.04	0.07	0.04	0.23	0.34	0.21
CD at 5%	-	-	-	0.13	0.19	0.11	0.67	0.99	0.58

Table-2 : Interaction effect of irrigation levels and mulches on physical water productivity (kg ha⁻¹ mm).

Mulches	Irrigation levels														
	2019					2020					Pooled				
	0.30 PE	0.45 PE	0.60 PE	0.75 PE	0.75 IW/CPE ratio	0.30 PE	0.45 PE	0.60 PE	0.75 PE	0.75 IW/CPE ratio	0.30 PE	0.45 PE	0.60 PE	0.75 PE	0.75 IW/CPE ratio
No mulch	2.66	2.68	3.09	2.66	2.56	2.96	2.99	3.33	2.88	3.13	2.81	2.83	3.21	2.77	2.85
Dust mulch	2.73	2.82	3.13	2.72	2.65	2.91	3.02	3.45	2.93	3.13	2.82	2.92	3.29	2.83	2.89
Straw mulch	3.11	3.82	3.69	3.23	3.31	3.71	4.31	4.16	3.63	3.42	3.41	4.06	3.93	3.43	3.37
Polythene mulch	2.91	3.66	3.30	2.92	2.81	3.38	4.18	3.74	3.28	3.14	3.15	3.92	3.52	3.10	2.98
				S.Em ±	CD at 5 %				S.Em ±	CD at 5%				S.E m.±	CD at 5%
Irrigation at same level of mulch				0.12	0.33				0.16	0.46				0.10	0.28
Mulch at same level of irrigation				0.10	0.28				0.15	0.42				0.12	0.35

application under similar irrigation regimes was consistently related with greater values of physical water productivity, which resulted in better soil moisture use and reduced soil evaporation. The fact that straw mulch conserved soil moisture by acting as a barrier at the surface and presenting higher resistance to water flow from the soil surface to the atmosphere may account for the low water use under the straw mulching treatment. With a proportionate increase in seed cotton output, the effect of straw mulch on physical water productivity was conditioned by the effects of better moisture conserve capacity and less water loss by evaporation. It is argued that the increased water stored in soil as a consequence of soil mulching was used in the transpiration process and contributed to the increase in crop physical water productivity. The results confirmed the findings of Ramesh *et al.* (2006).

Interaction effect of irrigation levels and mulches :

Data depicted in table-2 indicated that there was significant difference on physical water productivity due to interaction effect of irrigation levels and mulches during both the years and on pooled results. Results revealed that irrigation level of 0.45 PE along with straw mulch gave maximum physical water productivity which was significantly superior to no mulch, dust mulch and polythene mulch in combination with all levels of irrigation in 2019, 2020 and on pooled result basis. Further, under 0.45 PE, straw mulch also gave maximum physical water productivity which was significantly higher than no mulch, dust mulch and polythene mulch treatments in 2019, 2020 and pooled result basis with every irrigation level. Further, data showed that straw mulch with irrigation level of 0.45 PE gave highest physical water productivity, which was at par with 0.60 PE and significantly superior to 0.30 PE and

Table-3 : Interaction effect of irrigation levels and mulches on economical water productivity (₹ m^{-3}).

Mulches	Irrigation levels														
	2019					2020					Pooled				
	0.30 PE	0.45 PE	0.60 PE	0.75 PE	0.75 IW/ CPE ratio	0.30 PE	0.45 PE	0.60 PE	0.75 PE	0.75 IW/ CPE ratio	0.30 PE	0.45 PE	0.60 PE	0.75 PE	0.75 IW/ CPE ratio
No mulch	14.00	14.06	16.23	13.99	13.48	15.57	15.70	17.51	15.11	16.45	14.79	14.88	16.87	14.55	14.96
Dust mulch	14.35	14.82	16.47	14.31	13.94	15.31	15.85	18.11	15.38	16.45	14.83	15.33	17.29	14.85	15.20
Straw mulch	16.34	20.05	19.39	16.97	17.42	19.50	22.66	21.86	19.06	17.97	17.92	21.35	20.63	18.01	17.69
Polythene mulch	15.30	19.22	17.33	15.35	14.77	17.76	21.96	19.63	17.24	16.52	16.53	20.59	18.48	16.30	15.64
				S.Em. ±	CD at 5 %				S.Em. ±	CD at 5 %				S.Em. ±	CD at 5 %
Irrigation at same level of mulch				0.61	1.75				0.83	2.40				0.51	1.46
Mulch at same level of irrigation				0.52	1.49				0.77	2.21				0.65	1.85

0.75 IW/CPE in both the years and on pooled basis. This increased WP in case of irrigation level of 0.45 PE along with straw mulch in cotton may be due to reduced loss of moisture, reduce nutrient losses and improved hydrothermal regime of soil.

Economical water productivity : It is clear from the data depicted in the table-1 that there was significant difference on economical water productivity among treatments of differed with irrigation levels and mulches during both the years and pooled result basis. Significantly highest economical water productivity (₹ 17.39, 19.28 and 18.32 m^{-3} of water) in 2019, 2020 as well as on pooled basis was observed with irrigation level of 0.60 PE, which was at par with 0.45 PE level of irrigation as compared to 0.30 PE, 0.75 PE and 0.75 IW/CPE ratio, respectively. The increase in economical WP under deficit irrigation can be attributed to several factors, such as the reduction of losses due to evaporation and the increased value of yield parameters (Unlu *et al.*, 2011). Singh *et al.* (2010) found significant differences in the water productivity for different irrigation deficits. The similar effect of deficit irrigation on WP of cotton was reported by Ramesh *et al.* (2006), Sampathkumar *et al.* (2006), Shruti and Aladakatti (2017) and Singh *et al.* (2018). Among mulch treatments, mulches were found to be effective in increasing economical water productivity of cotton. Straw mulch proved effective in terms of economical water productivity ($18.03, 20.21$ and 19.12 m^{-3} of water) over no mulch, dust mulch and polythene mulch in 2019, 2020 and pooled result basis, respectively. Straw mulching is well-known for retaining soil moisture and enhancing water productivity in a cost-effective manner. Mulch application was consistently associated with higher values of economical water productivity under similar irrigation regimes, resulting in better soil moisture use and less soil evaporation. The results confirmed the findings of Ramesh *et al.* (2006).

Interaction effect of irrigation levels and mulches :

Data presented in table-3 indicated that economical water productivity influenced significantly due to interaction effect of irrigation levels and mulches during both the years and on pooled results. Results document that irrigation level of 0.45 PE along with straw mulch gave maximum economical water productivity which was significantly superior to no mulch, dust mulch and polythene mulch in combination with all levels of irrigation in 2019, 2020 and on pooled result basis. Further, under 0.45 PE, straw mulch also gave maximum economical water productivity which was significantly higher than no mulch, dust mulch and polythene mulch treatments in 2019, 2020 and pooled result basis with every irrigation level. Further, data showed that straw mulch with irrigation level of 0.45 PE gave highest economical water productivity, which was at par with 0.60 PE and significantly superior to 0.30 PE and 0.75 IW/CPE in both the years and on pooled basis.

Conclusions

On the basis of present experiments, it may be concluded that cotton crop gave maximum physical and economical water productivity with drip irrigation at 0.60 PE and application of straw mulch.

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Socio-Economic Status of Farmers Adopting Integrated Farming System in Agro-Climatic Zone (IVa) of Rajasthan

Lokesh Kumar¹, Poonam Kumari², Nitesh Kumar Tanwar¹, Jitendra Kumar Meena¹ and Durga Shankar Goswami³

¹Department of Extension Education, Rajasthan College of Agriculture (MPUAT), Udaipur Raj.

²Department of Plant Pathology, SKN College of Agriculture, (SKNAU), Jobner Raj.

³Department of Animal Production, Rajasthan College of Agriculture (MPUAT), Udaipur Raj.

*Corresponding Author Email : lavi0016@gmail.com

Abstract

The study was conducted on different integrated farming systems practicing small and marginal farmers in agro climatic zone (IVa) of Rajasthan state to identifying their socio-economic status. The selected IFS practicing farmers have been interviewed personally with the help of a well-structured and pre-tested interview schedule. The findings of the study observed that majority of the respondents were middle-aged, medium annual income, medium level of extension contact, medium level of mass media utilization, medium level of extension participation, medium level of farming experience, agriculture is main occupation, nuclear type family, small land holding, belongs to other backward class, pucca type of house and primary level of education.

Key words : *Integrated farming system, socio-economic.*

Introduction

Agriculture in the 21st century faces multiple challenges: it has to produce more food and fibre to feed a growing population with a smaller rural labour force, more feedstocks for a potentially huge bioenergy market, contribute to overall development in the many agriculture-dependent developing countries, adopt more efficient and sustainable production methods and adapt to climate change. In India, agriculture production is a backbone of Indian economy, but in recent past agriculture in gross domestic product is declining 14%, average size of land holding is gradually decrease 85% of the farming community. Under the continuing decrease of land holding, horizontal extension of land is not possible. For this reason, vertical integration of farm enterprises will make farming more cost-effective and reliable. The Rajasthan covers an area of 3, 42,239 square kilometer which is 10.4 per cent of the total geographical area of India. It is the largest state of India and the seventh-largest by population. Rajasthan is located on the north-western side of India. The state is endowed with diverse soil and weather conditions comprising of several agro-climatic situations, warm humid in south-eastern parts to dry cool in western parts of the state. About 65 per cent population (i.e. about 56.5 million) of the state is dependent on agriculture and allied activities for their livelihood. Agriculture in Rajasthan is primarily rainfed covering country's 13.27% of available land. The diversity in climatic conditions of the state creates potentiality to develop certain combinations of crops. Integrated farming

system which integrates natural resources and regulation mechanisms into farming activities to achieve maximum replacement of off-farm inputs, secures sustainable production of high quality food and other products through ecologically preferred technologies, sustain farm income, eliminates or reduces sources of present environment pollutions generated by agriculture and sustains the multiple function of agriculture.

Materials and Methods

An ex-post facto research design was used in present study. The present study was conducted in Rajasthan which literally means land of kings. The State of Rajasthan was purposively selected for the present study. The Integrated Farming System (IFS) approach was implemented in all agro climatic zones of Rajasthan under National Mission on Sustainable Agriculture. Out of ten agro climatic zones the sub humid southern plain and aravalli (IVa) zone was selected purposively for the study. It comprises of four districts Bhilwara, Chittorgarh, Rajsamand and Udaipur. Thus, all four districts were selected for the study. Two clusters from each district was selected for present study on the basis of maximum number of farmers benefitted about different farming systems. Therefore, a total of eight clusters were taken for the study. An equal number 30 farmers were selected randomly from each identified cluster. Thus, a total of 240 farmers were selected for the present study. The data was collected through well-structured and pre-tested interview schedule. The collected data was coded, classified and

tabulated with the help of appropriate statistical tools to draw meaningful conclusion.

Results and Discussion

Age : The findings from Table-1 indicate that 61.25 per cent of the respondents belonged to the middle-age category followed by 17.50 per cent and 21.25 per cent of the respondents belonged to the young and old age category, respectively. It is clear from the data the majority of the respondents (61.25 %) were in middle age group. These findings are in consideration with the findings of Lahoti and chole (2010).

Caste : The findings from Table-2 indicate that 44.16 per cent of the respondents belonged to the OBC category followed by 24.58, 15.83 and 15.4 per cent of the respondents belonged to the ST, SC and Higher Caste category, respectively. It is clear from the data the majority of the respondents (44.16 %) were in OBC caste category. The present findings are accordance with the findings of Sharma *et al.* (2004).

Annual income : Table-3 shows the overall distribution of annual income. It was found that majority of the respondents (68.75%) were from medium level of annual income followed by high level (14.58%) and low level (16.66%) of annual income. The family income status of respondents can be attributed to the fact that majority of them had rural background and agriculture as the main source of family income and occupation. The finding are in conformity with the finding of Meshram *et al.* (2020).

Education : The data incorporated in Table-4 clearly shows that majority of farmers belongs to primary education level (25.83%) followed by (17.50%) illiterate, (17.19%) middle level, (14.16) can read and write, high school (7.91%) (6.66%) can read only and (5.41%) above high school, respectively. Similar findings are reported by Girish *et al.* (2020) revealed that 35.00 per cent of the respondents were educated up to primary school level followed by 19.44 per cent educated up to middle school. Similar findings are also reported by Nandwana (2004).

Land Holding : The data in Table-5 indicates that out of 240 respondents, (30.00%) were from marginal category, while (70.00%) were from small farmers category, respectively. The present finding gets support from research reported by Hanumanaikar *et al.* (2008).

Experience : The data presented in Table-6 revealed that, majority (69.58%) of the respondents studying in Zone (IVa), of Rajasthan were from middle level of farming experience, and followed by high level (13.33%) and low level (17.08%) of family experience. The present finding gets support from research reported by Ram *et al.* (2018) and Prakash *et al.* (2020).

Family Type : The data presented in Table-7 indicated that majority of the respondents (74.16%) belonged to the nuclear family system and remaining (25.83%) belonged to joint family system. The present findings are similar with the findings of Devaki (2015) who reported that Majority (59.00 %) of the farm women had nuclear family, while the remaining 41.00 per cent had joint family. Similar findings are also reported by Prasad *et al.* (2017).

Occupation : The data presented in table-8 revealed that majority of the respondents (78.34%) have agriculture as a primary occupation followed by, govt / bussiness (21.66%). The findings are in accordance the observation of Singh *et al.* (2020) and Bharti and Sagar (2021).

House type : The above Table-9 reveals that majority (81.66%) of the respondents have pucca house followed by kachha house (18.33%).The present findings are similar with the findings of Singh (2020) who reported that that 45.20 per cent respondents having their houses of mixed types, followed by 43.60 per cent were residing in pucca houses and 11.20 per cent were such who had kaccha houses.

Extension contact : The data presented in Table-10 revealed that majority (71.66%) of the respondents were from middle level of extension contact, followed by high level (15.41%) and low level (12.91%) of extension contact. The findings are in accordance the observation of Kumar *et al.* (2021) and Naik *et al.* (2021).

Mass Media contact : The result from the Table-11 found that majority (58.33%) of the respondents were from middle level of mass media contact, followed by high level (19.16%) and low level (22.50%) of mass media contact. The findings are in accordance the observation of Saryam and Jirli (2020), fogya *et al.* (2020).

Extension Participation : Data in Table-12 found that majority (66.64%) of the respondents were from middle level of extension participation, followed by high level (10.86%) and low level (22.50%) of extension participation. The findings are in accordance the observation of Mahesh *et.al.* (2020).

Conclusions

Integrated farming system is important role in agriculture production. The findings of the study revealed that majority of the respondents were middle-aged, medium annual income, medium level of extension contact, medium level of mass media utilization, medium level of extension participation, medium level of farming experience, agriculture is main occupation, majority of respondents belongs to nuclear type family, small land holding, other backward class, pucca type of house and primary level of education.

Table-1 : Distribution of the farmers according to their age.

S. No.	Category	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N = 240	
		F	%	F	%	F	%	F	%	F	%
1.	Young age (up to 34)	11	18.33	10	16.66	12	20.00	9	15.00	42	17.50
2.	Middle age (34 to 52)	39	65.00	42	70.00	30	50.00	36	60.00	147	61.25
3.	Old age (above 52)	10	16.66	8	13.33	18	30.00	15	25.00	51	21.25
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-2 : Distribution of the farmers according to their caste.

S. No.	Category	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N = 240	
		F	%	F	%	F	%	F	%	F	%
1.	SC	10	16.66	11	18.33	12	20.00	5	8.33	38	15.84
2.	ST	18	30.00	17	28.33	10	16.66	14	23.33	59	24.58
3.	OBC	23	38.33	26	43.33	29	48.33	28	46.66	106	44.16
4.	Higher Caste	9	15.00	6	10.00	9	15.00	13	21.66	37	15.42
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-3 : Distribution of the farmers according to their annual income.

S. No.	Category	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N = 240	
		F	%	F	%	F	%	F	%	F	%
1.	Low (up to Rs. 48339)	8	13.33	15	25.00	12	20.00	5	8.33	40	16.66
2.	Medium (Rs. 48339 to 213176)	45	75.00	41	68.33	39	65.00	40	66.66	165	68.76
3.	High (above Rs. 213176)	7	11.66	4	6.66	9	15.00	15	25.00	35	14.58
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-4 : Distribution of the farmers according to their education level.

S. No.	Farmers Education	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N = 240	
		F	%	F	%	F	%	F	%	F	%
1.	Illiterate	8	13.33	12	20.00	14	23.33	8	13.33	42	17.50
2.	Can read only	3	5.00	4	6.66	5	8.33	4	6.66	16	6.66
3.	Can read and write	9	15.00	10	16.66	8	13.33	7	11.66	34	14.16
4.	Primary	12	20.00	12	20.00	17	28.33	21	35.00	62	25.83
5.	Middle	20	33.33	18	30.00	9	15.00	7	11.66	43	17.19
6.	High school	4	6.66	3	5.00	4	6.66	8	13.33	19	7.91
7.	Above high school	4	6.66	1	1.66	3	5.00	5	8.33	13	5.41
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-5 : Distribution of the farmers according to their land holding.

S. No.	Land Holding	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N=240	
		F	%	F	%	F	%	F	%	F	%
1.	Small	37	61.66	40	66.66	42	70.00	49	81.66	168	70.00
2.	Marginal	23	38.33	20	33.33	18	30.00	11	18.33	72	30.00
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-6 : Distribution of the farmers according to their farming experience.

S. No.	Category	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N = 240	
		F	%	F	%	F	%	F	%	F	%
1.	Low (up to 12 years)	13	21.67	15	25.00	9	15.00	4	6.66	41	17.08
2.	Medium (12 to 18 years)	40	66.68	36	60.00	46	76.66	45	75.00	167	69.58
3.	High (above 18 years)	7	11.65	9	15.00	5	8.34	11	18.34	32	13.34
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-7 : Distribution of the farmers according to their family type.

S. No.	Family Type	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N=240	
		F	%	F	%	F	%	F	%	F	%
1.	Single	44	73.34	41	68.34	45	75.00	48	80.00	178	74.16
2.	Joint	16	26.66	19	31.66	15	25.00	12	20.00	62	25.84
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-8 : Distribution of the farmers according to their occupation.

S. No.	Occupation	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N=240	
		F	%	F	%	F	%	F	%	F	%
1.	Agriculture	51	85.00	48	80.00	53	88.33	36	60.00	188	78.34
2.	Govt./Business	9	15.00	12	20.00	7	11.67	24	40.00	52	21.66
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-9 : Distribution of the farmers according to their house type.

S. No.	House type	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N=240	
		F	%	F	%	F	%	F	%	F	%
1.	Kachha	10	16.67	12	20.00	14	23.34	8	13.33	44	18.34
2.	Pucca	50	83.33	48	80.00	46	76.66	52	86.67	196	81.66
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-10 : Distribution of the farmers according to their extension contact.

S. No.	Category	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N = 240	
		F	%	F	%	F	%	F	%	F	%
1.	Low (up to 13 years)	6	10.00	12	20.00	9	15.00	4	6.66	31	12.90
2.	Medium (13 to 20 years)	45	75.00	38	63.34	46	76.67	43	71.68	172	71.66
3.	High (above 20 years)	9	15.00	10	16.66	5	8.33	13	21.66	37	15.14
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-11 : Distribution of the farmers according to their mass media exposure.

S. No.	Category	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N = 240	
		F	%	F	%	F	%	F	%	F	%
1.	Low (up to 11)	12	20.00	15	25.00	17	28.33	10	16.66	54	22.50
2.	Medium (11 to 18)	38	63.34	37	61.67	31	51.67	34	56.68	140	58.34
3.	High (above 18)	10	16.66	8	13.33	12	20.00	16	26.66	46	19.16
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

Table-12 : Distribution of the farmers according to their extension participation.

S. No.	Category	Bhilwara		Chittorgarh		Rajsamand		Udaipur		Over all N = 240	
		F	%	F	%	F	%	F	%	F	%
1.	Low (up to 12)	16	26.66	13	21.66	19	31.66	6	22.50	54	22.50
2.	Medium (12 to 21)	39	65.00	41	68.34	37	61.66	43	71.66	160	66.64
3.	High (above 21)	5	8.34	6	10.00	4	6.68	11	18.34	26	10.86
	Total	60	100	60	100	60	100	60	100	240	100

F = frequency, % = per cent

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Variability in Flowering Characteristics of *Moringa* Accessions Collected from Different Parts of Rajasthan

Sheetal Tak and I.B. Maurya

Department of Vegetable Science, College of Horticulture and Forestry, Agriculture University, Kota (Raj.)

Abstract

Drumstick [*Moringa oleifera* Lam.] is one of the best known and most widely distributed and naturalized species of a monogeneric family Moringaceae. Drumstick is considered as an evergreen tree in India. Flowering in drumstick varies depending on environmental or genetic factors. Generally two flowering seasons are observed in South India, whereas only one flowering has been noticed under North Indian conditions. Flowers are edible and gives taste like mushroom on cooking. Studies among 36 genetic stocks of drumstick assembled from different places of Rajasthan (Ajmer, Jhalawar, Kota, Udaipur) were quantified by multivariate analysis for flowering character like flowering peak, duration of flowering peak, inflorescence colour. All the genotypes showed a great variation with respect to flowering pattern. Further, all the genotypes except JWRM-4 and JWRM-8, collected from Ajmer district, had three flowering peaks i.e. July, September-October/November-December and March/April whereas the genotypes collected from Udaipur had two peaks i.e. November/December/January and March/April. However, only one peak i.e. in the month of December - February was noted in the genotypes collected from Kota and Jhalawar districts. Twenty three genotypes produced flower of white colour whereas ten genotypes JWRM-5, JWRM-6, JWRM-7, JWRM-11, JWRM-13, JWRM-16, JWRM-26, JWRM-31 and JWRM-33 produced cream coloured flower. Four genotypes viz., JWRM-10, JWRM-14, JWRM-20 and JWRM-28 produced cream coloured flowers with red streaks.

Key words : Drumstick, stocks, streaks, genotypes, edible, genetic, *Moringa oleifera*.

Introduction

Drumstick [*Moringa oleifera* Lam. (Syn. *M. pterygosperma* Gaertn.)] is one of the best known and most widely distributed and naturalized species of a monogeneric family Moringaceae. The genus *Moringa* has more than 13 species of which two species viz., *M. oleifera* Lam. (syn. *M. pterygosperma* Gaertn.) and *M. concanensis* Nimmo occur in India and the former being the vegetable type (Panday *et al.*, 2011). *M. oleifera* (the drumstick tree, horse radish tree, West Indian Ben) is a fast growing and medium sized tree having tripinnate leaves. It is a drought resistant species and found widely in the sub Himalayan tracts of the northern India (Singh, 2011). The tree of other species (*M. concanensis*) is small having bipinnately compound longer leaves are yellow flowers streaked with pink or red. It is locally used for edible fruits and medicinal purpose (Wealth of India, 1962; Singh, 2011). *Moringa oleifera* is an important food commodity which has had enormous attention as the 'natural nutrition of the tropics'. The leaves, fruit, flowers and immature pods of this tree are used as a highly nutritive vegetable in many countries, particularly in India, Pakistan, Philippines, Hawaii and many parts of Africa (D'souza and Kulkarni, 1993; Anwar and Bhangar, 2003; Anwar *et al.*, 2005).

Moringa has many medicinal properties. Almost all parts viz., root, bark, gum, leaf, fruit (pod), flower, seed and seed oil have been used for treatment of various inflammation and infectious diseases along with

cardiovascular, gastrointestinal, haematological and hepatorenal, disorders. (Singh *et al.*, 2011). Flowers are used as stimulant, tonic and diuretic. They are useful in increasing the flow of bile. The unopened flowers are eaten as vegetable or used to make tea which provides adequate amounts of calcium and potassium (Koul and chase, 2015) Total antioxidant content of flower is also found higher than other plant parts (Vyas and Kothari, 2015). The vitamin C content in flowers was found to be in highest when compared to other parts (Ahmed *et al.* (2015). A number of qualitative analysis of various flower extracts confirmed the presence of saponins, tannins, alkaloids, flavonoids, steroids, glycosides, terpenoids and phenols (Sumathey *et al.* 2014; Sundari *et al.* 2012; Sankhalkar and Vernekar, 2016; Kheir *et al.* 2014). According to Fuglie 2000, *Moringa* is used in alley cropping, biogas, fertilizer, nutrient, gum, honey and sugar from flower nectar and for medicine.

Murungai poo is the dried flower of *Moringa oleifera* used as cure for inflammations and muscle diseases (Olson, 2002). In Siddha flower of *M. oleifera* is used in the preparation of *Panca cuta meluku* which is administered for curing cough, chest diseases, chronic bronchitis, urticaria caused by beetle sting, syphilitic ulcer, etc. (The Siddha Formulary of India 2011). An important treatise on Ayurveda depicts *M. oleifera* as Drusti Pathya meaning wholesome food for eyes (Subhashree, 2015). India is the largest producer of

Table-1 : Source of drumstick collection.

S. No.	Genotypes	Origin/Place of collection	Cultivated types	Year of planting
1.	JWRM-1	Dhola Bhata Colony, Ajmer	KG	2003
2.	JWRM-2	Govind Colony, Ajmer	KG	2005
3.	JWRM-3	Govind Colony, Ajmer	KG	2003
4.	JWRM-4	Gora Colony, Ajmer	KG	1998
5.	JWRM-5	Surya Nagar Colony, Ajmer	KG	2004
6.	JWRM-6	Dhola Bhata Colony, Ajmer	KG	1999
7.	JWRM-7	Dhola Bhata, Ajmer	KG	2001
8.	JWRM-8	Dhola Bhata, Ajmer	KG	1999
9.	JWRM-9	9 No. Petrol pump, Ajmer	KG	2003
10.	JWRM-10	Chauhan Farm, Jhalawar	FP	1991
11.	JWRM-11	Chauhan Farm, Jhalawar	FP	1997
12.	JWRM-12	Chauhan Farm, Jhalawar	FP	1996
13.	JWRM-13	Anand Vihar Colony, Jhalawar	FP	1993
14.	JWRM-14	Rata Devi, Jhalawar	RSP	1991
15.	JWRM-15	Manpura, Jhalawar	RSP	1986
16.	JWRM-16	Manpura, Jhalawar	FP	1991
17.	JWRM-17	Manpura, Jhalawar	FP	1986
18.	JWRM-18	Manpura, Jhalawar	FP	1989
19.	JWRM-19	Bhawani Club, Jhalawar	FP	1986
20.	JWRM-20	Near Vigyan Nagar, Kota	FP	1991
21.	JWRM-21	Suket, Kota	FP	1981
22.	JWRM-22	Suket, Kota	FP	1979
23.	JWRM-23	Suket, Kota	FP	1986
24.	JWRM-24	Dara, NH-12, Kota	FP	1993
25.	JWRM-25	Dara, NH-12, Kota	RSP	1986
26.	JWRM-26	Dara, NH-12, Kota	RSP	1986
27.	JWRM-27	Dara, NH-12, Kota	RSP	1983
28.	JWRM-28	RCA Farm, Udaipur	FP	1976
29.	JWRM-29	RCA Farm, Udaipur	Cultivated	1999
30.	JWRM-30	RCA Farm, Udaipur	Cultivated	1999
31.	JWRM-31	Ganesh Nagar, Udaipur	RSP	1981
32.	JWRM-32	Ganesh Nagar, Udaipur	KG	1986
33.	JWRM-33	CTAE Campus, Udaipur	FP	1993
34.	JWRM-34	Durga Nursery Road, Udaipur	FP	1996
35.	JWRM-35	Hiran Magri, Udaipur	RSP	1986
36.	JWRM-36	RNT medical College, Udaipur	RSP	1991

KGFP and RSP denotes Kitchen Garden, Field plantation and Road Side Plantation respectively.

Moringa with an annual production of 1.1-1.3 million tonnes of tender fruits from an area of 38,000 ha.

Materials and Methods

The present investigation was conducted during the year 2011-12 at the College of Horticulture and Forestry, Jhalawar. The location of the experimental site is comprised of four districts of the Rajasthan namely Jhalawar, Kota, Ajmer and Udaipur. The mean weekly weather data of temperature, relative humidity and rainfall recorded during the experimentation period (June, 2011-May, 2012). Jhalawar district falls under sub-humid South Eastern Plains under agro-climatic zone V. Udaipur has a sub tropical climate characterized by mild winter and

summer. Ajmer and Kota both have hot semi arid climate, with high temperature throughout the year. The experimental material comprised of 36 genotypes of drumstick collected from four districts of the Rajasthan namely Ajmer, Jhalawar, Kota and Udaipur through a survey made during February- March, 2012 with the help of local people. Initially, 15-20 trees of drumstick, growing naturally on road side or planted in open field/ boundary wall or grown in kitchen garden, were identified from each district but finally 9 bearing trees showing variability for morphological characteristics were Selected for the present investigation (Table-1). The observation were recorded on flowering characters like flowering peak, flowering duration and inflorescence colour.

Table-2 : Flowering behavior of 36 genotypes of Moringa.

Genotypes	Flowering peak			Duration of flowering peak			Inflorescence Colour
	I	II	III	I	II	III	
JWRM-1	July	Oct	Mar	July-Aug	Oct-Dec	Mar-Apr	W
JWRM-2	July	Nov	Apr	July-Aug	Nov-Jan	Apr-May	W
JWRM-3	July	Nov	Mar	July-Aug	Nov-Jan	Mar-May	W
JWRM-4	Oct	Mar	—	Oct-Nov	Mar-Apr	—	W
JWRM-5	July	Oct	Mar	Jul-Aug	Oct-Dec	Mar -Apr	C
JWRM-6	July	Oct	Mar	Jul-Aug	Oct-Nov	Mar -Apr	C
JWRM-7	July	Nov	Mar	Jul-Aug	Nov-Jan	Mar -Apr	C
JWRM-8	Sep	Dec	—	Sep-Oct	Dec-Jan	—	W
JWRM-9	Sep	Dec	Apr	Sep-Oct	Dec-Jan	Apr-May	W
JWRM-10	Feb	—	—	Feb-Mar	—	—	CWRS
JWRM-11	Feb	—	—	Feb-Mar	—	—	C
JWRM-12	Jan	—	—	Jan-Mar	—	—	W
JWRM-13	Jan	—	—	Jan-Mar	—	—	C
JWRM-14	Jan	—	—	Jan-Feb	—	—	W
JWRM-15	Jan	—	—	Jan-Feb	—	—	CWRS
JWRM-16	Feb	—	—	Feb-Mar	—	—	C
JWRM-17	Dec	—	—	Dec-Jan	—	—	W
JWRM-18	Dec	—	—	Dec-Jan	—	—	W
JWRM-19	Jan	—	—	Jan-Feb	—	—	W
JWRM-20	Jan	—	—	Jan-Feb	—	—	CWRS
JWRM-21	Jan	—	—	Jan-Feb	—	—	W
JWRM-22	Dec	—	—	Dec-Feb	—	—	W
JWRM-23	Dec	—	—	Dec-Jan	—	—	W
JWRM-24	Dec	—	—	Dec-Jan	—	—	W
JWRM-25	Jan	—	—	Jan-Feb	—	—	W
JWRM-26	Jan	—	—	Jan-Feb	—	—	C
JWRM-27	Jan	—	—	Jan-Feb	—	—	W
JWRM-28	Nov	Mar	—	Nov-Dec	Mar-May	—	CWRS
JWRM-29	Nov	Mar	—	Nov-Dec	Mar-May	—	W
JWRM-30	Dec	Mar	—	Dec-Jan	Mar-May	—	W
JWRM-31	Dec	Mar	—	Dec-Jan	Mar-Apr	—	C
JWRM-32	Jan	Apr	—	Jan-Feb	Apr-May	—	W
JWRM-33	Dec	Apr	—	Dec-Feb	Apr-Jul	—	C
JWRM-34	Nov	Apr	—	Nov-Jan	Apr-May	—	W
JWRM-35	Dec	Mar	—	Dec-Jan	Mar-May	—	W
JWRM-36	Dec	Mar	—	Dec-Jan	Mar-Apr	—	W

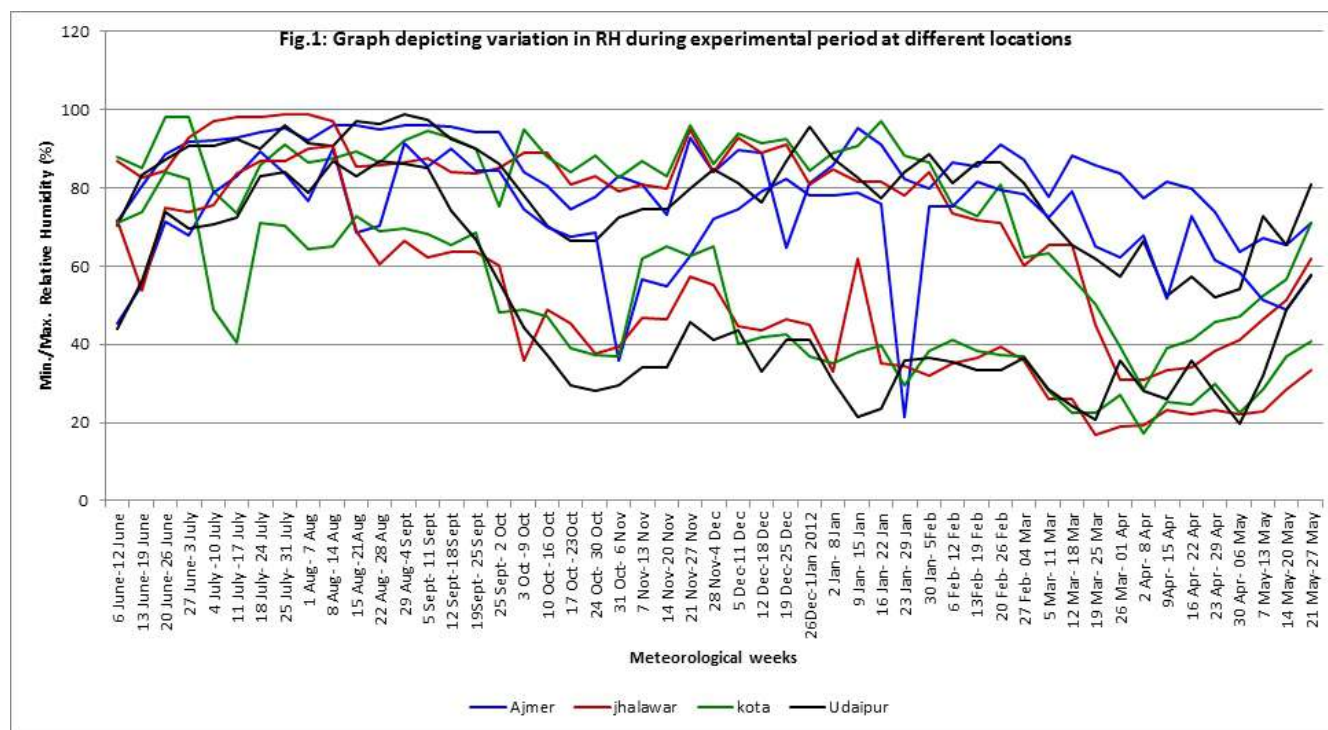
W, C, CWRS denotes white, cream and cream with red streaks

Results and Discussion

Flowering in plants is dependent on climate factors as well as genetic factors. It can be continuous, seasonal or erratic. Continuity of flowering can be due to constancy of environmental conditions or intensity of environmental fluctuations. The variable climate, particularly variation in minimum and maximum values of relative humidity prevailing in these regions, may be attributed for this (Fig.-1). Variability in flowering time was reported by several workers in many locations (Pushpangathan *et al.*, 1996).

The present study revealed that flowering time in

drumstick was not common but it varied with location to location. In the present study 7, 9 and 18 genotypes showed three, two and one flowering peak(s) in a year. The genotypes showed three flowering peaks were JWRM-1, JWRM-2, JWRM-3, JWRM-5, JWRM-6, JWRM-7 and JWRM-9 (Table 2). It was further interesting to note that the genotypes collected from Jhalawar and Kota districts had one flowering peak whereas two flowering peaks were noted in the genotypes of Udaipur. All the genotypes of Ajmer produced three flowering peaks except two i.e. JWRM-4 and JWRM-8 which flowered twice a year. The variable climate, particularly variation in minimum and maximum values of relative humidity prevailing in these regions, may be attributed for



this (Fig.-1). Variability in flowering time was reported by several workers in many locations (Ramachandran *et al.*, 1980; Pushpangathan *et al.*, 1996). However, Muthusamy (1954) reported two main flowering seasons viz., March-April and July-September under Coimbatore condition. There was only one flowering during February-March in Lucknow and Punjab condition (Singh, 1962; Nair and Singh, 1974).

Flower colour of most of the genotypes was mostly white. Genotypes JWRM-5, JWRM-6, JWRM-7, JWRM-11, JWRM-13, JWRM-16, JWRM-26, JWRM-31 and JWRM-33 produced cream coloured flower whereas four genotypes produced white flower with red streaks. The variable floral architecture and colour determine the mating systems in plant populations and also it plays a major role in attracting insects like bees and ants which are the main pollinators in drumstick. Flower shedding was seen in all the genotypes. This may be due to moisture stress or other physiological reasons.

Conclusions

The present study revealed that flowering time in drumstick was not common but it varied with location to location. The morphological traits are controlled by a number of genes and are highly influenced by the environment. whereas molecular markers are not confounded by the environmental effects. Thus, molecular system could be utilized for more efficient determination of genetic diversity in drumstick genotypes. Nevertheless,

the information about the genetic diversity in the 36 genotypes of drumstick could be successfully utilized in further breeding programmes.

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Evaluation of Wheat Genotypes against Rice Weevil, *Sitophilus oryzae* (Linnaeus)

Ashok Kumar*, T. Hussain and Abhishek Pareek

Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur-313001, Rajasthan

*Email : bishnoiashok92@gmail.com

Abstract

An investigation on "Varietal preference, life cycle and management of rice weevil, *Sitophilus oryzae* L. was carried out in the laboratory at Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during the year 2008. Among the ten wheat genotypes, *S. oryzae* preferred MP-1203 as most suitable host to complete their developmental period in a faster rate with more F₁ progeny. In contrast, LOK-1 variety was not much preferred by rice weevil because of their slower rate of development with less number of F₁ progeny. As far as damage is concerned genotypes viz., LOK-1 and RAJ-3777 proved better in terms of less percentage of grain damage as well as weight loss.

Key words : *S. oryzae*, progeny, wheat, genotypes, weevils.

Introduction

Insects are one of the major limiting biotic factors that affect proper storage of food grains and their produce. More than a dozen stored grain pests have been recorded infesting wheat and other cereals in storage. The weevils viz., *Sitophilus oryzae* (Linnaeus), *Sitophilus granaries* (Linnaeus) and *Sitophilus zeamais* (Motsch) are classified as the most important primary pests of stored wheat, whose adults damage grains and larvae inhabit and feed inside the grain (Rees, 2004; Beckett, *et al.*, 2007). Adults of *S. oryzae* feed mainly on the endosperm, thus reducing the carbohydrate content, but larvae feed preferentially on the germ of the grain and remove a large percentage of the proteins and vitamins (Belloa, *et al.*, 2000). In case of severe infestation cent per cent grains get damaged; however, the physio-chemical characters of a variety may affect the damage potential by the pest. The grain characters interfere with the normal physiology or feeding of the insect, affecting the biology adversely and thereby rendering a variety to be less preferred or tolerant or resistant to insect attack (Gupta *et al.*, 1999; Tiwari and Sharma, 2002; Bamaiyi *et al.*, 2007). The damage potential of *S. oryzae* has been the subject of considerable research, mainly on the relative preference of some genotypes by the pest. Presently, the management of this pest relies upon insecticides and fumigants (Rajendran, 1989), which cause problems of resistance development and toxic residues in food grains. Keeping in view the importance of storage of wheat and the losses caused by *S. oryzae*, the present study was carried out to evaluate the response of a few wheat genotypes for preference/ tolerance/ resistance to *S. oryzae* aiming towards safe storage of wheat.

Materials and Methods

The experiment on evaluation of a few wheat genotypes (varieties) against *S. oryzae* was conducted in the Storage Entomology Laboratory at Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture, Udaipur in a complete randomized design in four replications during 2009. The following ten wheat varieties were obtained from Department of Agronomy, Rajasthan College of Agriculture, Udaipur for the purpose to studying the host preference of *S. oryzae*.

RAJ-3765	LOK-1	RAJ-3077	RAJ-3777	MP-1203
HI-8627	MPO-1215	RAJ-4161	MP-4010	RAJ-4164

The grains were freezed and their moisture content was adjusted to 13 percent as described earlier. After tempering the grains, 30 g of each test material was taken in small plastic containers. The samples in all containers were infested with 15 pairs (Males and Females) of two weeks old adults obtained from the laboratory culture. The released adults were removed by using 10 mesh sieves from the test material after 7 days and the samples were replaced in the respective containers. Each container was carefully observed daily, starting at 30th day after removal of the released adults. The F₁ progeny emerging in each container were separated daily from the grains by using a number 10 mesh sieve, counted and discarded. After sieving, the grains were replaced in the respective containers and the same process was repeated on the following days till the emergence of the F₁ progeny was completely stopped in all containers. The average developmental period taken by F₁ progeny in each container was calculated. Damaged and undamaged grains were separated and counted from each container under magnifying glass lens. The

Table-1 : Development and response of *Sitophilus oryzae* (L.) on different wheat genotypes.

Genotypes	Mean developmental period (days)	Total no. of F ₁ progeny emerged	Mean grain damage (%)	Mean weight loss (%)
RAJ-3765	37.37	131.00	36.88 (37.39)	11.59 (19.90)
LOK-1	41.08	118.50	23.31 (28.87)	9.31 (17.76)
RAJ-3077	34.39	143.25	60.94 (51.32)	15.02 (22.80)
RAJ-3777	39.11	123.00	23.80 (29.20)	9.87 (18.31)
MP-1203	31.89	159.25	66.15 (54.43)	18.92 (25.78)
HI-8627	33.22	148.75	63.38 (52.76)	18.35 (25.36)
MPO-1215	36.17	140.25	50.07 (45.04)	14.73 (22.56)
RAJ-4161	37.49	129.50	36.50 (37.17)	11.49 (19.80)
MP-4010	36.33	135.25	45.72 (42.54)	12.94 (21.08)
RAJ-4164	38.04	128.75	33.99 (35.66)	10.64 (19.03)
SEm±	0.54	2.42	0.376	0.348
CD (5%)	1.57	7.01	1.086	1.004

* Figures in parentheses are retransformed per cent values.

damaged and undamaged grains were weighed separately on an electronic balance. The per cent weight loss was worked out by count and weight method (Dick, 1987).

$$\text{Per cent weight loss} = \frac{(UNd) - (DNu)}{U (Nd + NU)} \times 100$$

Where,

U = Weight of undamaged grains

Nu = Number of undamaged grains

D = Weight of damaged grains

Nd = Number of damaged grains

Results and Discussion

Average developmental period : The mean number of days taken to complete the development of the weevils from egg to adult stages differed significantly on different wheat genotypes tested (Table-1 and Fig.-1). The longest developmental period was recorded on LOK-1 (41.08 days) and the shortest on MP-1203 (31.89 days). The average developmental period recorded on different wheat varieties viz., RAJ-3777, RAJ-4164, RAJ-4161, RAJ-3765, MP-4110, MPO-1215, RAJ-3077 and HI-8627 were as 39.11, 38.04, 37.49, 37.37, 36.33, 36.17, 34.39 and 33.22 days, respectively. However no significant difference was observed between the treatments of RAJ-3765, RAJ-4161, MP-4010 and MPO-1215 and RAJ-3777 and RAJ-4164. Similar findings were obtained by Singh and Thapar (1998) and Barbhuija and Devashish (2002), who reported the developmental period for *S. oryzae* on wheat genotypes to range from 35-42 days.

Number of F₁ progeny produced : The total number of F₁ progeny produced on different wheat genotypes (Table-1) varied from 118.50 to 159.25. Lowest number of

F₁ progeny was produced on LOK-1 (118.50) while the highest number on MP-1203 (159.25) genotypes. However, the number of F₁ progeny produced on MP-1203 (159.25) differed significantly over rest of the genotypes as with the number of progeny produced on HI-8627 (148.75), RAJ-3077 (143.25), MPO-1215 (140.25), MP-4010 (135.25) RAJ-3765 (131.00), RAJ-4161 (129.50), RAJ-4164 (128.75) and RAJ-3777 (123.00). It was notable that higher the developmental period and lower the F₁ progeny produced (Table-1 & Fig.-1). These findings are in accordance with the findings of Uttam *et al.* (2004) who reported that with more of fecundity (251.66 days), higher the F₁ progeny emerged (166.23).

Per cent damage grain : A significant difference was recorded for per cent damaged grains in different wheat genotypes. The results (Table-1) indicate that LOK-1 showed least damages to grains (23.31 per cent) while MP-1203 had maximum damage (66.15 per cent) to grains. The extent of damage recorded on HI-8627, RAJ-3077, MPO-1215, MP-4010, RAJ-3765, RAJ-4161, RAJ-4164 and RAJ-3777 were 63.38, 60.94, 50.07, 45.72, 36.88, 36.50, 33.99 and 23.80 per cent, respectively. Similar to these findings, Paul *et al.* (2005) recorded the grain damage in the range of 41.67 to 80.00 per cent in different wheat genotypes. Arve *et al.* (2014) observed that wheat genotypes, GW 496, GW 11, GW 322 and GW 173 were less susceptible; while GW 366 and Lok-1 were moderately susceptible (Fig.-2).

Per cent weight loss : The weight damaged and undamaged grains were taken separately with the help of an electronic balance. Net weight loss due to the feeding of the insect was as low as 9.31 per cent in LOK-1 and as high as 18.92 per cent in MP-1203. The net weight loss recorded in HI-8627, RAJ-3077, MPO-1215, MP-4010, RAJ-3765, RAJ-4161, RAJ-4164 and RAJ-3777 were

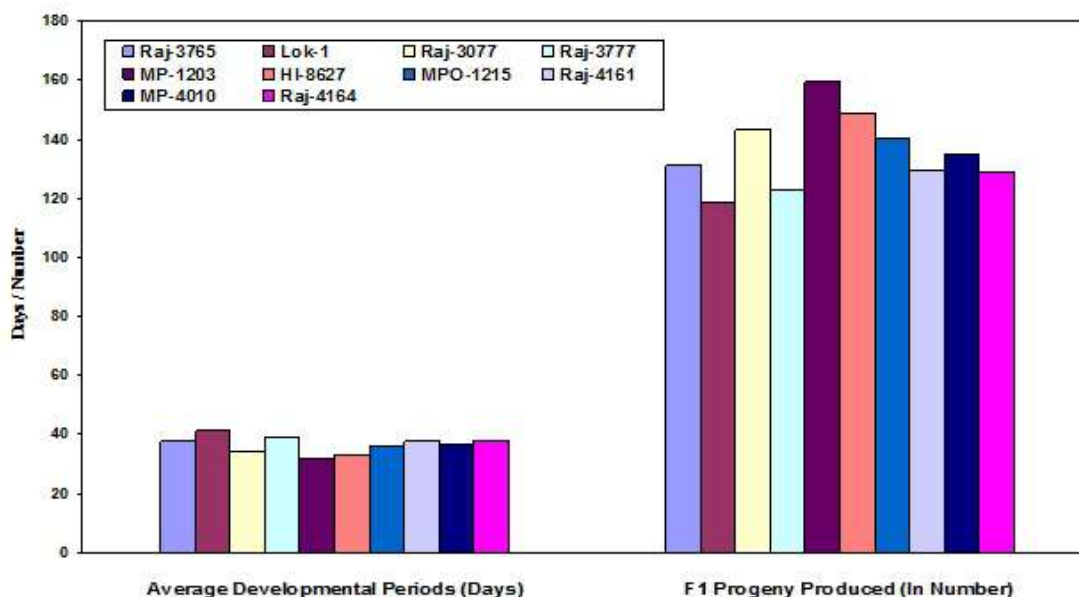


Fig.-1 : Developmental period and F₁ Progeny of *S. oryzae* in different wheat varieties.

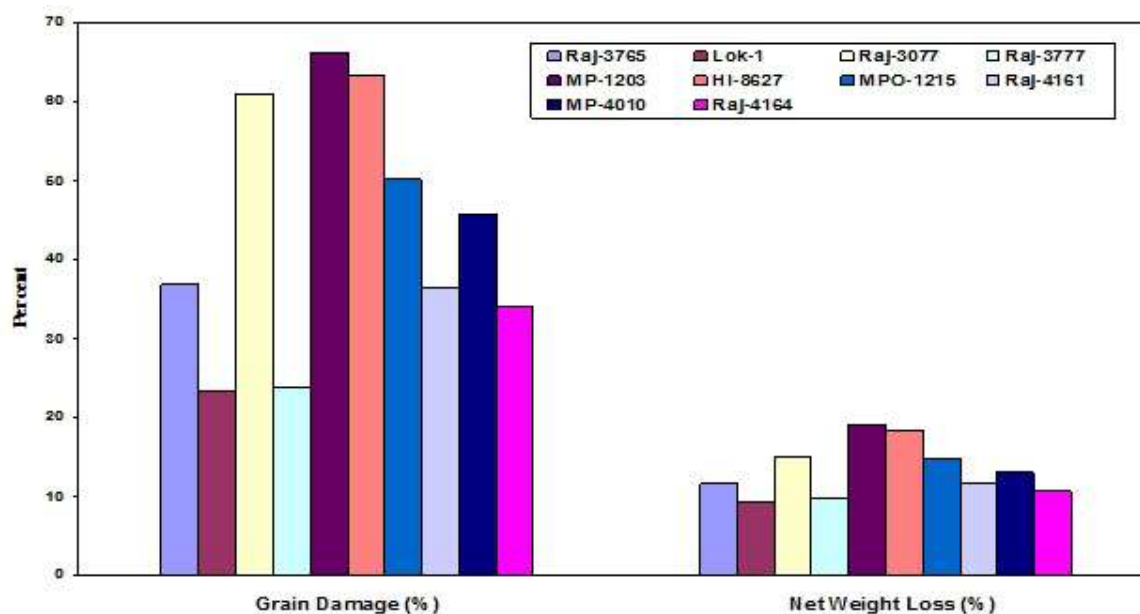


Fig.-2 : Varietal response of wheat varieties to *S. oryzae* in per cent grain damage and per cent loss in weight.

18.35, 15.02, 14.73, 12.94, 11.59, 11.49, 10.64 and 9.87 per cent, respectively. The difference in weight loss in case of RAJ-3765 and RAJ-4161 was not found significant, but it was significantly higher than the weight loss in LOK-1 and RAJ-3777. Similarly the difference in weight loss in MP-1203 and HI-8627 was not significant, but was higher than that in other genotypes. Genotype LOK-1 had significantly less weight loss (%) over rest of the genotypes except RAJ-3777. (Table-1 and Fig.-2). Among the genotypes evaluated for preference by *S. oryzae*, on the basis of per cent weight loss (net), the variations recorded were from 9.31 (LOK-1) to 18.92

(MP-1203) with much close to HI-8627 (18.35). LOK-1 and RAJ-3777 as well as RAJ-4161 and RAJ-3765 were among the genotypes which were found at par. Similar to our findings, Lasker and Ghosh (2005) reported that weight loss in different wheat varieties varies significantly, highest being for PBW (13.50%) and lowest for HP-1731 (6.33%); while, Sharma *et al.* (2005) recorded maximum weight loss in HP-1731 (9.25%) and minimum in K-9107 (3.15%). Arve *et al.* (2014) observed that the weight loss (%) ranged from 14.12 to 20.27 per cent; however, the maximum weight loss was recorded from HD 2189 (20.27%), followed by LOK-1 (18.00%).

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Effect of Green Fodder on Voluntary Water Intake and Milk Production in Crossbred and Gir Cows

Om Prakash Choudhary^{1*}, R.P. Jat¹, Subhash Yadav¹, Sohan Lal Boori¹, Gotam Chopra²

¹Department of Livestock Production Management, S.K.N. Agriculture University Jobner, Jaipur, Rajasthan

²Department of Animal Husbandry and Dairying, SHUATS, Prayagraj, (U.P.)

*Corresponding Author Email : omprakashchoudhary9365@gmail.com

Abstract

The present research was conducted on effect of green fodder on voluntary water intake and milk production of crossbred and gir cows. Twenty lactating cows (which includes 10 Crossbred and 10 Gir Cows) were divided into four different groups on basis of nearest their body weight and milk yield/day at animal farm of S.K.N. College of Agriculture, Jobner and subjected to four dietary treatments were formulated. i.e., Green Lucerne 10.0 kg + Wheat straw ad-lib. + Concentrate for T₁ crossbred and T₃ gir cow group, Green Lucerne 20.0 kg + Wheat straw ad-lib. + Concentrate for T₂ crossbred and T₄ gir cow group and the studied for their voluntary water intake and milk production. The average daily voluntary water intake (litre) in T₁, T₂, T₃ and T₄ groups were 36.93±0.084, 33.63±0.070, 31.20±0.083 and 29.92±0.085 respectively. Total voluntary water intake per kg DMI in T₁, T₂, T₃ and T₄ was 3.03±0.024, 2.63±0.019, 2.82±0.025 and 2.60±0.025 litre, respectively. The total milk production in T₁, T₂, T₃ and T₄ was 11.13±0.078, 11.24±0.041, 8.38±0.032 and 8.52±0.027 litre/day, respectively.

Highlights

The average daily voluntary water intake (litre) in T₁, T₂, T₃ and T₄ groups were 36.93±0.084, 33.63±0.070, 31.20±0.083 and 29.92±0.085 respectively.

The total milk production in T₁, T₂, T₃ and T₄ was 11.13±0.078, 11.24±0.041, 8.38±0.032 and 8.52±0.027 litre/day, respectively.

Key words : Green fodder, voluntary water intake, milk production, crossbred, Gir cow.

Introduction

Livestock in India has a very important role in the agricultural sector, Indian economy and consequently in its rural economy. About 20.5 million people depend upon livestock for their livelihood. Livestock contributed 16% to the income of small farm households as against an average of 14% for all rural households. India has 192.49 million cattle population, which includes 50.52 million cross-bred/exotic and 142.11 million Indigenous cattle (Anonymous 2019). Cattle are an important farm animal which plays a significant role in the economy of the country by providing milk, manure, and draught power with very little input. Gir is a famous milch cattle breed of India. Cattle of this breed are famous for their tolerance to stress conditions and resistant to various tropical diseases. Cross-breeding programmed of dairy cattle has played significant role in attaining India's top position as highest milk producer country of the world. Ad-lib. feeding of green fodder to cattle has been used for economic milk production by earlier workers (Gill *et al.*, 1976; Pachauri and Singh, 1990) but ad lib feeding cannot be adopted under Indian conditions in view of their limited availability. However, proper and balanced feeding is essential for economic milk production and reproduction to make dairy farming a successful enterprise. In India availability of

green fodder is very much seasonal. However, green fodder which is also in deficit supply has got definite role in livestock production. It has beneficial effects in terms of voluntary feed intake and nutrient availability. Green fodder is essential component of feeding high yielding milch animal to obtain maximum level of milk production. There for, the present study will be taken to assess to optimum level of green fodder in ration and the effect of green fodder on voluntary water intake and milk production of crossbred and gir cows and to make recommendations for their better performance.

Materials and Methods

The experiment was conducted between 22 December 2018 to 21 March 2019 (90 days) at animal farm, S.K.N. college of Agriculture, Jobner, Jaipur (Rajasthan, India) to assess the effect of green fodder on voluntary water intake and milk production of crossbred and gir cows. Twenty lactating 10 Cross-bred (Tharparkar/Sahiwal x Holstein Friesian) and 10 Gir lactating cows were selected for the experiment. They were randomly divided into four groups of five in each group on the basis of nearest in their body weight and milk yield and four dietary treatments were formulated. i.e., Green Lucerne 10.0 kg + Wheat straw ad-lib. + Concentrate for T₁ Crossbred and T₃ Gir cow group and Green Lucerne 20.0 kg + Wheat straw

Table-1 : Feeding schedule of Cross-bred and Gir cows.

Feed and fodder	Quantity of feed and fodders
Green Lucerne	10.0 kg for T ₁ and T ₃ group and 20.0 kg for T ₂ and T ₄ group.
Wheat straw	fed ad-lib.
Concentrate mixture	2.0 kg for maintenance ration per cow and @ 1kg /2.5 litre milk yield for production ratio

Table-2 : Voluntary water intake (litre) of Crossbred and Gir cow under different treatments.

Parameters	Crossbred		Gir cow	
	T ₁	T ₂	T ₃	T ₄
Morning	14.10 ^a ±0.063	12.60 ^d ±0.083	13.57 ^b ±0.076	13.49 ^c ±0.092
Evening	22.83 ^a ±0.089	21.03 ^b ±0.056	17.63 ^c ±0.085	16.43 ^d ±0.073
Total VWI	36.93 ^a ±0.084	33.63 ^b ±0.070	31.20 ^c ±0.083	29.92 ^d ±0.085
VWI / kg DMI	3.03 ^a ±0.024	2.63 ^{cd} ±0.019	2.82 ^b ±0.025	2.60 ^d ±0.025

Means having different superscripts differ significantly (P<0.05)

Table-3 : Total water intake (litre) of crossbred and Gir cow under different treatments.

Parameters	Crossbred		Gir cow	
	T ₁	T ₂	T ₃	T ₄
Water intake from feed & fodder	9.38 ^{cd} ±0.083	12.86 ^a ±0.074	9.27 ^d ±0.061	12.14 ^b ±0.083
VWI	36.93 ^a ±0.084	33.63 ^b ±0.070	31.20 ^c ±0.083	29.92 ^d ±0.085
Total VWI	46.31 ^b ±0.166	46.49 ^a ±0.197	40.47 ^d ±0.177	42.06 ^c ±0.190
TWI / kg DMI	3.80 ^a ±0.021	3.64 ^d ±0.024	3.65 ^{cd} ±0.019	3.66 ^{bc} ±0.023
TWI / litre milk production	4.16 ^{cd} ±0.034	4.13 ^d ±0.036	4.82 ^b ±0.034	4.93 ^a ±0.038

Means having different superscripts differ significantly (P<0.05)

ad-lib. + Concentrate for T₂ Crossbred and T₄ Gir cow group and studied their effect.

Parameters studied and observation taken : The voluntary water intake, total water intake and daily milk yield etc. were recorded.

Voluntary water intake : The data of voluntary water intake (VWI) along with feed intake was also recorded for two consecutive days at fortnightly intervals. The measured quantity of clean and fresh water was offered to individual animals during morning and evening and refusal of water; if any was also measured to know the actual voluntary water consumption.

Determination of water intake through feed and fodder : Moisture content of the representative samples of feed offered on the day of voluntary water intake was estimated by oven drying method. The available water from feeds was calculated by multiplying the number of feeds and fodders consumed and moisture percentage of the feeds.

Milking and milk yield : The milking of the animals was performed twice daily and milk yield was recorded daily at each milking house by digital balance. The milk yields were be recorded daily in the morning at 4 to 5 AM and evening at 4 to 5 PM to nearest 50 gm with the help of 100 kg electronic weighing machine during the experiment. Milking of individual cows was done by hand and machine milking.

Statistical Analysis : The experiment data were statistically analyzed using standard statistical methods

(Snedecor and Cochran, 1994). The experiment planned with subjected to analysis of variance (ANOVA) for a (2X2) factorial randomized block design (FRBD) and the means were tested by least significance difference.

Results and Discussion

The data collected during the experiment were subjected to standard methods of statistical analysis and presented in this chapter in the form of tables, figures along with the implications of the results to the effect of green fodder on their nutrients utility and production performance of cows under following heads:

Voluntary water intake : The average daily voluntary water intake (VWI) of crossbred and Gir cows in different treatments is presented in Table 2. The average daily voluntary water intake (litre) in T₁, T₂, T₃ and T₄ groups were 36.93±0.084, 33.63±0.070, 31.20±0.083 and 29.92±0.085 respectively. The TVWI /kg DMI in T₁, T₂, T₃ and T₄ was 3.03±0.024, 2.63±0.019, 2.82±0.025 and 2.60±0.025 litre, respectively. The differences between treatments were significant (P<0.05). The voluntary water intake of cows was higher (P<0.05) in T₁ than treatments T₂, T₃ and T₄. The TVWI/kg DMI was significantly (P<0.05) higher in (10 kg lucerne fed) group T₁ (3.03±0.024) crossbred compared to T₃ (2.82±0.025) Gir cows group. similar trend was reported in (20 kg lucerne fed) group T₂ (2.63±0.019) crossbred compared to T₄ (2.60±0.025) Gir cows group. The evening VWI was higher as compared to morning in all groups due to low cold stress and higher ambient temperature. The results showed that the 10 kg lucerne feed group T₁ and T₃ cows had more voluntary

Table-4 : Average daily milk production (liter)/cow under different treatments.

Parameter	Crossbred		Gir cow	
	T ₁	T ₂	T ₃	T ₄
Morning	5.71 ^b ±0.045	5.77 ^a ±0.020	4.42 ^d ±0.018	4.62 ^c ±0.013
Evening	5.42 ^b ±0.033	5.47 ^a ±0.021	3.96 ^{cd} ±0.014	3.90 ^d ±0.014
Total	11.13 ^b ±0.078	11.24 ^a ±0.041	8.38 ^d ±0.032	8.52 ^c ±0.027

Means having different superscripts differ significantly (P<0.05)

water intake due to more DM intake from wheat straw and less amount of green lucerne resulting in lower supply of water through feeds and fodder compared to 20 kg lucerne feed group T₂ and T₄. Result of experiment are in agreement with the result reported by Singh *et al.* (2000) and Chaudhary *et al.* (2003).

Total water intake : The average daily Total water intake (TWI) of crossbred and Gir cows in different treatments is presented in Table-3. The average daily total water intake (litre) in T₁, T₂, T₃ and T₄ groups were 46.31±0.084, 46.49±0.070, 40.47±0.083 and 42.06±0.085 respectively. The differences between treatments were significant (P<0.05). The total water intake of cows on treatments T₂ was higher than treatments T₁, T₄ and T₃. The TWI /kg DMI in T₁, T₂, T₃ and T₄ was 3.80±0.024, 3.64±0.019, 3.65±0.025 and 3.66±0.025 litre, respectively. Total water intake per litre milk production was 4.16, 4.13, 4.82 and 4.93 in T₁, T₂, T₃ and T₄, respectively. Water is an important constituent with wide range of functions in the intermediary metabolism, heat regulation and water electrolyte balance. It is very difficult to explain the increased or decreased of water intake by the animals under different treatments during the winter season because the water intake is governed by various factors like quality and quantity of feed consumed, the type of animals, DMI, milk yield and composition and change in body weight etc. The water intake is most linked with dry matter consumed to the animals there was a positive relationship between water intake and milk production and dry matter per cent of the diet in lactating cows. Similar findings were reported by Yadav and Chaudhary (2010) and controversy result was observed by Chaudhary *et al.* (2003) in buffalo.

Milk yield : The mean value of milk production data as recorded under different treatments is presented in Table-4. The average milk production in morning was 5.71±0.045, 5.77±0.020, 4.42±0.018 and 4.62±0.013 litre in T₁, T₂, T₃ and T₄, respectively. The average milk production in evening was 5.42±0.033, 5.47±0.021, 3.96±0.014 and 3.90±0.014 litre in T₁, T₂, T₃ and T₄, respectively. The total milk production in T₁, T₂, T₃ and T₄ was 11.13±0.078, 11.24±0.041, 8.38±0.032 and 8.52±0.027 litre/day, respectively. Milk production was increase (2.11%) in T₁, (2.36%) T₂, (2.69%) T₃ and (4.66%) in T₄. Milk production increase (%) was higher in

T₃ and T₄ Gir cows compared to T₁ and T₂ Crossbred. Group T₂ milk production was higher compared to T₁ in (crossbred) and also similar trend was noted in T₄ compared to T₃ in (Gir cows). Overall milk production was obtained higher in 20 kg green lucerne fed group T₂ (crossbred) compared to T₄ (Gir cows) and similar trend was reported in 10 kg green lucerne fed group T₁ (crossbred) compared to T₃ (Gir cows). The findings of present experiment are in agreement with the findings of Chaudhary (1998), Singh *et al.*, (2007), Singh *et al.*, (2011), Mahmoud and Ebeid (2014).

Conclusions

On the basis of present investigation, it may be concluded that VWI (litre/animal) was significantly (P<0.05) higher in T₁ (36.93) as compared to T₂ (33.63), T₃ (31.20) and T₄ (29.92). VWI (litre/animal) was significantly (P<0.05) higher in T₁ as compared to T₂ in crossbred and also higher in T₃ compared to T₄ in Gir cow. Overall VWI (litre/animal) significantly (P<0.05) higher in T₁ and T₂ crossbred as compared to T₃ and T₄ Gir cow. Overall TWI (litre/animal) was significantly (P<0.05) higher in T₂ and T₁ crossbred as compared to T₃ and T₄ Gir cow. Average daily milk production (litre) was significantly (P<0.05) higher in T₂ compared to T₁, T₄ and T₃. Average daily milk production (litre) was significantly (P<0.05) higher in T₂ as compared to T₁ in crossbred and also higher in T₄ compared to T₃ in Gir cow. It is also showed that the better performance as well as increased palatability and utility of wheat straw in same group of Crossbred and Gir cows.

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Feed Cost of Milk Production Influenced by Different Level of Green Lucerne in the Diet of Crossbred and Gir Cow

Om Prakash Choudhary^{1*}, R.P. Jat¹, Subhash Yadav¹, Goatm Chopra² and Jhabar Mal Tatarwal²

¹Department of Livestock Production Management, S.K.N. Agriculture University Jobner, Jaipur, Rajasthan

²Department of Animal Husbandry and Dairying, SHUATS, Prayagraj, (U.P.)

*Corresponding Author Email : omprakashchoudhary9365@gmail.com

Abstract

A study was conducted on 20 milking cows (which includes 10 Crossbred and 10 Gir Cows) were divided into four different group on the basis of nearest their body weight and milk yield/day at animal farm (LPM) S.K.N. College of Agriculture, Jobner (Rajasthan) and subjected to four dietary treatments were formulated. i.e., Green Lucerne 10.0 kg + Wheat straw ad-lib. + Concentrate for T₁ Crossbred group and T₃ Gir cow group, Green Lucerne 20.0 kg + Wheat straw ad-lib. + Concentrate for T₂ Crossbred and T₄ Gir cow group and studied for their feed cost of milk production. Average feed cost/litre milk production was higher in T₄ (27.13) than T₃ (23.26), T₂ (21.52) and T₁ (16.36). The feed cost of per litre milk production was higher in group T₂ as compared to T₁ in (crossbred group) and also found higher in group T₄ as compared to T₃ in (Gir cows group).

Key words : Feed cost, green lucerne, cross-bred and Gir cows.

Introduction

Livestock in India has a very important role in the agricultural sector and consequently in its rural economy. About 20.5 million people depend upon livestock for their livelihood. Livestock contributed 16% to the income of small farm households as against an average of 14% for all rural households. India has 192.49 million cattle population, which includes 50.52 million cross-bred/exotic and 142.11 million Indigenous cattle (Anonymous 2019). Cattle are a important farm animal which play a significant role in the economy of the country by providing milk, manure, and draught power with very little input. Gir is a famous milch cattle breed of India. Cattle of this breed are famous for their tolerance to stress conditions and highly resistant to various tropical diseases. Cross-breeding programme of dairy cattle has played significant role in attaining India's top position as highest milk producer country of the world. Economic analysis of milk production is very essential for knowing the profit or loss from a dairy farm and it is also providing the present position of dairy farm. There for, the present study will be done to assess to optimum level of green Lucerne (*Medicago sativa*) fodder in ration for higher profit and feed cost of milk production in cows as influenced by level of green lucerne in the diet of two different breeds (cross-bred and Gir cows). This study also makes the recommendations of green fodder for better production and performance of dairy cows.

Materials and Methods

This experiment was conducted between 22 December 2018 to 21 March 2019 (90 days) at animal farm, S.K.N. college of Agriculture, Jobner, Jaipur (Rajasthan, India).

The experiment was conducted in order to achieve the objectives of present investigation. The detail of materials and method followed during the course of investigation are presented below:

Experimental Animals and Treatments : Twenty milking cows was selected for this study which includes 10 Cross-bred (Tharparkar/Sahiwal x Holstein Friesian) and 10 Gir cows. They were randomly divided into four different group of five in each group on the basis of nearest in their body weight and milk yield. Four dietary treatments were formulated and offered to each group of animals randomly to following feed supplements/ treatments :

T₁ (Cross Bred) : Green Lucerne 10.0 kg + Wheat straw ad-lib. + Concentrate.

T₂ (Cross Bred) : Green Lucerne 20.0 kg + Wheat straw ad-lib. + Concentrate.

T₃ (Gir cow) : Green Lucerne 10.0 kg + Wheat straw ad-lib. + Concentrate.

T₄ (Gir cow) : Green Lucerne 20.0 kg + Wheat straw ad-lib. + Concentrate.

Housing Management of Experimental Animals : Similar housing and managerial facilities were provided to all the groups. The experimental cows were kept individually tied day and night during experimental period in cattle shed as Tail-to-Tail system of Conventional barn. The animals were offered individual feeding.

Parameters Studied and Observation Taken : The

Table-1 : Feeding schedule of Crossbred and Gir cows.

S. No.	Feed and fodder	Quantity of feed and fodders
1.	Green Lucerne	10.0 kg for T ₁ and T ₃ group and 20.0 kg for T ₂ and T ₄ group.
2.	Wheat Straw	fed ad-lib.
3.	Concentrate Mixture	2.0 kg for maintenance ration/cow and @ 1kg /2.5 litre milk yield for production ration.

Table-2 : Feed cost of milk production under different treatments.

Particulars	Cross-Bred		Gir Cow	
	T ₁	T ₂	T ₃	T ₄
Total quantity of green lucerne (qtl.)	45.0	90.00	45.0	90.00
Total quantity of wheat straw (qtl.)	31.05	30.15	26.55	25.65
Total quantity of concentrate (qtl.)	21.28	21.55	20.16	20.38
Feed cost (in Rs.)				
Lucerne	27,000	54,000	27,000	54,000
Wheat straw	19,872	19,296	16,992	16,416
Concentrate	35,112	35,557	33,264	33,627
Total feed cost	81,984	108,853	77,256	104,043
Total milk production in 90 days	5004.8	5056.3	3769.8	3833.9
Total income sale of milk (90 days)	170,163.2	171,914.2	128,173	130,352.6
Estimated milk production in (300 days) lactation (litre)	3339	3372	2214	2556
Milk yield/cow per day (litre)	11.13	11.24	7.38	8.52
Average daily feed cost per animal	182.18	241.89	171.68	231.20
Feed cost/litre of milk	16.36	21.52	23.26	27.13

meteorological observations, feed intake and cost of feed and fodder were recorded.

Feed Cost of Milk Production : The feed cost of milk production was calculated based on actual cost of feed and fodders paid by the Department of Livestock Production Management, S.K.N. College of Agriculture, Jobner. The cost of lucerne, wheat straw and concentrate palleted feed was Rs. 600/Qtl, Rs.640/Qtl and Rs. 1650/Qtl., respectively. The milk was sold to milk window @ Rs. 34/lit. during experiment period.

Results and Discussion

The data collected during the experiment were subjected to standard methods of statistical analysis and presented in this chapter in the form of table, figures along with the implications of the results to the feed cost of milk production fed different level of green lucerne under following heads:

The feed cost of per litre milk production was presented in Table-2. Total feed cost in was (Rs.) 81,984, 95,353, 77,256, 90,543 in T₁, T₂, T₃ and T₄, respectively. Per litre milk production cost was (Rs.) 16.36, 18.85, 23.26 and 23.61 in T₁, T₂, T₃ and T₄, respectively. The feed cost of per litre milk production was higher in T₄ than T₃, T₂ and T₁. The feed cost of per litre milk production was higher in group T₂ compared to T₁ in Crossbred groups

and also higher in group T₄ compared to T₃ in Gir cow groups. The overall feed cost of per litre milk production was higher in group T₄ and T₃ Gir cow group compared to T₂ and T₁ Crossbred groups. Similar result was obtained by Kaware and Yadav (2014), Boori (2018) in cattle and Chaudhary *et al.* (2000) in buffalo.

Conclusions

Based on the above said findings, it is concluded that the cost of per litre milk production was higher in 20.0 kg green lucerne fed group as compared to 10.0 kg green lucerne fed group and in relation to breeds Gir cows Group (T₄ and T₃) milk production cost was higher compared to Crossbred group (T₂ and T₁). The feed cost of per litre milk production was higher in group T₄ and T₃ (Gir cows) compare to group T₂ and T₁ (Cross-bred). And it is also found that the feeding of green lucerne significantly ($P < 0.05$) increased the milk production and performance as well as increased palatability and utility of wheat straw in crossbred and Gir cows during winter season.

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Performance of Rice under Different Crop Establishment Methods in Cauvery Command Area

P. Thimmegowda

Zonal Agricultural Research Station, V.C. Farm, Mandya-571405, UAS, Bangalore, Karnataka.

Email : thimmegowdap@gmail.com

Abstract

The field experiment was carried at 'I' Block of ZARS, V.C. Farm, Mandya during *Kharif* 2019 and 2020 for two years to evaluate the performance of rice under different crop establishment methods in Cauvery Command Area. The seven rice establishment methods viz., traditional transplanting, mechanical transplanting, system of rice intensification, drum seeding, wet direct seeding (broadcasting), dry direct sowing (multicrop planter) and aerobic method of rice cultivation were evaluated in RCBD design with three replications. The results of two years pooled data revealed that, among the rice establishment methods, direct dry seeding of treated paddy seeds in well prepared land through multicrop planter at row to row spacing of 22.5 cm found to record almost at par yield (73.25 q/ha) as that traditional transplanted rice (74.52 q/ha) with higher net returns (Rs. 65,431/ha) and B:C ratio (2.72) and saves 55% irrigation water and matures 10 to 12 days early. As compared to traditional transplanting methods, SRI recorded 7-8 % higher yield, while other methods recorded lower yield. The significantly lower yield as compared to traditional transplanted rice noticed in wet direct sowing (8.0%) and aerobic rice (18%). While, the mechanical transplanting, drum seeding and dry direct sowing recorded almost comparable yield as that of traditional transplanting method.

Key words : *Aerobic rice, dry direct seeding, SRI, transplanted rice and wet direct seeding.*

Introduction

Food security depends on the ability to increase production with decreasing availability of water to grow crops. Rice, as a submerged crop, is a prime target for water conservation because it is the most widely grown of all crops under irrigation. To produce 1 kg of grain, farmers have to supply 3-4 times more water in rice fields than other cereals (Barker *et al.*, 1998). The study revealed that to grow one kg of rice 4000-5000 litre of water is required. In Asia, more than 80% of the developed freshwater resources are used for irrigation purposes; about half of which is used for rice production (Dawe *et al.*, 1998). Rapidly depleting water resources threaten the sustainability of the irrigated rice and hence the food security and livelihood of rice producers and consumers (Tuong *et al.*, 2000). In Asia, 17 million hectare (M ha) of irrigated rice areas may experience physical water scarcity and 22 M ha may have economic water scarcity by 2025 (Tuong and Bouman, 2002). There is also much evidence that water scarcity already prevails in rice-growing areas, where rice farmers need technologies to cope with water shortage and ways must be sought to grow rice with lesser amount of available water (Tuong and Bouman, 2002).

In Karnataka rice is grown under a variety of soils and wide range of rainfall and temperature. Only around 44 per cent of the total acreage is under irrigation while the rest is under the regime of monsoon. Rice is cultivated

in places where the rains are as heavy as 3000 mm and in others where it is just 600 mm. In some areas only one crop is grown and in certain other areas three crops are raised. In Southern Karnataka rice is mainly grown in Cauvery Command Area by utilizing canal water in area of 1.5 lakh ha. However, in recent years, the area of rice and productivity is declining year by year in the Cauvery Command Area due to low rainfall in transitional belt due to shifting climate. As a results, it takes time for filling up of the dam and tanks and hence, authorities delaying the release of water into the canal. As a result of delay in release of water into the canal, transplanting of paddy getting delayed and consequently great loss in productivity was observed due to prevalence of low temperature during panicle initiation to flowering.

Rice is very sensitive to water stress, especially during panicle initiation to flowering period and attempts to reduce water inputs may tax true yield potential. The challenge is to develop novel technologies and production systems that would allow rice production to be maintained or increased at the face of declining water availability with reduced labour cost. Several strategies are in vogue to reduce the labour dependency, rice water requirements, such as system of rice intensification (SRI), mechanical transplanting, drum seeding, wet direct sowing (broadcasting), dry direct sowing (multicrop planter) and aerobic method of rice cultivation. All these alternative rice production system are evaluated in the field to study

Table-1 : Growth and yield parameters of rice as influenced by establishment methods (Pooled data of two years).

Treatment	Plant height at harvest (cm)	Days to 50% flowering	Days to maturity	No. of panicles/hill	Panicle length (cm)	No. of filled grains/panicle	1000 seed weight (gm)
Conventional transplanting	129.56	91	125	15.56	22.36	166.41	19.62
Mechanical transplanting	128.54	92	124	16.12	22.32	167.41	19.73
SRI method	131.52	93	127	19.52	25.36	182.41	20.02
Drum seeding	127.36	88	116	15.05	22.52	164.25	19.28
Wet direct seeding	123.56	87	115	13.65	19.85	162.23	19.02
Dry direct seeding	128.84	86	110	16.63	23.85	168.96	19.38
Aerobic rice	120.63	86	109	15.03	18.96	155.21	18.52
S.Em.+	2.25	3.12	3.52	2.02	1.36	5.52	0.99
C.D. @ 5%	6.72	NS	10.56	6.02	4.08	16.56	NS

Table-2 : Yield, economics and water productivity of rice as influenced by establishment methods.

Treatment	Grain yield (q/ha)	Straw yield	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio	Irrigation Water applied (mm)	Water productivity (kg/ha cm)
Conventional transplanting	74.52	91.51	45800	105243	59443	2.30	992	7.51
Mechanical transplanting	73.21	88.15	42800	103376	60576	2.42	942	7.77
SRI method	80.75	99.52	47500	114045	66545	2.40	825	9.79
Drum seeding	71.21	87.41	40800	100568	59768	2.46	820	8.68
Wet direct seeding	67.65	85.45	38800	95565	56765	2.46	825	8.20
Dry direct seeding	73.25	88.12	38000	103431	65431	2.72	425	17.24
Aerobic rice	61.15	76.21	40500	86372	45872	2.13	412	14.84
S.Em.+	3.12	3.85	-	-	-	-	12.12	-
C.D. @ 5%	9.36	11.55	-	-	-	-	35.62	-

its performance with respect to growth, yield, water productivity and economics.

Materials and Methods

The field experiment was carried at 'I' Block of ZARS, V.C. Farm, Mandya during *Kharif* 2019 and 2020 for two years. The initial soil analysis of the experimental site indicated that, the soil was slightly alkaline with a pH of 7.87, low in organic carbon (0.37%), low in available nitrogen (235 kg/ha), available P_2O_5 (22.5 kg/ha) and available K_2O (121 kg/ha). The experiment comprising of seven rice establishment methods *viz.*, traditional transplanting, mechanical transplanting, system of rice intensification, drum seeding, wet direct seeding (broadcasting), dry direct sowing (multicrop planter) and aerobic method of rice cultivation. These 7 establishment method were tested in completely randomized design with four replications. The prominent rice hybrid KRH-4 developed at Zonal Agricultural Research Station was grown as a test crop. The recommended fertilizers dose 100:50:50 kg/ha was applied for all the treatments commonly. The seed rate used was 15 kg/ha in all the treatments except SRI method and aerobic rice where 2.5 kg/ha seeds were used. Under traditional transplanting method, 22 days old seedlings were transplanted in the field at a spacing of 20 cm X 10 cm. In mechanical transplanting, 20 days old seedlings were transplanted to main filed at a spacing of 22.5 cm X 10 cm by using Korean model 8 row paddy

transplanter. In drum seeding the pre-germinated (soaking in water for 24 hours and kept in gunny bag for 36 hours) seeds were put into the seeder drum (4 number drum seeder with 8 rows at a spacing of 20 cm between row) and pulled manually in the puddled field to drop the seeds in the mud. Whereas, in wet direct seeded rice, the pre-germinated seeds were broad casted in the well puddled land and care has been taken to ensure that seeds were dropped in mud. In dry direct seeded rice, the recommended seeds were treatment with chemical and then sown by using multicrop planter in a well prepared field. The spacing given was 22.5 cm between the rows. In SRI method 12 days young seedlings were transplanted in the well puddled field with a spacing of 25 cm X 25 cm. In aerobic rice, the treated seeds were sown at a spacing of 25 cm X 25 cm in a well prepared field and 2-3 seeds were sown per hill. In all the treatments, the crop was fertilized with 100:50:50 kg N: P_2O_5 : K_2O /ha and 50% nitrogen, entire dose of phosphorous and potassium was applied as basal in addition to zinc sulphate @ 25 kg/ha. The remaining 50% of the nitrogen was top dressed at two equal splits at tillering and panicle initiation stage. In transplanted rice and mechanical transplanted rice, 5 cm water was maintained throughout the cropping season and irrigation was stopped 20 days prior to harvest. In SRI method soil moisture was maintained at saturation point throughout the cropping season.in drum seeding and wet direct seeded rice, saturation point was maintained up to

germination and then crop flooded with 2-3 cm of water. While in aerobic and dry direct seeded rice moisture level at field capacity was maintained throughout the crop period. The gross plot size was 40 m². All other agronomic and plant protection measures were adopted as per the recommended packages of UAS, Bangalore. The observations on crop growth and yield parameters and yield were recorded at regular intervals. The economics viz., cost of cultivation, gross returns, net returns and B:C ratio were worked out by considering prevailing market rates of input and output during the cropping period. All the data obtained in the study were statistically analysed using F-test, the procedure given by Gomez and Gomez (1984). Critical difference values at P=0.05 were used to determine the significance of differences between means.

Results and Discussion

Growth and yield attributes of rice : Plant height indicate the health and vigour of the plant. It is directly proportional with the development of root system and availability and uptake of moisture and nutrient from the soil. Rice establishment methods had significant influence on the plant height. Among the establishment methods, significantly taller plants were observed in SRI method of rice cultivation (131.52 cm) at harvest as compared to others. However, it was on par with conventional transplanting, mechanical transplanting, drum seeding and dry direct sowing with multi crop planter. While, the lower plant height was observed in wet direct seeding and aerobic rice (123.56 and 120.63 cm, respectively). The days taken for 50% flowering not varied significantly among the rice establishment methods. However, the rice transplanted in puddled soil takes more days as compared to direct sowing treatments. Whereas, days to maturity varied significantly and direct sown rice matured 10-12 days early as compared to seedling transplanted treatments. Among the establishment methods, dry direct seeding and aerobic rice took significantly lesser days (110 and 109 days, respectively) for maturity as compared to others. The similar findings are also reported by Bouman *et al.* (2007).

As a consequence of higher growth parameters, SRI method recorded significantly higher yield attributing parameters viz., No. of panicles/hill (19.52), panicle length (25.36 cm) and No. of filled grains/panicle (182.41) as compared to others. However it was on par with conventional transplanting, mechanical transplanting and dry direct sowing by multicrop planter. This enhanced yield attributes in these treatments was mainly attributed to availability of more moisture, nutrients and space for individual plant and this in turn enhance the growth attributes and lead to production and translocation of more photosynthates sink. These results are in

agreement with Sharma *et al.* (2006), Bohra *et al.* (2006) and Singh *et al.* (2005). The 1000 grain weight was not varied significantly among the rice establishment methods.

Yield of rice : The grain and straw yield of rice varied significantly among rice establishment methods. Among them, system of rice intensification records significantly higher grain and straw yield (80.75 and 99.52 q/ha, respectively) as compared to others. However it was on par with conventional transplanting, mechanical transplanting and dry direct sowing through multicrop planter. This increased yield in these treatments was mainly attributed to enhanced yield attributes, as a result of translocation of more photosynthates reproductive parts due to availability of more moisture, nutrients and space for individual plant. The results are in line with the earlier findings of Jnanesha and Ashish Kumar (2017) and Bhushal *et al.* (2007). As compared to traditional transplanting methods, SRI recorded 7-8 % higher yield, while other methods recorded lower yield. The significantly lower yield as compared to traditional transplanted rice noticed in wet direct sowing (8.0%) and aerobic rice (18%). While, the mechanical trans planting, drum seeding and dry direct sowing recorded almost comparable yield as that of traditional transplanting method.

Economics : The cost of cultivation was lower in direct seeded rice as compared to traditional seedling transplanting. Among the different methods, lower cost of cultivation was observed in dry direct seeding through multicrop planter (Rs. 38000/ha) due to reduced nursery and transplanting cost and highest was observed in SRI method (Rs. 47500/ha) due to more labour requirement for transplanting. The higher net returns and B:C ratio was obtained with dry direct seeding (Rs. 65431 and 2.72, respectively) as compared to others. This was mainly due to reduced labour cost as compared to traditional transplanting. The next best treatments were drum seeding and wet direct seeding through broadcasting.

Irrigation water used and IWUE : Among the rice establishment methods, lower irrigation water used in dry direct sowing and aerobic method of rice (295 and 306 mm, respectively). These two method required 55-58% lower irrigation water as compared to traditional transplanted rice. As a result this, the water productivity was also highest in these treatments (17.24 and 14.84 kg/ha cm of water, respectively). This lower water requirement in these treatments was mainly attributed to elimination of puddling and maintenance of moisture level at near field capacity throughout the cropping season. The similar findings are also reported by Bouman and Tuong (2001), Borrell *et al.* (1997). As compared to traditional

transplanting method, the water saving in mechanical transplanting was 5.0%, SRI was 16.8%, drum seeding was 17.3% and wet direct seeding was 16.8%%.

Conclusions

Direct dry seeding of treated paddy seeds in well prepared land through multicrop planter at row to row spacing of 22.5 cm found to almost at par yield as that traditional transplanted rice with higher net returns and B:C ratio and saves 55% irrigation water and matures 10 to 12 days early.

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Molecular Characterization of Stripe Rust in Wheat (*Triticum aestivum* L.) by using SSR Markers

Sandeep Kumar Bangarwa*, Tuhina Dey and Amardeep Kour

¹Division of Plant Breeding and Genetics, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu-180009 (J&K).

*Email : sandeepbangarwa123@gmail.com

Abstract

In the present study, molecular characterization with two SSR markers strongly linked to stripe rust resistance was carried out in the resistant bulks obtained from the progeny of the F₁s. Maximum desirable positive heterosis for grain yield in the cross IBWSN 1175 x PBW 550 (15.00 percent) followed by DWR 41 x PBW 550 (10.52 percent) and IBWSN 1175 x RSP561 (05.00 percent) with a disease reaction ranging between resistant to trace type of resistant reaction. Out of them, none possesses both the resistant genes Yr18 and Yr 40 in combination. The cross IBWSN 1047 x PBW 550 carrying both the Yr genes in combination showed resistant type of rust reaction. However it was poor yielding with grain yield per plant of 12.0 g. This cross can be carried further by backcrossing with high yielding adapted parent and if successful depicts the role of MAS.

Key words : Heterosis, MAS, resistance, SSR markers, stripe rust.

Introduction

Wheat (*Triticum aestivum* L.) is a crop of global significance, grown in diversified environments. Among the most important biotic factors that reduce wheat production significantly are those caused by the rusts (stripe, leaf and stem). The wheat rusts are caused by three species of the fungal genus *Puccinia*; stripe rust or yellow rust is caused by *Puccinia striiformis* f.sp. *tritici*;

leaf rust by *Puccinia triticina*; and stem rust by *Puccinia graminis* f.sp. *tritici*. The North Western Plain Zone which is considered the bread basket of India usually experiences a favourable weather for the development and proliferation of the stripe rust pathogen.

Development of resistant varieties is the ecologically safe and sustainable means to overcome the threat. Several resistant varieties have been bred till now, however the resistance of most varieties are short-lived due to evolution of new races of the pathogen. Long term robust resistance based upon the 'stacking' of different sources of genes with a proven level of durability offers the best solution. The effects of moderate resistances can be additive and combined to provide near immunity (1). Conventional breeding aided by genome analysis and other marker-aided gene pyramiding provide powerful alternative to facilitate gene deployment and gene pyramiding for quick release of rust resistant cultivars.

Therefore in the present study, F₁s were developed using three adapted and six resistant parents. The resistant parents were characterized for the spectrum of Yr genes and F₂ generation was evaluated for

incorporation and distribution of Yr genes using molecular markers.

Materials and Methods

The material consisted of six stripe rust resistant lines and three adapted varieties of wheat crossed in Line X Tester fashion during off season 2013 at Dalang Maidan, Lahaul Spiti. The details of the material used and methods adopted during the course of investigation are listed in Table-1. The six female lines were crossed with three male testers to generate 18 single crosses. These F₁s along with parents were grown during Rabi 2013 at Research Farm, Division of Plant Breeding and Genetics, SKUAST Chatha, Jammu. Progeny from all the twenty seven genotypes (9 parents and 18 hybrids) were evaluated in randomised block design in three replications during off season 2014 at Dalang Maidan, Lahaul Spiti.

The stripe rust severity was recorded as percent of the rust infection on the wheat plants according to the modified Cobb's scale (Fig.-1) (2) and the field response scale referred to the infection type as described in Table-2 (Fig.-2) (3,4). The data on disease severity and host reaction was combined to calculate the coefficient of infection (CI) by multiplying the severity value of 0.10, 0.4, 0.8, 1.0 for host response ratings R, MR, MS, S respectively. (5)

The molecular studies were carried out at the Laboratory, Division of Plant Breeding & Genetics, SKUAST Jammu. Primers name, linked gene, forward and backward sequence and expected product size (bp) are given in Table-3.

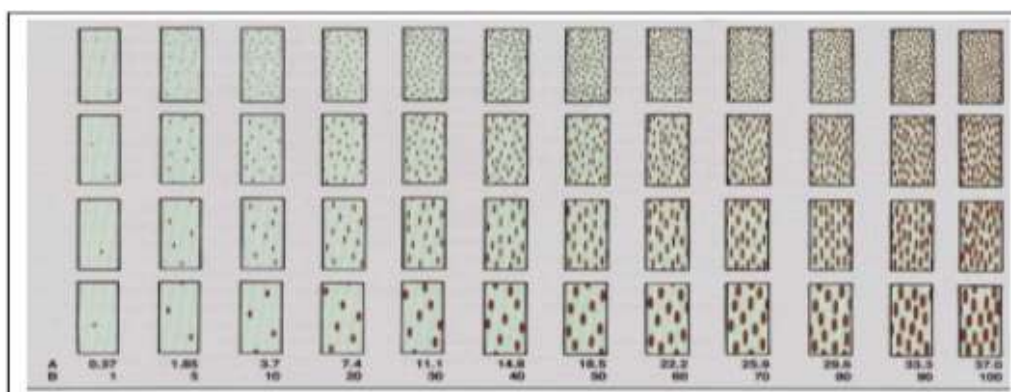


Figure-1 : The Modified Cobb's scale A refers to the actual percentage occupied by rust Uredinia and B pertains to rust severities of the modified Cobb's scale (2).

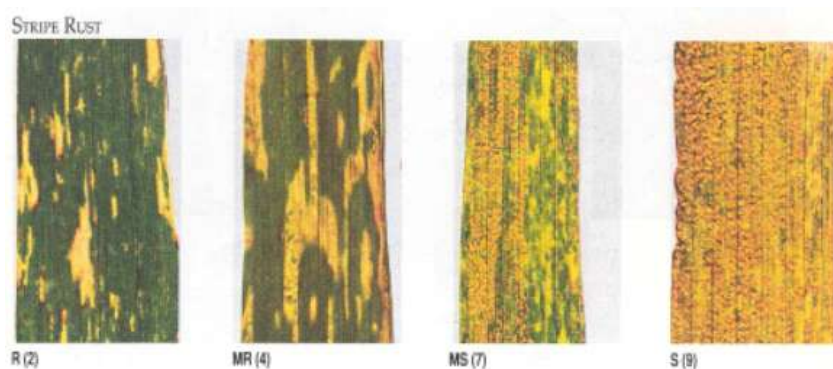
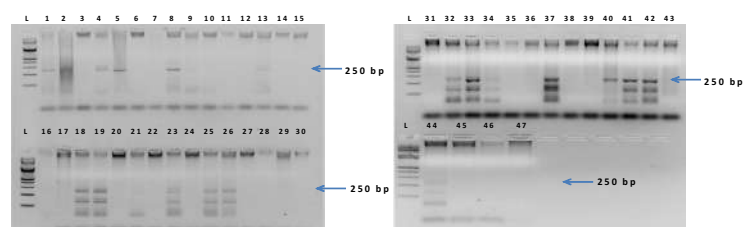
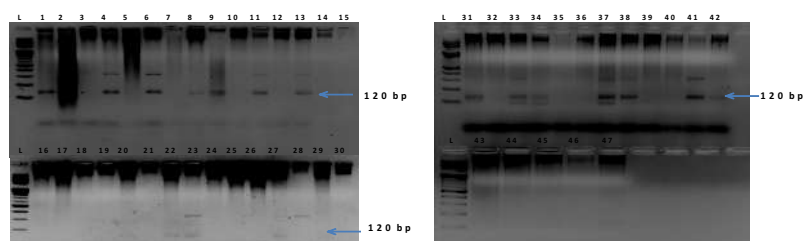


Figure-2 : The Modified Cobb's scale (Source: 3,4).



Lane 1-9 Parents
Lane 10-47 Crosses

Figure-3 : PCR Amplification of winter wheat genotypes using *Xbarc352* primer for *Yr18* gene.



Lane 1-9 Parents
Lane 10-47 Crosses

Figure-4 : PCR Amplification of winter wheat genotypes using *Xgwm382* primer for *Yr40* gene.

Table-1 : Name of parents, their pedigree and source of collection.

S. No.	Name of parents	Pedigree	Source
FEMALES			
1.	1047,44th IBWSN	BAV92//IRENA/KAUZ/3/HUITES/4/DOLL	44th IBWSN, CIMMYT
2.	1174,44th IBWSN	(C.80.1/B*BATAVIA//I*WBLL1/5/REH/HARE//2*BCN/...)	44th, IBWSN, CIMMYT
3.	1175,44th IBWSN	(SERI.18*2/3/KAUZ*2/BOW//KAUZ/4/CROC)	44th IBWSN, CIMMYT
4.	DWR 19	IC 296783/ IC 253000	DWR, Karnal
5.	DWR 41	IC 296436	DWR, Karnal
6.	DWR 46	IC 296446	DWR, Karnal
MALES			
1.	RSP-561	HD 2687/Ae. crassa//HD 2637	SKUAST, Jammu
2.	PBW-550	WH594/RAJ3858/W485	PAU, Ludhiana
3.	DPW-621-50	KAUZ//ALTAR84/AOS/3/MILAN/KAUZ/4/ HUITES	DWR, Karnal

Table-2 : Disease severity of parents and crosses in the adult plant stage.

Parents/Hybrids	Disease severity	Infection type
FEMALES		
IBWSN 1047	10MR	Moderately resistant
IBWSN 1174	TR	Trace resistant
IBWSN 1175	R	Resistant
DWR-19	10MR	Moderately resistant
DWR-41	R	Resistant
DWR-46	10MR	Moderately resistant
MALES		
RSP-561	20S	Susceptible
PBW-550	40S	Susceptible
DPW-621-50	40S	Susceptible
HYBRIDS		
IBWSN 1047×RSP-561	20S	Susceptible
IBWSN 1047×PBW-550	R	Resistant
IBWSN 1047×DPW-621-50	10S	Susceptible
IBWSN 1174×RSP-561	5S	Susceptible
IBWSN 1174×PBW-550	5MR	Moderately resistant
IBWSN 1174×DPW-621-50	20S	Susceptible
IBWSN 1175×RSP-561	TR	Trace resistant
IBWSN 1175×PBW-550	R	Resistant
IBWSN 1175×DPW-621-50	TR	Trace resistant
DWR-19×RSP-561	5S	Susceptible
DWR-19×PBW-550	20S	Susceptible
DWR-19×DPW-621-50	5S	Susceptible
DWR-41×RSP-561	R	Resistant
DWR-41×PBW-550	R	Resistant
DWR-41×DPW-621-50	20S	Susceptible
DWR-46×RSP-561	10S	Susceptible
DWR-46×PBW-550	R	Resistant
DWR-46×DPW-621-50	40S	Susceptible

For each genotype, genomic DNA was isolated by a modified Cetyl Trimethyl Ammonium Bromide (CTAB) method (6). The PCR products of *csLV34*, *Xgwm382* and *Xbarc352* were separated on 1% agarose gel. A 100bp molecular ladder was used to estimate product sizes in base pairs (bp) for gel.

The statistical analysis was conducted over mean of ten selected plants for each entry in each replication. The analysis was done as per (7).

Results and Discussion

Results pertaining to the disease reaction in terms of adult plant reaction to stripe rust under field conditions of the parents and the hybrids have been presented in Table-2. Adult plant reaction of the lines (the source of resistance) ranged from R to 10MR (resistant to 10 percent infection with moderately resistant reaction).

Molecular characterization of the parents and hybrids was done with two SSR markers viz., *Xbarc352* and *Xgwm382* linked to *Yr 18* and a QTL for stripe rust resistance *Yr 40* respectively. Studies with *Xbarc352* revealed the presence/absence of band at 250 bp indicating the presence of *Yr18* gene. This was observed in the parents IBWSN 1047, DWR19, DWR 41, PBW 550 and DPW 621-50 indicating the presence of *Yr 18* in these varieties. Further the progenies of the following crosses IBWSN1047 x PBW 550, IBWSN1175 x DPW 621-50, IBWSN1047 x DPW 621-50, DWR 41 x PBW 550, IBWSN1175 x PBW 550, IBWSN1174 x DPW 621-50, DWR 19 x PBW 550 and DWR 19 x DPW 621-50 were also positive for band at 250bp indicating the presence of *Yr18* (Figure-3).

Molecular studies with *Xgwm382* revealed the presence of band at 120 bp in the parents IBWSN1047, IBWSN1174, DWR 46, PBW 550 and DPW 621-50 indicating the presence of *Yr 40* in these varieties. In the crosses IBWSN1047 x RSP 561, IBWSN1047 x PBW 550, IBWSN1047 x DPW 621-50, IBWSN1175 x PBW 550, IBWSN1174 x DPW 621-50, DWR 46 x PBW 550, DWR 19 x PBW 550 were also having band at 120 bp indicating the presence of *Yr 40* (Figure 4). Cross DWR 19 x RSP 561 shows the presence of band with *Xgwm382* which is not the likely outcome as this QTL is absent in both the parents.

Lane 1-9 Parents : IBWSN1047, IBWSN1174,

Table-3 : List of Primers used.

S. No.	Primer Name	Linked gene	Forward Sequence	Backward Sequence	Expected Product Size (bp)
1.	Xbarc 352	Yr 18	5'CCCTTTCTCGCTCGCCTATCCC3'	5'CTGTTTCGCCCAATCTCGGTGTG3'	250
2.	Xgwm 382	Yr 40	5'GTCAGATAACGCCGTCCAAT3'	5'CTACGTGCACCACCATTTTG3'	120

IBWSN1175, DWR-19, DWR-41, DWR-46, RSP-561, PBW-550, DPW-621-50

Lane 10-47 Crosses : IBWSN1047x IBWSN1175, IBWSN1047X DWR-41, IBWSN1047X DWR-46, IBWSN1047X RSP-561, IBWSN1047X DPW-621-50, IBWSN1174X IBWSN1175, IBWSN1175X DWR-46, IBWSN1175X RSP-561, IBWSN1175X PBW-550, IBWSN1175X DPW-621-50, DWR-19X DWR-41, DWR-19X DWR-46, DWR-19X PBW-550, DWR-19X DPW-621-50, RSP-561X DPW-621-50.

Lane 1-9 Parents : IBWSN1047, IBWSN1174, IBWSN1175, DWR-19, DWR-41, DWR-46, RSP-561, PBW-550, DPW-621-50

Lane 10-47 Crosses : IBWSN1047x IBWSN1175, IBWSN1047X DWR-41, IBWSN1047X DWR-46, IBWSN1047X RSP-561, IBWSN1047X DPW-621-50, IBWSN1174X IBWSN1175, IBWSN1175X DWR-46, IBWSN1175X RSP-561, IBWSN1175X PBW-550, IBWSN1175X DPW-621-50, DWR-19X DWR-41, DWR-19X DWR-46, DWR-19X PBW-550, DWR-19X DPW-621-50, RSP-561X DPW-621-50

Therefore, seven crosses were short listed from the present study which showed resistant to trace resistance reaction types, these were the ones that were further investigated for yield and the presence of resistant gene/s using molecular markers. On the basis of yield, out of the seven resistant or near resistant crosses, (with TR infection type) four had yield which was superior or at par to better parent, and were likely to be the candidates for carrying forward as per the conventional breeding/backcrossing approach. Upon investigating the parents and the crosses with two markers *Xbarc* 352 and *Xgwm* 382 linked to Adult Plant Resistance genes *Yr* 18 and *Yr* 40 (a QTL for stripe rust resistance) it was found that the

resistant crosses with high yield possess only one of the two resistant genes. Further, it was interesting to decipher the results of molecular studies that one of the resistant crosses IBWSN1047 x PBW 550 though had a low grain yield per plant but accumulated both the resistant genes and should not be rejected on the basis of yield. This infers to the conclusion that RSP 561, the resistant variety released specifically for this region does not possess either *Yr* 18 or *Yr* 40 but the resistance may be due the presence of other combination of genes which needs to be validated in future.

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Technological Gap in Adoption of Improved Wheat Production Technology Among the Farmers of Mungeli District of Chhattisgarh

Shailendra Kumar*, P.K. Sangode and M.A. Khan

Department of Agricultural Extension, College of Agriculture, IGKV, Raipur-492012 (C.G.)

Email : shailendra187kurrey@gmail.com

Abstract

The present investigation was conducted to study on technological gap in adoption of improved wheat production technology among the farmers of Mungeli district of Chhattisgarh during 2020-21. The study reveals that in context to knowledge level and adoption level of improved wheat production technology, majority (71.00%) of the respondents had partial knowledge and (78.00%) partial adoption. In context to technological gap in adoption of improved wheat production technology, majority (49.00%) of the respondents had medium technological gap followed by less and more technological gap. Irrigation method had least technological gap as each and every farmer known how to irrigate wheat crop at the time of requirement.

Key words : Knowledge, Adoption, Technological gap, Wheat production technology.

Introduction

Agriculture is one of India's largest and most important economic industries. The Indian economy relies heavily on agronomical and horticultural crops, as well as food and fodder products. Wheat (*Triticum aestivum* L.) is one of the most widely farmed cereal crops in the world, and one of the most important staple foods for approximately 2.5 billion people. Wheat is the most important staple food crop in North Africa and West and Central Asia, accounting for over half of the calories consumed. Wheat (*Triticum* spp.) is the most widely grown crop on the planet. India is one of the world's leading wheat producers and consumers. Uttar Pradesh (33.02%), Punjab (19.26%), Haryana (13.27%), Madhya Pradesh (9.67%), and Rajasthan are the top five wheat-growing states in India (9.31%). The wheat crop provides not just food grains but also animal feed. Wheat is mostly consumed by humans. It is nutrient-dense, easy to store and transport, and can be processed into a variety of food types. Gluten protein can be found in wheat. The wheat grain is utilized as a human food in the form of chapatti, which is made from wheat flour. Most bread, rolls, crackers, cookies, biscuits, cakes, noodles, pizza, and other hot & cold breakfast food contain it. Wheat straw is used for feeding cattle and can also be used for production of wide variety of value-added products like straw particle board, packaging materials, insulators, biodegradable plastics, etc.

Wheat is grown in India during the Rabi season. It's usually planted in November and harvested in March or April. At the national level, wheat cultivated area increased by 1.5 million hectares (5 per cent) from 29.04 million hectares to 30.54 million hectares. With 9.75

million hectares (32 per cent), Uttar Pradesh has the biggest area share, followed by Madhya Pradesh (18.75 per cent), Punjab (11.48 per cent), Rajasthan (9.74 per cent), Haryana (8.36 per cent), and Bihar (8.36 per cent) (6.82 per cent). The crop was cultivated on approximately 30.54 million hectares (14 per cent of the global area) to produce an all-time high output of 99.70 million tonnes of wheat (13.64 per cent of global production) with a record average productivity of 3421 kg/ha. (Source: DES, Ministry of Agriculture and Farmers Welfare (DAC&FW), Government of India; 2019-20)

In Chhattisgarh wheat is grown in 116.27 lakh hectare area with an average production of 135.89 lakh million tons/hectare and Productivity of 1169 kg/hectare in the year. (2019-20) Mungeli district is one of the largest tehsil amongst the state. This new district's population is made up of three development blocks. The new districts comprises three Tehsil Mungeli, Pathariya and Lormi. Major crops grown in mungeli district are Rice, Coarse Grains, Wheat, Maize, Groundnut, Pulses and Oilseeds. Wheat crop are cultivated in an area of 5.61 thousand hectare with production 7.41 thousand metric tons and productivity 1321kg/hectare.

Materials and Methods

The study was carried out in Mungeli district of Chhattisgarh state. There are 3 blocks in Mungeli district namely Mungeli, Lormi and Pathariya. Out of which Mungeli block was selected for the present study. Ten Villages were selected from Mungeli block namely (Dullapur, Shinghanpuri, Nagopahari, Sambalpur, Rajpura, Karesara, Bundeli, Jhitkaniya, Pauni and Koliha.) and ten wheat growers were selected from each selected village. In this way total 100 (10 x10=100) wheat

Tables-1 : Distribution of respondents according to their overall knowledge level. (n=100)

Categories	Frequency	Percentage
Low knowledge level (< 26 score)	13	13.00
Partial knowledge level (26-31 score)	71	71.00
Complete knowledge level (> 31 score)	16	16.00
$\bar{X} = 19.67 = 4.701$		

Table-2 : Distribution of respondents according to their overall adoption level. (n=100)

Categories	Frequency	Percentage
Low adoption level (< 22 score)	14	14.00
Partial adoption level (22- 34 score)	78	78.00
Complete adoption level (> 34 score)	08	08.00
$\bar{X} = 15.60 = 5.64$		

disease management with adoption index of 49.00 per cent. This result shows that most of them had partial adoption of major production technologies of wheat. Partial adoption here signifies that they either adopt some of the improved technology with the same expanse they adopt some of the non improved technology.

Technological gap signifies the lack of adoption i.e. greater the adoption lesser will be the technological gap. In other words, the production technologies which is delivered from the laboratory is properly delivered to the farmers is evaluated with the help of technological gap. The distribution of respondents according to their technological gap in various practices with their

Table-3 : Distribution of respondents according to their practice wise technological gap with their mean scores regarding wheat cultivation. (n=100)

Sl. No.	Wheat cultivation practices	Actual obtained score (A)	Maximum obtainable score (R)	Technological gap		
				Mean score (R-A)	Technological gap index (%) ($\frac{R-A}{R} \times 100$)	Rank
1.	Preparation of land	129	200	71	35.50	XI
2.	Seed treatment	83	200	117	58.50	I
3.	Sowing method and seed rate	126	200	74	37.00	X
4.	Improved variety	110	200	90	45.00	V
5.	Integrated nutrient management	115	200	85	42.50	VII
6.	Irrigation method	134	200	66	33.00	XII
7.	Time of irrigation	118	200	82	41.00	VIII
8.	Weed management	102	200	98	49.00	IV
9.	Integrated pest management	91	200	109	54.50	III
10.	Disease management	90	200	110	55.00	II
11.	Time and method of harvesting	125	200	75	37.50	IX
12.	Method of storage	114	200	86	43.00	VI

growers were selected as respondents for the present study. The data was collected personally through pre-tested interview schedule. An interview schedule is basically a list containing a set of structured questions that have been prepared, to serve as a guide for researchers in collecting information about a specific topic. The statistical tools like Mean, Standard deviation, Frequency, Percentage, correlation were used to analyse the data.

Table-1; reveals that majority (71.00%) of the respondents had partial knowledge followed by complete (16.00%) knowledge and low (13.00%) knowledge. This result shows that evident to the fact that the complete knowledge is not transformed to grass root level which is the major reason for technology gap.

Table-2; reveals that majority (78.00%) of the respondents had partial adoption followed by low (14.00%) adoption and complete (8.00%) adoption. Moreover, majority of the respondents had adopted appropriate irrigation method with 78.00% of adoption index and minimum adoption was under the practice of

technological gap index is presented in Table-3. Majority of the respondents had the knowledge about preparation of land with 90.33 per cent of knowledge index and minimum knowledge about seed treatment with knowledge index of 61.00 per cent. Majority of the respondents had adopted appropriate irrigation method with 78.00% of adoption index and minimum adoption was under the practice of disease management with adoption index of 49.00 per cent. This result shows that most of them had partial adoption of major production technologies of wheat. Majority (49.00%) of the respondents had medium technological gap followed by less (37.00%) and more (14.00%) technological gap. The result also portrays that seed treatment with maximum technological gap index (58.50%) is the major wheat production facility which had more technological gap in adoption of improved wheat production technology followed by disease management (55.00%), integrated pest management (54.50%), weed management (49.00%), improved variety(45.00%), method of storage

Table-4 : Distribution of respondents according to their overall technological gap. (n=100)

Categories	Frequency	Percentage
Less technological gap (< 33 score)	37	37.00
Medium technological gap (33-66score)	49	49.00
More technological gap (> 66 score)	14	14.00

(43.00%), integrated nutrient management (42.50%), time of irrigation (41.00%), time and method of harvesting (37.50%), sowing method and seed rate (37.00%), preparation of land (35.50%) and irrigation method (33.00%). Irrigation method had least technological gap as each and every farmer known how to irrigate wheat crop at the time of requirement.

Table-4; reveals that majority (49.00%) of the respondents had medium technological gap followed by less (37.00%) and more (14.00%) technological gap.

Conclusions

It is therefore concluded from the study that majority of the respondents falls under medium level of knowledge and adoption. Majority of the respondents not used technology correctly i.e., regarding the technological gap of wheat growers was found to be the highest in seed treatment followed by disease management, integrated pest

management and weed management. Majority of the respondents had medium level input about technological gap in response to the enquiries. Most of the respondents were unaware of the various cultivation practices of wheat production technology.

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Assessment of Morphological and Genetic Diversity in *Moringa Oleifera* Genotypes of Rajasthan

Sheetal Tak, I.B. Maurya, K. Arvindakshan and Pawan Kumar Pareek

Department of Horticulture, College of Horticulture and Forestry, Jhalawar, Agriculture University, Kota, Rajasthan

Abstract

Genetic diversity assessment is prerequisite for future crop improvement programme therefore in the present study, morphological and genetic diversity among the 36 drumstick genotypes were assessed which collected from different parts of Rajasthan. Under open field condition 18 characters were recorded to assess the diversity. This study aimed to assess the diversity of *Moringa oleifera* at different districts of Rajasthan state. Thirty six genotypes were characterized morphologically and genetically using 18 characteristics. The studied genotypes were classified according to each characterization, and the correlation between morphological and genetic diversity was investigated.

Thirty-six genetically diverse genotypes of drumstick were assembled from different places of Rajasthan (Ajmer, Jhalawar, Kota, Udaipur) and subjected to a multivariate analysis regarding the content of vitamin C, protein, nitrogen, phosphorous, potassium, calcium, iron, and magnesium. All 36 genotypes could be grouped into five clusters. Genetic diversity arises due to geographical separation or due to genetic barriers to cross ability. In any crop breeding programme, genetic diversity is an essential pre-requisite in selecting parents for hybridization and evolving high yielding genotypes. Heritability estimates were over 94% for all characters studied, except iron (64%), indicating that selection was possible.

Keywords : *Moringa oleifera*, agro-ecological conditions, clonal selection, genetic differentiation, group constellation, evaluation, genotypes

Introduction

Moringa oleifera Lam. is an underutilized out crossing diploid ($2n=28$) tree species belonging to the family Moringaceae and indigenous to the sub-Himalayan tracts (Fahey, 2005; Jyothi *et.al.*1990; Parrotta, 2009). It has been successfully introduced and established in other parts of India, Pakistan, Afghanistan, Bangladesh, Sri Lanka, Southeast Asia, East and West Africa, Southern Florida, throughout the West Indies, and from Mexico to Peru, Paraguay and Brazil (Ramachandran *et.al.*1980; Parrotta, 2009). Of all the species in the genus *Moringa*, *M. oleifera* is the most economically cultivated because all its parts are useful as medicine, food, fodder, domestic cleaning agent, green manure, rope, tanning hides and as water purifier (Adebayo, 2011; Popoola and Obembe, 2013). However, in spite of all these economic importance, *M. oleifera* has not witnessed successful breeding for genetic improvement to further enhance its productivity. The knowledge of the levels of genetic diversity and relatedness of introduced landraces or populations to different locations in Rajasthan is limited, though cultivation and utilization has greatly increased. Our recent field survey indicated possibility of transfer of similar genotypes to different locations in Nigeria, which may further narrow gene pool. The reviews of literature also indicate that knowledge of their intraspecific relationships is poorly understood and where available it is limited in scope, bearing in mind that any successful

genetic improvement depends on the inter- and intra-specific variability. Also, in meeting the future demands for various uses such as food, medicine, bio-diesel and other allied products, it will be very important to select the best planting materials for higher productivity, which can only be achieved through characterization. More scientific studies in the areas of reproductive biology, ecology and genetic characterization are therefore needed to achieve desirable success in its selection, breeding and improvement, conservation and utilization.

The tree itself is rather slender with drooping branches and height ranges from 5 to 10 m (Morton, 1991). It can grow well in the humid tropics or hot drylands and survives in destitute soils (Morton, 1991). It tolerates a wide range of rainfalls (250 to 3000 mm) and soil pH (5.0-9.0) (Palada and Changl, 2003). Drumstick is an important food commodity which has received enormous attention as the 'natural nutrition' of the tropics. Moringa has many medicinal properties. Almost all parts viz., root, bark, gum, leaf, pod, flower, seed and seed oil have been used for treatment of various inflammation and infectious diseases along with cardiovascular, gastrointestinal, haematological and hepatorenal, disorders (The Wealth of India, 1962; Morimitsu *et al.*, 2000; Siddhuraju and Becker, 2003; Singh *et al.*, 2011). Leaves of moringa represent an important source of nutrients for rural populations (Gupta *et al.*, 1989; Lockett *et al.*, 2000). Many reports indicate that moringa leaves are rich in

Table-1 : Source of drumstick collection.

S. No.	Genotypes	Origin/Place of collection	Cultivated types	Year of planting
1.	JWRM-1	Dhola Bhata Colony, Ajmer	KG	2003
2.	JWRM-2	Govind Colony, Ajmer	KG	2005
3.	JWRM-3	Govind Colony, Ajmer	KG	2003
4.	JWRM-4	Gora Colony, Ajmer	KG	1998
5.	JWRM-5	Surya Nagar Colony, Ajmer	KG	2004
6.	JWRM-6	Dhola Bhata Colony, Ajmer	KG	1999
7.	JWRM-7	Dhola Bhata, Ajmer	KG	2001
8.	JWRM-8	Dhola Bhata, Ajmer	KG	1999
9.	JWRM-9	Petrol pump, Ajmer	KG	2003
10.	JWRM-10	Chauhan Farm, Jhalawar	FP	1991
11.	JWRM-11	Chauhan Farm, Jhalawar	FP	1997
12.	JWRM-12	Chauhan Farm, Jhalawar	FP	1996
13.	JWRM-13	Anand Vihar Colony, Jhalawar	FP	1993
14.	JWRM-14	Rata Devi, Jhalawar	RSP	1991
15.	JWRM-15	Manpura, Jhalawar	RSP	1986
16.	JWRM-16	Manpura, Jhalawar	FP	1991
17.	JWRM-17	Manpura, Jhalawar	FP	1986
18.	JWRM-18	Manpura, Jhalawar	FP	1989
19.	JWRM-19	Bhawani Club, Jhalawar	FP	1986
20.	JWRM-20	Near Vigyan Nagar, Kota	FP	1991
21.	JWRM-21	Suket, Kota	FP	1981
22.	JWRM-22	Suket, Kota	FP	1979
23.	JWRM-23	Suket, Kota	FP	1986
24.	JWRM-24	Dara, NH-12, Kota	FP	1993
25.	JWRM-25	Dara, NH-12, Kota	RSP	1986
26.	JWRM-26	Dara, NH-12, Kota	RSP	1986
27.	JWRM-27	Dara, NH-12, Kota	RSP	1983
28.	JWRM-28	RCA Farm, Udaipur	FP	1976
29.	JWRM-29	RCA Farm, Udaipur	Cultivated	1999
30.	JWRM-30	RCA Farm, Udaipur	Cultivated	1999
31.	JWRM-31	Ganesh Nagar, Udaipur	RSP	1981
32.	JWRM-32	Ganesh Nagar, Udaipur	KG	1986
33.	JWRM-33	CTAE Campus, Udaipur	FP	1993
34.	JWRM-34	Durga Nursery Road, Udaipur	FP	1996
35.	JWRM-35	Hiran Magri, Udaipur	RSP	1986
36.	JWRM-36	RNT medical College, Udaipur	RSP	1991

KG, FP and RSP denotes Kitchen Garden, Field plantation and Road Side Plantation.

protein and present an amino acid composition, which is suitable for human and animal nutrition (Gupta *et al.*, 1989; Makkar and Becker, 1996; Freiburger *et al.*, 1998). Fahey (2005) referred to moringa as a nutrient dense food source because of its high nutritional value of leaves, pods and seeds. In general, 100 g of moringa leaves contain four times more vitamin A than the same quantity of carrots, four times more calcium than 100 mL of milk, four times more iron than 100 g of spinach, seven times more vitamin C than 100 g of oranges and three times more potassium than 100 g of bananas. The protein quality of drumstick leaves also rivals that of milk and eggs (Fahey, 2005).

Materials and Methods

The present investigation entitled "Genetic variability in drumstick (*Moringa oleifera* Lam.) was conducted during the years of 2011-12 at the College of Horticulture and Forestry, Jhalawar. The location of the experimental site is comprised of four districts of Rajasthan, namely Jhalawar, Kota, Ajmer and Udaipur. The mean weekly weather data of temperature,

relative humidity and rainfall were recorded during the experimentation period (June, 2011 May, 2012). The experimental material comprised 36 genotypes of drumstick collected from four districts of Rajasthan,

Table-2 : Tree characteristics of 36 genotypes of drumstick.

Genotype	Age (yrs)	Tree height (m)	Tree girth (cm)	Bitterness (Bitter/Non-bitter) of pod
JWRM-1	8	8.3	48	Slightly bitter
JWRM-2	6	5.5	30	Non-bitter
JWRM-3	8	5.5	46	Non-bitter
JWRM-4	13	7.1	42	Non-bitter
JWRM-5	7	6.5	56	Non-bitter
JWRM-6	12	8.3	52	Non-bitter
JWRM-7	10	7.2	30	Non-bitter
JWRM-8	12	8.7	52	Non-bitter
JWRM-9	8	8.3	36	Non-bitter
JWRM-10	20	12.5	50	Bitter
JWRM-11	14	11	74	Bitter
JWRM-12	15	9.5	48	Non-bitter
JWRM-13	18	8	45	Slightly bitter
JWRM-14	20	8.5	52	Bitter
JWRM-15	25	11	35	Bitter
JWRM-16	20	12	30	Non-bitter
JWRM-17	25	12	42	Non-bitter
JWRM-18	22	9	36	Non-bitter
JWRM-19	25	12	45	Non-bitter
JWRM-20	20	8.5	60	Bitter
JWRM-21	30	8	49	Bitter
JWRM-22	32	12.5	78	Non-bitter
JWRM-23	25	10.5	52	Bitter
JWRM-24	18	6.9	39	Non-bitter
JWRM-25	25	10	72	Bitter
JWRM-26	25	11.2	61	Non-bitter
JWRM-27	28	12.5	65	Non-bitter
JWRM-28	35	10.5	68	Bitter
JWRM-29	12	7	32	Non-bitter
JWRM-30	12	6.5	34	Non-bitter
JWRM-31	30	10.2	42	Non-bitter
JWRM-32	25	11.3	39	Non-bitter
JWRM-33	18	8.5	54	Non-bitter
JWRM-34	15	7.6	44	Non-bitter
JWRM-35	25	7.1	41	Non-bitter
JWRM-36	20	6.5	38	Slightly bitter
Mean	18.97	9.06	47.69	

namely Ajmer, Jhalawar, Kota and Udaipur. The collection was based on a survey made during February-March, 2012 with the help of local people. Initially, 15-20 trees of drumstick, growing naturally on the roadside or planted in open fields/at field boundaries or grown in kitchen gardens, were identified from each district but finally 9 bearing trees from each district showing variability for morphological characteristics were selected for the present investigation (Table-1 and 2). The recorded observations for all genotypes comprised 18 different economic and nutritive parameters of leaf and pod viz., pod weight, pod length, pod girth, number of seeds per pod, 10-seed weight, number of leaflets per

leaf, leaf length, dry matter, TSS, chlorophyll, vitamin C, protein and nutrient contents (N, P, K, Ca, Fe and Mg). Observations on nutritive parameters were recorded from leaf samples. Vitamin C content was determined by titrating with 2,6-dichlorophenol-indophenol solution. Potassium content was estimated by flame photometer, and phosphorous, iron, magnesium, and calcium contents were estimated by atomic absorption spectrophotometer (AAS) method. Analysis of variance was carried out by the Panse and Sukhatme (1978) method. D2 statistics analysis (Mahalanobis, 1936) was undertaken for all seven morphometric traits. The cluster formation was confirmed by Torcher's method (Rao, 1952) and the dendrogram of the 36 genotypes of drumstick was based on squared Euclidean distance. Heritability (broad sense) and genetic advance was calculated by using the formula of Burton and Devane (1953) and Lush (1949), respectively.

Results and Discussion

Morphological diversity for the tree characters are showing in the table-2. Highly significant differences were noted for all of the eight traits evaluated, indicating the presence of considerable divergence among the 36 drumstick genotypes. Genotypes could be grouped into five clusters (Table-3) and enormous diversity among genotypes was indicated by a wide range of D2-values (16.86 to 26.33) for the collections from Ajmer, Jhalawar, Kota and Udaipur. Cluster I comprised the smallest number of genotypes (2), while the maximum of genotypes (12) was found in cluster IV. The clustering pattern revealed that, in general, genotypes from the same origin had no tendency to be in the same cluster. It is evident from Table 4 that the average inter-cluster D2 value was highest between cluster II and cluster III (693.105) and lowest between cluster III and cluster V (246.925). Theoretically, a maximum amount of heterosis will manifest itself in a cross combination involving the most diverse parents. Therefore, hybridization between the most diverse parents is realized with the aim to isolate superior lines from the advanced segregating generations.

In the present study, cluster II and III had maximum inter-cluster distance, therefore, the genotypes of these two clusters with high trait performance could be utilized in breeding programmes. The existing differences in cluster means for all the characters are presented in

Table 5. Cluster III exhibited maximum mean value for pod length (43.4 cm), number of seed

per pod (19.0), 10-seed weight (4.9 g), chlorophyll (1.2 mg), vitamin C (203.0 mg), protein (26.6%), nitrogen (4061.8 mg), phosphorous (172 mg), iron (25.6 mg) and

Table-3 : drumstick genotypes included in each cluster.

S. No.	Clusters	Number of genotypes	Genotypes
1.	I	2	JWRM-15, JWRM-22
2.	II	7	JWRM-19, JWRM-20, JWRM-21, JWRM-24, JWRM-25, JWRM-26, JWRM-27
3.	III	5	JWRM-30, JWRM-31, JWRM-32, JWRM-33, JWRM-34
4.	IV	12	JWRM-1, JWRM-2, JWRM-7, JWRM-10, JWRM-11, JWRM-12, JWRM-13, JWRM-14, JWRM-16, JWRM-17, JWRM-18, JWRM-23
5.	V	10	JWRM-3, JWRM-4, JWRM-5, JWRM-6, JWRM-8, JWRM-9, JWRM-28, JWRM-29, JWRM-35, JWRM-36

Table-4 : Inter cluster divergence.

Cluster	I	II	III	IV	V
I	—	498.941	577.890	352.443	632.089
II		—	693.105	284.194	566.610
III			—	431.272	246.925
IV				—	349.535
V					—

Table-5 : Cluster mean for 18 characters in 36 genotypes of drumstick.

S.No.	Character	Cluster				
		I	II	III	IV	V
1.	Pod weight (g)	39.25	37.47	46.02	48.92	51.62
2.	Pod length (cm)	36.98	40.46	43.37	42.38	41.35
3.	Pod girth (mm)	19.34	12.29	16.07	15.28	16.27
4.	Number of seeds/pod	16	15	19	16	18
5.	10 seed weight (g)	2.84	3.71	4.88	3.67	4.59
6.	No. of leaflets/leaf	11.67	10.76	9.73	10.67	11.67
7.	Leaf length (cm)	49.90	46.65	45.03	50.46	48.33
8.	Dry matter (%)	34.4	33.5	29.0	31.1	30.5
9.	TSS (%)	6.15	7.12	6.53	6.28	6.61
10.	Chlorophyll(mg)	0.96	1.15	1.21	1.00	1.01
11.	Vitamin C in leaves (mg/100g)	185.12	171.55	202.97	188.85	194.01
12.	Protein content (%)	23.63	22.81	26.40	23.91	25.55
13.	Nitrogen (mg/100gm)	3635.30	3508.17	4061.81	3677.98	3930.71
14.	Phosphorous (mg/100 g)	159.1	170.1	172.0	167.6	165.2
15.	Potassium (mg/100g)	825.79	751.27	1108.77	927.95	1127.36
16.	Calcium (mg/100 g)	1487.3	1963.5	1753.1	1821.4	1957.1
17.	Iron (mg/100g)	18.82	21.09	25.58	20.13	21.48
18.	Magnesium (mg/100 g)	306.2	305.8	330.4	299.0	290.1

magnesium (330.4 mg). Similarly, the maximum mean values for pod weight (51.3 g), number of leaflets per leaf (11.6) and potassium (1127.4 mg) were recorded in cluster V. Pod girth (19.3 mm) and dry matter (34.4%) were found to be maximum in cluster I whereas cluster II had maximum mean value for TSS (7.1%) and calcium (1963 mg). Cluster IV had high mean value only for leaf length (51.0). Cluster III showed maximum inter-cluster distance as well as high mean value, hence, parents of these clusters could be effectively utilized in hybridization for generating highly diverse recombinant materials to improve horticultural traits including quality parameters in drumstick.

An analysis of cluster composition revealed that the

largest cluster grouping was comprised of genotypes collected from Ajmer, Jhalawar and Kota districts of Rajasthan. Looking at the pattern of varietal distribution into different clusters in the present study, it appeared that geographical distance between the genotypes had no relation with the genetic divergence as the genotypes from the same location had fallen into different clusters and a given cluster contained genotypes from different sources/locations. The noted differences probably occurred over time. Introduction and exchange of genetic stocks, the free movement of plant material from location to location, the diverse agro-ecological conditions, genetic drift, gene flow, and out-crossing, are the possible factors responsible for such diversity in drumstick.

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Economic Feasibility Analysis of Plant Growth Regulators Application in Okra [*Abelmoschus esculentus* (L.) Moench.] Cultivation in Western Arid Rajasthan

Sonu Kumari^{1*} and M.L. Meena², S.K. Moond¹ and Rakesh Chouhan¹

¹Department of Horticulture, College of Agriculture, Jodhpur-342304, Rajasthan

²Department of Horticulture, College of Agriculture, Baytu-344034, Barmer, Rajasthan

*Corresponding Author Email : sonujakhar999@gmail.com

Abstract

The financial feasibility analysis of capital investment in okra cultivation using plant growth regulators viz. 6-benzylaminopurine (BAP), gibberellic acid (GA₃) and naphthalene acetic acid (NAA) was carried out during *kharif* season, 2020; at the Instructional farm, Agricultural Research Station, Jodhpur. The experiment comprised ten treatments consisting of three levels (25, 50 and 75 ppm) each of BAP, GA₃ and NAA along with control. The experiment was laid out in randomized block design with three replications. The cost of cultivation of okra with application of different plant growth regulators varied from ₹ 40,322 to ₹ 55,676, highest occurring with application of BAP @ 75 ppm and the lowest in control. Evidently, use of plant growth regulators in okra increased the returns as compared to the control. The highest gross returns (₹ 1,98,180) were recorded with NAA @ 75 ppm whereas the lowest (₹ 1,39,320) in the control. Similarly, net returns also reflected increment with application of different plant growth regulators than control. The highest net returns (₹ 1,55,269) were obtained with NAA @ 75 ppm whereas the lowest net returns (₹ 98,998) in the control. A perusal of the data pertaining to cost of cultivation of okra revealed that application of BAP recorded lower B:C (benefit: cost) ratio at all concentrations as compared to the control, whereas application of NAA and GA₃ at all concentrations recorded higher B:C ratio as compared to the control (2.46). Application of PGRs at optimum concentration in okra is ought to have better economic returns.

Key words : NAA, BAP, GA₃, Feasibility, Plant growth regulators, B:C Ratio, Net returns, Cost of cultivation.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench, 2n=2x=130] is a herbaceous warm season vegetable grown in tropical and subtropical parts of the world (Balock, 1994). It is popularly known as lady's finger and belongs to the family Malvaceae (Brouk, 1975). The cultivated okra is native of Ethiopia (Vavilov, 1951). It is cultivated from ancient times and is disseminated from Asia to Africa, Southern Europe and America (Ariyo, 1993 and Oyelade *et al.*, 2003). Okra is presently grown in many countries including India, Turkey, Iran, Western Africa, Bangladesh, Afghanistan, Burma, Pakistan, Malaysia, Japan, Brazil, Cyprus, Ethiopia, Ghana and United States of America. India is the largest okra producing country in the world with 5.19 lac hectare area and 63.71 lac MT production (Anonymous, 2020). In Rajasthan area and production of okra is 4.15 thousand ha and 21.39 thousand metric tonnes, respectively (Anonymous, 2020).

Plant growth regulators have high potential of increasing economic returns by improving the plant growth and yield in okra but their application has to be planned quite sensibly in terms of optimum dose, stage of application, crop and season specificity (Khan and Chaudhary, 2006), because same plant growth regulator can bring different results at different doses of application. B:C ratio has shown significant improvement with

application of NAA and GA₃. However, controversy lies as some studies have shown higher B:C ratio with application of GA₃ (Surendra *et al.* 2006; Kumari *et al.* 2015) while some observed the maximum B:C ratio in okra production with NAA (Patil and Patel, 2010; Kumawat *et al.* 2019). Although research work has been undertaken on the economic productivity of different PGRs application in okra but there is dearth of literature subjected to this topic. BAP has rarely been considered for checking its economic feasibility in okra. Moreover, there is a huge lack of research in western Rajasthan regarding the economic perspectives of using PGRs in okra cultivation.

Considering aforementioned facts, the present investigation was planned to find out economic feasibility of PGRs application in okra and find out the best PGR with optimum dose for highest returns.

Materials and Methods

The experiment was carried out at Instructional Farm, Agriculture Research Station, Jodhpur which is situated at 26°15' N to 26°45' North latitude and 73°00' E to 73°29' East longitude, at an altitude of 231 meters above mean sea level. Jodhpur falls under agro-climatic zone Ia (Arid Western Plains) of Rajasthan which is typically arid climate with hot summers and dry mild cool winters. The soil in the experimental area was loamy sand in texture,

Table-1 : Total cost of cultivation (₹/ha)

Treatments	Common cost of cultivation (₹/ha)	Treatment cost (₹/ha)	Total cost of cultivation (₹/ha)
T ₁	40,322	-	40,322
T ₂	40,322	6,178	46,500
T ₃	40,322	10,766	51,088
T ₄	40,322	15,354	55,676
T ₅	40,322	2,145	42,467
T ₆	40,322	2,700	43,022
T ₇	40,322	3,255	43,577
T ₈	40,322	1,923	42,245
T ₉	40,322	2,256	42,578
T ₁₀	40,322	2,589	42,911

mildly alkaline in reaction, low in organic carbon (0.13%), nitrogen (171.0 kg/ha), available phosphorus (23.2 kg/ha) and medium in available potassium (319.0 kg/ha). The experiment was conducted on okra var. Arka Anamika with application of plant growth regulators viz., NAA, GA₃ and BAP each at three levels (25, 50 and 75 ppm) as spray application. The plant growth regulator solutions were prepared fresh on the day of spray application of the treatments. The first spray was done at 20 DAS (days after sowing) followed by second spray at 40 DAS and third spray at 60 DAS.

The cost concepts used in the present study are as follows: total Cost=Expenditure on casual labour, farm machinery, seeds, fertilizer and manure, plant protection chemicals, irrigation, miscellaneous expenditure (cost of transportation, baskets) and treatment wise cost

In order to evaluate the economic feasibility of the treatments, total cost, net returns and B:C ratio were worked out on the basis of prevailing market prices so that most remunerative treatment could be recommended to the growers of the region.

Total cost = Fixed cost + Treatment wise cost

Gross returns (₹/ha) = Returns from fruit yield (₹/ha)

Net returns (₹/ha) = Gross Returns – Total Cost of cultivation (₹/ha)

Benefit : Cost (B:C) ratio = $\frac{\text{Gross return (₹/ha)}}{\text{Cost of cultivation (₹/ha)}} \times 100$

Results and Discussion

The data related to the economics of application of different plant growth regulator in okra have been presented in table-1. The cost of cultivation of okra with application of different plant growth regulators varied from ₹ 40,322 to ₹ 55,676 with the highest cost of cultivation with the application of BAP @ 75 ppm and the lowest in control. The application of different plant growth

regulators in okra increased the returns as compared to the control. The highest gross returns (₹ 1,98,180) were recorded with NAA @ 75 ppm whereas the lowest gross returns (₹ 1,39,320) in the control. The net returns also increased with application of different plant regulators as compared to the control. The highest net returns (₹ 1,55,269) were obtained with NAA @ 75 ppm whereas the lowest net returns (₹ 98,998) were obtained in the control. A perusal of the data pertaining to cost of cultivation of okra (Table-1) revealed that application of BAP recorded lower B:C ratio at all concentrations as compared to the control, whereas application of NAA and GA₃ at all concentrations recorded higher B:C ratio as compared to the control (2.46). The highest B:C ratio (3.62) was noted with the application of NAA @ 75 ppm whereas the lowest B:C ratio (2.39) was noted with the application of BAP @ 75 ppm.

The data pertaining to the effect of plant growth regulators on cost of cultivation, gross returns, net returns and B:C ration of okra have been presented in Table 1. Amongst the plant growth regulator treatments, the highest cost of cultivation was in BAP @ 75 ppm treatment and lowest in NAA @ 25 ppm, owing to the comparatively high cost of BAP and low cost of NAA. Highest gross returns were recorded in NAA @ 75 ppm due to highest yield in this treatment. Net returns were also highest in NAA @ 75 ppm due to highest yield and comparatively low cost of cultivation under this treatment. The B:C ratio was the highest with NAA @ 75 ppm, whereas lower than control B:C ratio was under all the concentration of BAP, it was because of its highest cost but comparatively smaller effect in increasing yield of okra. The findings are supported by Patil and Patel (2010), Kumawat *et al.* (2019) and Kumar *et al.* (2021).

Cost concept for okra cultivation : Table-1 indicated the cost concept for okra cultivation in western arid Rajasthan under study area. The cost of cultivation of okra with application of different plant growth regulators varied from ₹ 40,322 to ₹ 55,676. The per hectare total cost of cultivation of okra includes common cost (Expenditure on casual labour, bullock labour, farm machinery, seeds, fertilizer and manure, plant protection chemicals, irrigation, miscellaneous expenditure (cost of transportation) of cultivation and treatment cost (BAP, GA₃, NAA).

Benefit cost ration, Cost and return structure of okra production : The BCR, total cost incurred and returns are presented in Table-2. The total common cost constituted was 40,322 on experimental farm. The total cost was varied from ₹ 40,322 to ₹ 55,676. The gross return was varied from 1,39,320 to 1,98,180 /hectare. The net return

Table-2 : Effect of plant growth regulators on economics of okra cultivation.

Treatment	Cost of cultivation (₹)	Gross returns (₹)	Net Returns (₹)	B:C ratio
Control (T ₀)	40,322	1,39,320	98,998	2.46
BAP @ 25 ppm (T ₁)	46,500	1,57,950	1,11,450	2.40
BAP @ 50 ppm (T ₂)	51,088	1,76,250	1,25,162	2.45
BAP @ 75 ppm (T ₃)	55,676	1,88,505	1,32,829	2.39
GA ₃ @ 25 ppm (T ₄)	42,467	1,45,320	1,02,853	2.42
GA ₃ @ 50 ppm (T ₅)	43,022	1,74,825	1,31,803	3.06
GA ₃ @ 75 ppm (T ₆)	43,577	1,65,750	1,22,173	2.80
NAA @ 25 ppm (T ₇)	42,245	1,59,450	1,17,205	2.77
NAA @ 50 ppm (T ₈)	42,578	1,79,820	1,37,242	3.22
NAA @ 75 ppm (T ₉)	42,911	1,98,180	1,55,269	3.62

was varied from 98,998 to 1,55,269 /hectare. The benefit cost ratio was varied from 2.39 to 3.62.

Conclusions

Economic Analysis of cost and returns of okra in jodhpur district Rajasthan state revealed that the highest cost of cultivation with the application of BAP @ 75 ppm and the lowest in control. The highest net returns (₹ 1,55,269) were obtained with NAA @ 75 ppm whereas the lowest net returns (₹ 98,998) were obtained in the control. The highest B:C ratio (3.62) was noted with the application of NAA @ 75 ppm whereas the lowest B:C ratio (2.39) was noted with the application of BAP @ 75 ppm. Application of PGRs in okra provided good monetary returns. NAA has been found best PGR among NAA, GA₃ and BAP and 75 ppm has been found the optimum dose for NAA to get highest B:C ratio.

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Humic Substances Extracted from Enriched Compost Prepared by Waste Material of Crop Residues

Ajit Kumar Meena^{*1}, Buddhabhushan D. Wankhade¹, S. D. Jadhao¹, Neha Khardia², Sundar Anchra², Kartik Salvi², Deshraj Meena² and Surendra Dhayal²

¹Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapith, Akola (MH)

²Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan-313001

*Corresponding Author Gmail- ajitkumarmeena907@gmail.com

ABSTRACT

The present investigation on chemical characterization and functional group analysis of humic substances extracted from enriched compost prepared by using various organics was conducted during the year 2018-19 at research farm, department of soil science and agricultural chemistry. The enriched compost was prepared by pit method with sorghum stubbles, wheat straw and shredded cotton stalk and glyricidia leaf along with rock phosphate @ 12 per cent. The mixture containing sorghum stubble, wheat straw, shredded cotton stalk and glyricidia leaf along with rock phosphate @ 12 per cent and *trichoderma viride* @ 1 kg per tonne of crop residues were decomposed up to 90 days and thereafter kept for 30 days for curing. Turning was given at 10 days interval up to 90 days. Glyricidia leaves @ 10% (100 kg tonne⁻¹) were incorporated in the pit at 15 days interval in T7 and T8 treatment. The enriched compost sample were collected treatment wise at 15, 30, 60, 90 and 120 days during decomposition and analyzed for various chemical parameter. The organic carbon, total N and total P content of enriched compost prepared by various crop residues was improved as compared to initial. The C:N ratio of prepared compost was decreased in the range of 20.94 to 26.45. The decomposed compost was subjected for extraction of various humic substances (HS). The result indicated that, compost prepared from various combination of crop residues and different ingredients yielded quite high recovery of HS. The higher value of all the functional groups was observed in humic acid than fulvic acid. The total acidity, carboxylic and phenolic functional group range between 7.8 to 9.4, 2.9 to 3.6 and 4.2 to 6.1 meq/g respectively. The humic acid and fulvic acid extracted from compost prepared from 100% wheat straw (glyricidia leaves at 15 days interval) recorded higher values total acidity and phenolic(OH) group.

INTRODUCTION

The term "humus" originates from the Romans, when it was familiarly used to signify the entire soil. Later the term was used to denominate soil organic matter and compost or for different parts of this organic matter, as well as for complexes created by chemical agent treatments to a wide palette of organic substances. The principal definition of humus, as decomposed organic matter, originates from 1761. His comprehensive study on the acidic nature of HAs is thought to be his most important benefit to humus chemistry. Research on the chemical properties of HS was extended by the Swedish researcher Berzelius, whose main contribution was the isolation of two light-yellow coloured HS from mineral water and slimy mud rich in iron oxides. Enormous advances have been made during the last decade thanks to modern physicochemical methods. Nevertheless, the structural chemistry of lignin and HS did not advance so fast as the chemistry of animal-originated biopolymers.

The humic substances are differentiated on the basis of their extractability-precipitation in alkali-acid solutions yielding three fractions (i) HA (Humic acid),

fraction of SOM that coagulates when the alkaline extract is acidified; (ii) FA (Fulvic acid), both acid and alkaline soluble fraction; and (iii) Humin, insoluble in both acid and alkali. These materials originate from the decomposition and further subsequent polymerization of organic residues of plant and animal origin lead to heterogeneity in these fractions with distinct functional groups, elemental composition and properties from the type of OM and existing environment. In any ecosystem, status and composition of these humic substances were governed by most of the factors as importantly management > climate > biota > topography = parent material > time. Thus, better understanding of characteristics and functional groups of humic substances induced by land use management may serve as essential guide in the study of soil organic matter. Therefore, present study was carried out to know the elemental composition mainly C and N, total acidity and spectral characterization i.e., E4/E6 ratio of humic substances extracted from soils of major land use systems (LUS) viz., forests (natural and social forests), horticultural systems like coffee and coconut plantations;

Table-1 : Recovery of humic substances.

Treatment		Recovery of Humic Substances (%)			HI	HA/FA
		FA	HH	H		
T ₁	100% WS	23.34	12.45	64.21	0.56	0.53
T ₂	100% SCS	20.36	10.09	69.55	0.44	0.50
T ₃	50% WS + 50% SCS	22.22	11.67	66.11	0.51	0.53
T ₄	40% WS + 40% SCS +20% GL	23.90	13.45	62.65	0.60	0.56
T ₅	30% WS+30% SCS +20% GL + 20% SS	24.15	11.90	63.90	0.56	0.49
T ₆	25 % WS + 25% SCS +25 % GL +25% SS	24.92	12.67	59.12	0.60	0.51
SE (m) ±		0.56	0.37	1.60	-	-
CD at 5%		1.66	1.09	4.77	-	-

Table-2 : Functional group of extracted humic substances.

Treatments		Humic Acid			Humin		
		Functional Group (meq g ⁻¹ of HS)					
		Total Acidity	Carboxylic -OH	Phenolic-OH	Total Acidity	Carboxylic -OH	Phenolic-OH
T ₁	100% WS	8.55	3.60	4.95	4.88	2.80	1.95
T ₂	100% SCS	7.85	2.90	4.95	4.65	2.30	1.75
T ₃	50% WS + 50% SCS	8.10	3.90	4.20	5.48	1.90	3.85
T ₄	40% WS + 40% SCS + 20% glyricidia leaves	8.25	3.80	4.45	5.08	2.95	2.15
T ₅	30% WS + 30% SCS + 20% glyricidia leaves + 20% sorghum stubbles	8.40	4.10	4.30	4.80	2.88	2.20
T ₆	25% WS + 25% SCS + 25% glyricidia leaves + 25% sorghum stubbles	9.73	3.70	6.03	6.18	3.90	2.15
SE(m)±		0.23	0.19	0.21	0.27	0.19	0.26
CD at 5%		0.67	0.58	0.62	0.81	0.56	0.78

vegetable and potato fields, field crops (paddy) and mulberry fields of Hassan district of Karnataka (India).

Humic substances can be divided into components according to their solubility in different media. humic acids and fulvic acid represent alkali-soluble humus fragments; HAs are commonly extracted using diluted alkali and precipitated with an acid, and so are separated from the soluble fulvic acid. Humin represents the insoluble residue.

Humic acids, one of the most important components of HS, help break up clay and compacted soils, assist in transferring micronutrients from soil to plants, enhance water retention, increase seed germination rates, and stimulate the development of micro flora populations in soils. Humic acids also slow down water evaporation from soils. This is especially important in soils where clay is present at low concentration or not at all, in arid areas, and in sandy soils without the capability to hold water. Humic acids provide also sites for microflora to colonize. Bacteria secrete enzymes which act as catalysts, liberating calcium and phosphorous from insoluble calcium phosphate, and iron and phosphorous from insoluble iron phosphate. The chemical structure of HAs is very complicated and depends on their source. The elemental composition of different FAs and HAs shows that the major elements in their composition are C, H, O,

N, and S. These major elements are always present regardless their origin and country or continent. Moreover, besides elemental composition, group composition is used to characterize HS as it gives information about the chemistry and structural properties of HS. Fulvic acids contain more functional groups of an acidic nature, particularly COOH. The total acidities of fulvic acids (900. 1400mmol/100g) are considerably higher than for humic acids (400.870mmol/100g). Another important difference is that while the oxygen in fulvic acids is largely in known functional groups. (COOH, OH, C=O), with a high oxygen content, the acidity and degree of polymerisation all change systematically with increasing molecular weight. The proportion of oxygen in humic acids seems to occur as a structural component of the nucleus.

EXPERIMENT

Preparation of compost

The enriched compost was prepared by decomposing various crop residues (wheat straw, shredded cotton stalk, glyricidia leaves and sorghum stubbles), cow dung slurry with rock phosphate, urea, elemental sulphur and PDKV. decomposer. The enriched compost was prepared by pit method. Turnings are given at 10 days interval up to 120 days of decomposing. After 90 days of decomposing, heaps of enriched compost were collected at one place as

treatment wise and allowed to cure for another 30 days. Compost was watered regularly at 10–15 days of interval so as to maintain moisture content up to 60-70%.

Extraction of humic Substances

50 grams of air dried compost samples were taken in 500 ml conical flask to which 300 ml of 0.5 N NaOH was added under stirring for half an hour. After 24 hour the content were centrifuged for 15 minutes at 5000 rpm. This operation was repeated until the supernatant was obtained clear. This combined fractions comprised humic and fulvic acids. To separate the humic acids, the pooled supernatants were then treated with concentrated HCl (pH 2). The acidified extracts allowed to stand overnight and centrifuged to separate humic acids from fulvic acids. The precipitated portion (crude humic acid) was collected by centrifugation. The supernatant (crude fulvic acid fraction) was filtered through Whatman No. 1 filter paper.

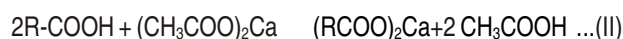
Qualitative analysis of extracted Humic acid and Humin

E4/E6 ratio recorded at 90 and 120 days after decomposition of enriched compost measure the absorbance at 465 and 665 nm wavelength in spectrophotometer as described by Schnitzer (1982).

Functional Group analysis of Humic acid and Humin

1. Carboxylic

The method is based on the liberation of acetic acid when acids are treated with calcium acetate and its titration with standard 0.1 N NaOH (Schnitzer and Khan, 1972).



To fifty milligrams of HA/FA in a stopper flask, 10 ml of 1 N $(CH_3COO)_2Ca$ and 40 ml of CO_2 free distilled water were added, a blank was also set up simultaneously. After shaking at room temperature for 24 hr the suspension was filtered and the residue was washed with CO_2 free distilled water. The filtrate and washings were titrated potentiometrically with standard 0.1 N NaOH to pH 9.8.

$$\begin{aligned} & \text{COOH groups (me g}^{-1}\text{)} \\ &= \frac{(\text{TV for sample} - \text{TV for blank}) \times \text{Normality of base (0.1N)}}{\text{Wt. of sample (mg)}} \times 1000 \end{aligned}$$

2. Total acidity

Total acidity in HA/FA was determined by $Ba(OH)_2$ method (Wright and Schnitzer 1961). In the modified procedure of Schnitzer and Gupta (1965), the sample is allowed to react with an excess of $Ba(OH)_2$. The unreacted $Ba(OH)_2$ could be determined by back titration with standard acid.



Fifty milligrams of HA/FA along with blank was taken in separate stopper flasks and 20 ml of 0.2 N $Ba(OH)_2$ was added. The flasks were shaken for 24 hr at room temperature. The suspension was filtered and the residue was washed with CO_2 free distilled water. The filtrate and washings were titrated against 0.5 N HCl to pH 8.4 potentiometrically. Identical blanks were maintained simultaneously.

$$\begin{aligned} & \text{Total acidity (me g}^{-1}\text{)} \\ &= \frac{(\text{TV for blank} - \text{TV for sample}) \times 0.5N}{\text{Wt. of sample (mg)}} \times 1000 \end{aligned}$$

3. Phenolic

The Phenolic-OH groups were calculated as the difference between total acidity and COOH acidity.

$$\begin{aligned} \text{Phenolic-OH groups (me g}^{-1}\text{)} &= (\text{Total acidity (me g}^{-1}\text{)}) - (\text{COOH acidity (me g}^{-1}\text{)}) \end{aligned}$$

RESULT AND DISCUSSION

Extraction of humic substances from enriched compost.

The humic substances were extracted from various compost, the recovery of humic acid, fulvic acid and humin are presented in Table-8.

The recovery fulvic acid varied from 20.36 to 24.92 % in compost prepared from various crop residues. The significantly highest value of fulvic acid (24.92%) was recorded in compost prepared from 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25 % sorghum stubbles followed by 30% wheat straw + 30% shredded cotton stalk + 20% glyricidia leaves and 20% sorghum stubbles. Significantly lower fulvic acid content (20.36%) was observed in compost prepared from 100% shredded cotton stalk followed by 50% wheat straw + 50 % shredded cotton stalk.

The humic acid varied from 10.09 to 13.45 % in compost prepared from various crop residues. The significantly highest value of humic acid (13.45 %) was recorded in compost prepared from 40% wheat straw + 40% shredded cotton stalk + 20% glyricidia leaves followed by 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25% sorghum stubbles. Significantly lower humic acid content (10.09 %) was observed in 100% shredded cotton stalk followed by 50% wheat straw + 50 % shredded cotton stalk.

The humin varied from 59.12 to 69.55 % in compost prepared from various crop residues. The significantly highest value of humic acid (69.55 %) was observed in compost prepared from 100% shredded cotton stalk

followed by 50% wheat straw + 50% shredded cotton stalk. Significantly lower humin content (59.12 %) was observed in 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25% sorghum stubbles followed by 30% wheat straw + 30% shredded cotton stalk + 20% glyricidia leaves and 20% sorghum stubbles.

The fulvic and humic acid contents obtained from farmyard manure were 0.62 and 0.92% respectively, where in vermicompost 0.86 and 1.26% respectively. Among the manures, humic acid and fulvic acid contents were more in vermicompost than farmyard manure. The data shows that humic acid content was more than fulvic acid content in both the organic manures. Similar results were reported by several workers (Shailaja, 2006; Ramalakshmi, 2011; Kar *et al.*, 2012; Revathi, 2012; Srilatha *et al.*, 2013 and Metwally *et al.*, 2014).

E4/E6 ratio in humic substances

The E4/E6 ratio in humic acid, fulvic acid and humin varied from 2.50 to 3.67, 7.30 to 8.04 and 3.17 to 3.84. Significantly highest value of E4/E6 ratio in humic acid (3.67) of compost prepared from 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25 % sorghum stubbles followed by 30% wheat straw + 30% shredded cotton stalk + 20% glyricidia leaves + 20% sorghum stubbles. Significantly lower E4/E6 ratio in humic acid (2.50) was observed in compost prepared from 100% shredded cotton stalk followed by 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25 % sorghum stubbles.

The significantly highest value of E4/E6 ratio in fulvic acid (8.07) of compost prepared from 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25 % sorghum stubbles followed by 40% wheat straw + 40% shredded cotton stalk + 20% glyricidia leaves. Lower value of E4/E6 ratio in fulvic acid (7.30) was observed in 100% shredded cotton stalk followed by 100% wheat straw.

The ratio of optical densities at 465 nm (E4) and 665 nm (E6) is used for characterization of humic and fulvic acids. The relationship of E4/E6 is related to the aromaticity and to the degree of condensation of the chain of aromatic carbons of humic acids, and could be used as a humification index (Kononova, 1966, Schnitzer and Khan, 1972 and Stevenson, 1982). This ratio, referred to as E4/E6 ratio, is independent of concentration of humic and fulvic acids but varies with humic material extracted from different soil types (Sailaja and Rao, 2000, Pospisilova and Fasurova, 2009 and Tahiri *et al.*, 2016).

Functional group of extracted humic substances

The total acidity in humic acid and humin varied from 8.10

to 9.73 m eq g⁻¹ and 5.08 to 6.18 m eq g⁻¹ respectively. The significantly highest value of total acidity in humic acid i.e. 9.73 m eq g⁻¹ extracted from compost 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25% sorghum stubbles followed by 100% wheat straw. The lower value of total acidity in humic acid (8.10 m eq g⁻¹) was observed in 50% wheat straw + 50% shredded cotton stalk. Significantly highest value of total acidity in humin (6.18 m eq g⁻¹) was recorded in 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25 % sorghum stubbles followed by 50% wheat straw + 50% shredded cotton stalk. Significantly lower total acidity in humin (5.08 m eq g⁻¹) was recorded extracted from compost of 40% wheat straw + 40% shredded cotton stalk + 20% glyricidia leaves.

The carboxylic OH in humic acid and humin varied from 2.90 to 4.10 meq g⁻¹ and 1.90 to 3.90 meq g⁻¹ respectively. The significantly highest value of carboxylic OH in humic acid (4.10 meq g⁻¹) was found in 30% wheat straw + 30% shredded cotton stalk + 20% glyricidia leaves and 20% sorghum stubbles followed by 50% wheat straw + 50% shredded cotton stalk. Significantly lower carboxylic OH in humic acid (2.90 m eq g⁻¹) was observed in 100 % shredded cotton stalk. Significantly highest value of carboxylic OH in Humin (3.90 m eq g⁻¹) was observed in 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves + 25% sorghum stubbles followed 30% wheat straw + 30% shredded cotton stalk + 20% glyricidia leaves and 20% sorghum stubbles. Significantly lower carboxylic OH in humin (1.90 meq g⁻¹) extracted from compost of 50% wheat straw + 50% shredded cotton stalk.

The phenolic OH of humic acid and humin extracted from compost varied from 4.20 to 6.03 meq g⁻¹ and 1.75 to 3.85 meq g⁻¹. The significantly highest value of phenolic OH in humic acid (6.03 meq g⁻¹) extracted from compost of 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves and 25% sorghum stubbles followed by 100% wheat straw. Significantly lower phenolic OH in humic acid (4.20 meq g⁻¹) was observed in 50% wheat straw + 50% shredded cotton stalk. Significantly highest value of phenolic OH in Humin (3.85 meq g⁻¹) was found in 50% wheat straw + 50% shredded cotton stalk. followed 30% wheat straw + 30% shredded cotton stalk + 20% glyricidia leaves and 20% sorghum stubbles. Significantly lower phenolic OH in humin (1.75 meq g⁻¹) was observed in 100% shredded cotton stalk.

High molecular weight humic acids which may also result in high content of carboxyl groups (Lal and Mishra, 2000 and Srilatha *et al.*, 2013). Total acidity and carboxyl group contents were higher in humic acid and fulvic acid extracted from compost than humic acid obtained from

vermicompost. These results are in accordance with the results of Kar *et al.* (2012).

Conclusion

From, the above the study it can be concluded that 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves and 25% sorghum stubbles found beneficial to enriched to compost in term to total N, P, K, S and micronutrient. The recovery of humic substances viz; humic acid, fulvic acid and humin are higher in compost prepared from 40% wheat straw + 40% shredded cotton stalk + 20% glyricidia leaves. The functional group viz; carboxylic OH, phenolic OH and total acidity was improve where humic acid, fulvic acid and humin were preared from 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves and 25% sorghum stubbles. The elemental composition i.e. total nitrogen and sulphur content in humic acid, fulvic acid and humin was improved where compost prepared from 25% wheat straw + 25% shredded cotton stalk + 25% glyricidia leaves and 25% sorghum stubbles.

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Quality and Yield of Greengram (*Vigna radiata* L.) as Influenced by Vermicompost and Zinc Application in Western Arid Zones of India

Anita Todawat¹, S.R. Sharma² and Seema Pooniyan³

^{1&2}Department of Soil Science and Agricultural Chemistry, S.K.N. College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan

³Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

*Corresponding Author Email: annutodawat161616@gmail.com

Abstract

Soil fertility maintenance requires a balanced application of organic and inorganic nutrient sources. Organic sources (vermicompost) of nutrients are the best option maintain the health of soil, plant and animal and provide the equal opportunity for all living existence to live and use from their beneficial activities, like nitrogen fixation, phosphorus solubilization, recycling of animal waste etc. Zinc is one of the most functional micro-nutrients in plants and animals and it play a physiological role in the growth and development. The effect of vermicompost and zinc levels on response study and productivity of greengram (*Vigna radiata* L.) in southern region of Rajasthan. A field experiment was undertaken during *Kharif* 2016 at Agronomy Farm, S. K. N. College of Agriculture, Jobner, Jaipur (Rajasthan). The treatments comprised of four levels of vermicompost (VC) i.e. control, VC @ 2.5, 5.0 and 7.5 t ha⁻¹ and four levels of zinc application i.e. control, 2.0, 4.0 and 6.0 kg Zn ha⁻¹. The experiment was laid out in a factorial randomized block design with three replications. The increasing levels of vermicompost and zinc up to 5.0 t ha⁻¹ and 4.0 kg Zn ha⁻¹, respectively increased significantly (P=0.05) the yield and protein content in seed of greengram. However, the combined application of vermicompost @ 7.5 t ha⁻¹ and 6.0 kg Zn ha⁻¹ was found to record significantly higher grain and straw yield of greengram.

Introduction

India is the world's largest producer and consumer of a wide variety of pulses which is dominated by tropical and sub-tropical crops such as chickpea, black gram, red gram (pigeon pea), green gram (mungbean), and lentil and so on, high in protein, fiber, vitamins and also suppliers of high quality carbohydrates, minerals and vitamins. The carbohydrates provided by pulses are released slowly as compared to cereals and so have a high value for maintaining optimal blood sugar levels and restoring energy over a long period of time after the meals. Pulses in general are one of most sustainable crop utilizing just 359 liter of water to produce one kg of pulses, as compared with 1,802 for soybeans and 3,071 for groundnut. They also contribute to soil quality by fixing nitrogen in the soil. In India, production of pulses is around 25.75 million tons with a very low average productivity of 817 kg ha⁻¹. Currently, total area under pulses is 28.34 million ha (FAI, 2020-21), there is a massive yield gap between India and other developed countries and also within India, between research station yield and farmers' yields. In Rajasthan, greengram occupy 2.46 lakh ha area with a production of 1.22 lakh tonnes. However, productivity (495 kg ha⁻¹) of greengram is low in Rajasthan (FAI, 2020-21). One of the important reasons of low productivity is poor fertility of soil. The problem is compounded by the fact that the majority of the farmers in rainfed areas are resource poor with low risk bearing capacity and they generally do not apply recommended

dose of fertilizers, either through organic or inorganic sources.

The organic manure is an eco-friendly, economically viable and ecologically sound that also played a significant role in soil biology, chemistry and physics. It is interesting that each year, human, livestock and crops produce approximately 38 billion metric tons of organic waste worldwide, which may be an efficient source of organic matter supply in soils. According to a conservative estimation, around 600 to 700 million tones of agricultural waste (including 272 million tonnes of crop residues) are available in India every year, but most of it remains unutilized. This huge quantity of wastes can be converted into nutrient rich vermicompost for sustainable land restoration practices (Suthar, 2008b). In general, a great proportion of the crop nutrient input during cultivation returned in the form of the plant residues. Estimation showed that 30-35 % of applied N & P and 70-80 % for K remained in the crop residues of food crops. The earthworm-processed organic wastes, often referred to as vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, and water holding capacity (Edwards and Burrows, 1988). The vermicomposting is biooxidation and stabilization of organic material involving the joint action of earthworms and microorganisms. Although, microbes are responsible for the biochemical degradation of the organic matter, earthworms are the important drivers of the process, conditioning the substrate and altering biological activity

Table-1 : Effect of vermicompost and zinc on protein content in grain of greengram.

Treatments	Protein content (%)
Vermicompost levels (t ha ⁻¹)	
Control (VC ₀)	20.51
2.5 (VC _{2.5})	22.56
5.0 (VC _{5.0})	24.65
7.5 (VC _{7.5})	25.03
S.Em+	0.16
CD (P=0.05)	0.47
Zinc levels (kg ha ⁻¹)	
Control (Zn ₀)	20.89
2 (Zn ₂)	22.40
4 (Zn ₄)	24.13
6 (Zn ₆)	25.34
S.Em+	0.16
CD (P=0.05)	0.47

(Suthar, 2008c). The studies have revealed that vermicompost may be potential sources of nutrients for field crops if applied in suitable ratios with synthetic fertilizers. Also, vermicompost may contain some plant growth-stimulating substances. The plant-hormone-like is extensively reported in worm-processed materials possibly due to higher microbial populations (Mascolo *et al.*, 1999).

Micronutrients are essential for crop production and their deficiency affects growth and metabolism especially during reproductive phase of the plant and also in animals and human beings. Shukla *et al.* (2021) reported that 36.5, 23.2, 13, 12.8, 7.1 and 4.2% soils of India are deficient in zinc, boron, molybdenum, iron, manganese and copper, respectively. Zinc is considered the most important micronutrient for normal and healthy plant growth (Tahir *et al.*, 2018). It is a structural component or cofactor of various enzymes involved in many biochemical processes. In plants, it is involved in photosynthesis, carbohydrate metabolism, protein metabolism, pollen formation, auxin metabolism, maintenance of membrane integrity, and induction of tolerance against various stresses (Alloway, 2008). The total concentration of Zn in soil ranges from 10 to 300 mg Zn kg⁻¹ soil, and the average is 55 mg Zn kg⁻¹ soil. Therefore, a very small amount of Zn is normally available for plant uptake.

Zinc is one of the vital elements involved in metabolic and enzymatic functions of plants, animals and human beings (Hotz and Brown, 2004). It is involved in protein synthesis and carbohydrates metabolism. It plays a significant role in maintaining the integrity of cellular membrane and also involved in expression of genes and tolerance against stress (Broadley *et al.*, 2007). Insufficiency of micronutrients becomes a common issue

for low nutritional quality & little energy consumption in most parts of the globe (Stewart *et al.*, 2010) and approximately 20% children casualties under age of 5 might be due to low intake of vitamin A and deficiency of zinc, iron or iodine (Prentice *et al.*, 2008). Population of developing countries is facing deficiency of zinc because more than 80% consume foods which are low in Zn nutrition (Bouis *et al.*, 2011). Different soil factors are responsible for zinc deficiency in plants and humans; high soil pH, less OM, low soil Zn contents, salinity and sodicity, high bulk density and calcareousness (Singh *et al.*, 2005) and environmental problems including arid, semiarid (Cakmak *et al.*, 2010) and different weather modifications over the globe (Lopez-Millan *et al.*, 1980).

Materials and Methods

Experimental site and soil: The experiment was conducted during *Kharif* 2016 at the Agronomy Farm, S. K. N. College of Agriculture, Jobner, Jaipur situated at an altitude of 427 metres above mean sea level and at 26°05' latitude and 75°28' longitude. The region falls under agro-climatic zone-IIIa (Semi Arid Eastern Plain) of Rajasthan. Soil of the experiment was loamy sand in texture, saline in reaction (8.10±0.11), normal in electrical conductivity (0.90±0.02 dSm⁻¹), medium in organic carbon (0.18±0.01%), low in available N (136.60±4.45 kg ha⁻¹), P (17.50±0.30 kg ha⁻¹), medium in available K (149.50±4.10 kg ha⁻¹) and low in available zinc (0.430±0.010 mg kg⁻¹).

Experimental design and treatments: The experiment was laid out in factorial randomized block and replicated thrice in the plot size of 4.0 m x 3.0 m (12 m²). The treatments comprised of four levels of vermicompost viz., control, 2.0, 5.0 and 7.5 t ha⁻¹ and four levels of zinc application viz., control, 2.0, 4.0 and 6.0 Zn ha⁻¹. The greengram var. SML-668 was sown in lines 30 cm apart. As per the treatments, whole quantity of VC was broadcasted and incorporated in to the soil at the time of sowing. There commended dose of nitrogen (20 kg ha⁻¹) was applied in two equal splits, the half as basal and the remaining half was top dressed at the time of first irrigation. The basal dose was applied through urea after adjusting the quantity supplied through diammonium phosphate. The whole quantity of phosphorus (30 kg ha⁻¹) through diammonium phosphate and potassium (10 kg ha⁻¹) through muriate of potash and zinc through ZnSO₄.7H₂O was drilled as basal dose at 8-10 cm depth along with half dose of nitrogen prior to sowing.

Observations recorded: The observations on yield character were recorded as per the standard method. The clean grain obtained from individual plots was weighed and the weight recorded as grain yield in terms of kg ha⁻¹. The data obtained from various characters under study

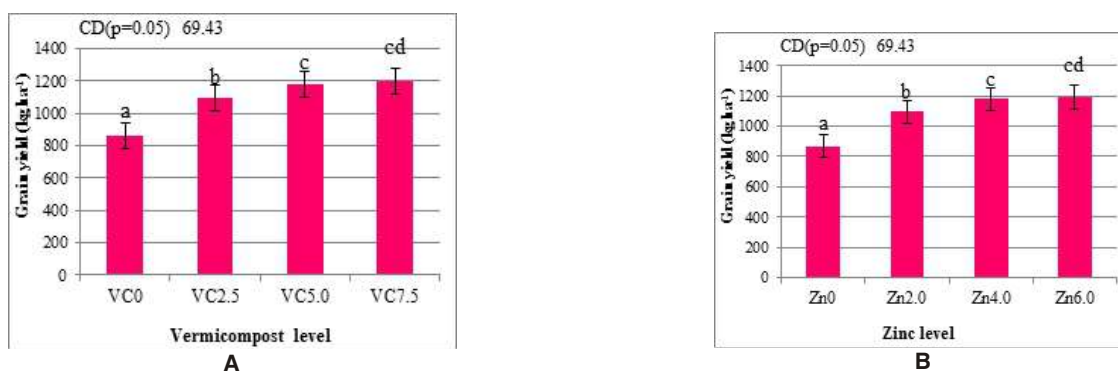


Figure-1 : Effect of (A) VC and (B) zinc application on grain yield of greengram

*Error bars indicates the standard error of mean

**Columns marked with same letters are statistically similar at $p=0.05$

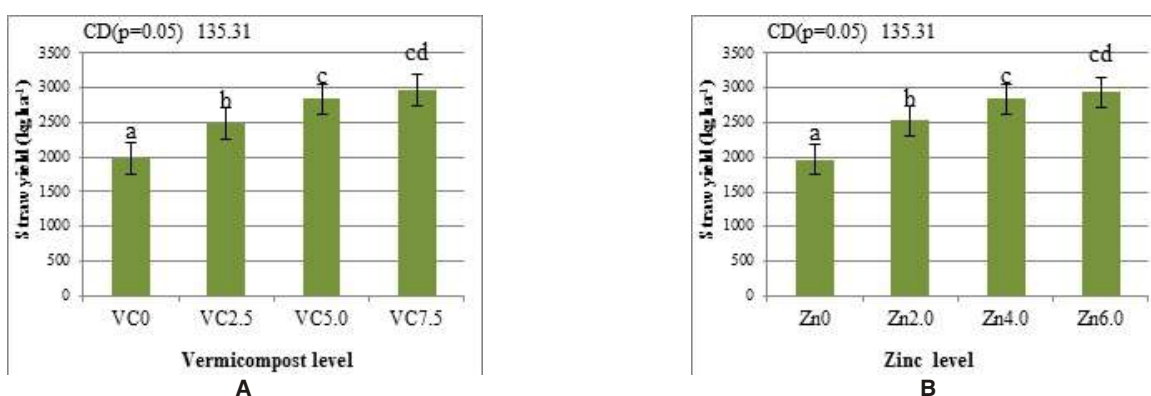


Figure-2 : Effect of (A) VC and (B) zinc application on straw yield of greengram

*Error bars indicates the standard error of mean

**Columns marked with same letters are statistically similar at $p=0.05$

were analyzed by the method of analysis of variance as described by Panse and Sukhatme (1985).

Protein content: The protein content in grain was obtained by multiplying the per cent nitrogen content by 6.25 (A.O.A.C., 1960).

Statistical analysis: The data recorded for different parameters were analyzed with the help of analysis of variance (ANOVA) technique for a factorial randomized block design. The results are presented at 5% level of significance ($P=0.05$).

Results and Discussion

Protein content

Effect of vermicompost

The increasing levels of vermicompost significantly increased the protein content in greengram grain (Table 1). The significantly maximum protein content of grain (25.03 per cent) was observed under the treatment VC_{7.5} (vermicompost @ 7.5 t ha⁻¹) and the minimum (20.51 per cent) under control (VC₀). However, the increase was significant upto VC_{5.0} which was also found to be

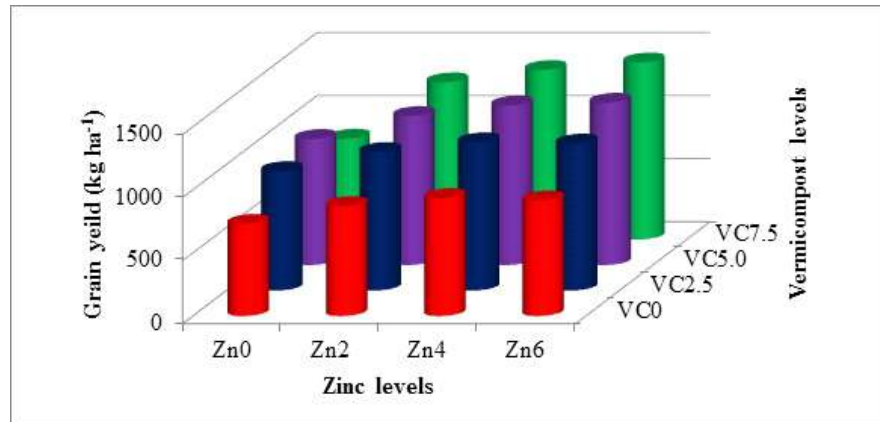
statistically at par with VC_{7.5}. The application of vermicompost @ 2.5, 5.0 and 7.5 t ha⁻¹ increased the protein content of grain to the extent of 9.99, 20.18 and 22.03 per cent, respectively as compared to control (VC₀). The significant increase in protein content in grain on application of vermicompost seems to be due to increased availability of nitrogen to the plant from vermicompost resulting in increased nitrogen content in plant which has significant role in synthesis of protein in grain. The results obtained in the present investigation are in close conformity with those of Jat *et al.* (2013) and Meena *et al.* (2021).

Effect of zinc

The application of zinc significantly increased the protein content of grain as compared to control. The significantly maximum protein content of grain (25.34 per cent) was observed under the treatment Zn₆ (zinc @ 6 kg ha⁻¹) and the minimum (20.89 per cent) under control (Zn₀). The application of Zn₂, Zn₄ and Zn₆ increased the protein content in grain to the extent of 7.22, 15.50 and 21.30 per cent, respectively as compared to control (Zn₀) (Table-1). The increased content of protein in grain due to

Table-2 : Interactive effect of vermicompost and zinc on grain yield (kg ha⁻¹) of greengram.

Treatments	VC ₀	VC _{2.5}	VC _{5.0}	VC _{7.5}
Zn ₀	729.20	946.22	998.43	798.45
Zn ₂	870.30	1096.70	1180.30	1244.81
Zn ₄	934.04	1173.67	1264.02	1342.95
Zn ₆	915.18	1164.46	1285.92	1402.85
S.Em±		48.079		
CD (P=0.05)		138.86		

**Figure-3 : Interactive effect of vermicompost and zinc on grain yield (kg ha⁻¹) of greengram.**

application of zinc might be due to role of zinc as a metal activator and is an essential component of enzymes such as proteinase and peptidase which are responsible for assimilation of nitrogen in the form of amino acids and protein. It also helps in chlorophyll formation and plays an important role in nitrogen metabolism. These findings are in agreement with those of Jat *et al.* (2012) and Jat *et al.* (2013).

Yield

Effect of vermicompost

The application of vermicompost enhanced the grain and straw yield of greengram. The significant increase in grain and straw yield under the influence of vermicompost was largely a function of improved growth and yield attributes (Figure 1). The application of vermicompost @ 7.5 t ha⁻¹ recorded the maximum value of these parameters. However, the increase was significant upto VC₂ which was also found to be statistically at par with VC₃. The significant increase in grain and straw yield under the influence of vermicompost was largely a function of improved growth and yield attributes which eventually contributed in increased grain and straw yield. The increase in yield due to addition of vermicompost might be the result of overall improvement in soil physico-chemical properties of soil due to decrease in bulk density, pH, electrical conductivity and increase in particle density, porosity, water holding capacity and cation exchange capacity (Biswas, 2011). The beneficial response of

vermicompost to yield attributes and yield might also be attributed to the availability of sufficient amounts of plant nutrients throughout the growth period and especially at critical growth periods of crops resulting in better uptake, plant vigour and superior yield attributes. The higher availability of nutrients in soil due to vermicompost application during seed development might have retarded senescence and resulted in large filling period for greater seed, stover and biological yield (Biswas and Narayansamy, 2006). The gradual release and steady supply of nutrients from vermicompost throughout the growth and development of plants maintained the photosynthetic efficiency and production of metabolites at higher level and later on the translocation of photosynthates to various sinks resulting into higher yield attributes, grain and straw yield (Patil *et al.*, 2011). The interrelationship between various yields attributes of the crop and its grain and straw and biological yield had also been observed by Biswas (2011) and Meena *et al.* (2021).

Effect of zinc

The grain and straw yield were also significantly increased by the application of zinc (Figure 2). However, the increase was significant upto Zn₂ which was also found to be statistically at par with Zn₃. The favourable influence of applied zinc on grain and straw yield may be due to catalytic or stimulatory effect of zinc on most of the physiological and metabolic processes of plants. The increase in grain and straw yield with zinc fertilizer application might be due to the fact that zinc plays an

important role in biosynthesis of indole acetic acid and initiation of primordial for reproductive part which have favored the metabolic reaction within plant (Tak *et al.*, 2014). The increase in the yield due to zinc application may be attributed to the fact that the initial status of available zinc in the experimental soil was low. The increase in yield attributes may be due to increased supply of available zinc to plants by way of its addition to soil which resulted in proper growth and development. The significant increase in straw yield due to zinc fertilization could be attributed to the increased plant growth and biomass production, possibly as a result of the uptake of nutrients (Mahilane and Singh, 2018). Datta and Dhiman (2001) reported that increase in seed and stover yield may be due to the fact that the zinc exerts a great influence on basic plant life processes such as nitrogen metabolism uptake of N and protein quality.

Interaction effect of vermicompost and zinc application on grain yield

The interactive effect of vermicompost and zinc on grain yield was found significant; however, it was non-significant in case of straw yield (Table 2 and Figure 3). The grain yield increased with increasing levels of zinc under all the levels of vermicompost except VC_{7.5} over VC_{5.0} under Zn₄ and Zn₆ levels of zinc. The highest value of grain yield was obtained under VC_{7.5}Zn₆ (1402.85 kg ha⁻¹) and the lowest under VC₀Zn₀ (729.20 kg ha⁻¹) treatment combination might have resulted in improved nutritional environment of rhizosphere as well as physico-chemical properties of soil thereby improving the efficiency of utilization of native as well as applied nutrients (Chitdeshwari and Krishnaswami, 1998). The increase in seed yield and stover yield might be due to the fact that vermicompost and zinc had an additive effect. Since the experimental soil was deficient in nutrients especially Zn the supplementation of Zn with VC incorporation improved the availability of both nutrients as well as water by increased water and nutrient retention in the root zone by reducing infiltration and percolation. The applied vermicompost and zinc might have reacted synergistically in increasing the availability and steady supply of plant nutrients for plant metabolism and photosynthetic activity resulting into optimum growth and development which increased ultimately the grain and straw yield of blackgram substantially (Meena, 2021). These findings are in agreement with those of Jat *et al.* (2015) on mustard.

Conclusion

On the basis of experimental finding, it can be concluded that the application of vermicompost @ 5.0 t and 4.0 kg Zn ha⁻¹ along with the recommended dose of fertilizer results in significantly higher productivity and quality of

greengram under Typic Ustipsamment soil of Semi Arid Eastern Plain Region of Rajasthan.

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Effect of Organic and Inorganic Nutrient Sources on Growth and Quality of Maize (*Zea mays* L.)

Abhimanyu Yadav and Awadhesh Kumar Singh

Department of Agricultural Chemistry and Soil Science, P.G. College, Ghazipur (U.P.)

Corresponding Author Email : abhimanyuyadav1049@gmail.com

Abstract

A field experiment was conducted to study the effect of organic and inorganic nutrient sources on growth and quality of maize during two consecutive *kharif* seasons of years 2019 and 2020, respectively. The experiment was laid out in randomized block design (RBD) assigning eight treatments of organic and inorganic nutrient sources comprising of (T₁) RDF (120:60:40 kg N:P₂O₅:K₂O ha⁻¹), (T₂) RDF + Zn, (T₃) RDF + S, (T₄) RDF + Zn + S, (T₅) RDF + VC (5 t ha⁻¹), (T₆) RDF + VC (10 t ha⁻¹), (T₇) RDF + VC (10 t ha⁻¹) and (T₈) RDF + FYM (10 t ha⁻¹) and were replicated thrice. The results reported that the higher plant height, number of leaves plant⁻¹, protein content (%) and protein yield (kg ha⁻¹) of maize were recorded under application of RDF + FYM (10 t ha⁻¹) which was statistically at par with RDF + FYM (10 t ha⁻¹) during both the year.

Key words : Protein content, leaves, sulphur, inorganic, zinc and maize.

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crop plays a pivotal role in agriculture economy both as food for man and feed for animals. It has tremendous genetic variability, which enables it to thrive in tropical, subtropical and temperate climates. There is no any cereal on the earth, which has so immense potentially as to maize and also gives high biological yield as well as grain yield in a short period due to its unique photosynthesis mechanism owing to C₄ mechanism and hence, occupied a place as “Queen of cereals”. It occupies an important place as a source of human food (25%), animal feed (12%), poultry feed (49%), starch (12%) and 1% each in brewery and seed.

Maize protein is called “Zein” and the grains content significant amount of vitamin A, nicotinic acid, riboflavin and vitamin E. Maize utilized in many ways like other grain crops. Green cobs are roasted and eaten by people with great interest. Several food dishes including *chapaties* are prepared out of maize flours and grains. It is also a good feed for poultry, piggery and other animals. It supplies raw materials to thousand of industries manufacturing starch, oil, protein, alcohol, acetic acid, glucose, synthetic rubber, dyes, resin, cosmetic, textile gum, paper industry *etc.* Maize is also important not only because of its great adaptability to widely divergent conditions, but also because of its high responsiveness to better management practices (Mehta *et al.*, 2005).

Sustainable crop production system can be achieved through replenishing nutrients removed by the crop from the soil and maintaining physical conditions of the soil (Gruhn *et al.*, 2000). Thus, adoption of

appropriate soil fertility and nutrient management practices may help farmers to enhance crop production and conserve natural resources and this can be accomplished through application of mineral and organic fertilizers (FAO, 2004).

Mineral fertilizers have been important input to get higher crop productivity. However, over reliance on mineral fertilizers is related with decline in some important soil properties and crop yields over time (Beyza, 2014). On the other hand, use of organic fertilizers regularly lead to increased soil organic matter, water holding capacity, improved soil structure, and nutrient cycling and helps to keep soil nutrient status, cation exchange capacity and soil's biological activity. Therefore, combined use of mineral and organic fertilizers is a viable approach for efficient nutrient usage which improves efficiency of the mineral fertilizers while reducing nutrient losses (Achieng *et al.*, 2010).

However, information regarding organic and inorganic nutrient sources in maize production in Uttar Pradesh is lacking. Keeping in view the above discussed facts of sufficient information and sparse related research, the present investigation was undertaken to find out the effect of organic and inorganic nutrient sources in maize under Ghazipur conditions.

Materials and Methods

The experiment was conducted during two consecutive *kharif* seasons of years 2019 and 2020, respectively at Farmers field of Village Tulsipur, Post- Bikrampur, Ghazipur, Uttar Pradesh, situated at latitude of 25° 36' North and longitude of 83° 09' East. The total rainfall of 780.1 and 1140.3 mm were received during crop growing

Table-1 : Plant height (cm) influenced by different organic and inorganic nutrient sources at different intervals of maize crop.

Treatments		Plant height (cm)							
		30 DAS		60 DAS		90 DAS		At harvest	
		2019	2020	2019	2020	2019	2020	2019	2020
T ₁	RDF (120:60:40)	30.33	32.88	98.64	102.87	154.74	156.21	153.54	155.16
T ₂	RDF + Zn	31.42	33.48	99.43	103.97	158.73	161.02	157.34	160.55
T ₃	RDF + S	31.91	34.12	100.43	103.74	160.83	163.21	159.35	162.35
T ₄	RDF + Zn + S	32.02	34.25	101.14	104.97	162.33	164.51	161.24	163.14
T ₅	RDF + VC (5 t ha ⁻¹)	32.42	36.74	105.81	108.18	164.21	166.34	163.32	165.54
T ₆	RDF + VC (10 t ha ⁻¹)	34.03	36.79	112.61	115.55	175.73	178.54	174.35	177.35
T ₇	RDF + FYM (5 t ha ⁻¹)	32.24	34.54	104.91	107.91	163.85	166.52	162.74	165.74
T ₈	RDF + FYM (10 t ha ⁻¹)	32.90	35.02	109.05	113.41	170.51	172.54	169.95	171.19
	SEm±	1.25	1.31	2.16	2.37	3.48	3.67	3.11	3.34
	CD at 5%	NS	NS	6.50	7.12	10.57	11.02	9.34	10.08

Table-2 : Number of leaves plant⁻¹ influenced by different organic and inorganic nutrient sources at different intervals of maize crop.

Treatments		Number of leaves plant ⁻¹							
		30 DAS		60 DAS		90 DAS		At harvest	
		2019	2020	2019	2020	2019	2020	2019	2020
T ₁	RDF (120:60:40)	4.10	5.21	7.41	8.59	8.19	9.26	7.86	8.99
T ₂	RDF + Zn	4.14	5.26	7.67	8.91	9.56	10.67	8.54	10.12
T ₃	RDF + S	4.25	5.37	7.89	8.99	9.87	10.88	8.87	10.34
T ₄	RDF + Zn + S	4.30	5.51	8.09	9.21	10.11	11.24	9.01	10.69
T ₅	RDF + VC (5 t ha ⁻¹)	4.73	5.67	8.30	9.41	10.42	11.37	9.45	11.26
T ₆	RDF + VC (10 t ha ⁻¹)	4.66	5.78	9.27	10.42	11.56	12.88	10.41	12.29
T ₇	RDF + FYM (5 t ha ⁻¹)	4.43	5.56	8.19	9.33	10.23	11.34	9.18	10.99
T ₈	RDF + FYM (10 t ha ⁻¹)	4.54	5.87	8.99	10.24	10.95	12.58	10.02	12.01
	SEm±	0.23	0.26	0.27	0.30	0.34	0.38	0.31	0.32
	CD at 5%	NS	NS	0.84	0.91	1.02	1.14	0.94	0.98

season of year, 2019 and 2020, respectively. Soil of the experiment field had sandy loam in texture, slightly alkaline in reaction, low in electrical conductivity, low in organic carbon, available nitrogen and medium in available phosphorus and potassium.

The experiment was laid out in randomized block design (RBD) assigning eight treatments of organic and inorganic nutrient sources comprising of (T₁) RDF (120:60:40 kg N:P₂O₅:K₂O ha⁻¹), (T₂) RDF + Zn, (T₃) RDF + S, (T₄) RDF + Zn + S, (T₅) RDF + VC (5 t ha⁻¹), (T₆) RDF + VC (10 t ha⁻¹), (T₇) RDF + VC (10 t ha⁻¹) and (T₈) RDF + FYM (10 t ha⁻¹) and were replicated thrice. The soil of the experimental field was sandy clay loam in texture having slightly alkaline in reaction (pH 7.21 and 7.20), low in organic carbon (0.36 & 0.37%) and available nitrogen (174.96 and 185.29 kg ha⁻¹), but medium in available phosphorus (20.13 and 20.69 kg ha⁻¹) and potassium (192.06 and 216.98 kg ha⁻¹) during first and second year, respectively. Sulphur and zinc nutrition (Each 25 kg ha⁻¹) through elemental sulphur and chelated zinc, respectively were applied as basal dose during both the experimental years. Nitrogen was applied 50% as basal and remaining in two equal splits. Maize variety "Azad Kamal" were used

for the investigations. Growth characters of maize recorded as standard procedure. However protein content of maize analyse as per method suggested by AOAC (1990). The data relating to each character were analyzed as per the procedure of analysis of variance and significance was tested by "F" test (Gomez and Gomez 1984).

Results and Discussion

Growth characters : Data on periodic plant height recorded at 30, 60, 90 days after sowing (DAS) and lastly at harvest are presented in Table-1. Perusal of the data showed that plant height continued to increase with the advancement of crop age and this increase was rapid during early crop growth period and thereafter, a slow rate of increase in plant height was observed at 90 DAS to harvest. In general, higher plant height at all the growth stages were recorded during the second year as compared to first year. Marked variations in plant height were recorded due to different organic and inorganic nutrient sources at all the growth stages except at 30 DAS during both the years. At 30 DAS, different sources of nutrients failed to show any significant effect on plant height of maize during both the experimental years.

Table-3 : Grain protein content and protein yield influenced by different organic and inorganic nutrient sources at harvest of maize crop.

Treatments		Qualitative characters			
		Grain protein content (%)		Protein yield (kg ha ⁻¹)	
		2019	2020	2019	2020
T ₁	RDF (120:60:40)	9.39	9.43	237.19	244.90
T ₂	RDF + Zn	9.51	9.53	261.05	267.03
T ₃	RDF + S	9.73	9.74	282.27	288.99
T ₄	RDF + Zn + S	10.36	10.38	312.25	320.64
T ₅	RDF + VC (5 t ha ⁻¹)	11.40	11.43	366.17	376.28
T ₆	RDF + VC (10 t ha ⁻¹)	11.99	12.02	444.11	459.04
T ₇	RDF + FYM (5 t ha ⁻¹)	11.38	11.41	354.03	368.20
T ₈	RDF + FYM (10 t ha ⁻¹)	11.73	11.76	420.05	436.18
	SEm±	0.34	0.35	12.68	13.42
	CD at 5%	1.06	1.08	38.12	40.29

However, at 60 DAS application of RDF + VC (10 t ha⁻¹) recorded significantly higher plant height (112.61 and 115.55 cm) which was statistically at par with application of RDF + FYM (10 t ha⁻¹) during both the years of investigations. Similar trend was observed at 90 DAS and at harvest stage during both the years of study.

Number of leaves plant⁻¹ were recorded periodically at 30, 60, 90 DAS and at harvest (Table-2) and data revealed that leaves showed increasing trend up to 90 DAS and conspicuous decrement recorded thereafter at harvest stage during both the experimental years. Among the different organic and inorganic nutrient sources at 60 DAS, application of RDF + VC (10 t ha⁻¹) recorded significantly higher number of leaves plant⁻¹ (9.27 and 10.42) which was statistically at par with application of RDF + FYM (10 t ha⁻¹) during both the years of investigations. However, least number of leaves plant⁻¹ (7.41 and 8.59) was observed with application of RDF (120:60:40 N:P₂O₅:K₂O ha⁻¹). Similar trend was observed at 90 DAS and at harvest stage during both the years of study. However at 30 DAS, different nutrient sources could not reach the level of significance during both the years.

The significant effects of these parameters a consequence of vermicompost and chemical fertilization is attributed to the favourable nutritional status of soil resulting into increased plant height and number of leaves plant⁻¹ of the maize. This may also be attributed to favourable effect of vermicompost and farm yard manure on microbial activity and root proliferation in soil which caused solubilizing effect on native phosphorus and other nutrients. However, as fertilizer dose increased the beneficial effects decreases because due to excessive use of fertilizers exploitation nutrients particularly micronutrients. The higher values of growth characters in this treatment might be due to improved nutritional status of rhizosphere, particularly N, enabling plant to absorb

more nutrients which is further increased due to improvement in soil physical conditions as a result of added organic amendment in the form of vermicompost and farm yard manure. The results of combined use of fertilizers and FYM are in close agreement with the findings of Panwar (2008); Dadarwal *et al.* (2009); Singh *et al.* (2009); Kumar and Dhar (2010) and Dilshad *et al.* (2010).

Protein content (%) and protein yield (kg ha⁻¹) : The data on grain protein content is presented in Table-3 revealed that the protein content was significantly influenced by different organic and inorganic nutrient sources during both the years. Maximum protein content (11.99 and 12.02%) in maize was found with application of RDF + VC (10 t ha⁻¹) which was statistically at par with RDF + FYM (10 t ha⁻¹), RDF + VC (5 t ha⁻¹) and RDF + FYM (5 t ha⁻¹) during both the years. However, least protein content was noted under application of RDF (120:60:40 N:P₂O₅:K₂O ha⁻¹) in test crop. Higher (444.11 and 459.04 kg ha⁻¹) protein yield of maize grain was recorded with application of RDF + VC (10 t ha⁻¹) which was statistically at par with RDF + FYM (10 t ha⁻¹) but both were significantly superior over rest of the treatments during both the experimental years. The results of the present study that combined use of organic manure and chemical fertilizer has been found to be providing higher protein content and protein yield with those reported by Ramesh *et al.* (2008); Dadarwal *et al.* (2009); Paradkar *et al.* (2010); Sharma and Banik (2012); Kannan *et al.* (2013).

Conclusions

From the above overall study, it is recommended that to obtain higher vegetative growth and protein yield of maize should be grown by combined application of RDF + VC (10 t ha⁻¹) under agro-climatic conditions of Ghazipur region under Eastern Uttar Pradesh.

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Groundwater Quality Assessment for Irrigation Purposes Based on Chemical Properties in the Villages of the Bap Tehsil of Jodhpur, Rajasthan

Asha Serawat¹, Ranjeet Singh¹, Minakshi Serawat^{2*}, Anil Kapoor³, Kamlesh Choudhary¹ and Basta Ram²

¹Department of Soil Science and Agriculture Chemistry, SKRAU, Bikaner-334006, Rajasthan, India

²Department of Soil Science, GBPUAT, Pantnagar-263145, Uttarakhand, India

³Department of Agronomy, GBPUAT, Pantnagar-263145, Uttarakhand, India

*Corresponding Author Email : sherawatminakshi591@gmail.com

Abstract

In present study, the quality of groundwater for irrigation in Bap tehsil of Jodhpur district, Rajasthan was examined. Bap tehsil bounded by Bikaner district to the north and east, Jaisalmer district to the west and northwest, Phalodi tehsil of Jodhpur district to the south. Georeferenced sixteen water samples of tube well/open well were collected from different villages where the waters are being used for irrigation for last few years. The water samples were analyzed for various chemical properties like EC, pH, major cations: Na⁺, Ca⁺⁺, Mg⁺⁺, K⁺ and anions: CO₃⁺⁺, HCO₃⁻, Cl⁻ and SO₄⁻. Subsequently, Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), Adjusted SAR was also calculated. The quality of irrigation water was categorized on the basis of Salinity (EC), Sodicity (SAR) and Alkalinity (RSC) into 2 salinity (C-2 and C-4) classes, 3 sodicity (S-1 to S-3) classes and 4 alkalinity (A-1, A-3, A-4 and A-5) classes, respectively. Besides this, the quality of irrigation water was also categorized on the basis of the EC, SAR and RSC into four classes viz. Good, High SAR saline, Marginally alkali and Highly alkali. The results showed that 6.25 per cent water samples were good, 56.25 per cent water samples were high SAR saline, 18.75 per cent water samples were marginally alkali and 18.75 per cent water samples were Highly alkali in nature and it is found that most of the irrigation water came under high SAR saline category.

Key words : Groundwater, RSC, SAR, salinity, sodicity.

Introduction

Water is the basic and essential natural resource, needed to ensure food security in sustainable manner. Sustainable development and efficient management of water is an increasingly complex challenge in India. Increasing population, growing urbanization and rapid industrialization combined with the need for raising agricultural production generates competing claims for water. Groundwater has an important role in meeting the water requirements of agriculture, industrial and domestic sectors in India. About 85 per cent of India's rural domestic water requirement, 50 per cent of its urban water requirement and more than 50 per cent of its irrigation requirements are being met from groundwater resources. It has become the main source of growth in irrigated area over the past three decades and now it accounts for over 60 per cent of the irrigated area in the country. It is estimated that over 70 per cent of India's food grain production comes from irrigated agriculture, in which groundwater plays a major role (Gandhi and Namboodiri, 2009).

The ground water available for irrigation is estimated to be 36.42 million hectare-meters. Out of this, the utilizable ground water resources for irrigation are 32.77 million hectare meters or 90 per cent. Over the last two

decades, 84 per cent of the total addition to net irrigated area came from groundwater, only 16 per cent from canals (Briscoe and Malik, 2006). Indiscriminate use of poor quality water for irrigating agricultural crops decreases the productivity because of development of salinity, sodicity and toxic effects on crop plants. The saline water negatively affects soil chemical and biological properties whereas sodic water adversely impact soil physical, chemical and biological properties, making it difficult for plant growth and ultimately reduces crop yield (Emdad *et al.*, 2006).

In India, 6.73 Mha of land is affected by salinity and sodicity (Singh *et al.*, 2009). About 10 Mha of land is lost because of salinity caused by irrigation water each year. Out of total cultivated cropped area in Rajasthan, 1.183 Mha of land is salt affected (AICRP, 2010). Although groundwater is widely distributed and renewable resources of the earth but the quality of this is not assured. Excessive pumping, low recharge, wrong agricultural practices have led to the situation of shrinkage groundwater and groundwater becoming brackish (Venu and Rishi, 2010). Therefore, an appraisal on the nature, properties and quality of irrigation water is essential for sound irrigation so as to assess any possibility of development of secondary salinization/sodification in this region.

Materials and Methods

The Bap tehsil is situated in north part of Jodhpur district between latitudes of 27°10'584" and 27°20'738" N and longitudes of 71°53'715" and 72°29'740" E. The field survey was conducted to study the groundwater quality in respect of ionic composition and chemical characteristics of the Bap tehsil of Jodhpur District of Rajasthan. The area studied lied in the agro-climatic zone ²A (Arid North-Western Sandy Plain) and IIB (Alluvial Plain of Luni Basin). Geo-referenced 16 water samples were collected from Bap tehsil of Jodhpur district during March 2019. In order to get representative samples; pump was kept in operation before collecting the sample. Collected samples were stored in cleaned, rinsed and properly label bottles. Before the bottles were corked, few drops of toluene were also added to check the microbial growth. The position of sampling points was recorded by GPS at each location. The water samples were analysed for various chemical properties like EC, pH, major cations: Na⁺, Ca⁺⁺, Mg⁺⁺, K⁺ and anions: CO₃⁻, HCO₃⁻, Cl⁻ and SO₄⁻ by the procedure outlined in USDA Handbook No. 60 (Richards, 1954). Residual sodium carbonate (RSC), sodium absorption ratio (SAR), adjusted SAR, soluble sodium percentage (SSP) and pH_c were calculated as described the following formulas :

$$\text{Sodium adosprtion ratio (SAR)} = \frac{\text{Na}}{\sqrt{\frac{\text{Ca}^{+2} + \text{Mg}^{+2}}{2}}}$$

$$\text{Adj. SAR} = \frac{\text{Na}}{\sqrt{\frac{\text{Ca}^{+2} + \text{Mg}^{+2}}{2}}} - 1 \quad (8.4 \text{ pH}_t)$$

Soluble sodium percentage (SSP)

$$= \frac{\text{Na}^+}{\text{Ca}^{+2} + \text{Mg}^{+2} + \text{K}^+} \times 100$$

$$\text{RSC (me L}^{-1}\text{)} = (\text{CO}_3^{-} + \text{HCO}_3^{-}) - (\text{Ca}^{++} + \text{Mg}^{++})$$

Results and Discussion

The results showing the various chemical properties of ground water of Bap tehsil of Rajasthan are presented in Table-1. The pH value of irrigation water varied from 7.52 to 8.33 with an average value of 7.84. The minimum (7.52) and maximum (8.33) pH value were recorded in Sev₂ and Sev₁ ground water sample, respectively. Divekar *et al.* (2005) also observed that the higher concentration of bicarbonate in water samples responsible for the development of alkalinity and thereby the higher pH values. Similar result was also reported by Kumar *et al.* (2016), More *et al.* (2017), Selvakumar *et al.* (2017) and Dhaker *et al.* (2020).

The electrical conductivity of water varied from 0.56 to 9.77 dS m⁻¹ with the mean values of 14.66 dS m⁻¹. The minimum (0.56 dS m⁻¹) value observed in Sev₁ water sample while, the maximum value (9.77 dS m⁻¹) was recorded in Cha water sample. As per classification of irrigation water given by Gupta (1986) based on electrical conductivity, most of the water samples show low to medium EC. This is mainly due to the presence of neutral salts of chloride and sulphate in ground water samples. Similar result was also reported by Rajput and Polara (2013), Chopra *et al.* (2014), Kumar *et al.* (2017) and Dhaker *et al.* (2020).

The RSC values varied from 0 to 6.01 me L⁻¹ with the mean value of 3.37 me L⁻¹. The maximum (6.01 me L⁻¹) value was observed in Bap₁ irrigation water sample and minimum value (0 me L⁻¹) was observed in various irrigation water samples (7 samples). The most of the samples of ground irrigation water show less than 1.25 RSC. Similar results also reported by Singh *et al.* (2006), Ashraf *et al.* (2013), Kumar *et al.* (2017) and Dhaker *et al.* (2020).

Sodium absorption ratio of irrigation water varied from 4.32 to 22.03 with the mean value of 14.66. The maximum value (22.03) was found in Bap₁ water sample while minimum value (4.32) was found in Sev₁ water sample. Increased in SAR values of irrigation waters with the increase in pH and EC of irrigation water might be due to dominance of soluble Na⁺ over Ca⁺⁺, Mg⁺⁺. Similar results were also obtained by Khan and Sharma (2007), Kumar *et al.* (2017), More *et al.* (2017) and Dhaker *et al.* (2020).

Soluble sodium percentage varied from 52.65 to 84.88 with mean value of 72.74. The minimum (52.65) and maximum (84.88) soluble sodium percentage values were found in Cha and Bamp irrigation water sample, respectively. Due to continuous use of irrigation waters having higher concentration of chloride and sulphate salts might have resulted in increased salinity (EC) of irrigated fields. This results in accordance with the findings of Gupta (1979) and Bali *et al.* (2015).

The pH_c value of irrigation water varied from 5.80 to 7.90 with a mean value of 6.63. The minimum (5.80) and maximum (7.90) values of pH_c were found in Cha and Sev₁ irrigation water samples, respectively. Similar results were also reported by Girdhar and Yadav (1982) and Bali *et al.* (2015).

Adj. SAR varied from 6.74 to 61.68 with a mean value of 40.92. The minimum value (6.74) of Adj. SAR was found in Sev₁ and the maximum value (61.68) of Adj. SAR was found in Bap₁ water sample. Similar results were also reported by Sharma *et al.* (2004).

Table-1 : Chemical properties of irrigation water of Bap tehsil.

S. No.	Sample Code	pH	EC (dS m ⁻¹)	SAR	RSC (me L ⁻¹)	Adj. SAR	pHc	SSP
1.	Amap	7.65	5.16	15.79	1.70	44.21	6.6	75.82
2.	Baar	7.74	4.36	16.78	3.45	43.64	6.8	79.89
3.	Bamp	8.06	3.95	19.55	3.60	48.87	6.9	84.88
4.	Bap ₁	8.06	6.01	22.03	6.01	61.68	6.6	82.64
5.	Bap ₂	7.80	5.31	21.04	4.07	54.69	6.8	83.05
6.	Cha	7.65	9.77	10.70	Nil	38.50	5.8	52.65
7.	Dho	7.95	4.21	15.68	1.95	40.78	6.8	78.56
8.	Dur	8.10	4.55	15.65	1.57	42.26	6.7	77.42
9.	Nne ₁	7.90	3.56	10.96	Nil	28.51	6.8	70.43
10.	Nne ₂	7.69	4.61	11.28	Nil	34.97	6.3	67.28
11.	Nne ₃	7.74	6.09	12.35	Nil	38.27	6.3	65.61
12.	Ran	7.73	4.87	18.38	3.19	51.46	6.6	80.77
13.	Sek	7.72	6.48	19.70	4.80	57.14	6.5	78.90
14.	Sev ₁	8.33	0.56	4.32	Nil	6.47	7.9	69.42
15.	Sev ₂	7.52	5.89	10.04	Nil	31.11	6.3	59.04
16.	She	7.75	6.91	10.39	Nil	32.21	6.3	57.49
Mean		7.84	5.14	14.66	3.37	40.92	6.63	72.74
Maximum		8.33	9.77	22.03	6.01	61.68	7.90	84.88
Minimum		7.52	0.56	4.32	NIL	6.47	5.80	52.65

Table-2 : Ionic composition of irrigation water of Bap tehsil.

S. No.	Sample Code	Ionic composition (me L ⁻¹)							
		Cations				Anions			
		Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻
1.	Amap	4.20	8.00	39.00	0.24	5.50	8.40	31.99	5.21
2.	Baar	3.60	4.90	34.60	0.21	4.50	7.45	27.46	3.89
3.	Bamp	2.10	3.60	33.00	0.18	4.10	5.20	25.28	4.40
4.	Bap ₁	4.10	6.00	49.50	0.30	5.82	10.29	37.26	6.15
5.	Bap ₂	4.00	4.75	44.00	0.23	4.40	8.42	34.51	5.32
6.	Cha	20.80	24.80	51.07	0.33	15.61	15.23	58.62	7.82
7.	Dho	3.60	5.20	32.90	0.18	4.00	6.75	27.78	3.17
8.	Dur	3.60	6.40	35.00	0.21	3.37	8.20	28.21	5.42
9.	Nne ₁	5.00	5.20	24.76	0.20	4.37	4.21	22.42	3.97
10.	Nne ₂	6.20	8.40	30.48	0.22	8.51	5.90	27.75	3.49
11.	Nne ₃	8.00	12.60	39.62	0.17	5.41	9.23	40.19	5.48
12.	Ran	4.20	4.90	39.20	0.23	5.30	6.99	30.19	5.81
13.	Sek	2.80	10.60	51.00	0.24	8.50	9.70	38.88	7.22
14.	Sev ₁	0.70	0.90	3.86	0.10	0.46	0.91	3.36	0.82
15.	Sev ₂	11.40	12.40	34.62	0.22	5.42	8.90	37.10	6.90
16.	She	11.80	17.20	39.56	0.25	7.32	11.21	43.52	6.37
Mean		6.01	8.49	36.39	0.22	5.79	7.94	32.16	5.09
Maximum		20.80	24.80	51.07	0.33	15.61	15.23	58.62	7.82
Minimum		0.70	0.90	3.86	0.10	0.46	0.91	3.36	0.82

The data on ionic composition (cations and anions) of ground water of Bap tehsil are presented in Table-2. Soluble cation Ca⁺⁺ varied from 0.70 to 20.80 me L⁻¹ with the mean value of 6.01 me L⁻¹. Soluble cation Mg⁺⁺ varied from 0.90 to 24.80 me L⁻¹ with the mean value of 8.49 me L⁻¹. The presence of Ca⁺⁺ in groundwater might be attributed to calcium-rich minerals such as amphiboles, pyroxenes and feldspars and the Mg⁺⁺ in groundwater might be due to olivine mineral and the ion exchange is with the ions in minerals. Soluble cation Na⁺ varied from 3.86 to 51.07 me L⁻¹ with the mean value of 36.39 me L⁻¹. In general, sodium was found dominant cation followed

by magnesium, calcium and potassium. The presence of Na⁺ in groundwater primarily results from the chemical decomposition of feldspars, feldspathoids and some iron, magnesium minerals. Soluble cation K⁺ varied from 0.10 to 0.33 me L⁻¹ with the mean value of 0.22 me L⁻¹.

Soluble anion CO₃²⁻ varied from 0.46 to 15.61 me L⁻¹ and HCO₃⁻ varied from 0.91 to 15.23 me L⁻¹ with the mean value of 5.79 me L⁻¹ and 7.94 me L⁻¹, respectively. The reason for carbonate (CO₃²⁻) and bicarbonate (HCO₃⁻) concentrations in groundwater can be ascribed to carbonate weathering as well as from the dissolution of carbonic acid in the aquifers. Soluble anion SO₄²⁻ varied

from 0.82 to 7.82 me L⁻¹ with the mean value of 5.09 me L⁻¹. Soluble anion Cl⁻ varied from 3.36 to 58.62 me L⁻¹ with the mean value of 32.16 me L⁻¹. Chloride was observed as dominant anion in irrigation water of Bap tehsil of Jodhpur district followed by bicarbonate, sulphate and carbonate. The results are in accordance with the findings of Singh *et al.* (2006), Narsimha *et al.* (2013), Kumar *et al.* (2016), Kumar *et al.* (2017), Selvakumar *et al.* (2017) and Dhaker *et al.* (2020).

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Horticultural Therapy in India : A Systematic Review

Baireneni Navya¹ and B. Jamuna Rani²

¹College of Community Sciences, Professor Jayashankar Telangana State Agricultural University, Hyderabad

²Professor Jayashankar Telangana State Agricultural University, Hyderabad

Email : navyarao456@gmail.com

Abstract

Horticultural therapy is a relatively modern field that combines the fields of horticulture and rehabilitation. It is a natural method which is now becoming popular in India to cure many diseases. We systematically reviewed evidence for the horticulture therapy studies done in India. A systematic search of Sage Journal, Science Direct, Google Scholar and hand search was conducted. Articles were selected if the study was conducted in India with horticulture as the main intervention and which were published in peer-reviewed scientific journals from 2010. The systematic search yielded 08 articles. The authors from a diverse range of occupational groups, like nursing, Agricultural, social work, and horticultural therapy carried out these studies. The results evaluated that the time-limited interventions was used having three steps (i.e., Pre horticultural therapy, horticultural therapy and post horticultural therapy) which also included a follow-up assessment to explore the beneficial effects of the intervention. It is found that the positive effects were observed in the studies on horticultural therapy. It also found that there is a significant gap in Indian literature both theoretically and practically.

Key words : Horticultural therapy, gardens, stress, depression, mental health and physical health.

Introduction

Horticultural therapy is a relatively modern field that combines the fields of horticulture and rehabilitation. Plants and gardening practices are used in therapy and recovery activities to help people feel better. (Detweiler et al.2012).

Now a day's many people have become conscious of the beneficial effects of human contact with plants and gardens over the last decade. Because of the recent rise in interest in this partnership, as well as the increased use of horticultural practices in recovery facilities, a variety of words for these programmes and activities have emerged, including therapeutic horticulture, garden therapy, social horticulture, and therapeutic gardening, to name a few. It's difficult to tell one from the other because these words are mostly used interchangeably, and horticultural therapy has become a catch-all word. In reality, there are some key distinctions between the words.

History of Horticultural Therapy : Around 500 BC, the Persians began creating gardens to please all of the senses simultaneously by combining beauty, fragrance, music (water) and cooling temperatures in the garden. In the 1100's St. Bernard described the benefits of a hospice garden at a monastery in Clairvaux, France, referring to the therapeutic benefits of privacy, green plants, birdsong, and fragrance (Gerlach-Spriggs, Kaufman & Warner, 1998).

In 1973 a group of horticultural therapy

professionals established the Council for Therapy and Rehabilitation through Horticulture (NCTRH) holding its first conference at the National Arboretum and USDA National Agricultural Library. In 1988 the organization changed its name to the American Horticultural Therapy Association (AHTA) (American Horticultural Therapy Association AHTA-2012).

Horticulture Therapy is a relatively new discipline that has been developing rapidly in the past 25 years. The significance of this discipline and the contribution it can make to advancing health and well being has just begun to be understood. Many studies on horticultural therapy have been conducted in foreign nations for decades, concentrating on various age groups with various health conditions. However, according to the researcher's investigation, just a few horticulture treatment studies have been conducted in India. This has recently gaining popularity in the society. The horticultural therapists are professionals with specific education, training, and credentials in the use of horticultural for therapy and rehabilitation.

Healing Gardens : Healing gardens are natural ecosystems populated by green plants, flowers, water, and other natural elements. They are often associated with hospitals and other healthcare environments, where they are designated as therapeutic gardens by the facility, are open to the public, and are intended to benefit the majority of users. A healing garden is intended to serve as a sanctuary and a place of respite for clients, guests, and workers, and is available for them to use whenever they

choose. Therapeutic gardens, horticultural therapy gardens, and restorative gardens are only a few of the many styles of healing gardens. These garden kinds are likely to overlap; hence the following definitions should only be used as a guide, as no two gardens are alike (American Horticultural Therapy Association AHTA-2012).

Types of Healing Gardens

Therapeutic Gardens : The term therapeutic garden describes outdoor gardens that include a variety of plants that are chosen for their aromatic and tactile qualities to attract biodiversity and to enhance sensory stimulation (Scott, T. L., 2017).

Horticultural Therapy Gardens : A horticultural therapy garden is a form of therapeutic garden that is designed to promote mainly horticultural activities while also accommodating client care objectives. A horticultural therapy garden is often planned in such a way that the garden's plant material can be cared for by the clients themselves (American Horticultural Therapy Association AHTA-2012).

Restorative Gardens : A restoration or meditation garden can be either public or private, and it does not have to be affiliated with a healthcare environment. This style of garden makes use of nature's restorative qualities to create an atmosphere that promotes mental rest, stress reduction, emotional healing, and increased mental and physical energy. The psychological, physical, and social needs of users are prioritized in the design of a restorative garden (American Horticultural Therapy Association AHTA-2012).

Research Methodology

Search Strategy : A critical review on Horticultural therapy related studies which were conducted in India and which were published in peer-reviewed scientific journals after 2010 were collected. They are collected in the context of, therapeutic gardening and gardening activities.

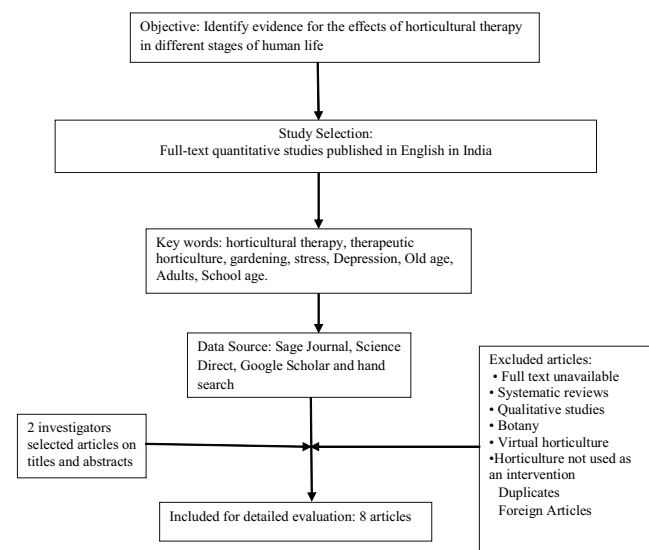
Keywords and search combinations are set up for the literature search. A systematic review technique is established containing two procedures : (1) literature search utilizing the keywords and combinations; (2) analysis of the significant studies.

Search Term : Horticultural therapy Or Therapeutic Gardening	Intervention Or Program or Clinical trials or a project or survey	Mental, or Physical, or Social, or Emotional, or Psychological Problems like depression, stress, anxiety, well being, etc.

Selection Criteria : Papers were selected for review if :

1. They included an evaluation of an intervention involving horticulture (gardening) activity.
2. Participants were different age groups experiencing functional mental and physical health difficulties
3. Published in a peer-reviewed journal; and
4. Written in English

Data extraction and analysis : To make the process of reviewing the papers and synthesizing the data easier, a data extraction form was developed. This was completed for each study that met the requirements for inclusion. The title of the research, author name, types of interventions created, the theoretical justification for the interventions, the environments in which they were used, sample size, the scale used for analysis, and the benefits of the interventions for service users were all taken into account.



Results and Discussion

Overview of selected papers : Eight papers met the inclusion criteria for the review. Two of the papers were written by the same research person on physically challenged people (Beela G.K 2015). The authors came from a diverse range of occupational groups, including nursing, Agricultural, social work, and horticultural therapy worked on horticultural therapy.

Systematic literature review of therapeutic landscapes/healing gardens in India : In view of understanding the current philosophies of therapeutic

Table-1 : An overview of studies included in review

Title	Author	Type of Gardening intervention	Sample size	Diagnose	Type of scales used	Main results
Horticultural therapy on self esteem and motor skills of physically challenged children	Beela. G. K. and B.R. Reghunath (2010)	Horticulture therapy	50 children (12-18 years of age group).	Self-esteem m and motor skills	Self Esteem Rating Scale (SERS) and observation schedule	Significant increases in self esteem and motor skills of the physically challenged children who underwent horticulture therapy
Effect of Horticulture Therapy on Level of Stress	Akshara P.V, and Manoj Kumar (2013)	Horticulture Therapy	60 children of 10-15 years were selected (30 in experimental and 30 in control)	Stress	structured stress questionnaire through interview method	Significant reduction in level of stress, maintained 3 weeks follow up. Horticulture therapy was found to be effective in reducing level of stress among Institutionalized children.
Horticulture Therapy for the Improvement of Self Concept in Adolescents with Locomotor and Hearing Impairment	Beela G.K., Reghunath B.R, And Johnson Jament (2015)	Horticulture therapy programme	36 adolescents (15 girls and 21 boys)	Self Concept	rating scale questionnaire	Significant increase in the self concept score over the period of programme by maintaining regular follow up for 20 days over the course of 9 weeks.
Effectiveness Of Horticulture Therapy On Depression Among Elderly At Selected Old-Age Home In Madurai.	Esther Rani.D Sheeba (2015)	Horticulture therapy	40 Elderly adults	Depression	Structured interview method	The intervention in Horticulture therapy is cost effective, non-invasive, non-pharmacological, free from side effects and highly feasible. It can be used as an effective intervention to improve the quality of life among elderly.
A Study to Assess the Effectiveness of Horticulture Therapy on Depression among Institutionalized Elderly in Selected Old Age Homes, Kancheepuram	Judie, Jeya,V, and Vijayalakshmi (2016)	horticulture therapy	140 (70 in study group and 70 in control group) elderly	Depression	Geriatric Depression Scale	The elderly living in the old age home exposed to horticulture therapy had significant decrease in the post-test depression score and it was concluded that the horticulture therapy was found to be effective in reducing the depression level of institutionalized elderly in the old age home.

landscapes/healing gardens in India, this part systematically reviews 8 research articles carried out by Indians in English language

Detailed analysis of the 8 studies : In the studies reviewed, most of the studies used questionnaires in an effort to get quantitative “hard data” on the effectiveness of the interventions. The most commonly used outcomes were depression, stress, and self esteem.

Of the studies evaluated, the time-limited interventions was used having three steps (i.e., Pre horticultural therapy, horticultural therapy and post horticultural therapy) which also included a follow-up assessment to explore whether the beneficial effects of the intervention had been maintained. It is found that the positive effects were observed in the studies on horticultural therapy.

Theories discussed in the Indian literature are mainly from the realm of horticultural therapy. There have been well established theoretical frameworks in western countries in this realm, Indian studies are relatively not segmented to different areas. There is a significant gap in Indian literature both theoretically and practically. Here the scholars suggest that using different theories in horticultural therapy will help in curing different illnesses. When talking about the application of theories, most of the studies were from western countries. In India they were not up to date in the use of this horticultural therapy. There is a need to integrate horticultural therapy from western countries into the Indian frameworks and need to work in different areas by various approaches.

Conclusions

There need to be a marked improvement in the quality of the research in India, there is still a need for well-designed, controlled trials to be established to reduce mental, physical, psychological, emotional and physical illness. (i.e. that the gardening-based intervention help in the improvement of human life from different problems). Furthermore, there is currently a lack of research exploring the active components of the interventions in India when compared to other countries.

In terms of clinical recommendations, in some settings it may be appropriate for clinical staff to consider setting up gardening projects for patients to get recover naturally.(e.g. for inpatient units).

The evidence for the efficacy of horticulture and gardening in a variety of therapeutic settings is provided by the data reviewed in the horticultural therapy literature. More research in this field, however, is needed to explore outcomes in greater depth and with a variety of different groups. This will provide solid evidence in favor of

therapeutic horticulture for a variety of vulnerable populations and individuals.

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Growth and Decomposition Analysis of Kharif Pulse Crops in Rajasthan

Harkesh Kumar Balai^{1*}, M.L. Meena², Kailash Chand Bairwa³, Hari Singh⁴ and G.L. Meena⁴

¹Department of Agricultural Economics, College of Agriculture, Indore, M.P.

²Department of Agricultural Economics, College of Agriculture, Baytu-344034, Barmer, Rajasthan

³Department of Horticultural, College of Agriculture, Baytu-344034, Barmer, Rajasthan

⁴Department of Agricultural Economics and Management, RCA, Udaipur-313001, Rajasthan

*Corresponding Author Email : harkeshbalai15@gmail.com

Abstract

The present study was conducted to analyze the growth rate and source of output growth in area, production and productivity of kharif pulse crops viz., black gram, green gram and pigeon pea crops in Rajasthan. The study was solely based on secondary time series data. The study period (1988-89 to 2017-18) has been divided into four periods namely period-I (1988-89 to 1997-98), period-II (1998-99 to 2007-08), period- III (2008-09 to 2017-18) and overall period (1988-89 to 2017-18). Exponential growth and principal decomposition models were used to measure the growth rates and relative contribution of factors in production of selected kharif crops. The area, production and productivity of black gram were increased significantly at the rate of 5.20, 8.89 and 3.75 per cent per annum, respectively. The production of black gram may be increased due to positive and significant contribution made by area and productivity of black gram. However, area and production of green gram in Rajasthan were increased significantly at the rate of 13.24 and 19.12 per cent per annum, respectively in the entire study period whereas, the productivity of this crop was increased non significantly at the rate of 5.20 per cent per year. In this period, the production of green gram might be increased due to positive and significant augmentation in area of green gram. In the overall period, the area under pigeon pea was declined significantly with annual growth rate of -3.17 per cent in Rajasthan. During same period, the production of this crop was recorded positive and significant growth rate with the magnitude of 0.10 per cent per annum. Further, the productivity of pigeon pea was increase non-significantly at the rate of 3.04 per cent over the year. The tinny growth in production of pigeon peas was highly attributed by positive growth in productivity of pigeon pea throughout the study period. At the same time, the area under this crop was registered negative growth; it might be due to positive and significant growth in area of its competitive crop i.e. black gram and green gram. During overall period area expansion was comparatively more instrumental in increasing in production of black gram while yield effect and its interaction effect were next in order with 12.63 per cent and 9.36 per cent contribution to the output growth of black gram. During overall period, the growth in production of green gram was mainly achieved through interaction and area effect. The contribution of interaction and yield effect in the production growth in this period was about 70.26 per cent and 64.99 per cent respectively. During overall period, however interaction effect turned out to be the most powerful factor in growth of pigeon pea with 100.66 per cent. Area and yield effect were very small during this time with -0.77 and 0.11 per cent, respectively.

Key words : Compound growth rate, decomposition, area, production and productivity of pulses.

Introduction

Production of pulses is one of the important segments of Indian agriculture after cereals and oilseeds. The pulses comprise of Chickpea, Pigeon pea, Lentil, Green gram, bean, Black gram bean and Field pea. These pulses are an important commodity group of crops that provide high quality protein with complementing cereal proteins for pre-dominantly substantial population of the country. Pulses are popularly known as “Poor man’s meat” and “rich man’s vegetable” as a result of being a major source of proteins, vitamins and minerals especially for vegetarian diets in India (Singh *et al.*, 2016). Pulses prove to be a boon for mankind as they are highly nutritive processing important gift of nature. They not only increase the fertility of the soil by nitrogen fixation but also increase the porosity of the soil due to their invasive tap root

system. Due to low requirement of water and ability to withstand serves revealed that decline in pulses consumption lead to increase in malnutrition due to decline in protein intake. (Shalendra *et al.*, 2013). India is presented about 24 percent of undernourished populace in the universe (Sharma *et al.*, 2016 and Ahlawat *et al.*, 2016). To make the public aware of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition, The United Nations declared 2016 as “International year of pulses (IYP). India is the largest producer, consumer and importer of the pulses in the world. India was the largest producer (25%), consumer (27%) and importer (14%) of pulses in the world. (Mohanty and Satyasai 2015).

Among the pulses, chickpea and pigeon are the important crops accounting for 50 per cent of pulse area and 60 per cent of total production. Madhya Pradesh,

Uttar Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, Bihar, Chattisgarh, Gujarat and Tamil Nadu. Pulses are grown in Kharif and Rabi seasons. chickpea, drypea, lentil and lathyrus are known as Rabi pulses. (Anonymous, 2018)

The pulses crop was cultivated over 85.40 million hectares along with 87.40 million tones production and 1023 kg/ha productivity. Chickpea, pigeon pea and lentil are major contributing crops in total world pulses production with the share of 16.69, 10.40 and 1 7.72 percent respectively (Anonymous 2019).

India secured the top position in area and production with 35 percent and 29 percent in the world respectively. India plays a significant role in the world pulse market. In India food grains occupy 65 per cent of total gross cropped area comprising cereals in 50 per cent and pulses in about 15 per cent. Pulses were cultivated over >27 million hectare area with production of 23.02 million tones and productivity of 823 kg/ha. (Anonymous, 2019).

In India, Madhya Pradesh secured first position in area with 6600 thousand hectare followed by Rajasthan, Maharashtra, Karnataka and Uttar Pradesh with 5907.62, 4002.23, 3556.66 and 2991 thousand hectare, respectively. In production Rajasthan secured first rank with 4497.13 thousand tones followed by Madhya Pradesh, Maharashtra, Uttar Pradesh and Karnataka with 4108.41, 3736, 2447.32 and 2155.89 thousand tones, respectively (Anonymous, 2019-20).

Considering decomposition analysis in agricultural output, it has remained an important part of interest to researchers and policy makers. A breakdown of growth into various component of area and yield facilitates in output projection with alternative targets and policies (Jamal and Zaman, 1992). Thus, decomposition of agricultural growth among its constituent forces is of great importance. The paper is divided in two sections. It begins with examinations of growth in area, production and productivity of kharif pulse crops namely black gram, green gram and pigeon pea in Rajasthan. And, secondly the estimate the relative contribution of area, yield and their interaction to produce the output of black gram, green gram and pigeon pea in Rajasthan. There are many studies such as Mathur and Henry (2005), Singh and Ranu (2009), Sharma *et al.* (2013) and Bairwa, *et al.* (2020) were presented growth performance of pulses at national level. It is prime component of researchers and policy makers to frame at the state level improved technology and improved varieties. So that farmers can get benefits for improving their skills and living standards in the society. through improved technology and Therefore, the present study is confined to Rajasthan state only.

The major challenges in Rajasthan is to provide an improved production technology for achieving sustained production of pulse crops. The present study has been conducted to answer the research questions whether there was significant growth in Rajasthan in area, production and productivity of pulse crops over the period as well as contribution of area and yield towards change in total pulses production in Rajasthan.

Materials and Methods

The study was based on secondary data collected from different sources i.e. Directorate of Agriculture and cooperation, GOI, Directorate of pulses development Bhopal, etc. The time series data of area, production and productivity of selected pulse crops have been taken for 30 years from 1988-89 to 2017-18. The study period (1988-89 to 2017-18) was divided into four periods i.e. period-I (1988-89 to 1997-98), period-II (1998-99 to 2007-08), period-III (2008-09 to 2017-18) and overall period (1988-89 to 2017-18). Two different analyses had been carried out in the study viz. (a) Compound annual growth rates was calculated period wise to study the growth in area, production and yield of selected pulses and (b) Decomposition analysis. Compound growth rates (CGR) of area, production and productivity of selected pulse were worked out for different periods as well as for entire period of analysis by fitting exponential function. To measure the relative contribution of area and yield towards the total output change with respect of individual pulse crop, decomposition model had been used. The study was restricted to major kharif crops viz., black gram, green gram and pigeon pea. These three crops accounted more than 45 and 40 per cent of total pulse crops cropped area and production in Rajasthan (Anonymous 2018).

Compound Growth Rate : Compound annual growth rates was estimated to know the growth pattern on area, production and productivity of major kharif pulse crops in Rajasthan. The growth rate was estimated by using exponential trend model (Veena, 1996).

$$\text{Exponential trend equation : } Y = ab^x$$

The compound growth rate was obtained for the logarithmic form of the equation as below:

$$\text{Log } Y = \log a + t \log b$$

Where,

$$Y = \text{area/production/yield}$$

$$a = \text{Intercept}$$

$$b = \text{regression coefficient} / (1 + r)$$

$$x = \text{Year}$$

Table-1 : Compound annual growth rate of area, production and productivity of Black gram in Rajasthan.

(CAGR in Per cent)			
Period	Area	Production	Productivity
Period-I	8.89* (0.011)	9.40 (0.032)	0.23 (0.028)
Period-II	-2.73 (0.035)	4.71 (0.051)	7.40 (0.036)
Period-III	43.22* (0.027)	62.93* (0.047)	14.02 (0.036)
Overall	5.20* (0.007)	8.89* (0.011)	3.75** (0.007)

Source : Author's own commutation from compiled time series data.

Note : Figures in parenthesis are standard error of selected growth model.

*, ** and ***, Significant at 1, 5 and 10 % levels of significance, respectively.

Table-2 : Compound annual growth rate of area, production and productivity of Green gram in Rajasthan.

(CAGR in Per cent)			
Period	Area	Production	Productivity
Period-I	21.34* (0.01)	16.41 (0.059)	-4.06 (0.055)
Period-II	20.50* (0.019)	65.20** (0.081)	37.40*** (0.068)
Period-III	15.88* (0.022)	42.89 (0.084)	23.31 (0.079)
Overall	13.24* (0.004)	19.12* (0.015)	5.20 (0.014)

Source : Author's own commutation from compiled time series data.

Note : Figures in parenthesis are standard error of selected growth model.

*, ** and ***, Significant at 1, 5 and 10% levels of significance, respectively.

Table-3 : Compound annual growth rate of area, production and productivity of Pigeon pea in Rajasthan.

(CAGR in Per cent)			
Period	Area	Production	Productivity
Period-I	1.16 (0.034)	1.86 (0.0741)	0.69 (0.046)
Period-II	-9.43* (0.012)	-10.67 (0.06)	-0.46 (0.055)
Period-III	14.29 (0.061)	21.90 (0.067)	6.41 (0.31)
Overall	-3.17* (0.08)	0.10* (0.012)	3.04 (0.008)

Source : Author's own commutation from compiled time series data.

Note : Figures in parenthesis are standard error of selected growth model.

*, ** and ***, Significant at 1, 5 and 10 % levels of significance, respectively.

$$r = \text{Compound growth rate} / (\text{Antilog } b) - 1$$

The percent compound growth rate (r) will be as,

$$r = [(\text{Anti log of } b) - 1] \times 100$$

Student 't' test was used for testing significance level of growth in area, production and productivity of selected kharif pulse crops (Dhakre and Sharma 2010).

Where,

't' = Student 't' test

CGR = Compound growth rate

SE (CGR) = Standard error of Compound growth rate

Standard error of Compound growth rate is calculated by using following formula :

$$SE (CGR) = \frac{100b}{\ln 10} SE(\ln b)$$

Decomposition Analysis : To study the contribution of area, yield and the interaction towards increasing the pulses production in India, a decomposition analysis was used as expressed below (Minhas and Vaidyanthan, 1965):

$$P = AB^* Y + YB^* A + A^* Y$$

= (Yield effect) + (Area effect) + (Interaction effect)

Where,

$$A = AC - AB$$

$$P = PC - PB$$

$$Y = YC - YB$$

AB, PB and YB are the area, production and yield of pulses for the base year.

AC, PC and YC are the area, production and yield of pulses for the current year.

A = Change in area

P = Change in production

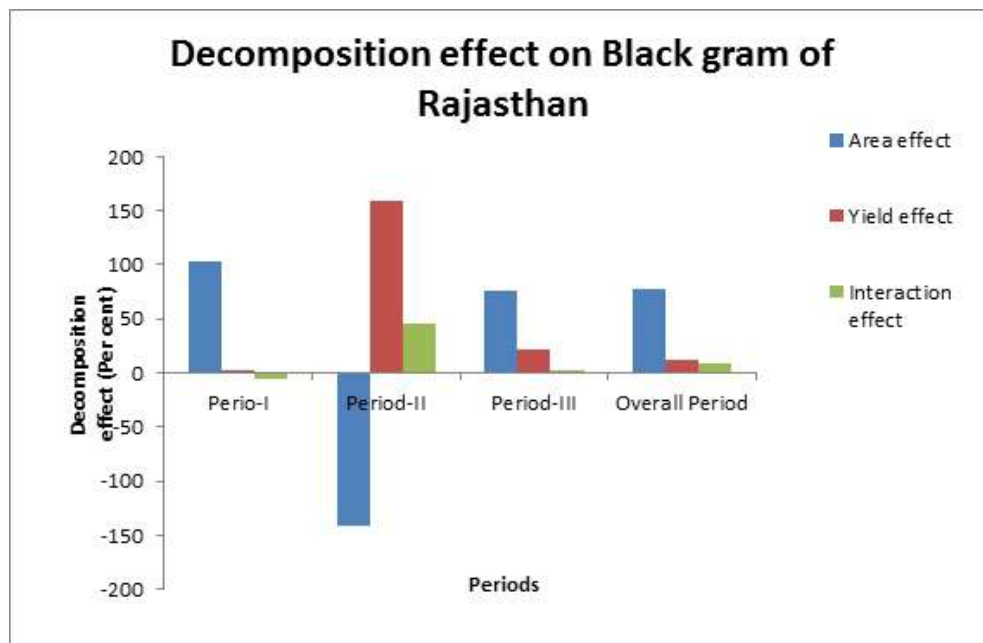
Y = Change in yield

Results and Discussion

Compound annual growth rate : The growth rate in area, production and productivity of kharif crops i.e. black gram, green gram and pigeon pea for the study period from 1988-89 to 2017-18 were calculated.

Table-4 : Per cent contribution of area, yield and their interaction on production of Black gram in Rajasthan.

Period	Area effect	Yield effect	Interaction effect
Period-I	102.69	2.65	-5.34
Period-II	-140.53	158.70	45.83
Period-III	75.52	21.25	3.23
Overall	78.01	12.63	9.36



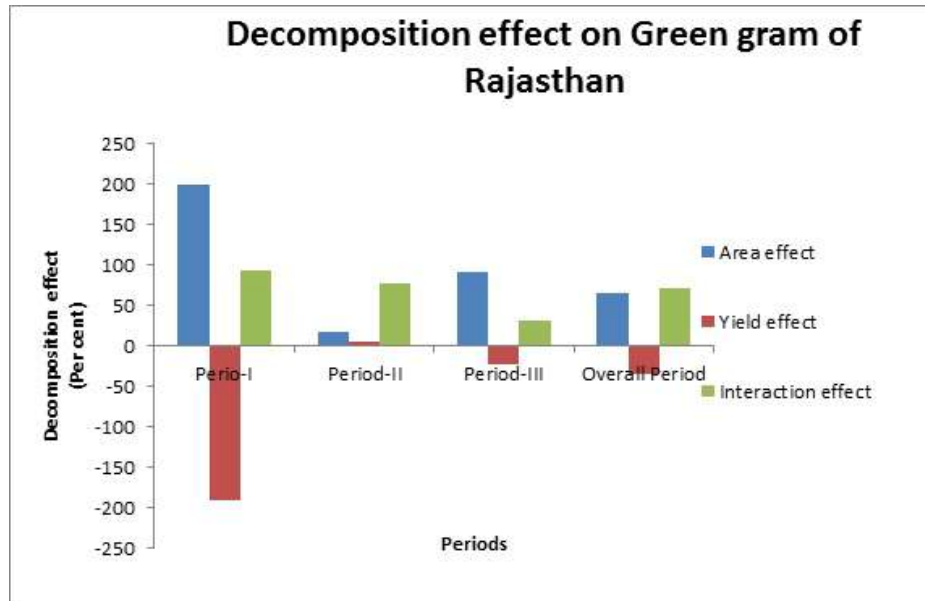
Black gram : Table-1 depicted the results of growth rate in area, production and productivity of black gram in Rajasthan. It was indicated in the table that during entire study period, the area, production and productivity of black gram were increased significantly at the rate of 5.20, 8.89 and 3.75 per cent per annum, respectively. The production of black gram may be increased due to positive and significant contribution made by area and productivity of black gram. In the period-I, the area, of black gram was increased significantly at the rate of 8.89 per cent per annum whereas production and productivity of this crop were also increased but non-significantly at the rate of 9.40 and 0.23 per cent per annum, respectively in the state. The production of black gram could be increased due to appreciable rise in area under black gram in period-I. During period-II, negative and non-significant growth rate was noticed under area (-2.73%) of black gram in Rajasthan. Further, the production and productivity of black gram were augmented at the rate of 4.71 and 7.40 per cent per annum respectively. In this period, productivity may be principal contributor to expend the production of black gram. The area under this crop might be declined due to drastic expanded in area of its competitive crop green gram. During period-III, the growth in all three aspects viz., area, production and productivity of black gram were reported at the rate of 43.22, 62.93

and 14.02 per cent per annum respectively in the state. In the mean time, area and production of this crop were notified remarkable and significant improvements in Rajasthan. The study thus reported that area and production of black gram were drastically changed in the period-III. At the same time, the production of black gram could be increased due to expanded in area and productivity of this crop. Bairwa *et al.* (2020), reported a positive growth rate in area, production and productivity of black gram in India during period 1998-2017.

Green gram : The results of growth rate in area, production and productivity of green gram were reported in Table-2. It was revealed from the table that area and production of green gram in Rajasthan were increased significantly at the rate of 13.24 and 19.12 per cent per annum, respectively in the entire study period whereas, the productivity of this crop was increased non significantly at the rate of 5.20 per cent per year. In this period, the production of green gram might be increased due to positive and significant augmentation in area of green gram. In the period-I (1988-89 to 1997-98), the area under green gram was increased significantly with annual growth rate of 21.34 per cent. In the mean time, the growth rate in production and productivity of green gram were reported at the rate of 16.41 and -4.06 per cent per annum, respectively. The production of green gram could

Table-5 : Per cent contribution of area, yield and their interaction on production of Green gram in Rajasthan.

Period	Area effect	Yield effect	Interaction effect
Period-I	198.69	-191.27	92.58
Period-II	17.67	5.48	76.85
Period-III	91.50	-22.62	31.12
Overall	64.99	-35.25	70.26



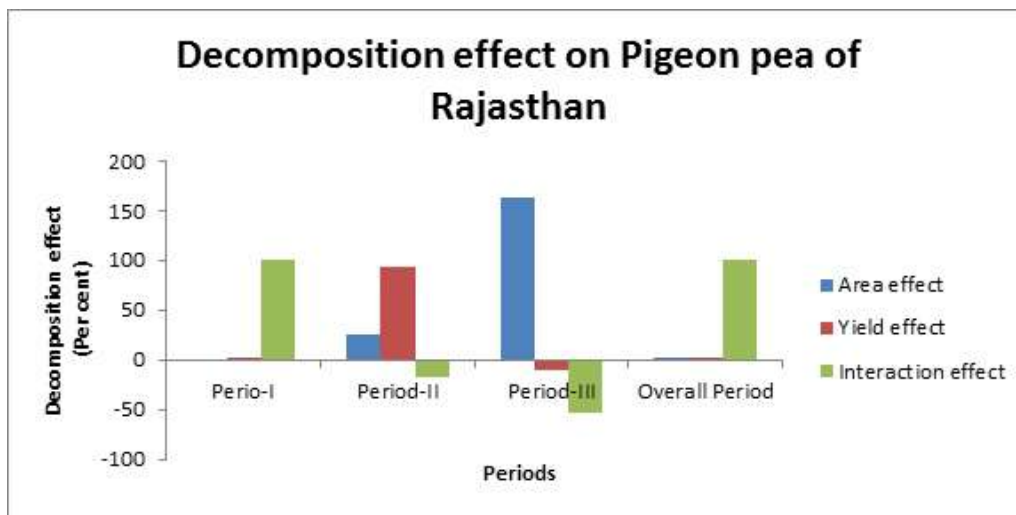
be enhanced due to expanded in area under this crop only. During period-II, the highest and significant growth rate was found in production (65.20%) of green gram followed by productivity (37.40%) and area (20.50%) per annum. In the same period, positive and significant expanded in area and productivity of green gram might be major contributor to enhance the production of this crop. In the period-III, the area under green gram in the state was increased significantly at the rate of 15.88 per cent annum. In case of production and productivity, the annual growth rate were recorded positive and non-significant with magnitude of 42.89 and 23.31 per cent per year, respectively. In this period, the area and production of green gram might be increased due to remarkable improvement in productivity of this crop. Similar results were reported by Mathur and Henry (2005) in area, production and productivity of mung bean in Rajasthan during 1976-2000.

Pigeon pea : The growth rate in area, production and productivity of pigeon pea were presented in the Table-3. It was revealed from this table that in the overall period, the area under pigeon pea was declined significantly with annual growth rate of -3.17 per cent in Rajasthan. During same period, the production of this crop was recorded positive and significant growth rate with the magnitude of 0.10 per cent per annum. Further, the productivity of pigeon pea was increase non-significantly at the rate of 3.04 per cent over the year. The tinny growth in production

of pigeon peas was highly attributed by positive growth in productivity of pigeon pea throughout the study period. At the same time, the area under this crop was registered negative growth; it might be due to positive and significant growth in area of its competitive crop i.e. black gram and green gram. During period-I, the results stated positive and non significant growth rate in all three aspects viz., area, production and productivity with annual rate of 1.16, 1.86 and 0.69 per cent, respectively. In this period, production of pigeon pea may be increased because of expansion in area and productivity of this crop. The study period-II reported negative and significant growth rate in area of pigeon pea at the rate of -9.43 per cent per annum while the production and productivity of this crop were also showed negative and non-significant growth rate of -10.67 and -0.46 per cent, respectively. In this period, the area under pigeon pea might be declined due to remarkable improvement in area of its competitive crop green gram. The production of pigeon pea could be declined due to negative growth rate in productivity and area of pigeon pea in period-II. During period-III, the highest and non-significant growth rate was recorded in production (21.90%) followed by area (14.29%) and productivity (6.41) of pigeon pea. This period was characterized positive growth rate in production of pigeon pea; it could be due to appreciable improvement in area and productivity of this crop. Kalmkar (2001) in his study recorded positive and significant growth rate in area,

Table-6 : Per cent contribution of area, yield and their interaction on production of Pigeon pea in Rajasthan.

Period	Area effect	Yield effect	Interaction effect
Period-I	-0.09	0.13	99.96
Period-II	25.19	92.88	-18.07
Period-III	163.03	-10.34	-52.69
Overall	0.77	0.11	100.66



production and productivity of pigeon pea in Maharashtra during 1961-62 to 1997-98.

Decomposition Analysis

Black gram : Decomposition of output growth into its constituent forces for black gram is presented in the Table-4. It was revealed from the this table that during overall period area expansion was comparatively more instrumental in increasing in production of black gram while yield effect and its interaction effect were next in order with 12.63 per cent and 9.36 per cent contribution to the output growth of black gram. Area accounted for 78.01 per cent of the output growth. During period-I, area effect was mainly responsible for the output growth of black gram accounting for 102.69 per cent and yield effect had very small contribution to extent of 2.65 per cent of the total output growth of black gram in Rajasthan while interaction effects on production was negative accounting -5.34 per cent. During period-II, increased in production of black gram was mainly due to yield effect and interaction effect with 158.70 per cent and 45.83 per cent contribution respectively while area effect was negative on production of black gram with -104.53 per cent contribution. During period-III, the contribution of area effect was higher than yield effect and interaction effect in accelerating the output of black gram. The output of black gram increased by 75.52 per cent, 21.25 per cent and 3.23 per cent due to expansion of area, yield and their interaction. More *et al.* (2015) in area effect, yield effect and their interaction effect of black gram in Gujarat state during 1960-61 to 2010-11.

Green gram : The relative contribution of yield, area and their interaction to change in production of gram in Rajasthan are presented in the Table-5. It could be seen from the table that during overall period, the growth in production of green gram was mainly achieved through interaction and area effect. The contribution of interaction and yield effect in the production growth in this period was about 70.26 per cent and 64.99 per cent respectively. The yield effect was however negative being -35.25 per cent. During period-I, area effect and interaction effect played a major role in increasing production of green gram with 198.69 per cent and 92.58 per cent. During period-II, interaction effect turned out to be most powerful factor in the growth of green gram crop with 76.85 per cent. The area effect and yield effect were small with magnitude of 17.67 per cent and 5.48 per cent respectively. During period-III, area effect and interaction effect played a major role in increasing production of green gram with 91.50 per cent and 31.12 per cent respectively. Latika *et al.* (2015) in area effect, yield effect and their interaction effect of total pulses in India during 1950-51 to 2014-15.

Pigeon pea : The Table-6 represented the contribution of area, productivity and their interaction to the output growth of pigeon pea in Rajasthan state. It was observed from this table that during overall period, however interaction effect turned out to be the most powerful factor in growth of pigeon pea with 100.66 per cent. Area and yield effect were very small during this time with -0.77 and 0.11 per cent, respectively. During period-I, increased in production of pigeon pea was mainly due to interaction

effect and with 99.96 per cent while yield effect was very small 0.13 per cent contribution. Area effect was negative on production of pigeon pea with -0.09 per cent. During period-II, yield effect was more dominant than the area effect and interaction effect to produce the output. In this period productivity and area influenced the production of pigeon pea crop during period-II to a large extent with its contribution as 92.88 per cent and 25.19 per cent to the output growth respectively. The interaction effect however had negative contribution to the production with -18.07 per cent. During period-III, area effect was mainly responsible for the output growth of pigeon pea accounting for 163.03 per cent of the total output growth while yield effect and interaction effect had negative effect on production with -10.34 and -52.69 per cent, respectively. More *et al.* (2015) reported similar findings on area effect, yield effect and their interaction effect of pigeon pea in Gujarat state during 1960-61 to 2010-11.

Conclusions

The present study found during throughout study period area, production and productivity of black gram and area and production of green gram reported positive and significant growth in entire study period. During period-I, positive and significant growth rate was observed under area of black gram and area of green gram in Rajasthan, while the production and productivity of this crop were showed positive and non-significant growth rates in the state. In period-II, the production and productivity of black gram were increased non-significantly while area was declined non-significantly and area, production and productivity of green gram were reported positive and significantly growth rate in Rajasthan. During period-III, the area and production of black gram and area of green were reported significant growth rates while productivity of black gram and production and productivity of green were non-significant. Production of pigeon pea was slightly increased whereas the area under this crop was declined in overall period. In Rajasthan, the area, production and productivity of pigeon pea were reported positive growth in period-I and III while in period-II, the performance of pigeon pea was negative in all aspects *viz.*, area, production and productivity of the crop.

Thus it can be inferred from above the analysis that area effect was more dominant during period-I, III and overall of black gram, in period-I and period-III of black gram and period-III of pigeon pea. Yield effect was major contributor to increase in production of black gram and pigeon pea during period-II. In case of period-II and overall interaction effect was major contributor to increase the production of green gram and period-I of pigeon pea in Rajasthan.

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Economics, Quality and Nutrient Uptake of Sesame [*Sesamum indicum* L.] as Response of Varieties to Varying Levels of Sulphur Fertilization

Lali Jat^{1*}, Laxman kumawat¹, M.L. Jat¹, Raju Dhayal¹, Sushila Aechra¹, Roshan Kumawat¹, Rajendra Kumar², B.C. Dhayal¹ and Balveer²

¹Sri Karan Narendra Agriculture University, Jobner-Jaipur

²Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.)

*Email : lalidhayal1990@gmail.com

Abstract

A field experiment was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner (Rajasthan) during *kharif*, on loamy sand soil. The experiment comprising of four levels of sulphur (0, 20, 40 and 60 kg/ha) and four sesame varieties (RT-125, RT-127, RT-346 and RT-351) there by making 16 treatment combinations was laid out in randomized block design and replicated thrice. Results revealed that N, P and S concentration in seed and straw, their uptake, protein and oil content in seed and oil yield were improved significantly upto 40 kg S/ha. Being at par with 60 kg/ha, sulphur fertilization at 40 kg/ha also exclude 12.7 and 64.2 per cent more net returns over 20 kg/ha and control, respectively. The maximum sulphur use efficiency was recorded when its level was raised from 0 to 20 kg/ha. It is anteriorly apparent from the data that N and P concentration in seed and straw of sesame was not effect significantly due to different varieties while S concentration in seed is significantly higher in RT-351 than the other varieties. It also represented significant improvement is nutrient uptake, oil content in seed and oil yield among all the varieties. Application of sulphur at 49.19 kg/ha was found as the optimum dose for sesame as derived from response function.

Key words : Sesame, net return, B : C ratio, nutrient uptake, protein content, oil content.

Introduction

Sesame is one of the oldest crops known to humans. There are archeological remnants of sesame dating to 5,500 BC in the Harappa Valley in the Indian subcontinent (Bedigia *et al.*, 1986). Sesame or gingelly (*Sesamum indicum* L.) commonly known as *til* also called as “queen of oilseeds” has been known to be one of the earliest domesticated edible oilseeds used by the mankind. Sesame is an important edible oilseed crop next to groundnut and rapeseed-mustard. Its oil content generally varies from 46 to 52 per cent and protein from 18 to 20 per cent. Nearly 73 per cent of the oil is used for edible purposes, 14.5 per cent for domestic uses including preparation of sweet candies as condiments, culinary and confectionary purposes, whereas 8.3 per cent for hydrogenization and 4.2 per cent for industrial purposes in the manufacture of paints, perfumed oils, pharmaceuticals and insecticides. Sesame oil is also used in soap, cosmetic and skin care industries (Johnson *et al.*, 1979). The seed of sesame has anti-bacterial, anti-viral, anti-fungal and anti-oxidant properties. Since, sesame oil is cholesterol free, it is also used in food industries and reduce LDC cholesterol and triglycerides protecting for heart patients. Sesame seeds were one of the first crops processed for oil as well as one of the earliest condiments (de Carvalho *et al.*, 2001).

The oil is highly resistant to oxidative rancidity and is

characterized for its stability and quality. Because of the best quality characters, it is also sometimes referred to as “poor mans substitute for ghee”. Sesame oil, other than its use as cooking medium, has certain industrial applications as it is used to make hair oil, hydrogenated oil and certain medicines (Salunkhe *et al.*, 1991; Suja *et al.*, 2004; Quasem *et al.*, 2009). The present review highlights the food/nutritional, medicinal and pharmaceutical uses of sesame seeds. Important role of sulphur in many physiological processes of plant like synthesis of sulphur containing amino acids (cystine, cystein and methionine), vitamins (biotin and thiamine), co-enzyme-A and chlorophyll and metabolism of carbohydrates, protein and fats. It helps in synthesis of glucosides in sesame oil and enhance the oil quality of oilseed crops. Sulphur also has an essential role in development of root system and increases drought and cold resistance in oilseeds due to disulphide linkage. It helps in control of diseases and pests and hastens the decomposition of crop residues. In such soils, each unit of sulphur applied can augment the supply of edible oil by 3.5 units (Tandon, 1995). It has been reported that on an average, production of one tonne of oilseed requires 12 kg sulphur (Jamal *et al.*, 2010).

The direct source of sulphur is elemental sulphur which is not only costly but unavailable also. The locally present material is gypsum and is being abundantly

excavated in the state of Rajasthan. Sulphur is an essential plant nutrient, deficiency of which has been observed in soils of semi arid regions, especially Jaipur, Jodhpur and Udaipur districts of Rajasthan (Jat and Yadav, 2015). The extent of adoption of improved agricultural technologies is a crucial aspect under innovation diffusion process and the most important for enhancing agricultural production at a faster rate. Large number of technologies evolved in the field of agriculture is not being accepted and adopted to its fullest extent by the farmers. The gap between recommendation made by the scientists and actual use the farmers is frequently encountered (Rohit and Singh, 2019).

Materials and Methods

A field experiment was conducted during *kharif* season of the year 2015 at Agronomy farm, S.K.N. College of Agriculture, Jobner to find out the economics, quality and nutrient uptake of sesame [*Sesamum indicum* L.] as response of varieties to varying levels of sulphur fertilization. The average annual rainfall of this area varies from 350 mm to 400 mm most of rainfall is received during the period of July to September. The soil of experimental field was loamy sand in texture, alkaline in reaction (pH 8.2), low in organic carbon (0.18%), available nitrogen (132.4 kg/ha), available sulphur (8.5 mg/kg) available phosphorus (18.25 kg P₂O₅/ha) and medium in available potassium (144.26 kg K₂O/ha) content. The experiment comprised four levels of sulphur (0, 20, 40 and 60 kg/ha) and four sesame varieties (RT-125, RT-127, RT-346 and RT-351) thereby making sixteen treatment combinations that were laid down in randomized block design and replicated thrice. The seed rate of 4 kg/ha in the rows spaced at 30 cm apart. Two irrigation was given to protect the crop from moisture stress condition.

Nutrient concentration

Nitrogen : Nitrogen was estimated by colorimetric method (Snell and Snell, 1949). Samples were digested with sulphuric acid and treated with hydrogen peroxide to remove black colour. Nessler's reagent was used to develop colour. The results so obtained were expressed as per cent N concentration on dry weight basis.

Phosphorus : Phosphorus concentration in seed and stalk were determined by "Vanadomolybdo phosphate" Yellow colour method. Digestion of samples was done by triacid mixture. Ammonium molybdate-ammonium vandate solution was used to develop colour and resultant intensity of colour was measured spectrophotometer at 420 nm wavelength and expressed as per cent phosphorus concentration on dry weight basis (Jackson, 1973).

Sulphur : Sulphur was estimated by turbidimetric method (Tabatabai and Bremmer, 1970). The plant samples (seed and straw) were digested in diacid mixture and barium chloride solution was used for development of turbidity. The resultant turbidity was measured on spectrophotometer at 420 nm wavelength.

Protein content in seed : Protein content in seed was calculated from the per cent nitrogen in the seed multiplied by the factor 6.25 (A.O.A.C., 1960) and expressed as per cent protein content.

Oil content (%) : Oil content in the seed was determined by "Soxhlet's apparatus using petroleum ether (60-80 °C) as an extractant (A.O.A.C., 1960).

Sulphur use efficiency : Agronomic efficiency, apparent recovery and physiological efficiencies of sulphur was calculated using the following formulae (Singh and Singh, 2012).

$$\text{Agronomic efficiency of S (AEs)} = \frac{Y_s - Y_c}{S \text{ applied}}$$

$$\text{Apparent recovery (\%) of S (REs)} = \frac{U_s - U_c}{S \text{ applied}} \times 100$$

$$\text{Physiological efficiency of S (PEs)} = \frac{Y_s - Y_c}{U_s - U_c}$$

Where :

Y = Yield of Sesame (kg/ha)

U = Uptake of S by crop (kg/ha)

s and c = Yield/uptake of crop under S applied treatment and under control, respectively (kg/ha).

Statistical analysis of the data was carried out using standard analysis of variance technique (Fisher, 1950).

Results and Discussion

Nitrogen, Phosphorus and Sulphur concentration in seed and stalk : Data indicated that increasing levels of sulphur fertilization in sesame significantly increased the N, P and S concentration in seed upto 40 kg/ha and stalk upto 20 kg/ha. However, the highest concentration in seed and stalk was obtained at 60 kg/ha. Further investigation of the data indicated that different varieties did not differ significantly with respect to nitrogen and Phosphorus concentration in seed and stalk of sesame crop at harvest stages. All the varieties of sesame differed significantly with respect to sulphur concentration in sesame seed. Remaining at par with each other, sesame varieties RT-346 and RT-127 were noted to attain significantly higher S concentrations in seed. The highest concentration was recorded under the variety RT-351 that was significantly higher as compared to RT-127 and

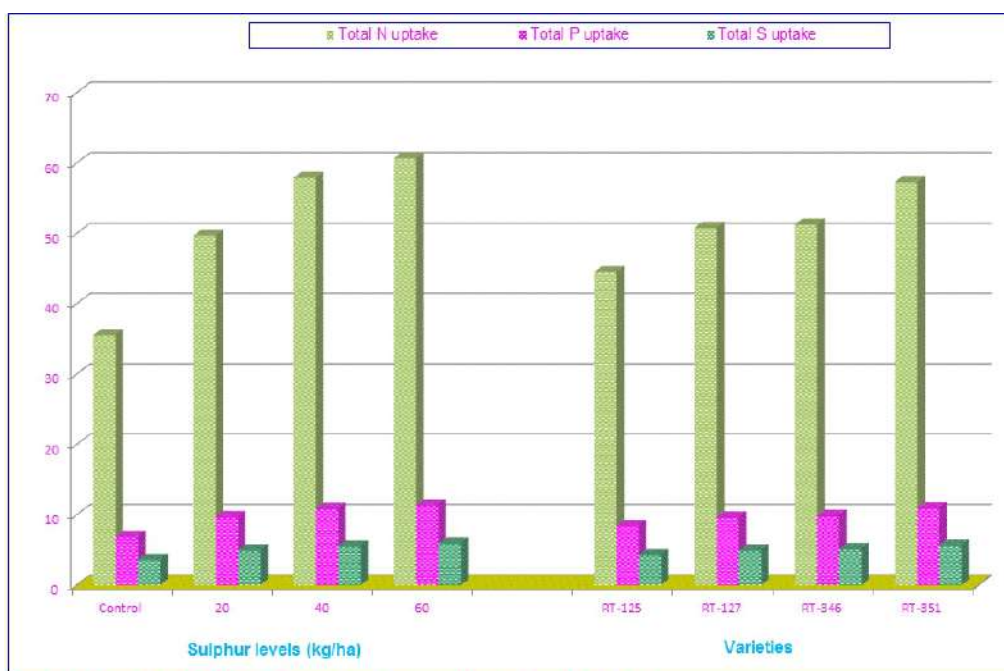


Fig. 4.7 Effect of sulphur fertilization and varieties on total uptake of N, P and S in sesame

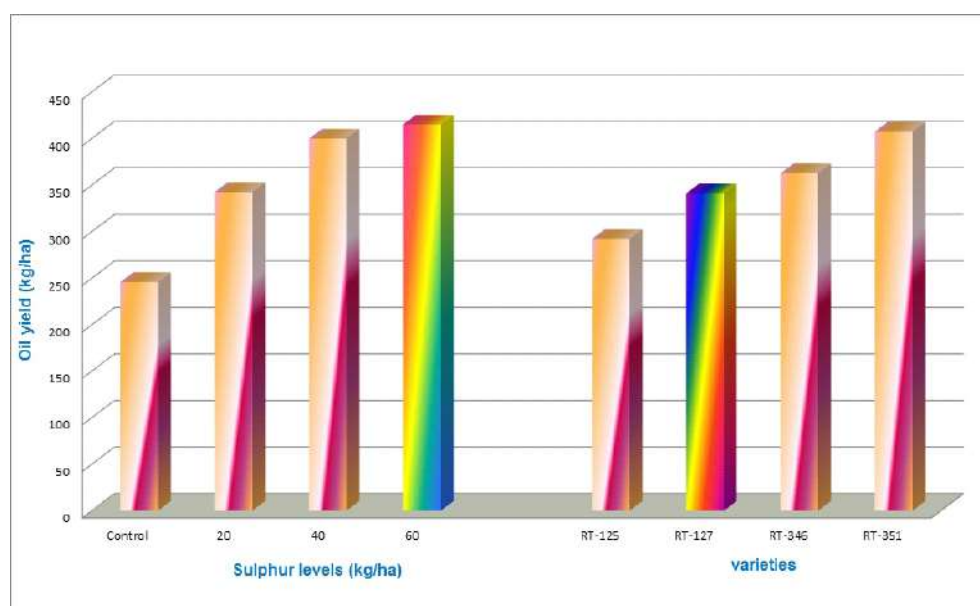


Fig. 4.8 Effect of sulphur fertilization and varieties on oil yield in sesame

RT-125, respectively. Sulphur concentration in straw was not influenced significantly due to different varieties.

Total Nitrogen, phosphorus and Sulphur uptake : Total uptake of nitrogen by crop exhibited profound increase due to sulphur fertilization. Application of 60 kg S/ha also recorded 22.2 and 70.7 per cent more uptake of total N as compared to 20 kg/ha and control, respectively and thus proved equally effective to 40 kg/ha. The highest uptake of 57.3 kg N/ha was recorded under the variety RT-351 indicating a significant increase of 6.7, 12.8 and 28.8 per cent over RT-346, RT-127 and RT-125 varieties,

respectively. Being at par with each other, RT-346 and RT-127 also registered a quantum increase of 6.72 and 6.29 kg N/ha over RT-125, respectively and thus observed as the next better varieties in enhancing N uptake by crop. It is presented in table-1 that every addition in graded level of sulphur upto 40 kg/ha resulted in significantly higher uptake of phosphorus over lower levels. All the varieties of sesame recorded significantly higher uptake of phosphorus than RT-125 (Table-2) remaining at par with each other, RT-346 and RT-127 improved the total uptake of P by 16.7 and 13.5 per cent over RT-125, respectively. The maximum uptake of 10.9

Table-1 : Effect of sulphur fertilization and varieties on N concentration in seed and stalk of sesame and its uptake.

Treatments	N concentration (%)		Total N uptake (kg/ha)
	Seed	Stalk	
Sulphur levels (kg/ha)			
Control	2.64	1.05	35.6
20	3.05	1.20	49.7
40	3.35	1.27	57.9
60	3.44	1.31	60.7
SEm +	0.06	0.03	1.33
CD (P=0.05)	0.19	0.08	3.83
Varieties			
RT-125	3.07	1.18	44.5
RT-127	3.16	1.21	50.8
RT-346	3.07	1.20	51.2
RT-351	3.18	1.24	57.3
SEm +	0.06	0.03	1.33
CD (P=0.05)	NS	NS	3.83
CV (%)	7.17	7.89	9.01

NS-Nonsignificant

Table-2 : Effect of sulphur fertilization and varieties on P concentration in seed and stalk of sesame and its uptake.

Treatments	P concentration (%)		Total P uptake (kg/ha)
	Seed	Stalk	
Sulphur levels (kg/ha)			
Control	0.605	0.176	6.86
20	0.711	0.199	9.72
40	0.735	0.205	10.86
60	0.752	0.213	11.37
SEm +	0.014	0.004	0.24
CD (P=0.05)	0.041	0.011	0.70
Varieties			
RT-125	0.683	0.195	8.44
RT-127	0.705	0.197	9.62
RT-346	0.698	0.199	9.85
RT-351	0.715	0.202	10.92
SEm +	0.014	0.004	0.24
CD (P=0.05)	NS	NS	0.70
CV (%)	7.09	6.45	8.62

NS-Non significant

kg P/ha was obtained under RT-351 that was higher by 1.07, 1.3 and 2.46 kg/ha over RT-351, RT-127 and RT-125, respectively. It was observed that total uptake of sulphur by crop was improved considerably with every increase in level of sulphur upto 40 kg/ha. Ahead increase in level of sulphur to 60 kg/ha also recorded significantly higher uptake of total sulphur. However, it was found statistically at par with 40 kg S/ha. Significant difference in total uptake of S was noted under different varieties of sesame (Table 3). Variety RT-346 and RT-127 recorded the total uptake of 5.13 and 4.94 kg S/ha. Remaining at

par with each other, these varieties improved the uptake by margin of 31.4 and 18.5 per cent over RT-125. The maximum uptake of 5.69 kg S/ha was obtained under RT-351 thereby increasing it to the extent of 15.2 and 31.4 per cent over RT-127 and RT-125, respectively. Higher uptake of N, P and S is directly associated with the higher nutrient concentration and increased seed and stalk yields due to application of sulphur. Several workers have also reported higher N, P and S concentrations and uptake due to S application (Kumar and Trivedi 2008, and Kader and Mona, 2013).

Protein, oil content and oil yield in seed : It is found that application of sulphur at 40 kg/ha significantly improved the crude protein, Oil content and oil yield in sesame seed as compared to 20 kg/ha and control, respectively. Further increase in level of sulphur to 60 kg/ha was found the highest protein content, oil content and oil yield but the difference between these two levels was not upto the level of significance. Results showed that none of the sesame variety could bring variation in crude potein content of sesame seed upto the levels of significance. The maximum oil content and oil yield was observed under the variety RT-351 which represented a significant increase of per cent over RT-127 and RT-125, respectively. However, it showed statistical similarity with RT-346 which also recorded higher oil content and oil yield than RT-125. The variety RT-125 was also found at par with RT-346 in this quality attribute of sesame. The lesser oil content and oil yield obtained with other varieties was the result of lower percentage of oil along with the lesser seed yield. Results obtained by Kewat *et al.* (2009) in sesame clearly showed that sesame varieties varied significantly in their oil content. Sulphur synthesized some sulphur containing amino acids like cystine, cystein and methionine and resulted in higher protein content which is in accordance with the findings of Saren *et al.* (2004). These results are also in agreement with the findings of Vaiyapuri *et al.* (2003) and Maragatham *et al.* (2006).

Sulphur use efficiency : A comparison of data presented in revealed that agronomic efficiency, apparent recovery and physiological efficiency of applied sulphur in sesame showed negative response with increasing levels of sulphur. Raising the level of sulphur from control to 20 kg/ha recorded the highest agronomic efficiency, apparent recovery and physiological efficiency in sesame. Afterwards, it showed significant decline upto 60 kg/ha, wherein, the lowest agronomic efficiency, apparent recovery and physiological efficiency was recorded. sesame varieties differed significantly with respect to agronomic efficiency and apparent recovery of sulphur wherein the highest efficiency was obtained under the variety RT-351 which was significantly higher than rest of the varieties. Remaining at par with each other, RT-346

Table-3 : Effect of sulphur fertilization and varieties on S concentration in seed and stalk of sesame and its uptake.

Treatments	S concentration (%)		Total S uptake (kg/ha)
	Seed	Stalk	
Sulphur levels (kg/ha)			
Control	0.162	0.135	3.64
20	0.188	0.152	4.94
40	0.197	0.160	5.60
60	0.210	0.166	5.91
SEm +	0.004	0.004	0.14
CD (P=0.05)	0.012	0.010	0.40
Varieties			
RT-125	0.182	0.148	4.33
RT-127	0.186	0.153	4.94
RT-346	0.191	0.155	5.13
RT-351	0.198	0.158	5.69
SEm +	0.004	0.004	0.14
CD (P=0.05)	0.012	NS	0.40
CV (%)	7.50	8.06	9.63

NS-Non significant

Table-4 : Effect of sulphur fertilization and varieties on protein and oil content in sesame seed and oil yield.

Treatments	Protein content (%)	Oil content (%)	Oil yield (kg/ha)
Sulphur levels (kg/ha)			
Control	16.50	44.03	245.6
20	19.06	47.51	342.3
40	20.94	50.75	395.9
60	21.50	51.11	403.9
SEm +	0.53	1.08	9.36
CD (P=0.05)	1.53	3.12	27.02
Varieties			
RT-125	19.19	46.44	289.0
RT-127	19.75	47.89	337.2
RT-346	19.19	49.79	358.6
RT-351	19.88	51.18	402.9
SEm +	0.53	1.08	9.36
CD (P=0.05)	NS	3.12	27.02
CV (%)	9.43	7.73	9.24

NS-Non significant

and RT-127 also resulted significant improvement of in agronomic efficiency and apparent recovery of sulphur as compared to RT-125, respectively. Further study of data (Table 5) revealed that the physiological efficiency of sulphur in sesame did not differ significantly among different varieties. Results obtained by Raja *et al.* (2007) and Rajiv *et al.* (2012) also corroborate with the findings of present investigation who reported that higher sulphur use efficiency of sesame varieties was directly correlated with higher values sulphur.

Table-5 : Effect of sulphur fertilization and varieties on sulphur use efficiency in sesame.

Treatments	AEs (kg seed/kg S)	REs (%)	PEs (kg/kg S)
Sulphur levels (kg/ha)			
Control	-	-	-
20	8.11	6.43	126.28
40	5.54	4.91	112.89
60	3.86	3.88	99.57
SEm +	0.15	0.14	2.97
CD (P=0.05)	0.43	0.39	8.56
Varieties			
RT-125	3.84	3.27	86.54
RT-127	4.35	3.73	85.67
RT-346	4.45	3.90	83.83
RT-351	4.86	4.33	82.71
SEm +	0.17	0.16	3.42
CD (P=0.05)	0.50	0.45	NS
CV (%)	8.91	9.21	9.10

AEs = Agronomic efficiency of sulphur (kg seed/kg S)

REs = Apparent recovery of sulphur (%)

PEs = Physiological efficiency of sulphur (kg seed /kg uptake of S)

Conclusions

On the basis of results summarized that N, P and S concentration in seed and straw, their total uptake, protein and oil content in seed and oil yield were improved significantly upto 40 kg S/ha. Being at par with 60 kg/ha, sulphur fertilization at 40 kg/ha also exclude 12.7 and 64.2 per cent more net returns over 20 kg/ha and control, respectively. Similarly, RT-351 was found the most superior variety of sesame wherein, the maximum total uptake, protein and oil content in seed and oil yield were recorded. On the basis of production function, application of sulphur at 49.19 kg/ha was worked out to be the optimum dose for sesame.

Future Scope : The present investigation has opened up new sesame varieties information and given rise to new ideas on sulphur use efficiency. Therefore, there is a decreasing trend in sesame production. Several factors such as pests and diseases, declining soil fertility status, drought, low yielding varieties, poor agronomic practices could be the major problems affecting production. However, among these challenges, production of sesame seeds by the farmer is the most important factor in increasing sesame production since socioeconomic and market related factors are secondary. Increasing sesame yield at farmer level will boost production because seed yield directly influences the quantity harvested. Sesame seed production could be increased through increasing area under cultivation while adopting proper agronomic practices. Therefore, there is need for intervention by farmers, policy makers, researchers and other stakeholders to increase sesame seed production. Future

research should focus on how to increase seed yield on farmers' fields and bridge the yield gap between researchers and farmers while adopting good agronomic practices of sesame production.

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Genetic Analysis for Agro-Physiological Characters of Pigeonpea [*Cajanus cajan* (L.) Millsp.] under Rainfed Condition

Lekha Ram^{1*} and Balram Baraiya²

¹Department of Plant Breeding and Genetics, R.A.K. College of Agriculture, Sehore, Madhya Pradesh-466001

²Department of Plant Physiology, R.A.K. College of Agriculture, Sehore, Madhya Pradesh-466001

*Corresponding author's email: lekhamscientist@gmail.com

Abstract

The present investigation was carried out during kharif 2017-2018 in randomized complete block design with three replications on sixteen genotypes to get the estimate of genetic variability, correlation coefficient and path analysis for sixteen characters including yield attributing and physiological traits. Analysis of variance exhibited significant differences among genotypes for all the characters. The elevated estimates of heritability coupled with elevated genetic advance as per cent of mean were recorded for seed yield per plant, number of seeds per pod, biological yield per plant, number of seeds per plant, number of secondary branches per plant, number of primary branches per plant, harvest index and number of pods per plant indicated that these characters were controlled by additive gene action and direct selection for these traits would be more effective for desired genetic improvement. Seed yield per plant showed positive association with number of seeds per plant, biological yield per plant, number of seeds per pod, days to 50 % podding, harvest index, number of pods per plant, 100-seed weight, number of primary branches per plant and plant height indicated that direct selection for these traits may lead to increase in genetic potential of seed yield. Path coefficient analysis revealed that traits viz., biological yield per plant, harvest index, number of seeds per plant and number of pods per plant exhibited highest positive direct effect and some traits have indirect positive effects on seed yield and these traits must be given preference while selecting the superior genotypes.

Key words : Agro-physiological characters, correlation, genetic advance, heritability, direct and indirect effect, pigeonpea, rainfed condition.

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an often cross pollinated crop with $2n=2x=22$ chromosomes belongs to the family Leguminosae. India is considered as the centre of origin of pigeonpea (Van der Maesen, 1990). Pigeonpea is a deep rooted and drought-tolerant leguminous food crop. It can grow in any warm climate; particularly throughout tropical and subtropical regions. It is highly proteinaceous and its seed contains 62.78 g. carbohydrates, 21.7 g. proteins and 1.49 g. fats per 100 grams (Techale et al. 2013). In India, pigeonpea has been grown on 4.2 million ha area with 3.68 million tons production and 832 kg per ha productivity, whereas in Madhya Pradesh it has been grown 6.47 lakh ha area with 8.07 lakh tons production and 1247 kg per ha productivity (Anonymous 2018-19).

The identification and development of drought tolerant genotypes due to extrinsic properties to withstand drought conditions has attracted the attention of scientists at globally to select appropriate genotypes that are insensitive to environmental fluctuations and can contribute sustainable yield. A clear understanding of variability in various quantitative characters existing in the breeding material helps plant breeder in selecting superior genotypes on the basis of different genetic

parameters. Therefore, it is necessary to estimate the relative amount of genetic and non-genetic variability exhibited by the characters under study. Estimation of genetic variability including heritability estimates and expected genetic advance for the particular character and correlation between these characters with the aim that some components which are less susceptible to environmental vagaries may provide more efficient basis of selection. The seed yield is not an independent character; it is a complex in nature and depends on the number of component characters that are quantitatively inherited (Rao and Rao, 2020). Thus, the selection pressure given only on the yield is misguided many times. The knowledge on the nature of association of the yield and its attributes enable a plant breeder to plan an effective breeding programme (Rao and Rao, 2020). Keeping this in consideration, the present investigation was undertaken to elucidate the nature and extent of genetic variability including heritability, genetic advance and to identify the seed yield influencing characters of pigeonpea.

Materials and Methods

The experimental material for present investigation consisted of sixteen genotypes of pigeonpea which was laid out in a randomized complete block design (RCBD)

ABBREVIATED FORM	CHARACTERS
DFI	= Days to flower initiation
DFF	= Days to 50% flowering
DFP	= Days to 50% podding
DM	= Days to maturity
PH	= Plant height (CM)
NPBPP	= Number of primary branches per plant
NSBPP	= Number of secondary branches per plant
NPPP	= Number of pods per plant
NSPP	= Number of seeds per plant
NS/Pod	= Number of seeds per pod
BYPP	= Biological yield per plant (g)
SYPP	= Seed yield per plant (g.)
HSW	= 100-Seed weight (g.)
HI	= Harvest index (%)
CC	= Chlorophyll content
LRWC	= Leaf relative water content

with three replications during kharif 2017-18. Each genotype was sown in 12 sq. m. (5.00 m × 2.4 m) plot size adopting 60 cm (Row to Row), 25 cm (Plant to Plant). The recommended package of practices for pigeonpea was adopted for growing and maintaining the healthy crop. The field experiment was conducted at the Research Farm, AICRP on Dryland Agriculture, College of Agriculture, Indore (M.P.). The experimental area was quite uniform with respect to topography and fertility. Indore is situated between latitude 20°43' N and longitude 76°54' E and at an altitude of 567 meters above the mean sea level in Malwa plateau (X ACZ) of western part of Madhya Pradesh. It has sub-tropical and semi-arid climate having a temperature ranged from 6.5°C to 44°C during winter and summer, respectively. Observations on characters viz. plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per plant, number of seeds per pod, seed yield per plant, biological yield per plant, 100-seed weight, harvest index, chlorophyll content and leaf relative water content were recorded on five randomly selected tagged plants, while the observations on days to flower initiation, days to 50% flowering, days to 50% podding, days to maturity were recorded on the basis of plot of each genotype under each replication. Genotypic coefficients of variation (GCV) and Phenotypic coefficients of variation (PCV) were calculated by the formulae given by Burton, 1952. The heritability was calculated by the formula as suggested by Hanson et al., 1956. The expected genetic advance (GA) as per cent of mean and phenotypic and genotypic correlation coefficients was computed according to the formula suggested by Johnson *et al.* (1995). The

Table-1 : List of pigeonpea genotypes used in the present study.

S. No.	Genotypes	S. No.	Genotypes
1.	TJT-501	9.	C-11
2.	ICP8863-08-39	10.	Pusa-992
3.	ICP8863-08-40	11.	DT-501
4.	ICP8863-08-41	12.	UPAS-120
5.	JKM-189	13.	MN-5
6.	JA 4-08-20	14.	ICPL 88039 08-01
7.	JKE-114 E	15.	ICPL 88039 08-02
8.	JA-4	16.	ICPL 88039 08-02

genotypic and phenotypic correlation and pathway analysis (Dewey and Lu, 1959) were calculated according to the procedure as described by Singh and Chaudhary (1985). Chlorophyll content estimated by the SPAD-502 a hand held chlorophyll meter was used for rapid and non-destructive estimation of chlorophyll in leaves. Leaf relative water content (RWC) was calculated by the formula as suggested by Kramer (1983).

Results and Discussion

Genetic variability is a prerequisite to improve any character of crop. Analysis of variance was carried out for all the characters under investigation. The analysis of variance was disclosed that differences among the genotypes were highly significant for all the characters (Table-2). It indicated that there was a wide range of variation observed for all the traits in the investigated material and signifies the importance of genetic components for these traits. The variability was further splitted into phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) to get an obvious picture about the variability in the material. Maximum PCV (21.4) and GCV (21.0) were recorded for the character seed yield per plant followed by number of seeds per plant (20.8 and 20.7). In present study, the phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the characters. At par results have been reported by Rangare et al. (2013), Shuny *et al.* (2013), Sharma et al. (2014) and Verma et al. (2018) for seed yield per plant. Findings in similar trend have been reported by Mallesh *et al.* (2017) for number of primary branches per plant and number of pods per plant. Similar trend was reported by Pushpavalli *et al.* (2018) for 100-seed weight and plant height.

In the present study, high estimates of heritability were recorded by characters viz., biological yield per plant (97.7), number of seeds per pod (97.3), seed yield per plant (96.3), number of seeds per plant (94.3) and harvest index (93.3). Results in similar trend were reported by Chetukuri (2013) as they observed high heritability for all the characters examined except days of

Table-2 : Analysis of Variance for various Agro-physiological Traits in Pigeonpea.

S. No.	Characters	Mean sum of squares		
		Replications	Treatments	Error
1.	DFI	8.92	19.27**	1.04
2.	DFF	14.63	43.70**	1.31
3.	DFP	8.75	73.78**	1.17
4.	DM	5.71	41.83**	3.9
5.	PH	56.09	64.83**	8.09
6.	NPBPP	0.25	9.92**	0.77
7.	NSBPP	8.37	753.96**	14.63
8.	NPPP	8.24	1359.75**	52.94
9.	NSPP	96.29	18758.82**	244.74
10.	NS/Pod	0.01	0.30**	0.01
11.	BYPP	7.2	1398.91**	1.38
12.	SYPP	0.23	152.16**	0.74
13.	HSW	0.03	1.02**	0.05
14.	HI	0.57	28.59**	0.47
15.	CC	0.52	17.28**	0.45
16.	LRWC	0.59	36.62**	0.57

*Significant at 5 % and **Significant at 1 % level of probability.

Table-3 : Estimates of mean, range, GCV, PCV, heritability (h²bs) and genetic advance as per the mean.

Characters	General Mean	Range		GCV (%)	PCV (%)	Heritability (h ² bs) (%)	Genetic Advance	Genetic Advance (%)
		Min	Max					
DFI	106	101	110	2.3	2.5	83.7	4.6	4.4
DFF	113	107	122	3.2	3.4	89.7	7.3	6.5
DFP	125	115	133	3.8	3.9	93.5	9.8	7.8
DM	165	160	171	2.1	2.4	74.9	6.3	3.8
PH	210	204	221	2.0	2.4	68.6	7.4	3.5
NPBPP	12	9	15	13.6	15.3	78.0	3.2	25.6
NSBPP	115	87	142	13.5	13.9	92.7	31.7	27.7
NPPP	189	139	215	10.7	11.3	87.4	40.2	21.2
NSPP	363	220	471	20.7	20.8	94.3	157.1	43.3
NS/Pod	2	1	2	16.4	16.5	97.3	0.6	34.6
BYPP	128	74	152	16.3	16.3	97.7	44.0	34.2
SYPP	33	18	41	21.0	21.4	96.6	14.4	43.2
HSW	10	8	10	5.8	6.3	84.6	1.1	11.3
HI	25	22	31	11.7	12.0	93.3	6.1	24.0
CC	43	39	46	5.4	5.6	90.6	4.6	10.9
LRWC	42	38	47	8.1	8.3	93.5	6.9	16.6

pod initiation, Mallesh *et al.* (2017) for days to 50% flowering, seed yield per plant, number of pods per plant and plant height, Pushpavalli *et al.* (2018) for days to 50 % flowering, days to maturity, number of pods per plant and 100-seed weight, Verma *et al.* (2018) for plant height, days to maturity, days to 50 % flowering, number of pods per plant and number of seeds per pod. High heritability estimate coupled with high genetic advance was exhibited by seed yield per plant (96.3, 43.2), number of seeds per plant (94.3, 43.3), biological yield per plant

(97.7, 34.2), number of seeds per pod (97.3, 34.6), number of secondary branches per plant (92.7, 27.7) and harvest index (93.3, 24.0) indicating lesser influence of environment in expression of these characters and presence of additive gene action, therefore these characters are amenable for simple selection. These results were in agreement with the Sharma *et al.* (2014) for number of seeds per plant and number of pods per plant, Birhan *et al.* (2013) for seed yield per plant, biological yield per plant and harvest index, Rangare *et al.* (2013), Shuny *et al.* (2013), Vanisree *et al.* (2013), Mallesh *et al.* (2017), Meena *et al.* (2017) for seed yield per plant and number of pods per plant, Rangare *et al.* (2013) for biological yield per plant and harvest index, Shuny *et al.* (2013) and Meena *et al.* (2017) for number of primary branches per plant. High heritability with moderate genetic advance was reported for leaf relative water content, 100-seed weight and chlorophyll content. High heritability with low genetic advance was reported for days to 50 % podding, days to 50 % flowering, days to flower initiation, days to maturity and plant height. It indicated that non-additive genes play major role in the

inheritance of these characters, thus, the direct selection based on these characters will not be appropriate and reliable. These results are in conformity with the findings of Pushpavalli *et al.* (2018) for days to 50 % flowering.

Estimation of correlation coefficients among different pairs of characters under the study exhibited in table-4. Seed yield per plant was positively and significantly correlated with number of seeds per plant (0.866), biological yield per plant (0.809), number of seeds per pod (0.764), days to 50% podding (0.725), harvest index

Table-4 : Genotypic correlation analysis among various agro-physiological traits in pigeonpea.

Character	DFI	DFP	DM	PH	NPBPP	NSBPP	NPP	NSPP	NS/Pod	HSW	BYPP	HI	CC	LRWC	SYPP
DFI	1	0.690**	0.825**	0.759**	0.254	0.563**	0.228	0.582**	0.540**	0.380*	0.766**	0.264	-0.379*	0.688**	0.727**
DFP		1	0.910**	0.788**	0.023	0.221	0.157	0.483**	0.344	0.188	0.730**	0.155	-0.227	0.224	0.631**
DM			1	0.810**	0.238	0.434*	0.397*	0.532**	0.449*	0.297	0.756**	0.216	-0.411*	0.356*	0.725**
PH				1	-0.134	0.333	0.302	0.378*	-0.065	-0.251	0.780**	-0.194	-0.489**	0.586**	0.282
NPBPP					1	0.747**	0.697**	0.473**	0.742**	0.648**	0.404*	0.440*	-0.115	0.043	0.535**
NSBPP						1	0.800**	0.787**	0.577**	0.292	0.737**	0.254	-0.667**	0.327	0.584**
NPP							1	0.492**	0.265	0.070	0.544**	0.050	-0.649**	0.062	0.313
NSPP								1	0.595**	0.212	0.786**	0.123	-0.291**	0.261	0.595**
NS/Pod									1	0.888**	0.471**	0.622**	-0.078	0.086	0.866**
HSW										1	0.177	0.690**	0.033	-0.018	0.764**
BYPP											1	0.767**	-0.430*	0.524**	0.591**
HI												1	-0.491**	0.360*	0.809**
CC													1	-0.346	0.669**
LRWC														1	-0.368*
SYPP															1

Table-5 : Direct (Diagonal bold) and indirect effects for agro-physiological traits in pigeonpea.

Character	DFI	DFP	DM	PH	NPBPP	NSBPP	NPP	NSPP	NS/Pod	HSW	BYPP	HI	CC	LRWC	SYPP
DFI	0.034	-0.024	0.007	-0.003	0.002	-0.001	-0.155	0.258	-0.163	-0.014	0.618	0.157	-0.006	0.010	0.727
DFP	0.024	-0.034	0.007	0.000	0.001	-0.001	-0.129	0.171	-0.081	-0.011	0.585	0.092	0.003	-0.003	0.631
DM	0.029	-0.032	0.008	-0.002	0.001	-0.002	-0.142	0.223	-0.128	-0.013	0.649	0.128	-0.004	0.003	0.725
PH	0.027	-0.028	0.006	0.003	0.001	-0.001	-0.101	-0.032	0.108	-0.013	0.417	-0.115	-0.005	0.006	0.282
NPBPP	0.009	-0.001	0.002	-0.010	0.002	-0.003	-0.126	0.359	-0.279	-0.008	0.329	0.261	0.002	-0.001	0.535
NSBPP	0.020	-0.008	0.003	-0.008	0.003	-0.004	-0.210	0.287	-0.125	-0.013	0.479	0.151	0.012	-0.006	0.584
NPP	0.008	-0.005	0.003	-0.007	0.002	0.005	-0.131	0.131	-0.030	-0.009	0.312	0.030	0.001	0.000	0.313
NSPP	0.020	-0.017	0.004	-0.005	0.002	-0.002	0.161	0.155	-0.091	-0.013	0.298	0.081	-0.009	0.008	0.595
NS/Pod	0.019	-0.012	0.004	-0.007	0.002	-0.001	-0.159	0.487	-0.382	-0.008	0.553	0.370	0.006	-0.005	0.866
HSW	0.013	-0.007	0.002	-0.007	0.001	0.000	-0.056	0.441	-0.421	-0.003	0.392	0.410	0.003	-0.002	0.764
BYPP	0.029	-0.023	0.006	-0.005	0.002	-0.003	-0.210	0.234	-0.076	-0.017	0.617	0.030	-0.002	0.002	0.591
HI	0.027	-0.025	0.006	-0.004	0.002	-0.002	-0.195	0.348	-0.214	-0.013	0.803	0.156	-0.353	0.268	0.809
CC	0.009	-0.005	0.002	-0.004	0.001	0.000	-0.033	0.309	-0.297	-0.001	0.152	0.581	0.157	-0.200	0.669
LRWC	0.027	0.052	0.009	0.023	0.015	0.014	0.155	0.082	-0.113	0.009	0.011	-0.014	-0.009	0.028	0.273
SYPP	0.002	0.001	0.001	0.002	0.009	0.000	0.007	0.000	0.000	0.032	0.015	-0.005	-0.001	0.019	0.082

(0.669), number of pods per plant (0.595), 100-seed weight (0.591), number of primary branches per plant (0.584) and plant height (0.535). The association analysis revealed that number of seeds per plant, biological yield per plant, number of seeds per pod, days to 50% podding, days to flower initiation, harvest index, days to 50% flowering, number of pods per plant, 100-seed weight, number of primary branches per plant and plant height were the important characters and may be selected to increase the seed yield. Present findings also revealed that by making selection for a particular character, simultaneous improvement in the associated characters may be achieved. The current findings are in line with those of Bhadru *et al.* (2010), Thanki *et al.* (2010), Rathore and Sharma (2011), Saroj *et al.* (2013), Chandana *et al.* (2014), Chitraneenal and Jebaraj (2015), Singh and Singh (2016), Pandey *et al.* (2016), Kesha Ram *et al.* (2016), Kothimbire *et al.* (2016), Meena *et al.* (2017), Pushpavalli *et al.* (2018) and Verma *et al.* (2018) for number of pods per plant, Saroj *et al.* (2013) for 100-seed weight, days to 50 % flowering, number of secondary branches per plant and number of primary branches per plant, Chandana *et al.* (2014), Chitraneenal and Jebaraj (2015), Kesha Ram *et al.* (2016), Kothimbire *et al.* (2016) for number of secondary branches per plant and number of primary branches per plant, Gendley *et al.* (2015) for plant height and 100-seed weight, Pandey *et al.* (2016) for biological yield per plant, number of secondary branches per plant, harvest index and 100-seed weight, Verma *et al.* (2018) for number of primary branches per plant and plant height and number of seeds per pod.

In the present investigation, the pathway analysis showing the direct and indirect effects of different traits was shown in table-5. The efficiency of selection in any breeding program mainly depends on the knowledge of the association of characters. Although the correlation coefficient indicates the nature of the association between traits, but path coefficient analysis splits the correlation values into direct and indirect effects to measure the relative importance of the involved causal factors. Biological yield per plant was exhibited the highest direct effect (0.803) on seed yield per plant followed by harvest index (0.581), number of seeds per plant (0.487) and number of pods per plant (0.161). This investigation revealed that substantial positive direct effect on seed yield was exerted by biological yield per plant followed by harvest index, number of seeds per plant and number of pods per plant. Therefore, these traits may be considered as the key traits while selecting for seed yield per plant and selection indices may be constituted by considering all these characters to improve seed yield per plant. Findings in similar trend were

reported by Thanki *et al.* (2010), Chandana *et al.* (2014), Pandey *et al.* (2016) for harvest index; Rathore and Sharma (2011), Vijayalakshmi *et al.* (2013) and Meena *et al.* (2017) for number of seeds per plant, Pandey *et al.* (2016) for number of seeds per plant and biological yield per plant. Contradictory result have also been reported by Bhadru *et al.* (2010), Saroj *et al.* (2013), Kesha Ram *et al.* (2016), Kothimbire *et al.* (2016), Meena *et al.* (2017), Pushpavalli *et al.* (2018) and Verma *et al.* (2018) for number of pods per plant. In this study, the characters viz., number of seeds per plant, biological yield per plant, number of seeds per pod and harvest index have the positive direct association with the seed yield per plant. Thus, these characters may be considered, while selecting the plant to increase seed yield.

Conclusions

The elevated estimates of heritability coupled with elevated genetic advance was recorded for seed yield per plant, number of seeds per pod, biological yield, number of seeds per plant, number of secondary branches per plant, number of primary branches per plant, harvest index and number of pods per plant indicated that these characters are governed by additive gene effects and direct selection for these characters would be more effective for genetic improvement in seed yield per plant. Seed yield per plant exhibited significantly positive relationship with number of seeds per plant, biological yield per plant, number of seeds per pod, days to 50 % podding, harvest index, days to 50 % flowering, number of pods per pod, 100-seed weight and number of primary branches per plant indicated that direct selection for these traits could increase the genetic potential of seed yield per plant. Selection would be more effective for the characters viz., number of seeds per plant, biological yield per plant, number of seeds per pod, days to 50 % podding, days to flower initiation, harvest index, days to 50 % flowering, number of pods per plant, 100-seed weight, number of primary branches per plant and plant height since, these characters were under the influence of additive gene action and they had highly significant and positive correlation with seed yield per plant. Path coefficient analysis revealed that traits such as biological yield per plant, harvest index and number of seeds per plant exhibited the highest positive direct effects and some traits have indirect positive effects on seed yield per plant and that each character must be given preference in selecting the superior types.

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Response of Management Practices on Growth Parameters and Yield of Wheat under Rice-Wheat Cropping System in Reclaimed Sodic Soils

Meena Choudhary¹, Vivek¹ and P.C. Sharma²

¹Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250110, Uttar Pradesh

²ICAR-Central Soil Salinity Research Institute, Karnal-132001, Haryana India

*Corresponding Author Email : meenac1191@gmail.com

Abstract

A field trial was carried out at ICAR- Central Soil Salinity Research Institute, Karnal (Haryana) to study the management (tillage, residue management and planting time) influence on weed dynamics, crop productivity and profitability in wheat under rice-wheat crop rotation. The experiment consisted of 4 main plot treatments (tillage and residue management) viz. conventional tillage (CT), zero tillage (ZT), ZT with anchored residue (ZTAR) and ZT with full residue (ZTFR); and 3 sub plot treatments (planting dates) viz. 25-October, 5-November and 15-November, laid out in Split Plot Design with three replications. Planting of wheat on 25-October recorded maximum and significantly higher plant height over 5-November and 15-November at 30, 60, 90, 120 DAS and at harvest. The result revealed that the increased in dry matter accumulation of zero till wheat with full residue was 22.04%, 13.81%, 10.20%, 4.75% and 4.29% at 30, 60, 90, 120 DAS and at harvest over conventional tillage respectively. ZTFR recorded significantly higher grain and straw yield (5.08 and 7.05 t/ha respectively). At early sowing, ZTFR recorded maximum and significantly higher yields (Grain and straw; 4.91 and 7.17 t/ha respectively). This study revealed that early ZT planting of wheat with residue retention may help in harnessing the full production potential of the crop under north-western Indo-Gangetic plains (IGP).

Key words : Tillage and residue management, planting dates, wheat.

Introduction

Rice-Wheat Cropping System (RWCS) provides the staple grain supply for a large portion of the world's population and is critically important for global food security. In south Asia, RWCS produce more than 30% of the rice and 42% of wheat and covers around 13.5 million hectare of cultivated land. Indo-Gangetic Plains (IGP) of India (10 million ha.) covers the majority of area under this system followed by Pakistan (2.2 million ha.), Bangladesh (0.8 million ha.) and Nepal (0.5 million ha.). RWCS is the backbone of the world food security as it feeds about 1.3 billion people (20% of the humanity) (Farooq *et al.*, 2007; Saharawat *et al.*, 2010). In India, these two major cereals are grown in an area of about 43 and 26 million hectare. 25% of the rice area of the country is grown in rotation involving wheat, whereas 40% of the wheat is grown in rotation with rice.

Wheat (*Triticum aestivum* L.) is the most widely grown and consumed food crop and is the staple food for 35% of the world population. The irrigated wheat systems contribute over 40% of wheat production in the developing world (Rajaram *et al.*, 2007). In India, wheat is not only constitutes the basic component of human diet and staple food but also contributes 14.4 % of the value added agriculture and 3.1 % to GDP. To meet the growing wheat demand, the global production needs an increase in annual growth rate from 1.6% to 2.6%. India being

second largest consumer as well as producer of wheat in the world wherein for the targeted food grain requirement by 2020, wheat has to contribute nearly 35 % (103 million tonnes). This necessitates 13 million tonnes additional wheat production in next five years essentially from same or less land area, less water, less labour, higher energy costs and climate change induced frequent variability in weather events.

Annual wheat yield losses by weeds infestation are much higher than caused by other pests. Worldwide, over 383 weed species have now been reported to have developed resistance to important herbicide. In wheat, yield losses by weeds may range from 10–82% depending upon the density and species of weed. The extent of severity depends upon duration of infestation, competing ability of crop plants under different agro-ecological conditions (Rao, 1994). Wheat generally has both, grassy weed viz. *Phalaris minor*, *Avena spp.* etc. and broad leaves weeds viz. *Chenopodium album*, *Fumariaparviflora*, *Melilotus indica*, *Anagalis arvensis* etc. (Malik *et al.*, 1989). These weeds are responsible for low productivity of wheat by sharing a greater part of nutrients, moisture, space and light with the crop. Besides their direct effect on wheat yield, weeds also lower the market value and hence bring enormous economic losses to the growers (Rao *et al.*, 1992). Weeds consume at least as much nutrients as crop plants. Moreover, in row crops much of the cost of inter-tillage, seedbed

Table-1 : Physico-chemical properties of experimental soil.

Soil properties	Value	Method Used
A. Mechanical Composition		
Sand (%)	19.54	International pipette method (Piper, 1966)
Silt (%)	46.56	
Clay (%)	33.90	
Texture	Loam	
B. Chemical analysis		
pH (1:2)	8.2	Glass electrode pH meter method (Jackson, 1973)
EC dSm ⁻¹ (1:2)	0.42	Conductivity bridge method (Richards, 1954)
Organic carbon (%)	0.43	Walkley and Black rapid titration method (Jackson, 1973)
Available N (kg ha ⁻¹)	135	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P (kg ha ⁻¹)	12	Olsen's method (Olsen <i>et al.</i> , 1954)
Available K (kg ha ⁻¹)	320	Flame photometric method (Jackson, 1973)

Table-2 : Effect of tillage and residue management and planting dates on plant height (cm) of wheat.

Treatment	Plant height (cm)				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
Main plot: Tillage and residue management					
Conventional tillage	23.70	46.09	84.64	100.62	112.29
Zero tillage	23.37	46.03	84.87	100.68	113.47
Zero tillage with anchored residue	23.01	46.93	85.48	103.87	113.80
Zero tillage with full residue	23.41	46.96	86.12	104.89	114.02
SEm	0.421	0.637	0.824	1.385	0.441
CD at 5%	NS	NS	NS	NS	NS
Sub plot : Planting dates					
25-October	24.15	48.41	86.89	103.75	114.62
5-November	23.23	45.83	85.04	102.88	113.00
15-November	22.73	45.27	83.90	100.91	112.57
SEm	0.226	0.606	0.597	0.535	0.420
CD at 5%	0.683	1.833	1.807	1.617	1.271

preparation and seed cleaning operations are due to weed infestation. In IGP of India, *Phalaris minor* is a big problem which is responsible for huge loss in the wheat yield. Being the similar in morphology, it is difficult to control until and unless good herbicides are available. To control such a problematic weed, proper herbicide with proper amount, time and stage of crop should be applied. Therefore, the present study was undertaken to assess whether planting date, tillage and crop residue retention would improve wheat growth performance and yield.

Materials and Methods

A field experiment was conducted during *Rabi* 2013-14 on CSISA (Cereal Systems Initiative for South Asia) research platform at ICAR-Central Soil Salinity Research Institute (29.42° N latitude, 76.57° E longitude and at an elevation of 243 m above msl), Karnal, Haryana, India. Climate of the region is semi-arid and sub-tropical with extreme hot and dry to wet summers (June-October) and cold dry winters (November-April), with an average annual rainfall of 670 mm (75–80% of which is received during southwest monsoon), minimum temperature of 0-4° C in January, maximum temperature of 41-46°C in

June, and relative humidity of 60-95% throughout the year. The soil of the experimental field was a deep alluvial silty loam (45.3% sand, 33.4% silt and 21.4% clay) neutral in reaction (pH-8.02), low in organic carbon (0.43%), available nitrogen (135 kg ha⁻¹), medium in available phosphorus (12 kg ha⁻¹) and high in available potassium (320 kg ha⁻¹). Sowing of wheat (cultivar; HD 2967) was done using a *Turbo-seeder* at a row spacing of 20 cm with a seed rate of 100 kg ha⁻¹ as per the treatments. The recommended dose of NPK (150:64:32 kg ha⁻¹) fertilizer was applied through NPK complex fertilizer (12:32:16) and urea by following the standard procedure. Crop was managed as per the recommended package of practices. A crop residue load of 2.5 and 8.0 Mg ha⁻¹ was maintained in the field under ZTAR and ZTFR plots, respectively. Weed dynamics (density and biomass) was recorded at 30 days after sowing (DAS) using quadrat sampling in already demarcated 50 x 50 cm area in the plot. Ten plants per plot were tagged randomly in each plot for recording their height. The height was measured from ground level to the tip of last fully opened leaf. The plant samples for dry matter accumulation were sun dried and then dried in oven at 72°C ± 0.5 °C for 72 hours or till the

Table-3 : Effect of tillage and residue management and planting dates on dry matter accumulation (g/metre row length) of wheat.

Treatment	Dry matter accumulation (g/m row length)				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
Main plot : Tillage and residue management					
Conventional tillage	9.98	33.96	115.80	239.69	253.98
Zero tillage	10.11	34.83	115.53	241.47	255.42
Zero tillage with anchored residue	11.20	36.68	124.72	247.92	262.91
Zero tillage with full residue	12.38	38.65	127.62	251.08	264.90
SEm	0.238	0.902	1.327	1.774	1.473
CD at 5%	0.838	3.181	4.680	6.259	4.984
Sub plot : Planting dates					
25-October	11.50	39.033	123.68	249.91	264.28
5-November	10.87	34.758	120.24	242.65	256.53
15-November	10.43	34.303	118.84	242.56	257.10
SEm	0.194	1.087	0.708	1.596	0.913
CD at 5%	0.587	3.287	2.142	4.827	2.761

Table-4 : Effect of tillage and residue management and planting dates on yield attributes and yield of wheat.

Treatment	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
Main plot : Tillage and residue management		
Conventional tillage	4.54	6.52
Zero tillage	4.63	6.72
Zero tillage with anchored residue	4.81	6.75
Zero tillage with full residue	5.08	7.05
SEm	0.036	0.087
CD at 5%	0.127	0.307
Sub plot : Planting dates		
25-October	4.96	7.17
5-November	4.72	6.78
15-November	4.61	6.34
SEm	0.036	0.054
CD at 5%	0.108	0.164

constant weight were achieved. The dry matter was expressed in gram per meter row length. The produce of each net plot was threshed separately with the help of pull man thresher. The weight of grains was recorded and computed in q ha⁻¹. Weight of total produce per net plot was recorded before threshing (called biological yield, q ha⁻¹). The straw yield was calculated by subtracting the grain yield from the weight of total produce of net plot and expressed in quintal per hectare.

Results and Discussion

Plant height : Plant height at various growth stages varied significantly due to planting dates. Planting of wheat on 25-October recorded maximum and significantly higher plant height over 5-November and 15-November at 30, 60, 90, 120 DAS and at harvest. Delayed planting of wheat on 5-November and 15-November was observed lesser plant height by 3.8% & 5.87%, 5.32% & 6.48%, 2.12% & 3.44%, 0.83% & 2.73% and 1.41% & 1.78% respectively over 25-October. Qasim *et al.*, 2008 reported that early planted wheat yielded maximum plant height

over delayed planting. This might be due to fact that earlier sown crop had longer vegetative growth period then late sown crop resulted in more plant height. Similar results were also reported by Singh *et al.*, (2011).

Tillage and residue management practices failed to affect the plant height at all the growth stages and total tillers of wheat. might be due to better placement of seed in soil and moderation of temperature, suppression of weeds and conserve soil moisture leads to better germination and crop growth. Rajkhowa and Borah (2008) reported that plant height of wheat did not vary significantly due to different straw management practices. The non significant effect of various tillage treatments on plant height may be due to the reduce growth of weeds from hard compact surface on ZT plots, moisture conservation due to surface residues of previous rice crop and efficient utilization of fertilizer due band placement and thus zero tillage with residue had equal performance in comparison to conventional tillage with regard to plant height (Usman *et al.*, 2010).

Dry matter accumulation (g/metre row length) : Data pertaining to dry matter accumulation of wheat (g/metre row length) at various stages of crop growth as influenced by tillage and residue management and planting dates presented in Table-3.

Tillage and residue management caused significant influence on dry matter accumulation of wheat at all stages during the experimentation. Zero tillage with full residue produced highest dry matter and significant over conventional tillage and zero tillage at all the growth stages and being on par with zero tillage with anchored residue at 90, 120 DAS and at harvest. The percent increase in dry matter accumulation of zero till wheat with full residue was 22.04, 13.81, 10.20, 4.75 and 4.29 at 30, 60, 90, 120 DAS and at harvest over conventional tillage respectively.

Grain and straw yield : The grain and straw yield of wheat increase significantly due to tillage and residue management practices during the year (Table-4). Data showed that zero tillage with full residue proved significantly beneficial improving the grain and straw yield over conventional tillage and being on par under zero tillage with anchored residue. However, zero tillage without residue was being on par with the conventional tillage in wheat. Zero tillage with residue increased productivity of grain and straw due to the favorable effects on growth and yield attributes as described earlier. Khankhane *et al.*, (2009) in his study on rice residue management on wheat productivity and soil fertility reported that residue removal is the most inferior and residue incorporation is the most superior among the residue management practices. Management of crop residue can contribute to increase nutrient cycling and greater crop yields (Al-Sheikh A. *et al.*, 2005, Cruse *et al.*, 2009 and Delgado *et al.*, 2007).

The grain and straw yield of wheat increased significantly due to sowing dates during the investigation. The highest values were associated with 25-October sowing followed by 5-November sowing and lowest in 15-November sowing. The increased productivity of earlier planted wheat apparently resulted from their favorable effects on various growth and yield components. Said *et al.*, (2012) reported that maximum biological yield and grain yield were produce from 1st to 15th November followed by 15th December planted wheat in Peshawar, Pakistan while sowing dates had no effects on harvest index. Our results were also supported by Mahboob *et al.*, (2005). Singh *et al.*, (2011) was reported that timely sowing of wheat crop generally gives higher yield as compared to late sown crop. Late sown wheat crop faces high temperature stress during ripening phase and reduces the tillering period as well as hot weather

during grain filling lead to forced maturity thereby reduces the grain yield. These results were also confirmed the findings of Qasim *et al.*, (2008).

Conclusions

In North-western IGP of India, *Turbo-seeder* sowing of wheat in rice-wheat cropping system helps in utilization of crop residues not only to moderate the micro-climatic conditions for better crop growth but also to residue burning. In this belt, ZT along with residue retention not only helps in advances in wheat plantings but also helps in obtaining higher productivity and profitability.

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Effect of Crop Geometry on Performance of Cluster Bean [*Cyamopsis Tetragonoloba* (L.) Taub] Varieties in Arid Western Rajasthan

N.K. Pareek¹, A.S. Bhati², Anand Kumar³ and Shri Rakesh¹

¹Agricultural Research Station, SKRAU, Bikaner, Rajasthan

²Krishi Vigyan Kendra, Banasthali Vidyapith, Tonk, Rajasthan

³Krishi Vigyan Kendra, Keshawana, Jalore, Rajasthan

Email : nkpnutrition@gmail.com

Abstract

Field experiments were carried out during three consecutive *kharif* seasons to study the effect of crop geometry on growth yield and physiological parameters of cluster bean varieties. The 27 treatment combinations comprised; three cluster bean varieties (RGC-936, RGC-1003 and RGC-1066), three row spacing (30, 45 and 60 cm) and three plant to plant spacing (10, 15 and 20 cm) were laid out in Randomized block design with three replications. On the basis of three years pooled data results revealed that variety RGC 936 recorded significantly higher values of number of pods/plant (22.2 pods/plant), seed yield (3.96 q/ha), proline content (0.35 mg/g), membrane stability index (31.0 %) and relative water content (70.8 %). Cluster bean crop sown at 45 cm row spacing produced significantly higher pods/plant, seed yield and proline content in leaf as compared to 30 cm row spacing. Further, results showed that crop sown at 15 cm plant to plant spacing recorded highest number of pods/plant (32 pods/plant) and seed yield (3.90 q/ha).

Key words : Cluster bean, crop geometry, proline, MSI, RWC.

Introduction

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] is a leguminous crop belongs to the family of Fabaceae. Cluster bean is mostly grown in *kharif* season in arid and semi-arid regions of India. It is a drought hardy nature, deep rooted and summer annual legume crop. Like the other legumes, cluster bean is an excellent soil-binding crop and can fix around 37-196 kg atmospheric nitrogen/ha/year in soil. Sometimes it is used in reclamation of saline and alkaline soils (Mahata *et al.*, 2009). Being a chief source of galactomannan (28- 33% guar gum), it has diversified foods and industrial uses viz., textiles, paper, petroleum, pharmaceuticals, food processing, cosmetics, mining explosives, oil drilling etc. India is leading producer of cluster bean in the world and contributing to around 75–82 per cent of the total global production. The Indian arid zone characterized by deficient moisture, nutrient and high sunlight provides optimum agro-climatic conditions for the successful cultivation of cluster bean, as the crop is known for high adaption towards poor and erratic rain, for its need of little surface water, abundant sunshine and low relative humidity during the cropping season (Pathak and Roy 2015). In India, it is mainly cultivated in the rainy season and grown over an area about 3.46 million ha with production of 1.31 million tonnes and average yield of 378 kg/ha (Anonymous 2020). Major producing states in India are Rajasthan, Haryana, Gujarat, Punjab, Uttar Pradesh and Madhya Pradesh. Rajasthan is a major cluster bean

growing and producing state of the country by contributing around 86% and 76% of its area and production, respectively. Total coverage under cluster bean in Rajasthan 2.84 million ha with a production 1.28 million tonnes and the productivity 452 kg/ha (Anonymous 2019). It is mostly grown in districts of Bikaner, Jaisalmer, Ganganagar, Hanumangarh, Badmer, Jodhpur, Churu, Nagaur, Sikar, Jhunjhunu, Jalore, Pali, Sirohi, Jaipur, Alwar and Ajmer.

Cluster bean yield in India is low and highly variable over the past several decades. This may be probably due to low and erratic distribution of rainfall and extreme temperatures. Farmers of arid tract are socio-economically poor and mainly using their own seed with traditional way of cultivating crops including broadcasting of seed leading to poor plant stand and low yield of cluster bean. These days increased availability of improved varieties along with adoption of good agronomic practices helps in improvement in productivity of cluster bean. The yield potential of different varieties of cluster bean may differ under different agro-climatic conditions because of their genetic makeup. Appropriate varieties helps to more efficient use of water, sunshine hours and higher photosynthetic rates. Optimum crop geometry is one of the major management variables under rainfed conditions. In water deficits regions large canopy growth may be disadvantageous as it may exhaust the available soil moisture more rapidly from root zone (Garg *et al.* 2005). The proper distance between plant to plant and

Table-1 : Effect of crop geometry on yield attributes and yield of cluster bean varieties.

Treatments	Plant population (000/ha) at harvest	Pods/plant	Seeds/pod	Test weight (g)	Yield (q/ha)
Varieties					
RGC 936	111.9	22.2	7.8	33.2	3.96
RGC 1003	112.6	21.1	7.7	32.5	3.63
RGC 1066	109.6	18.3	7.5	32.0	3.56
S.Em.	2.4	1.3	0.2	0.8	0.11
C.D. (5%)	NS	3.7	NS	NS	0.34
Row spacing					
30 cm	134.4	17.4	7.6	31.2	3.43
45 cm	106.3	21.6	7.7	33.1	3.81
60 cm	93.4	22.6	7.7	33.4	3.94
S.Em.	2.4	1.3	0.2	0.8	0.11
C.D. (5%)	7.3	3.7	NS	NS	0.34
Plant spacing					
10 cm	130.7	18.9	7.6	31.8	3.46
15 cm	107.5	21.0	7.7	32.8	3.84
20 cm	95.9	21.7	7.7	33.1	3.87
S.Em.±	2.0	0.7	0.1	0.5	0.13
C.D. (5%)	5.8	2.03	NS	NS	0.36

Table-2 : Effect of crop geometry on Relative water content (%), Proline content (mg/g fresh weight), Membrane stability index of cluster bean varieties.

Treatments	Proline content (mg/g fresh weight)	Relative water content (%)	Membrane stability index (%)
Varieties			
RGC 936	0.33	70.8	31.0
RGC 1003	0.30	68.3	28.5
RGC 1066	0.26	64.8	24.1
S.Em. ±	0.01	1.5	1.0
C.D. (5%)	0.04	4.6	3.1
Row spacing			
30 cm	0.27	65.8	27.6
45 cm	0.32	70.1	28.1
60 cm	0.30	68.0	27.9
S.Em. ±	0.01	1.5	1.0
C.D. (5%)	0.04	NS	NS
Plant spacing			
10 cm	0.28	66.4	27.8
15 cm	0.31	69.7	28.0
20 cm	0.30	67.8	27.8
S.Em. ±	0.01	1.1	0.7
C.D. (5%)	NS	NS	NS

row to row ensure proper utilization of different natural inputs, viz., soil plant nutrition, soil moisture, solar radiation and minimize the plant/crop competition for growth and development. The crop spacing depends on the optimum plant stand per unit area and varies for different regions having varied rainfall intensities. In Rajasthan, the area under cluster bean is increasing year after year due to drought hardy nature and better performance under moisture stress situation as compared to traditional legume crops. Looking to the

climatic conditions and socioeconomic conditions of farmers of the arid region, it is of primary importance to identify and develop non-monetary and low cost agronomical practices that helps in harvesting of yield potential of cluster bean.

Considering the above points in view, the experiment was undertaken on the "Effect of crop geometry on performance of cluster bean varieties" at Agriculture Research Station, SKRAU, Bikaner, Rajasthan.

Materials and Methods

Field experiments were conducted under rainfed conditions during three consecutive *kharif* seasons at Agriculture Research Station, SKRAU, Bikaner. The soil of the experimental field was sandy loam in texture, saline in reaction (pH 8.2) and low in available N (112.5 kg/ha), medium in available P (18 kg/ha) with low organic carbon (0.16%) but high in available K (175.3 kg/ha). The 27 treatment combinations comprised three cluster bean varieties viz., RGC-936, RGC-1003 and RGC-1066, three row spacing of 30, 45, 60 cm and three plant to plant spacing of 10, 15, 20 cm were laid out in Randomized block design with three replications. The cluster bean seeds were sown @ 15 kg/ha by line sowing. Other management practices were adopted as per recommendations of the crop under rainfed conditions. At harvest plant stands were counted per square meter area and then converted into 1000 plants per hectare. Five plants were taken randomly at harvest to determine the yield components viz., number of pods/plant, number of seeds/pod and test weight (1000 seed weight). Whole plot was harvested to determine yield per plot for all the plots and recorded in kilogram and converted by using conversion factors to express as kg/ha.

Plant samples were taken from each plot at the time of flowering to record Membrane stability index (MSI), proline content in leaves (mg g^{-1} of fresh weight) and Relative water content (RWC) of leaf discs using standard methods of Premachandra *et al.* (1990) and modified by Sairam *et al.* (1997), Bates *et al.* (1973) and Barrs & Weatherley (1968) respectively.

Data of the various treatments was compared together using CD at 5% significant levels as per the procedure given by Panse and Sukhatme (1967). Microsoft Excel 2000 was used in statistical processing of the data.

Results and Discussion

Plant stands : Results reveal that plant stands were influenced significantly due to crop geometry. Crop sown at 30 cm row spacing and 10 cm plant to plant spacing counted maximum plant stands as compared to rest of crop geometry.

Yield attributes and yield : All the yield attributing characters as pods/plant, No. of seeds/pod, test weight and yield were influenced by different varieties of cluster bean and crop geometry (Table-1). In comparison to other two varieties, variety RGC-936 resulted in higher values of pods/plant, No. of seeds/pod, test weight and yield. Variety RGC-936 recorded significant improvement in pods/plant and yield to the extent of 21.3 and 11.1 per

cent, respectively over variety RGC-1066 under rainfed conditions. The differential behaviour of cluster bean varieties with respect to yield attributes and yield could be explained by the variation in their genetic makeup and adaptability to soil and climatic conditions. The improvement in yield attributes and yield with the variety RGC-936 may be attributed to the increased growth, as a consequence of bushy growing habit along with small leaves and deep roots enabling the plants to extract moisture from deeper layers. This may lead to increased assimilation and accumulation of photosynthates for the formation of number of pods per plant (Singhal *et al.* (2014) in cluster bean). The results were in close conformity with the findings of Garg *et al.* (2003), Parihar *et al.* (2005), Rawat *et al.* (2013) and Meena *et al.* 2016.

Highest plant population of 1.34 lakh/ha. were recorded with crop sown at 30 cm row spacing. Contradictory to this, higher values of yield attributes viz., pods/plant, seeds/pod and test weight were recorded with comparatively wider row spacing of 45 cm. Further, wider row spacing of 60 cm did not bring significant improvement in these parameters and remained significantly at par with 45 cm row spacing. Cluster bean crop sown at 45 cm row spacing recorded a grain yield of 3.81 q/ha which was significantly higher by 11.3 per cent than crop sown at 30 row spacing. In rainfed conditions of western Rajasthan, higher plant population with close row spacing resulted in poor performance of cluster bean plants in terms of yield attributes because of lack of sufficient soil moisture for higher plant population. Higher plant stand compete for available soil moisture leading to poor growth and less number of yield attributing parameters and yield. Similarly, plant to plant spacing of 15 cm recorded significantly higher number of pods/plant (21.0/plant) and grain yield (3.84 q/ha) as compared to 10 cm. Further increase in plant to plant spacing of 20 cm did not bring about significant improvement in these parameters. In dry land areas, cluster bean production is dependent on availability of soil moisture. Optimum plant population is a key factor in getting higher production in these areas. With close plant spacing of 10 cm, number of plants per unit area might have been increased, but the yield attributes might have been decreased on individual plant basis and eventually the grain yield was reduced due to higher plant population with more inter plant competition for available soil moisture. Under wider spacing some of the yield attributes might have been increased on individual plant but would have been decreased on per unit area. Jagtap *et al.* (2011) recorded low seed yield under 30 cm spaced row as compared to 45 cm apart in cluster bean. In contrast to present results, Akhtar *et al.*, (2012) and Dhedhi *et al.* (2016) recorded

higher yield attributes and yield under 30 cm row spacing than 45 cm and 60 cm. Williams (1960) observed that crop grown at 50 cm row spacing produced more seed yield than spacing of 75 cm and 100 cm rows apart. Row spacing of 50 cm for cluster bean varieties is optimum used by Hymowitz and Matlock (1964). Satpal *et al.* (2018) found that cluster bean seed yield increased when row to row spacing was increased from 22.5 cm to 45 cm. Naik *et al.* (2017) observed the highest seed yield of cluster bean produced under crop geometry of 45 cm × 15 cm than those grown in 45 cm × 30 and 60 cm × 30 cm.

Physiological studies : All physiological parameters were influenced by different varieties of cluster bean (Table-2). Varieties RGC 936 and RGC 1003 accumulated more proline content than RGC 1066. Accumulation of osmotically active metabolites under low water stress conditions is a common phenomenon in cluster bean and other crops. The accumulation was comparatively higher in drought tolerant variety as compared to susceptible variety. The drought tolerant variety accumulated more proline content and showed higher osmotic adjustment capacity. The maximum relative water content noticed in variety RGC-936; whereas, the variety RGC-1066 recorded minimum relative water content in leaf. Relative water content is a robust indicator of water status of a plant (Lawlor and Cornic, 2002) hence the variety performed better may have better water holding capacity. Similar results were noticed earlier by Manzer *et al.*, (2015) in fababean.

Membrane stability index decreased significantly under water stress in all the varieties of cluster bean. Significantly highest membrane stability index was recorded by variety RGC 936 as compared to and RGC 1066 and it was at par with RGC 1003. RGC-936 and RGC 1003 maintained higher stability (less injury) than RGC-1066 under water stress conditions. It is well known that the water stress causes accumulation of reactive oxygen species which result in membrane damage. Higher membrane stability in RGC 1066 reflects the existence of stress resistance mechanism.

Among plant geometry, crop sown at 45 cm row spacing recorded significantly highest proline content (0.32 mg/g fresh weight of leaf) as compared to 30 and 60 cm row spacing indicating high water content in plants to mitigate low water stress efficiently. Similar finding also reported by Suresh *et al.* (2013) in pigeon pea and Mahfouz *et al.* (2019) in clitoria. Further, cluster bean sown at 15 cm row spacing resulted in higher values of relative water content, proline content and membrane stability index but the difference among the all plant to plant spacing were found to be non-significant.

Conclusions

Yield attributes, yield and physiological parameters of cluster bean were influenced by cluster bean varieties and plant geometry. Variety RGC 936 was found better than rest of tested varieties. Crop sown at 45 cm row spacing and 15 cm plant to plant spacing is optimum for gain better yield potential of cluster bean. Therefore, it was concluded that crop sown at 45 cm × 15 cm with using variety RGC 936 could be high yielding under rainfed condition.

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Effect of Phosphorus, Sulphur and *Kappaphycus* Sap on Economics of Blackgram

Narendra Jat^{1*}, Arvind Verma¹, A.L. Jat², S.K. Chongtham³ and Satyanarayan Regar⁴

¹Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

²Castor-Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar, Gujarat

³Multi Technology Testing Centre and Vocational Training Centre, CAEPHT, CAU (I) Ranipool, Gangtok, Sikkim

⁴Department of Agronomy, College of Agriculture, Ummedganj, AU, Kota, Rajasthan

*Email : agronarendra89@gmail.com

Abstract

A field experiment entitled "Effect of Phosphorus, Sulphur and *Kappaphycus* Sap on economics of Blackgram" was carried out at Instructional Farm Agronomy, Rajasthan college of Agriculture, Udaipur during two consecutive *Kharif* seasons of 2015 and 2016, to assess the growth, productivity, quality and economics of black gram through the enjoyment of appropriate phosphorus and sulphur levels and foliar application of *Kappaphycus* saps. The soil of the experimental field was clay loam in texture with medium in nitrogen, phosphorus and sulphur and high in potassium and slightly alkaline in reaction. The experiment consisted of 36 treatments combinations comprising three phosphorus levels (15, 30 and 45 kg P₂O₅ ha⁻¹), three sulphur levels (0, 20 and 40 kg S ha⁻¹) and four foliar sprays (water spray, 5, 10 and 15% *Kappaphycus* sap). These treatments were evaluated using split plot design (phosphorus and sulphur in main plots and foliar sprays in sub plots) with three replications. In respect to economics of experimental treatments phosphorus application at 45 kg ha⁻¹ to black gram crop gave maximum net returns of ₹ 42660 ha⁻¹ which was ₹ 5761 ha⁻¹ higher than 15 kg P₂O₅ ha⁻¹. However, application of 30 kg P₂O₅ ha⁻¹ was at par with 45 kg P₂O₅ ha⁻¹. Maximum benefit cost ratio of 2.90 was recorded with application of 30 kg P₂O₅ ha⁻¹ with at par to 45 kg P₂O₅ ha⁻¹. Application of 40 kg S ha⁻¹ to black gram gave maximum net returns of ₹ 44093 ha⁻¹ against obtained by 20 kg S ha⁻¹ (₹ 43312 ha⁻¹) and control (₹ 34105 ha⁻¹) with maximum benefit cost ratio of 2.98 but application of 20 kg S ha⁻¹ was at par with 40 kg S ha⁻¹. Spray of 10% *Kappaphycus* sap gave highest net returns of ₹ 43148 ha⁻¹. The highest net returns (₹ 45397) was registered by conjoint application of 15 kg P₂O₅ ha⁻¹ and 40 kg S ha⁻¹ which was at par with the net returns obtained when phosphorus at 30 with sulphur at 20 kg ha⁻¹, phosphorus at 45 with sulphur at 20 kg ha⁻¹, phosphorus at 30 with sulphur at 40 kg ha⁻¹ and 45 kg P₂O₅ ha⁻¹ combined with sulphur at 40 kg P₂O₅ ha⁻¹.

Introduction

Pulses a vital part of the Indian agriculture sector after cereals and oilseeds crops because it is the second important constituent of diet after cereals. Pulses are essential in regards to the contribution to human nutrition and also in respect of their contribution to farmer's income. They also contribute significantly through enriching the soil with nitrogen fixation. In South- Asia, *i.e.*, India, pulses have long been considered as the poor man's primary source of protein. India is the largest grower and consumer of pulses in the world. The country grows various types of pulse crops under a widespread of agro-climate conditions. The estimates for 2018-19 indicated that the total pulse production of India is 23.40 million tonnes from 29.03 million ha area, the majority of which fall under rainfed conditions, poor resource, and unfriendly environments frequently prone to drought and other abiotic stress conditions (Anon., 2019a). Farmers least prefer growing of pulses crops because of high risk and less remunerative than cereals; consequently, the productivity of the pulses is low. To fulfill the demand for pulses, India is at present importing about 3 million tonnes from other countries. By the year 2030, the country's

population is predicted to increase by up to 168 crores from the present 121 crores. Accordingly, the projected pulse requirement for the year 2030 would be 32.00 million tonnes, with an anticipated growth rate of 4.2 percent (IIPR, 2011). The per capita availability of pulses has come down from 60 g per capita per day in 1951 to 39.4 g per capita per day in 2011 due to increasing population and stagnant production, while, ICMR recommends the use of pulses at the rate of 65 g per capita per day to meet out the nutritional requirements of an individual. Because of this, we have to develop and adopt progressively more productive and efficient technologies to encourage farmers to bring more areas under pulses production. Black gram is a highly nutritious and drought-resistant crop of the *Kharif* season. In Rajasthan, it occupies 0.75 million ha area with estimated production and productivity of 0.37 million tonnes and 501 kg ha⁻¹, respectively (Anon, 2019b), because it is grown mainly on marginal and sub-marginal land without using the recommended dose of fertilizer and improved package of practices. Therefore, it is time to develop a strategy for a suitable combination of phosphorus, sulphur and organic supplements to boost the black gram production. Keeping the above facts in view, it was

Table-1 : Effect of phosphorus, sulphur and *Kappaphycus* sap on seed yield, net returns and B:C ratio of black gram.

Treatment	Seed Yield (kg ha ⁻¹)			Net return (ha ⁻¹)			B:C Ratio		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Phosphorus levels (P₂O₅ kg ha⁻¹)									
15	974	977	975	36803	36996	36899	2.71	2.72	2.72
30	1059	1084	1072	41225	42679	41952	2.86	2.93	2.90
45	1087	1129	1108	42156	43163	42660	2.85	2.90	2.88
SEm±	21	13	13	1233	1087	822	0.05	0.05	0.04
CD (P=0.05)	64	39	36	3697	3260	2368	NS	0.14	0.10
Sulphur levels (S kg ha⁻¹)									
0	930	940	935	33751	34460	34105	2.54	2.57	2.55
20	1081	1108	1095	42521	44103	43312	2.92	3.00	2.96
40	1109	1141	1125	43912	44275	44093	2.97	2.99	2.98
SEm±	21	13	13	1233	1087	822	0.05	0.05	0.04
CD (P=0.05)	64	39	36	3697	3260	2368	0.16	0.14	0.10
Kappaphycus sap spray									
Water spray	937	945	941	35540	36115	35827	2.73	2.76	2.75
Kappaphycus sap 5%	1046	1095	1070	41076	43830	42453	2.90	3.03	2.97
Kappaphycus sap 10%	1093	1110	1102	42649	43648	43148	2.88	2.92	2.90
Kappaphycus sap 15%	1084	1103	1094	40980	40191	40585	2.72	2.69	2.71
SEm±	14	13	10	830	1315	777	0.04	0.05	0.03
CD (P=0.05)	41	37	27	2354	3727	2179	0.10	0.15	0.09

Table-2 : Interaction effect of sulphur and *Kappaphycus* sap on seed yield.

Treatment	Seed Yield (kg ha ⁻¹)											
	2015				2016				Pooled			
	F ₀	F ₅	F ₁₀	F ₁₅	F ₀	F ₅	F ₁₀	F ₁₅	F ₀	F ₅	F ₁₀	F ₁₅
S ₀	786	912	1019	1002	770	966	1028	998	778	939	1023	1000
S ₂₀	980	1080	1135	1128	994	1136	1150	1152	987	1108	1142	1140
S ₄₀	105	1144	1126	1122	1070	1182	1153	1160	1058	1163	1140	1141
SEm±	25				22				17			
CD (P=0.05)	70				64				47			

considered appropriate to carry out an investigation entitled Effect of Phosphorus, Sulphur and *Kappaphycus* Sap on economics of Blackgram Materials and methods.

Materials and Methods

The experiments during both the years were carried out at Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur. The site was situated at South-Eastern part of Rajasthan state at an altitude of 579.5 meter above mean sea level with 24°35' N latitude and 74°42' E longitude. The region falls under agro-climatic zone "Sub-Humid Southern Plain and Aravalli Hills" (IVa) of Rajasthan. The soil of the experimental field was clay loam in texture with medium in nitrogen, phosphorus and sulphur and high in potassium and slightly alkaline in reaction. The experiment consisted of 36 treatments combinations comprising three phosphorus levels (15, 30 and 45 kg P₂O₅ ha⁻¹), three sulphur levels (0, 20 and 40 kg S ha⁻¹) and four foliar sprays (water spray, 5, 10 and 15% *Kappaphycus* sap). These treatments were evaluated using split plot design (phosphorus and sulphur in main plots and foliar sprays in sub plots) with three replications.

Net returns (ha⁻¹) : To find out the most profitable treatment, economics of different treatments were worked out in terms of net monetary returns (ha⁻¹) by subtracting the cost of treatment and the cost of cultivation from gross income obtained. Cost of cultivation and net profit were calculated on the basis of prevailing prices of produce and inputs.

Benefit-cost ratio : This was calculated by dividing net returns with cost of cultivation for each treatment to see the economic viability of treatments.

Analysis of variance and test of significance : The data recorded for evaluation of treatment were subjected to statistical analysis by applying technique of analysis of variance treatments was worked out, wherever, the "F" test was significant at 5 per cent level of significance. The homogeneity of error variances is tested using Bartlett (1947) chi-square test (x²). The error variances in the experiment were found homogeneous hence, pooled analysis were carried out for experimental design.

Results and Discussion

Phosphorus : A close examination of data presented in

Table-1 revealed that seed yield of black gram varied significantly under different levels of phosphorus during 2015 and 2016. The yield increased significantly with successive increase in rate of phosphorus application from 15 to 30 kg ha⁻¹ in each year of study. However, a significant enhancement in seed yield of black gram was recorded up to 45 kg P₂O₅ ha⁻¹. On pooled analysis of data, shows that that application of 45 kg P₂O₅ ha⁻¹ had maximum seed yield of black gram (1108 kg ha⁻¹), which was 13.64 and 3.35 per cent higher than 15 and 30 kg P₂O₅ ha⁻¹, respectively.

Sulphur : The data (Table-1) indicate that application of 20 kg S ha⁻¹ showed statistical superiority over control and found at par with 40 kg S ha⁻¹ in producing grain yield across the years. A similar result was also evident on pooled analysis of data (Table-1), in which seed yield of black gram responded significantly up to 20 kg S ha⁻¹ (1095 kg ha⁻¹). Increment in seed yield of black gram due to application of 20 and 40 kg S ha⁻¹ was to the tune of 17.11 and 20.32 per cent higher over control, respectively.

Kappaphycus sap : Perusal of the data presented in Table-1 revealed that seed yield of black gram varied significantly due to different seaweed sap treatments during 2015 and 2016. Maximum seed yield of black gram was recorded under application of *Kappaphycus* sap 10%, which statistically at par with *Kappaphycus* sap 15% and was significantly higher than rest of treatments during the first year. However, in the second year, increase in seed yield was significant up to 5% concentration of *Kappaphycus* sap. A thorough analysis of the pooled data indicated that increase in *Kappaphycus* sap concentration up to 10% markedly enhanced seed yield of black gram (1102 kg ha⁻¹) which was 17.10 per cent higher over control (Table 1).

Interaction effect of sulphur and *Kappaphycus* sap

Perusals of data Table-2 showed that seed yield of black gram was significantly influenced by interaction effect of sulphur and *Kappaphycus* sap during both the years. Application of 40 kg S ha⁻¹ in combination with spray of 5% *Kappaphycus* sap out yielded over rest of treatment and it was performed statistically at par with application of 20 kg S ha⁻¹ along with 5, 10 and 15 % *Kappaphycus* sap during both the years, respectively. The results revealed that P fertilization at 45 and 30 kg P₂O₅ ha⁻¹ significantly increased the yield. It is a fact that photosynthesis, together with the availability of assimilates (source) and storage organs (sink), exert an important regulative function on the complex process of yield formation. The regulatory functions of phosphorus in photosynthesis and carbohydrate metabolism of the leaves can be considered to be one of the major factors limiting plant growth, particularly during the reproductive phase. The level of

phosphorus during this period regulates the starch/sucrose ratio in the source leaves and reproductive organs (Kumar and Singh, 2011). Improvement in yield components of black gram due to P fertilization was also observed by Deo and Khandelwal (2009), Kumar et al. (2009), Singh et al. (2010), Nawange et al. (2011) and Shivran and Prakash, (2012).

Net Returns

Phosphorus : The data (Table-1) revealed that in both the years of study and on pooled basis, significantly greater net return was obtained with the application of 45 kg P₂O₅ ha⁻¹ which was at par with 30 kg P₂O₅ ha⁻¹ (41952). On pooled basis 30 and 45 kg P₂O₅ ha⁻¹ registered 13.69 and 15.61 per cent higher net returns over 15 kg P₂O₅ ha⁻¹, respectively.

Sulphur : The figures are clear in presenting the significance of 40 kg S ha⁻¹ overall preceding levels on pooled basis but at par with 20 kg in both the years. Pooled statistics (Table 4.31) indicate that application of 20 and 40 kg S ha⁻¹ resulted in 27.00 and 29.29 per cent increase in net return over control, respectively.

Kappaphycus sap : Perusal of the data presented in Table 4.31 revealed that monetary returns of black gram proved significantly due to different concentration of *Kappaphycus* sap treatments during 2015 and 2016. Highest net returns of black gram was recorded under sprayed of *Kappaphycus* sap 10%, it was fetched 7321, 695 and 2563 ha⁻¹ higher economic returns as compared to water spray, 5 and 15% *Kappaphycus* sap spray on pooled basis, respectively. Several researchers viz, Gupta (2007), Zodape et al. (2009), Singh (2010), Zodape et al. (2011), Dogra and Mandradia (2012) and Abou El-Yazied et al. (2012) also observed similar findings.

B : C Ratio

Phosphorus : A thorough examination of data presented in Table-1 clearly indicated that benefit cost ratio of black gram differed statistically due to various levels of phosphorus during 2016 while it was failed to showed significant variation in 2015. Similarly, marked improvement in B: C ratio of black gram was recorded up to 30 kg P₂O₅ ha⁻¹ (2.90) on pooled analysis of data (Table-1).

Sulphur : Perusal of the data presented in Table-1 revealed that increasing levels of sulphur up to 20 kg S ha⁻¹ markedly enhanced B: C ratio of black gram during 2015 and 2016. Similar result was also observed on close examination of pooled data (Table 4.31), in which B: C ratio of black gram responded statistically up to 40 kg S ha⁻¹ (2.98).

Kappaphycus Sap : On close scrutiny of the data

presented in Table 4.31, it was observed that different seaweed sap treatments had significant effect on B: C ratio of black gram during 2015 and 2016. B: C ratio of black gram improved significantly at 5% concentration of *Kappaphycus* sap, which was at par with 10 % concentrations of *Kappaphycus* sap, and significantly superior over water spray as well as 15% *Kappaphycus* sap spray on pooled basis, respectively.

Conclusions

On the basis of two years field experimentation on black gram at Udaipur, to standardize phosphorus and sulphur application and foliar application of sea weed *Kappaphycus* sap, the highest net return (50094 ha⁻¹) and B:C ratio (3.33) were obtained by fertilizing the crop with 30 kg P₂O₅ ha⁻¹ with 20 kg S ha⁻¹ and foliar application of sea weed sap *i.e.* *Kappaphycus* sap 5 %. Therefore, it is recommended that in the subtropical conditions of southern Rajasthan black gram should be supplied with 30 kg P₂O₅ ha⁻¹ combined with 20 kg S ha⁻¹ along with foliar application of *Kappaphycus* 5 % sap for the higher economic returns.

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Assessing the In-Vitro Degradation of Bifenthrin in Heavy Black Soil

Premlata Meena^{1*}, P.G. Shah¹, Kapil Atmaram Chobhe², Mamta², Ajit Kumar Meena³, Rajendra Bairwa⁴ and Indu Chopra²

¹Anand Agricultural University, Anand, Gujarat

²ICAR-Indian Agricultural Research Institute, New Delhi

³Maharana Pratap University of Agriculture & Technology, Udaipur, Rajasthan

⁴Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar

*Corresponding Author Email : ajitkumarmeena907@gmail.com

*Present address: ICAR-Indian Agricultural Research Institute, New Delhi-110012

Abstract

An experiment was conducted during 2017-18 at AINP on Pesticide Residues, ICAR Unit- 9, AAU, Anand, Gujarat to study the dissipation behavior of bifenthrin in heavy black soil under laboratory conditions. The bifenthrin was spiked in soil @ 0.06 and 0.12 $\mu\text{g g}^{-1}$. The experiment was conducted with three replications along with a control. The samples were collected on 0 (one hour after treatment), 1, 3, 5, 7, 10, 20, 30, 40, 50 and 60 days after treatment. Residues of bifenthrin were estimated by validated QuEChERS multi residue method using GC equipped with electron capture detector. The mean recovery was in the range of 81.71-98.32 percent. The residues of bifenthrin persisted for more than 50 days at both doses in heavy black soil. Higher persistence of bifenthrin in heavy black soil due to strong adsorption. It can be attributed to the presence of high organic matter and clay content that could bind the bifenthrin. Higher dose revealed longer persistence in soil than lower one.

Key words : Bifenthrin, method validation, QuEChERS, heavy black soil, GC-ECD

Introduction

Intensive agricultural practices often include the use of pesticides to enhance crop yields. However, the improvement in yield is sometimes concomitant with the occurrence and persistence of pesticide residues in soil and water (Ware and Whitacre 2004). Soil, an important component of the environment, acts as a sink for majority of the pesticides used in agriculture. It acts as a filter and buffer and has degradation potentials with respect to storage of pollutant through soil organic carbon (Buraue and Bassmann 2005). The fate of pesticides in the soil is greatly influenced by their interaction with soil components, the environment and their transport from one environmental compartment to another (Ismail and Kalithasan 2003; Racke 1993a, b). The rate of degradation of pesticides in the soil is one of the most important criteria that determine the behaviour of pesticides in the environment. Heavy usage of pesticides in agriculture may cause adverse effects on the environment and, consequently, on human health. The leaching of pesticides into groundwater is a major environmental concern because it affects the quality of underground water (Lehmann *et al.* 1993).

Soil texture has an important impact on termiticide performance, but the effects differ within termiticides. According to Wiltz (2010), the clay content in soils is significantly related to termite mortality across all

termiticides, application rates, and exposure times. In assays conducted with bifenthrin, fipronil and chlorfenapyr, *C. formosanus* mortality was the highest when clay content was low (Wiltz 2010). According to Osbrink and Lax (2002), the mortality of *C. formosanus* workers was higher in the fipronil-treated sand than in treated mixture of soil and clay. Sorption is greatly influenced by the amount of clay and organic matter. Fipronil indicates a significant decrease in adsorption coefficient as the soil clay content decreases, thereby, increasing its bioavailability (Bobé *et al.* 1997; Cox *et al.* 1998; 2001).

Bifenthrin [2-methylbiphenyl-3-ylmethyl(Z)- (1RS)-cis-3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethyl cyclopropanecarboxylate] is a synthetic pyrethroid insecticide with a broad range of acaricidal and insecticidal properties (Tewary *et al.*, 2005). It's used in agriculture all around the world to kill bugs on contact when they eat it, and it affects the nervous system (Mukherjee *et al.*, 2010; You *et al.*, 2013). The US Environmental Protection Agency has classed bifenthrin as Toxicity Class II, which means it is moderately harmful (WHO, 2009). Human amnion epithelial (FL) cell lines are both cytotoxic and genotoxic, and fish and other aquatic species are very toxic (Liu *et al.*, 2008). Bifenthrin has acute reference doses (ARfD) and recommended daily intakes (ADI) of 0.01 mg kg⁻¹ b.w. (JMPR, 2010),

Table-1 : Recovery of bifenthrin in heavy black soil.

Parameters	Fortification level ($\mu\text{g g}^{-1}$)		
	0.05	0.25	0.50
Mean Recovery (%) $n^* = 5$	98.32	81.71	97.27
Standard Deviation ($\pm\text{SD}$)	6.20	14.84	17.76
% RSD	6.31	18.16	18.26

* = No. of replication

indicating that it is potentially acutely hazardous to humans.

Materials and Methods

For laboratory experiment, heavy black soil was collected from Navsari Agricultural University (NAU), Navsari, Gujarat, India. Soil after drying was sieved through 2 mm sieve before use to remove the debris. Soil (10 g) was spiked with bifenthrin analytical standard solution ($100 \mu\text{g mL}^{-1}$) at two doses: single dose $0.06 \mu\text{g g}^{-1}$ (T_2) and double dose $0.12 \mu\text{g g}^{-1}$ (T_3) that were kept at room temperature. Moisture content was maintained at field capacity level. The experiment was replicated thrice along with control (T_1). Spiked soil samples collected at regular time intervals (0, 1, 3, 5, 7, 10, 20, 30, 40, 50 and 60 d) were analyzed for bifenthrin residue.

Chemicals and reagents : All the analytical grade reagent and chemicals were provided by Merck Life Science Private Ltd. Certified reference material (CRM) were procured from Sigma Aldrich India Limited.

Extraction procedure : (QuEChERS method) : A representative 10 g soil was transferred to a 50 mL polypropylene centrifuge tube and 20 mL acetonitrile followed by mixture of 1 g NaCl + 4 g MgSO_4 , shaken vigorously by hand (1 min.) before centrifugation. The tubes were centrifuged at 3500 rpm for 3 minutes. A 10 mL aliquot from the supernatant was transferred by auto pipette into a 15 mL polypropylene centrifuge tube containing 1.5 g MgSO_4 and 0.25 g PSA (Primary Secondary Amine), followed by centrifugation at 2500 rpm for 2 minutes. A 4 mL aliquot was transferred into glass test tube and acetonitrile was completely evaporated on Turbo Vap® LV. Final volume (2 mL) was made by petroleum spirit: acetone (1:1 v/v) and residues were quantified on GC-ECD.

Instrumentation : Bifenthrin residues were quantified on Varian 450 GC equipped with TG-5-Sil MS (30 m $\times$ 0.25 mm $\times$ 0.25 μm) column and ^{63}Ni ECD. The column temperature was maintained from 160 $^\circ\text{C}$ (2 min.), increased to 280 $^\circ\text{C}$, that was for 10 min. The injector and detector temperatures were 250 and 295 $^\circ\text{C}$, respectively. The carrier gas flow in the column was 1.5 mL/min and make up gas flow was 30 mL/min. The total run time was 10 min.

Calculation and statistical analysis : The simple statistical analysis was carried out in the Microsoft Excel-2010 program with the help of computer. The residues of bifenthrin were quantified with following equation :

$$\text{Bifenthrin concentration (mg/kg)} = \frac{A_1}{A_2} \frac{V}{W} C$$

Where, A_1 = Peak area/height of sample (mV), A_2 = Peak area/height of standard (mV), V = Volume of sample extract (mL), W = Weight of sample used for extraction (g) and C = Concentration of bifenthrin ($\mu\text{g/mL}$) in standard solution.

The half- lives of pesticides were also calculated by using the following equation :

$$t_{1/2} = \frac{\ln(0.5)}{k}$$

Where, $t_{1/2}$ = half-life of bifenthrin, days and k = dissipation rate constant, days $^{-1}$.

Recovery and limit of quantification : Before starting the experiment, method performance studies were carried out to check the efficiency for determining bifenthrin in soil sample as per SANTE guideline¹⁶. The calibration curve was determined by considering matrix-matched standards of bifenthrin at five different concentrations (0.01 – 1.0 $\mu\text{g mL}^{-1}$). The matrix standards were prepared by collecting matrix of control sample. The limit of detection (LOD) was defined as the analytes concentration that produced a signal-to-noise (S/N) ratio of 3 and the limit of quantification (LOQ) was related to an S/N ratio of 10. Soil was spiked at 0.05, 0.25 and 0.5 $\mu\text{g g}^{-1}$ levels in five replicates to evaluate the percentage recovery. The spiked samples were extracted and analyzed.

Results and Discussion

Linearity and recovery : The calibration curve of matrix-matched standards of bifenthrin demonstrated linear response in the range of 0.01-1.0 ppm with a correlation coefficient, $R^2 \geq 0.99$ as per the SANTE guideline¹⁶. The LOQ was 0.01 $\mu\text{g g}^{-1}$. The mean recovery of bifenthrin in soil was in the range of 81.71- 98.32 percent at three spiking levels, i.e. 0.05, 0.25 and 0.5 $\mu\text{g g}^{-1}$. The per cent relative standard deviation within the replicates (RSD) obtained for respective soils at different spiking levels was in the range of 6.31- 18.26 percent (Table-1). As per SANTE guidelines¹⁶, recoveries (Table-1) were above 85 per cent and RSDWR below 20% is accurate and precise. The gas chromatogram of bifenthrin in heavy black soil is depicted in Figure-1.

Dissipation and residue status : In heavy black soil, dissipation of bifenthrin was biphasic and triphasic at

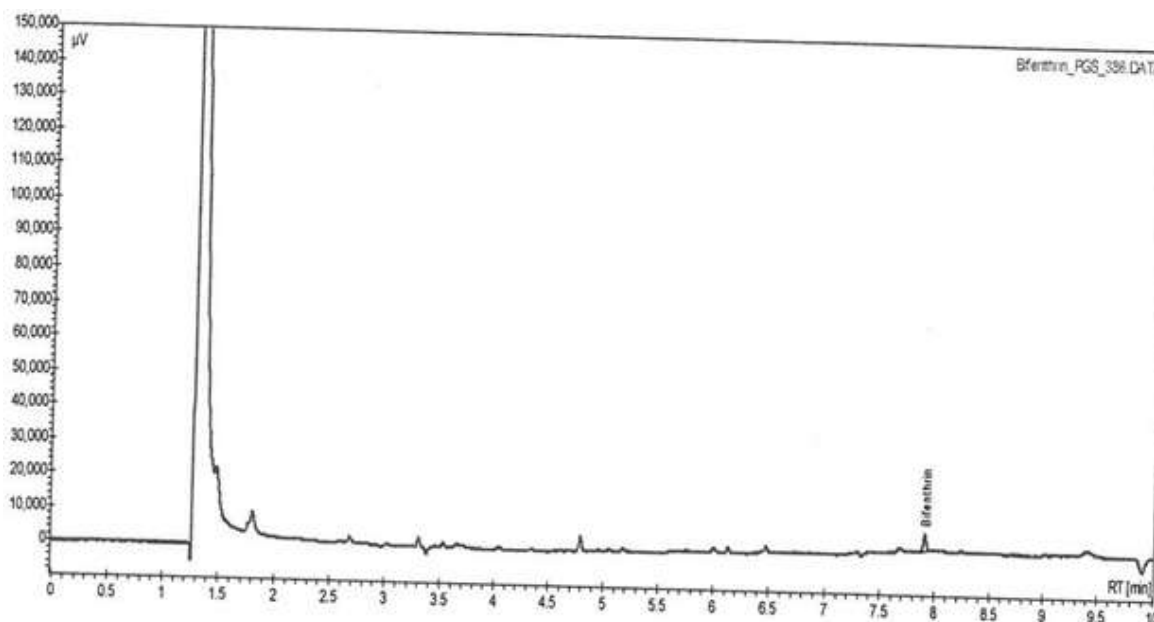


Figure-1 : The chromatogram of bifenthrin in heavy black soil at $0.06 \mu\text{g g}^{-1}$.

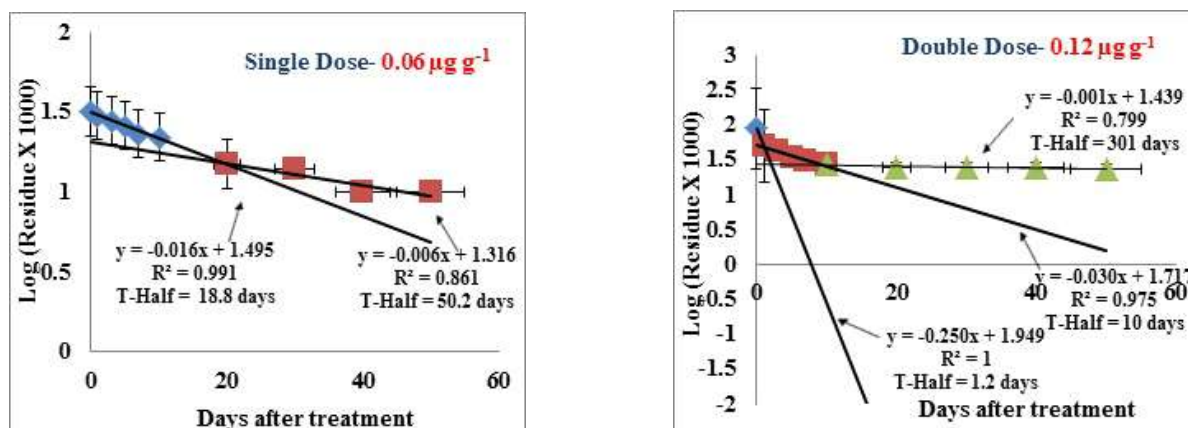


Figure-2 : Dissipation pattern of bifenthrin at single and double dose in heavy black soil.

single and double dose, respectively (Figure-2). Initially (one hour after treatment) residues were 0.032 and $0.089 \mu\text{g/g}$ which declined to 0.030 and $0.050 \mu\text{g/g}$ within 24 hours at single and double dose rendering 6.25 and 43.82 per cent loss, respectively (Table 6). At single dose, half-life values were 18.8 and 50.2 days during phase-I (0-20 days) and phase-II (20-50 days), respectively. At the double dose, half-life values were 1.2, 10 and 301 days during phase-I (0-1 days), phase-II (1-10 days) and phase-III (10-50 days), respectively (Table-2).

From the results of the study, it was found that bifenthrin residues persisted for more than 50 days at both doses in heavy black soil. Higher persistence of bifenthrin in heavy black soil due to strong adsorption. It can be attributed to the presence of high organic matter and clay content that could bind the bifenthrin. The higher soil clay content generally indicates lower proportion of

large pores, larger specific surface area per unit volume of soil, and higher adsorption affinity of soils for pesticides, resulting weaker mobility of pesticides (Petrovic and Larsson-Kovach, 1996). Similar results have also been reported for pyraclozil, which showed higher adsorption affinity to clay minerals and low mobility into the soil (Zhang et al., 2020; Ou et al., 2020). Bifenthrin showed a higher concentration in the top part of the soil column compared to fipronil and imidacloprid, indicating that bifenthrin is the most persistent among termiticides tested (Rashid et al., 2018). A similar finding was reported by Horwood (2007) who found that bifenthrin was higher than chlorfenapyr, chlorpyrifos, fipronil and imidacloprid. According to Kamble and Saran (2005), as bifenthrin has a higher Koc value, it has a high capability to remain in the soil particles, resulting in low leaching potential.

Table-2 : Residue and dissipation pattern of bifenthrin in heavy black soil.

Days after treatment	Residue ($\mu\text{g g}^{-1}$)				
	Dose				
	T ₁ (Control)	T ₂ (0.06 $\mu\text{g g}^{-1}$)		T ₃ (0.12 $\mu\text{g g}^{-1}$)	
		Mean ($\pm$ SD) (n = 3)	% loss over initial	Mean ($\pm$ SD) (n = 3)	% loss over initial
0	ND	0.032 ($\pm$ 0.002)	-	0.089 ($\pm$ 0.009)	-
1	ND	0.030 ($\pm$ 0.002)	6.25	0.050 ($\pm$ 0.003)	43.82
3	ND	0.028 ($\pm$ 0.004)	12.50	0.043 ($\pm$ 0.001)	51.69
5	ND	0.026 ($\pm$ 0.001)	18.75	0.035 ($\pm$ 0.003)	60.67
7	ND	0.023 ($\pm$ 0.001)	28.12	0.031 ($\pm$ 0.002)	65.16
10	ND	0.022 ($\pm$ 0.001)	31.25	0.027 ($\pm$ 0.002)	69.66
20	ND	0.015 ($\pm$ 0.001)	53.12	0.025 ($\pm$ 0.000)	71.91
30	ND	0.014 ($\pm$ 0.001)	56.25	0.025 ($\pm$ 0.001)	71.91
40	ND	0.010 ($\pm$ 0.001)	68.75	0.025 ($\pm$ 0.001)	71.91
50	ND	0.010 ($\pm$ 0.001)	68.75	0.023 ($\pm$ 0.001)	74.15
60	ND	<LOQ	-	<LOQ	-
Regression equation R ²	Phase-I	Y = -0.016X + 1.495 R ² = 0.991 (0-20 days) T-Half = 18.8 days		Y = -0.250X + 1.949 R ² = 1 (0-1 day) T-Half = 1.2 days	
	Phase-II	Y = -0.006X + 1.316 R ² = 0.861 (20-50 days) T-Half = 50.2 days		Y = -0.030X + 1.717 R ² = 0.975 (0-10 days) T-Half = 10 days	
	Phase-III	-		Y = -0.001X + 1.439 R ² = 0.799 (10-50 days) T-Half = 301 days	

A study by Meyer *et al.* (2013) also found that bifenthrin bonded to soils and sediment due to the strong binding capability towards soil particles. Organic matter is an important element attributed to absorption and leaching process (Bajeer 2012). Liu *et al.* (2006) indicated that organic matter was the primary sorptive medium for imidacloprid. This statement was also supported by Kurwadkar *et al.* (2014) who mentioned that low sorption of imidacloprid could be affected by the presence of low organic matter content. Soil organic matter is closely related to cation exchange capacity (Bajeer 2012; Kurwadkar *et al.* 2014). High organic matter content leads to high exchange capacity. Therefore, the higher amount of cation exchange capacity and organic matter in soil could increase the adsorption of termiticide, and simultaneously reduce the leaching probability. Chia and Zaidel (2011) studied the sorption, degradation and leaching of cypermethrin in three types of soils, and found that cypermethrin remains in the top 0–10 cm layer of the three soils. Manoj and Gajbhiye (2007) also reported similar results where mobility of bifenthrin in soil was low. Its residues remained within the top 15 cm and more than 99% of residues were recovered from the top 0–10 cm layer. Other researchers (Walker and Exposito 1998) proved that organic matter had an influence on the adsorption of pesticides in the soil, and leaching potential of pesticides in the soil is influenced by the soil's physico-chemical properties as its organic matter content and the solubility of the compound. The study revealed

pesticide applied at higher dose showed erratic pattern and longer persistence in soils as compared to the lower dose.

Conclusions

Bifenthrin persists for more than 50 days in heavy black soil. Higher dose revealed longer persistence in soils than lower one. Higher persistence of bifenthrin in heavy black soil due to strong adsorption. It can be attributed to the presence of high organic matter and clay content that could bind the bifenthrin. The higher soil clay content generally indicates lower proportion of large pores, larger specific surface area per unit volume of soil, and higher adsorption affinity of soils for pesticides, resulting weaker mobility of pesticides. The study revealed pesticide applied at higher dose showed erratic pattern and longer persistence in soils as compared to the lower dose. Thus, *in vitro* studies can be used to judge the comparative persistence of pesticide in soils.

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A Study of Problems/Constraints Faced by the Farmer Borrowers in Borrowing the Loans in Bikaner Region of Rajasthan

Raju Kumawat¹, B.L. Dhaya^{2*}, J.P. Meena² and N.K. Singh¹

¹Department of Agricultural Economics, SKRAU, Bikaner, Rajasthan-334001

²Krishi Vigyan Kendra, Vadodara, Gujarat-391125

*Corresponding Author Email : dhayalextn@gmail.com

Abstract

The present study was conducted in Bikaner region of Rajasthan to analyse repayment performance, overdues. Four districts viz., Sriganganagar, Hanumangarh, Bikaner and Churu district. A lead bank of each selected district was selected purposively for collection of secondary and primary data in respect of agricultural loan supplied to the farmers. The selected banks were Oriental Bank of Commerce from Sriganganagar, State Bank of Bikaner and Jaipur from Hanumangarh and Bikaner districts and Bank of Baroda for Churu district. A sample of 30 farmers was drawn as borrower farmers from each selected district by probability proportion to the number of borrower farmers in each group (small, medium and large farms). Similarly, 30 non-borrower farmers were also selected from each district using the similar method as borrower farmers to analyse the impact of credit. The study of constraints faced by the borrower farmers and lending institutions in financing the agricultural credit revealed that among the various constraints in getting the loan by the borrower farmers were lengthy and difficult procedure, inadequate amount of loan, time consuming in borrowing procedure, lack of knowledge about bank formalities. However, in case the constraints identified for the credit agencies in landing the credit to the farmers were inadequate staff, influences of politically and economically powerful farmers, less educated farmers, improper utilization of loan, lack of strict action against defaulters and defective landing policy.

Key words : constraints, borrowers, borrowing the loans.

Introduction

Agricultural credit in itself is not an input but it helps in creating environment for the adoption of modern production technology and encouraging private investment on the farms. Thus, credit in agriculture acts as lubricant which helps to run the machine swiftly and smoothly. It is more so in the context of Indian agriculture which is predominated by small and marginal farmers and agricultural labourers who have less resources and are in dire need of them. Unless the problem of inadequacy and defective credit system is solved, it will continue to hamper the development and modernized of agriculture. It is needed not merely for running the agriculture operation but more importantly to import an element of dynamism or growth oriented change in the traditional agriculture. The procurement of capital assets by the farmers depends on the credit availability and credit policy of term lending institutions. In this context the role of investment credit, becomes significant for capital formation in the agriculture sector. In order to reap the benefits of capital formation for enhancing agricultural production and productivity the farmers also require crop loans for a short-term period of time to buy seeds, fertilizers, payment of wages to workers etc. These production loans as production credit. It is thus evident that both production and investment credit are essential for sustaining high agriculture growth

in the economy. Recognizing the importance of credit, the National Agricultural policy adopted in July 2000 envisages a growth of 4 per cent of agriculture to achieve 8 per cent economic growth of the country and emphasizes adequate and timely supply of institutional credit to farmers. The agricultural credit institutions will therefore, have to gear up to meet this challenge. In addition, many financial institutions also suffer from poor management and lack of enthusiasm and dedication among members resulting in a great deal of inefficiency and poor service to the members. On the other hand, the lending procedure of financial institutions is very complicated. Many formalities and laxities are available in financial system. The delay in disbursement of credit is most common in this system. The sanctioned amount of loans is inadequate to purchase the agricultural inputs in required quantities due to escalation of cost of these inputs by the time the inputs are purchased.

Sharma and Singh (1980) examined the problems of small farmers under agricultural credit programme in the Kamrup district of Assam. Four development blocks were selected in such a way that each block comprised sufficiently large number of small farmers. eight villages which had majority of the small farmers were randomly selected for the selection of respondents. A sample of 200 small farmers was selected randomly by taking 25 small farmers from each village. The results of the study

revealed that the major constraints faced by the farmers in obtaining the loan were procedural difficulties followed by loan's security problems, high interest rate, lack of knowledge, inadequate supply of credit, late disbursement of loan, complicated repayment procedure and unsuitable repayment schedule.

Pandit *et al.* (2007) conducted a research on the topic "Financing agriculture: A study of Bihar and West Bengal potato cultivation". The study was based on primary data collected from four districts of west Bengal and three districts of Bihar. The reference period for the study was January-February 2007. The results of the study revealed that the potato grower farmers in both the states faced a lot of problems in availing credit. About 16 per cent and 14 per cent of the farmers in Bihar and West Bengal, respectively quoted lack of knowledge regarding bank procedures and formalities. Hence, the result clearly emphasized the need for simplifying the formalities of institutional loans and making it easily accessible to even the illiterates. In case of crop failure, they may face a lot of hardships in repaying the loan. Among the institutional loan avails, delay in disbursement was the most problematic. Most of the farmers reported that the loan was not available on time.

Research Methodology

The present study was conducted in the Bikaner region of Rajasthan. The Bikaner region of Rajasthan comprises with four districts namely, Bikaner, Sriganganagar, Hanumangarh and Churu. The Sriganganagar and Hanumangarh district agriculturally developed district. However, Bikaner and Churu district of this region are an agriculturally backward district which required extra care of the financial institutions for bringing it at par with other areas. Both primary and secondary data were required to arrive at the stated objectives. The secondary data to analyses the growth of formal credit to agriculture over the period of time, the periodical data were collected for 10 year (from 2003-04 to 2012-13) from lead bank office of the selected lead banks. Similarly, the information relating to credit amount actually disbursed to the selected farmers was collected from the respective selected branch for the agricultural year 2011-12. However, to analyses the repayment performance and overdues of agricultural loan, the secondary data were collected up to June 2014 from the records maintain by concerned bank branch in the study area.

Results and Discussion

The problems faced by the borrower's farmer in borrowing the loans from the credit agencies in the study area are depicted in table-1. The table shows that about 87.50 per cent of the total borrower's farmer expressed the problem

of inadequate supply of loan for their requirements. Category wise, 87.50 per cent of small, 83.78 per cent of medium and 92.59 per cent large borrower farmers reported to have faced this problem.

About 95 per cent of the borrower's farmer expressed the problem of lengthy and difficult lending procedure. Category-wise, 91.07 per cent of small, 97.30 percent of medium and 100 per cent of large farmer borrowers reported to have faced this problem. 50 per cent of borrower's farmer expressed that there was lack of proper technical guidance and 25.83 per cent of farmer borrowers reported that there was rigidity in the repayments of loan instalments. The problem of charging higher interest rate was more acute on small farms (62.50%), medium (62.16%) and large (59.26%) farmers reported for higher interest rate. At overall level 61.67 per cent farmers reported for higher interest rate.

Figures in parentheses are the percentages of farmer borrowers facing constraints by individual group of farmers of the total sample farmers of respective group. About 66.67 per cent borrower farmers replied that the repayment time fixed by the banks was not sufficient. Majority (83.93 per cent) farmers were from small groups and only 44 per cent large farmers were facing this problem. Only about 26 per cent borrower farmers of the study area reported that in general bank not considered the request for restructuring the repayment of credit instalments. Few small farmers (19.64%) pointed out that there was no flexibility in structuring of credit instalments for repayment. However, 37.84 and 22.22 per cent of medium and large farmers felt as constraints during the borrowing the loan. The study results revealed that 77.50 per cent of farmer borrowers did not have proper knowledge about bank's formalities. Category-wise, 82.14 per cent of small, 67.57 per cent of medium and 81.48 per cent of large farmer borrowers reported this problem. Moreover, 73.21 per cent of small, 70.27 per cent of medium and 62.96 per cent of large farmer borrowers disclosed that the amount of credit was not available when it was needed. As regards the problem of time consuming procedure of borrowing, 79.17 per cent of the farmer borrowers reported that the borrowing procedure was very time consuming. This problem was more acute on medium sized farms (94.59 per cent) as compared to that on small farms (67.86 per cent). 56.67 per cent of borrower's farmer pointed out that the bank's staffs were non-cooperative in nature. Category-wise, 55.36 per cent of small, 59.46 per cent of medium and 55.56 per cent of large borrower's farmer reported to have faced this problem. 66.67 per cent of farmer borrowers pointed out that red-tapsim was rampant in the loaning system. Category-wise, 73.21 per cent of small, 62.16 per cent of medium and 59.26 per cent of large

Table-1 : Problems/constraints faced by borrower farmers in borrowing the loans.

S. No.	Constraints	Small (56)	Medium (37)	Large (27)	Total (N = 120)
1.	Inadequate amount of loan	49 (87.50)	31 (83.78)	25 (92.59)	105 (87.50)
2.	Lengthy and difficult lending procedure	51 (91.07)	36 (97.30)	27 (100.00)	114 (95.00)
3.	Lack of proper technical guidance	29 (51.78)	16 (43.24)	15 (55.56)	60 (50.00)
4.	Higher interest rate	35 (62.50)	23 (62.16)	16 (59.26)	74 (61.67)
5.	Insufficient time for repayment	47 (83.93)	21 (56.76)	12 (44.44)	80 (66.67)
6.	Inflexibility in the structure of credit instalments for repayment	11(19.64)	14 (37.84)	6 (22.22)	31 (25.83)
7.	Lack of knowledge about bank's formalities	46 (82.14)	25 (67.57)	22 (81.48)	93 (77.5)
8.	Credit not available at time	41 (73.21)	26 (70.27)	17 (62.96)	84 (70.00)
9.	Borrowing procedure was time consuming	38 (67.86)	35 (94.59)	22 (81.48)	95 (79.17)
10.	Non-cooperation from bank's personnel	31 (55.36)	22 (59.46)	15 (55.56)	68 (56.67)
11.	Red-tapism	41 (73.21)	23 (62.16)	16 (59.26)	80 (66.67)
12.	Prevalence of corrupt practices	9 (16.07)	8 (21.62)	9 (33.33)	26 (21.66)

farmer borrowers reported to have faced this problem. Only 21.66 per cent of borrower's farmer reported that there was prevalence of corrupt practices in sanctioning of loans. Category wise, 16.07 per cent of small, 21.62 per cent of medium and 33.33 per cent of large farmer borrowers faced this problem. The similar results were observed by Sarmah and Singh (1980), Murthy at al. (1990), Gupta at al. (1996), Rajput and Verma (1998), Singh and Dularam (2007) and Singh at al. (2007). Thus, it might be concluded that inadequate supply of loan, lengthy and difficulty lending procedure, lack of knowledge about bank's formalities and borrowing procedure was time consuming were the main problems faced by the borrower farmers of the study area.

Conclusions

Among the problems and constraints faced by the borrower farmers in borrowing the loans from the banks in the study area, the major problems was identified that about 95 per cent of the borrower farmers were facing with the problem related lengthy and difficult lending procedure in borrowing the loan. The other major problems were reported by the borrower farmers were inadequate amount of loan (87.50%), time consuming in borrowing procedure (79.17%), lack of knowledge about bank's

formalities (79.17%). In case of the problem faced by the credit agencies in lending the credit to the farmers, the major problem were identified the inadequate staff and influence of politically and of economically powerful farmers were the major constraints faced by the employee of the credit agencies. The problem of less educate of the farmers, improper utilization of loan, lack of strict action against defaulters, defective lending policy were also identified as the major problems faced by bank personnel in lending the credit to the needy farmers of the study area.

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A study on Extent of Adoption of Recommended Management Practices and Constraints by Dairy Farms in Bikaner District of Rajasthan

Raju Kumawat¹, J.P. Meena² and B.L. Dhayal^{2*}

¹Department of Agricultural Economics, SKRAU, Bikaner, Rajasthan-334001

²Krishi Vigyan Kendra, Vadodara, Gujarat-391125

*Corresponding Author Email : dhayalextn@gmail.com

Abstract

The constraints for the lack of management practices adoption were non availability of green fodder inadequate quantity for purchasing, high cost of feed and fodder, lack of insufficient space in dairy farms, lack of awareness, among all dairy owners about scientific management practices and some dairy owners feel not necessary about management practices. Most of the dairy owners were practicing scientific management practices such as feeding of green fodder, cleaning of animals and animal shed and health practices adopted partially and few management practices such as dry fodder, salt and watering, deworming and treatment were adopting fully and totting, dehorning, hoof treaming, artificial insemination and vaccination practice were not adopted by majority of dairy owners.

Key words : Adoption level, management, recommended.

Introduction

Dairying in India occupies a prominent place in rural life and provides not only subsidiary occupation and nutritional standards but is also a source of organic manures and draught power. In India, as in many developing countries, dairying is a supplementary enterprise to crop farming and highly integrated with the crop production sector. Crop residues are used to feed animals and animal manure is used in the fields as organic manure and fuel in rural areas. Dairy farming has been a part of the mixed crop livestock farming system in India for centuries. The animals feed largely on the crop residues/crop by product and contribute, in return dung for fuel, manure for fertilizer and farm power for crop production. Animal husbandry in India is closely interwoven with agriculture and plays important role for the large majority of farmers as it is perhaps the only tangible asset and mainstay for their socio-economic security. Cattle supply the most important motive for almost all - agricultural operation such as ploughing, lifting water from well and the transport of produce from field to the markets. Their share in the total input is from 8 percent to 42 percent. Dairy farming helps directly in increasing crop production by making available draught power, manure and cash income on day to day bases. The livestock sector has also emerged as an important segment of generating employment to rural families especially women, who contribute over 70 percent of labour in cattle rearing. The employment in this sector was approximately 9.8 million in principal status and about 8.6 m in subsidiary status (National Sample Survey 1993-94). The performance of the dairy animals depends on the adoption of improved

animal husbandry practices and information on the extent of adoption of such practices is very much important to increase milk production in the country. Adoption of scientific animal husbandry practices is one of the important aspects, which influence livestock production.

Research Methodology

For the selection of dairy farms, a complete list of all dairy farms operating in Bikaner was obtained and five dairy farms having herdsize of more than 20 milch animals were selected randomly. The primary data were collected through personal interview method on pre-structured and pretested schedules from selected dairy farms to fulfill the objectives. Information on recommended management practices was recorded from College of Veterinary and Animal Sciences, Bikaner.

Results and Discussion

The rearing and performance of milch animals is directly associated with the various operational methods employed. The scientific practices recommended by experts play an important role in increasing the milk production efficiency of animals. Therefore, to know whether the dairy owners are adopting the recommended scientific practices for their milch animals, the essential information regarding adoption of various scientific practices were collected from the dairy owners and the collected data were analyzed and results are presented in table 4.25. It is discussed in detailed under the following sub-heads.

Feeding practices : The adoption of scientific feeding practices by dairy owner in respect of concentrate, green

Table-1 : Adoption of recommended management practices by different dairy farms (%).

S. No.	Scientific practices	Fully adopted	Partially adopted	Not-adopted
1.	Feeding			
a.	Concentrates	-	60	40
b.	Dry fodder	100	-	-
c.	Green fodder	-	100	-
d.	Salt	100	-	-
e.	Watering	100		
2.	Management			
a.	Cleaning of animals	60	40	-
b.	Cleaning of animal shed	30	70	-
c.	Housing facilities	-	70	30
d.	Tattooing	-	-	100
e.	Dehorning	-	-	100
f.	Hoof trimming	-	-	100
3.	Breeding			
a.	Artificial insemination	-	-	100
4.	Health practices			
a.	Vaccination	-	40	60
b.	Deworming	80	20	-
c.	Treatments	40	60	-
5.	Milking			
a.	Cleaning of milch animals and milking site before milking	45	55	-
b.	Cleaning of milking equipments	80	20	-

*Fully adopted : - Recommended practices adopted more than 75 percent by dairy owners.

*Partially adopted : - Recommended practices adopted up to 75 percent by dairy owners.

*Not adopted : - Recommended practices not adopted by any dairy farm.

fodder and dry fodder, as observed from the table reveals that no any dairy owners supplied concentrate to their milch animals as per recommended by experts. However, partially adopted the recommended quantity of concentrate was by 60 per cent dairy owners and 40 per cent dairy owners identified as non-adopter of scientific feeding practices recommended for concentrate. In respect of green fodder 100 per cent dairy owners adopting the scientific feeding practices partially due to one or other reasons. In the average most of the dairy owners (100 per cent) in the area were fully adopting the watering practices and fully adopting the feeding practices for dry fodder. Salt supplied by dairy owner to their milch animals were recorded 100 per cent fully adopted.

Management practices : Under the management practices, several scientific practices suggested by veterinary doctors are given in table 1. In the table it can be seen that cleaning of the animals and animals sheds was the major operation and generally adopted partially by 40 percent and 70 per cent dairy owners. Fully adopted practices were recorded on any dairy farms 60 and 30 per cent in these two management practices. In respect of housing for milch animals, it was found that all dairy owners not having the housing facilities for their milch

animals as per recommended by veterinarian only 70 per cent adopted partially and 30 per cent was not adopted. Further, the recommended tattooing practice was taking by 100 percent dairy owners not adopted the recommended practice. Dehorning and hoof trimming were not adopted by any dairy owners.

Breeding practices : During the investigation, it was noticed that all dairy owners were more confident on natural breeding. Thus artificial breeding practices were not taken regularly by any dairy farms. However, when they feel necessary for individual milch animal they taken to their animal for artificial insemination in the centre where this facility available.

Health Practices : In respect of health care, the vaccination, deworming and treatments are the most important operational activities as recommended by specialist for keeping the animals healthy and in better performance. It can be observed from the table 1. That the deworming was the major health care activity and adopted fully by 80 percent dairy owners in the area and only 20 per cent dairy owners adopted this management practice partially. In other health care practices treatment of milch animals was exercised by all dairy owners in fully (40 percent) and partially (60 percent). Vaccination in milch animals was not a common practice as it was

Table-2 : Constraints in adoption of recommended management practices by dairy owners (%).

S. No.	Constraints	Percentage
1.	Feeding of concentrates	
	1. Feed cost is very high	60
	2. Not aware about recommended quantity	40
2.	Feeding of green fodder	
	1. Not available sufficiently in the area for purchasing	100
3.	Management practices	
	A. Housing facilities	
	1. Lack of sufficient space	60
	2. Not aware about recommended practices	40
	B. Dehorning	
	1. Not aware about scientific methods	80
	2. Proper equipments and chemicals are not available	20
	C. Tattooing	
	1. Not much aware about these practices	20
	2. Don't feel necessary	80
	D. Hoof trimming	
	1. Lack of awareness and don't feel necessary	100
4.	Artificial Breeding	
	1. More confident in natural breeding	20
	2. Method is complicated	80
5.	Health practices like Vaccination, Deworming and Treatments	
	1. Lack of facilities	60
	2. Lack of awareness	40

partially adopted only by 40 percent dairy owners and 60 percent dairy owners are not conscious about Vaccination to their milch animals.

Milking : Cleaning of milch animals and cleaning site where milking is taking place was partially adopted 55 per cent and 45 per cent fully adopted by all dairy owners dairy owner as recommended by experts. Cleaning of milking equipments were found common in practice before milking of milk 80 percent dairy owners cleaning their milking equipment fully and 20 per cent partially as recommend by experts.

Constraint in adoption of Scientific practices by dairy farms

It was observed that number of problems is faced by dairy owners, regarding maintenance of their milch animals. Some important problems generally facing the dairy owners are related to the inadequate feeding, health care and management practices. These problems are directly associated with the performance of the milch animals. Due to various reasons, dairy owners could not maintain their milch animal as per recommended scientific practices. The reasons which are creating there problem in adopting the scientific practices are considered as constraints and the major constraints are presented in table 2.

Feeding of concentrates : It was observed that 100 per

cent dairy owners are facing the problems related the inadequate supply of concentrate against the quantity recommended by specialist. Among these dairy owner, 60 per cent dairy owners were unable to supply the adequate concentrates quantity to their milch animals due to higher concentrates cost and 40 per cent dairy owners not given importance about recommended quantity of concentrates to be supplied to their milch animals.

Feeding of green fodder : During the collection of information from sample dairy owners regarding feeding of green fodder, it was noticed that, the supplying of green fodder to the milch animals was very less in quantity especially in summer season due to one or another reasons. The major constraints was observed that no sufficient quantity of green fodder available in the area for purchasing as per dairy owners requirement and 100 per cent dairy owners were facing this problem.

Management practices : Sufficient space and other housing facilities playing the important role in maintaining the health and production efficiency of milch animals but due to some constraints, dairy owners were unable in adopting the housing facilities to their milch animals as per recommended by experts. The majority of the dairy owners were having the constraints of insufficient space in their dairy farms as per required for per milch animals. However, some of the dairy owners not given the importance of recommended housing facilities. Dehorning

of milch animals was not in a common practice in the dairy farms due to two reasons. Firstly, due to lack of awareness about scientific method of deworming and secondly, due to lack of availability of proper equipments, chemicals etc. The majority of dairy owners 80 per cent identified as they were not aware about scientific method of dehorning and only 20 per cent dairy owners wants to adopt the dehorning practices but due to lack of proper equipment, chemicals and other required facilities, the dehorning practices was not adopted by dairy owners. Tattooing practice of the animals was not a common practice on all the dairy farms, the 20 per cent dairy owners not much aware about this practice and 80 per cent dairy owners don't feel necessary of this practice. Hoof trimming by scientific methods is one of the important practices for health point of view but this practice was not a common and no any dairy owner was adopting this practice due to lack of awareness and don't feel necessary. Regarding the adoption of breeding practices in scientific manner, no any dairy owner was identified as a adopter and the major constraints was observed, that they are more confident in natural breeding and feel complicated of this method. No artificial breeding facilities were available with the dairy owner at their dairy farms.

Health practices like Vaccination, Deworming and Treatments : The health practices manly not adopted by dairy owners due to lack of facility and lack of awareness, about 60 per cent dairy owners facing these problems due to lack of facility and 40 per cent due to lack of awareness.

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Effect of Dietary Supplementation with Shatavari (*Asparagus Racemosus*) on Milk Yield of Lactating Crossbred Cows

Rashmi Bhinda*, J.L. Choudhary, Lokesh Gupta and Jeewan Ram Jat

Department of Animal Production, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan-313001

*Corresponding Author Email : rashmibhinda@gmail.com

Abstract

A study was conducted to determine the effect of shatavari supplementation on milk production performance in lactating crossbred cows. For this fifteen lactating crossbred cows were selected and divided into three groups of five animals each on the basis of their body weight and milk yield in completely randomized design. The different dietary groups were T₁ (control group), which received normal feed without shatavari supplementation, T₂ and T₃ that received shatavari root powder @ 150 mg and 200 mg/kg body weight, respectively. The study was conducted for a period of 90 days. Milk yield was recorded on weekly basis. The result showed that feeding shatavari to lactating crossbred cows significantly ($P<0.05$) increased milk yield. The average milk yield observed in the cows of T₁, T₂ and T₃ groups were 8.53, 9.47 and 9.83 kg, respectively. It was observed that the feed efficiency for milk production did not differ when shatavari was supplemented in the diet of lactating crossbred cows. The net return was estimated as Rs. 177.29, Rs. 197.57 and Rs. 206.14 per cow per day, respectively in Control (T₁), T₂ and T₃ groups whereas calculated benefit cost ratio of Control (T₁), T₂ and T₃ groups was 1:2.20, 1:2.21 and 1:2.23, respectively. It was concluded that supplementation of shatavari to lactating crossbred cows was cost effective and significantly improved milk production in crossbred cows.

Key words : Crossbred cows, economics, feed efficiency, milk yield, shatavari.

Introduction

The livestock sector plays a vital role in the rural economy as providing household income and generating gainful employment in the rural area. Livestock contributes 4.11 % in total GDP during the year of 2019-20. India is leading country in total milk production. Milk production in India is 187.7 million tonnes in 2018-19 and per capita availability is 394 gm/day in 2018-19 (Basic Animal Husbandry Statistics, DAHD&F, GOI, 2019). Milk comprises of protein, vitamins, carbohydrate, lipids and minerals in different concentrations. It is considered as protein rich nutritious food for all age group of people including infants and patients. In the last two decades, India has risen to become one of the world's leading dairy producers, with tremendous growth in milk production. On the other hand, the productivity of dairy animals in India is extremely low due to several issues like as underfeeding, malnutrition, various diseases, stress, etc. which hamper the economy of the dairy industry.

The herbal plants are commonly used as animal feed additives, improved feed palatability, utilization and animal productivity due to these increased the animal products and productivity especially milk yield and milk composition having galactagogue properties viz; Shatavari (*Asparagus racemosus*) Bhringraj (*Eclipta alba*), Jiwanti (*Leptadenia reticulata*), Papaya (*Carica papaya*) and Methi (*Trigonella foenum*) as reported by Chopra *et al.* (1952), Bakshi *et al.* (2004). These herbs

have been described to improve the general health, milk production and reproduction of both humans and animals. Among them, Shatavari (*Asparagus racemosus*) needs a special mention. Shatavari act as antiseptic, astringent diuretic and galactagogue properties. Roots contains saccharine and mucilaginous substances in large proportion. It helps in improving digestibility, increase milk production, helps in mammary gland development; stimulate lactiferous tissues and keeps udder and teats in smooth condition (Somkumar *et al.* 2005).

Shatavari (*Asparagus racemosus*) is the one most commonly used herb in traditional medicine due to the presence of steroidal saponins and sapogenins in various parts of the plant (Krishana *et al.*, 2005). The general pharmacology of shatavari are galactagogue and mammogenic, it enhances the blood prolactin level and encourages the cellular division in the mammary gland (Kumar *et al.*, 2008). The adoption of shatavari feed supplementation in animal production used as ancient history (somkuwar and pawar, 2005). Shatavari may constitute a very important component of livestock feed because of higher content of nutrients and also a good source of folic acid, potassium, dietary fibre. The *Asparagus racemosus* are used as animal feed additives, having galactagogue properties. Because of its galactagogue properties it is used to increase milk supply, helping the let-down, keeping the milk "fresh", and re-lactation. Therefore, *Asparagus racemosus* used to

Table-2 : Effect of shatavari supplementation on milk yield and related parameters (Mean±SE).

Parameters	Treatments		
	T ₁ (Control)	T ₂	T ₃
Milk yield (kg)	8.53 ^b ± 0.405	9.47 ^a ± 0.208	9.83 ^a ± 0.234
FCM yield (kg)	9.27 ^b ± 0.34	10.60 ^a ± 0.33	10.92 ^a ± 0.34
SCM yield (kg)	9.13 ^b ± 0.35	10.58 ^a ± 0.37	10.95 ^a ± 0.38
Feed Efficiency	25.53 ± 1.35	26.36 ± 1.50	27.69 ± 1.91

Means with various superscripts within a row differ significantly (p<0.05)

Table-3 : Economics of shatavari feeding for crossbred cows.

Attributes	Treatments		
	T ₁ (Control)	T ₂	T ₃
Total feed cost (Rs/cow/day)	146.85	146.85	146.85
Cost of shatavari (Rs/cow/day)	-	15.44	20.55
Total expenses (Rs/cow/day)	146.85	162.29	167.40
Av. daily milk yield (kg/day)	8.53	9.47	9.83
Cost of milk (Rs/kg)	38	38	38
Daily income on sale of milk (Rs/cow/day)	324.14	359.86	373.54
Net profit (Rs/day)	177.29	197.57	206.14
B:C ratio	1:2.20	1:2.21	1:2.23

examine the effect of shatavari on production performance of lactating crossbred cows.

Materials and Methods

The study was conducted to examine the effect of Shatavari on milk production and economics of milk production. Fifteen lactating crossbred cows at early stage of lactation were selected from the herd of livestock farm Rajasthan College of agriculture, MPUAT, Udaipur (Rajasthan) for the study purpose. After that, the animals were randomly placed into three groups of five animals each on the basis of nearness in their body weight and milk yield. All the animals were fed as per ICAR (2013) feeding standards to meet the requirement of nutrients. The experiment was carried out for a period of 90 days. The Asparagus root powder was added and mixed in concentrate uniformly in morning and fed individually to each animal. Throughout the experiment, all experimental cows were kept in a well-ventilated shed. Three different dietary trial feeds were given to the cows. (Table-1).

Table-1 : Experimental feeds offered to lactating crossbred cows.

Groups	Experimental feed
T ₁ (Control)	Wheat straw ad-lib. + 10 kg green fodder + Concentrate mixture
T ₂	T ₁ + Shatavari @ 150 mg/kg BW
T ₃	T ₁ + Shatavari @ 200 mg/kg BW

Sampling and Analysis

Milk yield : All crossbred cows were milked twice daily. The milk production of all the fifteen crossbred cows was measured on weekly basis.

Calculation of FCM and SCM : For the conversion of

whole milk in to 4% FCM, the following equation described by Gaines (1928) was adopted :

$$4\% \text{ FCM (kg)} = 0.4M + 15 F$$

Where,

M = Milk yield in kg

F = Weight of fat content in milk

The solid corrected milk (SCM) was calculated by the method of Tyrrell and Reid (1965) using the following equation:

$$\text{SCM (kg)} = 12.3 F + 6.56 \text{ SNF} - 0.0752 M$$

Where, 'F', 'SNF' and 'M' were expressed as kg of fat, kg of SNF and kg of milk, respectively.

The feed efficiency of milk production was calculated using the milk energy and digestible energy (DE) consumed by adopting the following formula :

$$\text{Feed efficiency (FE \%)} = \frac{\text{Milk energy (Mcal / d)}}{\text{DE consumed (Mcal / d)}} \times 100$$

Statistical analysis : Completely randomized design (CRD) was used to conduct the experiments and data were analyzed as per the procedure of Snedecor and Cochran (1980). Treatment means were tested by critical difference test.

Results and Discussion

Milk yield : Perusal of data in fig.-1 revealed that the supplementation of Shatavari was significantly (P<0.05) increased milk production of crossbred cows in treatment groups as compared to control group. Average daily milk yield per animal per day during 90 days period in

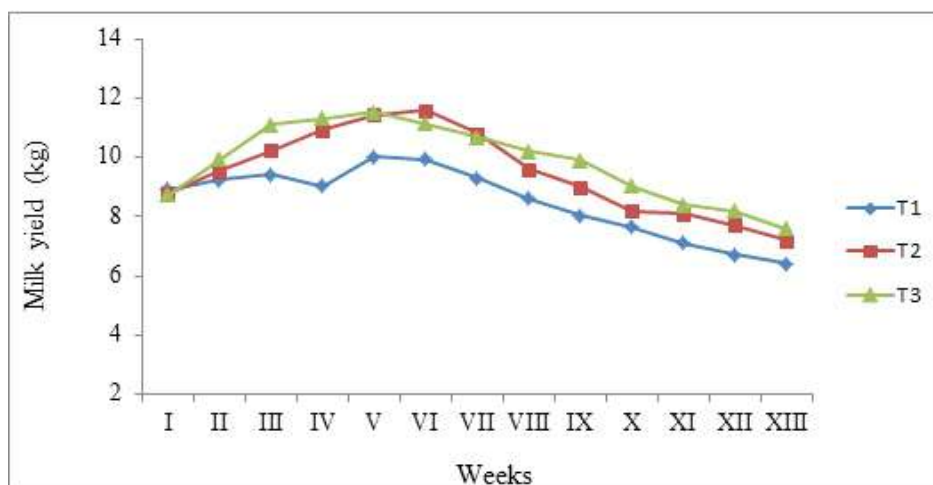


Fig.-1 : Average milk yield (kg) in lactating crossbred cows under different groups.

shatavari supplemented groups (T_2 and T_3) and control group (T_1) were 9.47 ± 0.208 , 9.83 ± 0.234 and 8.53 ± 0.405 kg, respectively. Milk yield was significantly ($P < 0.05$) higher in T_2 and T_3 supplemented group as compared to control group T_1 (Table-2), but non-significant difference in milk yield was observed between treatment groups. Average daily milk yield (kg/day) was higher in shatavari supplemented groups; T_2 by 11.02% and T_3 by 15.24% in comparison to the control group. The 4 per cent FCM yield was 9.27 ± 0.34 , 10.60 ± 0.33 and 10.92 ± 0.34 kg in treatments T_1 , T_2 and T_3 , respectively. The corresponding SCM yield in T_1 , T_2 and T_3 was 9.13 ± 0.35 , 10.58 ± 0.37 and 10.95 ± 0.38 kg, respectively. Feeding of asparagus root powder resulted in significant ($P > 0.05$) increase in FCM and SCM yield (Table 2). FCM was higher in T_2 by 14.34% and T_3 by 17.79% in comparison to the control group. The supplementation of Shatavari increases milk production in crossbred cows could be due to higher levels of the hormones prolactin and insulin in galactagogue herbal mixture (Dadkhah and Yeganehzad, 2011). The results are in agreement with the findings of Jingar *et al.* (2018) who reported that supplementation of Shatavari @50gm per day observed a significant increase in milk yield of buffaloes in comparison to their previous production. Soni *et al.* (2016) reported that feeding of *Asparagus racemosus* in Kankrej cows, significantly ($P > 0.01$) increased milk yield and fat corrected milk yield in supplemented groups as compared to control group.

Patel *et al.* (2017) reported that supplementation of galactagogue mixture of herbs significantly ($P < 0.05$) increased 4% fat corrected milk yield (kg/day) compared to the control group. Muwal *et al.* (2020) reported that supplementation of shatavari in Sahiwal crossbred cows significantly ($P < 0.05$) improved milk yield in treatment group as compared to control group. The feed efficiency of milk production in shatavari supplemented groups (T_2

and T_3) and control group (T_1) were 26.36 ± 1.50 , 27.69 ± 1.91 and 25.53 ± 1.35 percent, respectively. The feed efficiency of milk production was maximum in T_3 followed by T_2 and T_1 groups. However, the differences among the treatment groups were found to be non-significant.

These observations get supported from results obtained by earlier investigators (Kumar *et al.*, 2010, Divya *et al.*, 2015 and Saini *et al.*, 2018), who reported that the milk production efficiency did not vary when feeding shatavari herbal in the diet of lactating cows.

Economics of shatavari supplementation : Economics of Shatavari supplementation depicted in Table-3. Data revealed that the cost of shatavari supplementation (Rs/cow/day) was 15.44 and 20.55 in T_2 and T_3 , respectively. Total feed expenses was highest in T_3 and lowest in T_1 (control) group. Average daily milk yield in T_1 (control), T_2 and T_3 was 8.53, 9.47 and 9.83 kg/cow, respectively. Daily income from sale of milk (Rs/cow/day) was calculated as 324.14, 359.86 and 373.54 in T_1 (control), T_2 and T_3 groups, respectively. Hence the daily net profit was estimated as Rs.177.29, Rs.197.57 and Rs. 206.14 per cow in T_1 (control), T_2 and T_3 groups, respectively. The benefit-cost ratio was calculated as 1:2.20, 1:2.21 and 1:2.23 in T_1 (control), T_2 and T_3 groups, respectively. Dibya (2010) reported that given Asparagus root powder with regular ration of the cows resulted to increased income Rs. 9.75/day/cow. Jingar *et al.* (2018) who reported that increase in the income by feeding Shatavari root powder resulted to Rs. 12.00/day/animal.

Conclusions

It can be concluded, based on the above findings, that supplementation of Shatavari in the diet of lactating crossbred cows was cost effective and significantly improved animal productivity by enhancing milk

production and feed conversation efficiency in lactating crossbred cows. Utilization of *Asparagus racemosus* will not only improve productivity and health of animals but also support the farmer's generating income through production of more milk and early calving of animals.

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Effect of Different Pre and Post-Emergent Application on the Productivity of Black Gram under Sandy Loam Soils of Gwalior

Sudarshan Chicham^{1*}, S.S. Bhadauria¹, Jatin K.¹ and Vijay Kumar²

¹RVSKVV-College of Agriculture, Gwalior, M.P.

²RVSKVV-College of Agriculture, Indore, M.P.

*Corresponding Author Email : chicham30@gmail.com

Abstract

A field experiment entitled "Effect of different pre and post-emergence application on the productivity of Black gram under sandy loam soils of Gwalior" was conducted at Research Farm, RVSKVV, College of Agriculture; Gwalior (M.P.). The field experiment was carried out in randomized block design with twelve treatments viz., Imazethapyr @ 70 g a.i. ha⁻¹ PE, Imazethapyr @ 80 g a.i. ha⁻¹ PE, Imazethapyr @ 70 g a.i. ha⁻¹ PoE, Imazethapyr @ 80 g a.i. ha⁻¹ PoE, Imazethapyr + Imazamox (pre-mix) @ 70 g a.i. ha⁻¹ PE, Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha⁻¹ PE, Imazethapyr + Imazamox (pre-mix) @ 70 g a.i. ha⁻¹ PoE, Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha⁻¹ PoE, Pendimethalin @ 1000 g a.i. ha⁻¹ PE, Pendimethalin + Imazethapyr (pre-mix) @ 1000 g a.i. ha⁻¹ PE, Two hand weeding at 20 and 40 DAS and Weedy check. The results shown that the treatment Two hand weeding at 20 and 40 DAS recorded significantly higher grain (1003 kg ha⁻¹) and stover yield (2719 kg ha⁻¹). Further more weed control efficiency was significantly higher at 60 DAS, and weed index was lowest compared to other treatments. The treatment weedy check has recorded lowest grain yield (393 kg ha⁻¹). The study concludes that Two hand weeding at 20 and 40 DAS is the most effective treatment in controlling weeds under Gwalior conditions.

Key words : Hand weeding, imazamox, imazethapyr, Vignamungo L., WCE and yield.

Introduction

Black gram originated in India, where it has been cultivated from ancient times and is one of the most highly priced pulse of India. India is the largest producer and consumer of Black gram [*Vigna mungo* (L.) Hepper] in the world. It is grown during *Kharif* as well as summer season. It belongs to family Leguminosae. It is all rich in protein, which contains about 24 per cent protein. Pulses form an integral part of vegetarian diet in the Indian subcontinent. Black gram also enriches the soil by fixing atmospheric nitrogen up to 70-90 kg/ha (Satish *et al.*, 2018) and play a vital role in ensuring low input sustainable agriculture. It contributes about 13% of the total area in pulses and 10 per cent of their total production in India. Black gram was cultivated on an area of 5.4 m ha with a production of 3.86 m t and productivity of 655 kg ha⁻¹ in India during 2017 (Anon., 2018). It is extensively grown in the states of Madhya Pradesh, Maharashtra, Andhra Pradesh, Tamil Nadu, and Uttar Pradesh. In Madhya Pradesh, black gram is grown in 5.71 lakh hectares area, production is 1.48 lakh tonnes and productivity is 269 kg ha⁻¹ (Anon. 2018). In Gwalior district, black gram was sown in 5.07 thousand hectares area, production was 1.54 thousand tonnes and productivity was 303 kg ha⁻¹ during the year 2012 (C.L.R.S. 2015). Heavy weed infestation is a predominant restriction to realizing the full yield potential of black gram. According to Yadav (1992), weeds pose a serious problem in the rainy

(*Kharif*) season which causes losses even up to 50-60% have been recorded due to weeds in black gram. Weeds may mechanically be controlled by one hand weeding at 20 days and 40 days after sowing (DAS), but the biggest challenge is the availability of labour (Bhowmik and Gupta, 2005). Herbicidal weed management is cost-effective but the identification of suitable herbicide and its efficacy is the most important to be known. Hence, evolving a suitable weed management strategy is essential to avoid yield loss. Thus, a study was conducted to evaluate the efficacy of different pre and post-emergence herbicides in black gram in Gwalior with an objective of identification of the best control to effectively control weeds in Black gram.

Materials and Methods

An experiment was conducted at Research Farm, RVSKVV, College of Agriculture; Gwalior (M.P.). During the rainy season (*Kharif*) of 2015. The experimental field had sandy loamy soil texture with pH 7.57 and the soil having a content of 0.40 per cent organic carbon, 183.50 kg/ha available N, 14.4 kg/ha available P₂O₅ and 243 kg/ha available K₂O per ha. There were twelve treatments consisting of T₁ - Imazethapyr @ 70 g a.i. ha⁻¹ PE, T₂ - Imazethapyr @ 80 g a.i. ha⁻¹ PE, T₃ - Imazethapyr @ 70 g a.i. ha⁻¹ PoE, T₄ - Imazethapyr @ 80 g a.i. ha⁻¹ PoE, T₅ - Imazethapyr + Imazamox (pre-mix) @ 70 g a.i. ha⁻¹ PE, T₆ - Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha⁻¹ PE, T₇ - Imazethapyr + Imazamox (pre-mix) @ 70 g a.i.

Table-1 : Effect of various weed management practices on weed population, dry weight of total weeds, weed control efficiency and weed index.

Treatments	Total weed population	Dry weight of weeds (g/m ²)	WCE (%)	Weed index (%)
Imazethapyr @ 70 g a.i. ha ⁻¹	1.70(51.00)	61.30	62.77	32.50
Imazethapyr @ 80 g a.i. ha ⁻¹	1.59(39.00)	48.93	67.41	23.93
Imazethapyr @ 70 g a.i. ha ⁻¹	1.40(25.33)	25.30	83.80	15.65
Imazethapyr @ 80 a.i. ha ⁻¹	1.18(15.33)	16.47	90.01	8.57
Imazethapyr + Imazamox (pre-mix) @ 70 g a.i. ha ⁻¹	1.83(67.00)	76.87	52.04	41.58
Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha ⁻¹	1.76(57.67)	60.60	57.53	39.78
Imazethapyr + Imazamox (pre-mix) @ 70 g a.i. ha ⁻¹	1.25(17.67)	20.67	88.35	11.76
Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha ⁻¹	0.84(7.33)	10.07	94.26	4.19
Pendimethalin @ 1000 g a.i. ha ⁻¹	1.89(68.00)	75.40	51.57	41.87
Pendimethalin + Imazethapyr (pre-mix) @ 1000 g a.i./ha	0.89(8.33)	12.10	92.09	4.69
Two hand weeding at 20 and 40 DAS	0.82(6.67)	9.85	95.92	-
Weedy check	2.09(123.33)	134.42	-	60.82
S.E. (m)±	0.06	2.08	-	-
C.D. (at 5%)	0.17	6.13	-	-

DAS : Days after sowing figure in parentheses indicate original value.

Table-2 : Influence of herbicidal weed management on growth and yield attributes of black gram.

Treatments	Plant height at Harvest	No. of pods /plant	No. of seeds/pod	Grain yield (kg/ha)
Imazethapyr @ 70 g a.i. ha ⁻¹	68.00	32.33	6.70	677
Imazethapyr @ 80 g a.i. ha ⁻¹	70.47	35.53	7.07	763
Imazethapyr @ 70 g a.i. ha ⁻¹	76.73	40.40	7.23	846
Imazethapyr @ 80 a.i. ha ⁻¹	80.13	44.67	7.50	917
Imazethapyr + Imazamox (pre- mix) @ 70 g a.i. ha ⁻¹	66.67	29.20	6.20	586
Imazethapyr + Imazamox (pre- mix) @ 80 g a.i. ha ⁻¹	67.60	29.87	6.30	604
Imazethapyr + Imazamox (pre- mix) @ 70 g a.i. ha ⁻¹	76.53	43.73	7.47	885
Imazethapyr + Imazamox (pre- mix) @ 80 g a.i. ha ⁻¹	81.57	45.20	7.70	961
Pendimethalin @ 1000 g a.i. ha ⁻¹	66.33	29.57	6.13	583
Pendimethalin + Imazethapyr (pre-mix) @ 1000 g a.i./ha	81.00	45.20	7.67	956
Two hand weeding at 20 and 40 DAS	82.80	49.00	7.83	1003
Weedy check	56.97	22.07	4.87	393
S.E. (m)±	1.53	1.31	0.14	30
C.D. (at 5%)	4.50	3.96	0.40	89

ha⁻¹ PoE, T₈ - Imazethapyr + Imazamox (pre - mix) @ 80 g a.i. ha⁻¹ PoE, T₉ - Pendimethalin @ 1000 g a.i. ha⁻¹ PE, T₁₀ - Pendimethalin + Imazethapyr (pre -mix) @ 1000 g a.i. ha⁻¹ PE, T₁₁ - Two hand weeding at 20 & 40 DAS and T₁₂ - Weedy check. The experiment was laid out in randomized block design with three replications. Black gram variety T 9 was sown on July 20, 2015, in rows 30 cm apart and subsequently harvested on October 14, 2011. A basal dose of 20 kg N, 40 kg P and 20 kg ha⁻¹ were uniformly applied in all the plots. A knapsack sprayer fitted with a flat fan nozzle was used to apply the herbicide on the first day after sowing with a spray volume of 600 litre ha⁻¹ (Bhowmik and Gupta, 2005). Weed data were recorded at 30, 60 and 75 (at harvest) DAS by placing a quadrat of 50 cm x 50 cm area randomly at four spots in each plot. Observations on the height of crop plants were also recorded at 30 and 45 DAS (Bhowmik and Gupta,

2005). Data on grain yield (kg ha⁻¹) and its attributes were documented at harvest. Statistical analysis was done as per Gomez and Gomez (1984) to draw suitable conclusions.

Results and Discussion

The present study documented that *Cyperus rotundus*, *Echinochloa crusgalli*, *Dactyloctenium aegyptium* and *Arachanera cymosa* as narrow-leaf weeds and *Digera arvensis*, *Commelinabenghalensis* and *Phyllanthus niruri* as broad-leaf weeds are found to be major weeds in the experimental plots. Similar findings were recorded in several previous studies reports of Jakhar *et al.* (2015), Balyan *et al.* (2016) and Shashidhar *et al.* (2020), regarding weed flora's existence in the plot.

Influence of the weed density and dry weight on Black gram crop : Total weed population was significantly

lowest under two hand weeding at harvest stage (0.89m^{-2}) of crop growth. The all weed control treatments proved significantly better for reducing total weeds population over weedy check; which recorded significantly higher population. The minimum population of total weeds was counted with two hand weeding at 20 and 40 DAS over rest of the treatments. Amongst herbicidal treatments, PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha^{-1} being at par with PE application of Pendimethalin + Imazethapyr (pre-mix) @ $1000\text{ g a.i. ha}^{-1}$ and both were observed significantly superior other treatments. The higher weed control efficiency was recorded under two hand weeding at 20 and 40 DAS (95.92%). The next effective treatments was PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha^{-1} (94.26%) followed by PE application of Pendimethalin + Imazethapyr (pre-mix) @ $1000\text{ g a.i. ha}^{-1}$ (92.09%). The dry weight of total weed (gm^{-2}) at 30 & 60 DAS and at harvest stages of observation was significantly reduced by various weed control measures. The significantly lowest dry weight of total weeds was recorded under two hand weeding at 20 and 40 DAS; while highest was noted from weedy check. Amongst herbicidal treatments; minimum dry weight was recorded under PE application of Pendimethalin + Imazethapyr @ $1000\text{ g a.i. ha}^{-1}$; which was statistically at par with PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha^{-1} and both were observed significantly superior compared to other treatments. Significantly superior weed index was registered under two hand weeding at 20 and 40 DAS over rest of the treatments (60.82); while weedy check noticed uneconomic value of weed index (60.82%). Among herbicidal treatments; PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha^{-1} (4.19%) followed by PE application of Pendimethalin + Imazethapyr (pre-mix) @ $1000\text{ g a.i. ha}^{-1}$ (4.69%) were recorded effective value. Earlier reported by various researcher (Kumar et al., 2014), (Chand et al., 2014), (Kewat et al., 2014) and (Satish et al., 2018).

Influence on growth and yield of black gram : The plant height at 30 and 60 DAS and at harvest stages of crop growth has been recorded. The plant height increased with the advancement of crop age and reached maximum at harvest. The rate of increase in plant height was more during 30 to 60 DAS as compared to 60 DAS to harvest stage. The effect of various weed control treatments on plant height was found significant at all the stages of crop growth. All the weed control treatments significantly increased plant height over weedy check. The maximum plant height was registered under two hand weeding at 20 & 40 DAS i.e. 82.80 cm. Harvest stage followed by PE application Pendimethalin + Imazethapyr (pre-mix) @ $1000\text{ g a.i. ha}^{-1}$, application of Imazethapyr +

Imazamox (pre + mix) @ 80 g a.i. ha^{-1} and PoE application of Imazethapyr @ 80 g a.i. ha^{-1} without significant margin and all these treatments observed superior over rest of the treatments. The number of pods plant⁻¹ differed significantly due to different weed control measures. The two hand weeding at 20 and 40 DAS (49.00) recorded highest number of pods plant⁻¹, which was almost similar with PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha^{-1} (45.20) and PE application of Pendimethalin + Imazethapyr (pre-mix) @ $1000\text{ g a.i. ha}^{-1}$ (55.20) and significantly superior over rest of the treatments. The minimum number of pods plant⁻¹ was registered under weedy check (22.07). The number of seeds pod⁻¹ significantly influenced by different weed control treatments. Weedy check plot (4.87) recorded significantly lower number of seeds pod⁻¹. The maximum number of seeds pod⁻¹ was noted under two hand weeding at 20 & 40 DAS (7.83); which was statistically on par with PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha^{-1} (7.70), PE application of Pendimethalin + Imazethapyr (pre-mix) @ $1000\text{ g a.i. ha}^{-1}$ (7.67), PoE application of Imazethapyr @ 80 g a.i. ha^{-1} (7.50) and PoE application of Imazethapyr + Imazamox (pre-mix) @ 70 g a.i. ha^{-1} (7.47) and significantly better over remaining treatments. The grain yield/plant was significantly affected due to different weed control treatments. The maximum grain yield per plant was recorded under the application of two hand weeding at 20 & 40 DAS (12.11 g) followed by PoE application of Imazethapyr + Imazamox (pre-mix) @ 80 g a.i. ha^{-1} (11.75 g), PE application of Pendimethalin + Imazethapyr (pre-mix) @ $1000\text{ g a.i. ha}^{-1}$ (11.65 g) and PoE application of Imazethapyr @ 80 g a.i. ha^{-1} (11.30 g) were observed on par to each other and registered better values over remaining treatments. Weedy check plot produced the lowest value of grain yield plant⁻¹ (5.61 g). Similar results reported by (Adpawar et al., 2011), (Aggarwal et al., 2014), (Das, 2008), (Chand et al., 2014), (Kewat et al., 2014) and (Satish et al., 2018).

Conclusions

Two hand weeding at 20 and 40 was found to be the most effective practice about number of pods plant⁻¹ (7.83) and the grain yield (1003 kg ha^{-1}) thus demonstrated efficient and remunerative weed management treatment in black gram under sandy loam soils of Gwalior.

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Effect of Salicylic Acid and Nutrient Sources on Growth and Yield of Indian Mustard (*Brassica juncea* L.)

Surgyan Rundla, Pawan Kumar, Praveen Kumar, S.K. Thakral and R.D. Jat

Department of Agronomy, CCS Haryana Agricultural University, Hisar, Haryana

Corresponding Author Email : surgyan313@gmail.com

Abstract

A field experiment was conducted on loamy sand soil at CCS Haryana Agricultural University, Hisar over a period of two consecutive years during *Rabi* season (2018-19 and 2019-20). Results showed that salicylic acid applied as 200 ppm foliar spray at flower initiation and full bloom stage (F_3) recorded the maximum values of plant height 60 DAS, dry matter accumulation 30 DAS, number of branches, seed, stover and biological yield proved significantly superior over all other treatments. However, the treatment application of 200 ppm salicylic acid at flower initiation remained equally effective with regard to above parameters. Further, Results showed that application of treatment 1/3 each through FYM, vermicompost and biogas slurry (N_5) proved significantly superior over all other treatments with respect to Plant height 60 DAS, dry matter accumulation 30 DAS, dry matter partitioning 30 DAS, number of branches, seed, stover and biological yields.

Key words : Growth, yield, indian mustard, salicylic acid, nutrient sources.

Introduction

Indian mustard [*Brassica juncea* (L.) Czernj and Coss.] is the major oilseed crop, widely grown in *Rabi* season mostly in north and north western. The major mustard growing states are Rajasthan, UP, MP, Haryana, Gujarat, West Bengal, Assam, Bihar, Punjab and Jammu & Kashmir. Oilseeds are the second most important agricultural economy in India next to cereals growing at a pace of 4.1% per annum in the last three decades (Jat *et al.* 2019). The mustard seed in general, contains 30-33% oil, 17-25% proteins, 8-10% fibers, 6-10% moisture and 10-12% extractable substances (Sudhir *et al.*, 2013). Edible oils are the concentrated sources of energy, contain essential fatty acids (linoleic and linolenic), carriers of fat- soluble vitamins (A, D, E & K) and contribute to taste, flavour, palatability and satiety of food. The seed and oil of mustard have a peculiar pungency due to presence of glucosinolate and its hydrolysis products such as allyl-isothio-cynate making it suitable to use as condiment in the preparation of pickles and for flavouring curries and vegetables. At present time, mustard have identified as a good crop for supporting bee keeping activity.

The organic manures like farm yard manure, vermicompost, biogas slurry is known to play a number of vital roles in soil fertility, crop productivity and production in agriculture as they are eco- friendly and can be replace 25% chemical fertilizers that are able to get maximum crop yields. The inoculants of organic manure in soil plants, promote seed germination and initial vigor of plants by producing growth promoting substances also results in increased mineral, water holding capacity,

uptake, root development, vegetative growth and nitrogen fixation (Singh *et al.*, 2018). Salicylic acid plays a significant role in plant water relations, photosynthesis, growth and stomatal regulation under abiotic stress conditions and also created defense mechanism against insect pests (Arfan *et al.*, 2007). Moreover, salicylic acid creates plant tolerance capacity to different biotic and abiotic stresses by helping to gain systemic acquired resistance. The higher concentration of salicylic acid causes higher yield due to development of defense against abiotic stresses.

Materials and Methods

A field experiment was conducted at the Research Farm of the Department of Agronomy, CCS Haryana Agricultural University, Hisar over a period of two consecutive years during *Rabi* season 2018-19 and 2019-20. This place geographically is situated at 29° 10'N latitude and 75° 46'E longitude at mean elevation of 215.2 meter above mean sea level. The soil of experimental site was loamy sand in texture containing 127 & 128 kg/ha available nitrogen, 15.8 & 15.8 kg/ha phosphorus and 270 & 270 potassium, pH 8.1 & 8.0, EC 0.24 & 0.24 dSm⁻¹ and organic carbon 0.34 & 0.35% during 2018-19 & 2019-20, respectively in 0-15 cm depth. The experiment was laid out in split plot design with four replications, assigning twenty treatments consisting of four levels of foliar spray of salicylic acid (Water spray, 200 ppm Salicylic acid at flower initiation stage, 200 ppm Salicylic acid at full bloom stage and 200 ppm Salicylic acid at flower initiation and full bloom stage) and five different nutrient sources (RDF-80 kg N and 40 kg P₂O₅ ha⁻¹, 50% RDN through chemical fertilizers+50% RDN through FYM, 50% RDN

through chemical fertilizers+50% RDN through vermicompost, 50% RDN through chemical fertilizers + 50% RDN through biogas slurry and 1/3 RDN Each through FYM, vermicompost and biogas slurry). Mustard variety RH-725 was sown at 30 cm row spacing using seed rate of 4 kg ha⁻¹.

The data were recorded from five randomly selected plants from each treatment of each replication for plant population at 30 DAS and at maturity, plant height (cm) 30 and 60 DAS, dry matter accumulation (g) at 30 DAS, number of primary and secondary branches per plant, seed yield (q/ha), stover yield (q/ha), biological yield (q/ha) and harvest index (%). The observations recorded were during both of the years of study (2018-19 & 2019-20) and averaged for computation on per plant basis and statistically analysed as per Gomez and Gomez (1984) and Panse and Sukhatme (1961) using the statistical programme developed by O.P. Sheoran.

Results and Discussion

Crop growth : It is evident from pooled data of two years shows that the effect of different foliar sprays and nutrient sources on plant height (cm) at 60 DAS, dry matter accumulation (g/plant) at 30 DAS, dry matter partitioning at 30 DAS (g/plant) of leaves and stem, number of primary and secondary branches/plant significantly influence (Table-1 and 2).

Foliar spray : Plant population at 30 DAS and at maturity, plant height (cm) at 30 DAS, dry matter accumulation (g/plant) at 30 DAS, dry matter partitioning at 30 DAS (g/plant) of leaves and stem did not influence due to different foliar spray of salicylic acid during both the years of study and in pooled analysis. Data showed plant height at 60 DAS (119.20, 119.52 & 119.36 cm), primary branches (9.18, 9.90 & 9.54) and secondary branches/plant (19.75, 20.64 & 20.20) recorded significantly maximum in F₃ (200 ppm salicylic acid at flower initiation and full bloom stage) *i.e.*, which was found superior over all other treatments during 2018-19, 2019-20 and pooled data basis. The overall improvement in growth of crop with the addition of higher level of salicylic acid could be ascribed to its pivotal role in diverse physiological processes in plants which include thermogenesis, flower induction, nutrient uptake, ethylene biosynthesis, stomatal movement, photosynthesis, respiration, thermogenesis, flower formation and anti-oxidative enzymes (Hayat *et al.*, 2007).

Nutrient sources : Plant population at 30 DAS and at maturity and plant height (cm) at 30 DAS did not influence by nutrient sources during 2018-19, 2019-20 and in pooled basis. Data proved that plant height at 60 DAS (114.58, 115.13 & 114.86 cm), dry matter accumulation at 30 DAS (2.70, 2.76 & 2.73 g/plant), dry matter partitioning

Table-1 : Effect of foliar spray and nutrient sources on plant population, plant height (cm) and dry matter accumulation (g/plant) of mustard crop.

Treatments	Plant population (per m row length)						Plant height (cm)						Dry matter accumulation (g/plant)					
	30 DAS			At maturity			30 DAS			60 DAS			30 DAS			60 DAS		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Foliar sprays																		
F ₀	9.98	9.94	9.96	9.10	9.11	9.10	22.59	24.36	23.47	97.61	98.47	98.04	2.61	2.64	2.62	2.61	2.64	2.62
F ₁	10.10	10.33	10.21	9.22	9.45	9.33	23.16	24.48	23.82	107.70	107.50	107.60	2.63	2.69	2.66	2.63	2.69	2.66
F ₂	10.03	10.26	10.14	9.15	9.38	9.26	23.10	24.22	23.66	105.07	105.49	105.28	2.63	2.66	2.65	2.63	2.66	2.65
F ₃	10.46	10.59	10.52	9.58	9.71	9.65	23.39	24.86	24.12	119.20	119.52	119.36	2.67	2.74	2.71	2.67	2.74	2.71
SEM±	0.19	0.21	0.14	0.19	0.19	0.13	0.44	0.54	0.35	1.44	1.54	1.05	0.04	0.03	0.03	0.04	0.03	0.03
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	4.61	4.91	3.13	NS	NS	NS	NS	NS	NS
Nutrient sources																		
N ₁	10.03	10.40	10.22	9.15	9.58	9.37	23.01	24.39	23.70	104.46	105.45	104.95	2.59	2.62	2.61	2.59	2.62	2.61
N ₂	10.30	10.41	10.36	9.42	9.53	9.48	23.03	24.35	23.69	105.67	105.62	105.64	2.60	2.63	2.62	2.60	2.63	2.62
N ₃	10.30	10.42	10.36	9.42	9.54	9.48	22.74	24.65	23.69	106.23	106.81	106.52	2.61	2.64	2.63	2.61	2.64	2.63
N ₄	10.07	10.08	10.07	9.19	9.20	9.19	23.03	24.49	23.76	106.02	105.73	105.88	2.68	2.74	2.71	2.68	2.74	2.71
N ₅	10.01	10.07	10.04	9.13	9.20	9.17	23.50	24.51	24.00	114.58	115.13	114.86	2.70	2.76	2.73	2.70	2.76	2.73
SEM±	0.20	0.15	0.13	0.20	0.13	0.12	0.19	0.34	0.19	1.31	0.64	0.73	0.03	0.02	0.02	0.03	0.02	0.02
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	3.73	1.83	2.05	0.09	0.06	0.05	0.09	0.06	0.05

Table-2 : Effect of foliar spray and nutrient sources on dry matter partitioning at 30 DAS and number of branches/plant of mustard crop.

Treatments	Dry matter partitioning at 30 DAS (g/plant)						Number of branches/plant					
	Leaves			Stem			Total			Primary branches/plant		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Foliar sprays												
F ₀	2.34	2.36	2.35	0.27	0.28	0.28	2.61	2.64	2.62	7.33	8.16	7.74
F ₁	2.35	2.41	2.38	0.28	0.28	0.28	2.63	2.69	2.66	8.18	9.31	8.75
F ₂	2.36	2.38	2.37	0.28	0.28	0.28	2.63	2.66	2.65	7.87	8.54	8.20
F ₃	2.39	2.45	2.42	0.28	0.29	0.28	2.67	2.73	2.70	9.18	9.90	9.54
SEM±	0.04	0.03	0.02	0.005	0.003	0.003	0.04	0.03	0.03	0.23	0.24	0.17
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.73	0.78	0.50
Nutrient sources												
N ₁	2.32	2.36	2.34	0.27	0.28	0.27	2.59	2.64	2.61	7.57	8.64	8.11
N ₂	2.33	2.36	2.34	0.27	0.28	0.27	2.60	2.63	2.62	8.15	8.56	8.36
N ₃	2.34	2.37	2.35	0.27	0.28	0.28	2.61	2.64	2.63	8.54	8.95	8.74
N ₄	2.40	2.46	2.43	0.28	0.29	0.29	2.68	2.75	2.72	7.45	9.04	8.24
N ₅	2.42	2.45	2.43	0.28	0.29	0.29	2.70	2.73	2.72	8.99	9.69	9.34
SEM±	0.03	0.02	0.02	0.003	0.002	0.002	0.03	0.02	0.02	0.17	0.25	0.15
CD (P=0.05)	0.08	0.04	0.04	0.009	0.005	0.005	0.09	0.05	0.05	0.48	0.70	0.42

Table-3 : Effect of foliar spray and nutrient sources on yield (q/ha) and harvest index (%) of mustard crop.

Treatments	Yield (g/ha)						Harvest index (%)					
	Seed			Stover			Biological			Harvest index (%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
Foliar sprays												
F ₀	17.77	18.37	18.07	53.29	54.43	53.86	71.06	72.79	71.93	25.10	25.41	25.25
F ₁	22.37	22.73	22.55	74.42	75.51	74.97	96.79	98.24	97.51	23.15	23.16	23.15
F ₂	21.58	22.42	22.00	74.00	75.05	74.52	95.58	97.47	96.53	22.60	23.02	22.81
F ₃	24.70	25.62	25.16	86.58	88.62	87.60	111.28	114.24	112.76	22.21	22.44	22.33
SEM±	0.35	0.32	0.24	1.23	1.44	0.95	1.52	1.62	1.11	0.20	0.45	0.25
CD (P=0.05)	1.13	1.04	0.71	3.92	4.61	2.81	4.87	5.17	3.30	0.65	1.45	0.74
Nutrient sources												
N ₁	20.48	21.60	21.04	64.94	68.93	66.93	85.42	90.53	87.97	24.23	24.24	24.23
N ₂	21.08	22.09	21.58	70.65	71.78	71.21	91.72	93.87	92.80	23.20	23.74	23.47
N ₃	22.00	22.35	22.17	74.15	75.64	74.90	96.15	97.99	97.07	23.03	22.97	23.00
N ₄	21.74	22.10	21.92	73.83	72.98	73.40	95.58	95.07	95.33	22.87	23.34	23.11
N ₅	22.73	23.28	23.01	76.78	77.69	77.24	99.51	100.98	100.24	22.99	23.23	23.11
SEM±	0.21	0.17	0.13	0.68	0.84	0.54	0.69	0.90	0.57	0.32	0.28	0.21
CD (P=0.05)	0.58	0.49	0.38	1.94	2.38	1.51	1.97	2.56	1.60	0.92	0.80	0.60

Note : F₀ = Water spray, F₁ = 200 ppm Salicylic acid at flower initiation stage, F₂ = 200 ppm Salicylic acid at full bloom stage, F₃ = 200 ppm Salicylic acid at flower initiation and full bloom stage; N₁ = RDF (80 kg N and 40 kg P₂O₅ ha⁻¹), N₂ = 50% RDN through chemical fertilizers + 50% RDN through FYM, N₃ = 50% RDN through chemical fertilizers + 50% RDN through Vermicompost, N₄ = 50% RDN through chemical fertilizers + 50% RDN through Biogas slurry, N₅ = 1/3 RDN Each through FYM, Vermicompost and Biogas slurry.

Table-4 : Interaction effect of foliar spray and nutrient sources on yield (q/ha) of mustard crop.

Nutrient sources	Seed yield (q/ha)				Stover yield (q/ha)				Biological yield (q/ha)						
	Foliar sprays				Foliar sprays				Foliar sprays						
	2018-19				2018-19				2018-19						
	F ₀	F ₁	F ₂	F ₃	Mean	F ₀	F ₁	F ₂	F ₃	Mean	F ₀	F ₁	F ₂	F ₃	Mean
N ₁	16.39	20.99	20.21	24.33	20.48	45.37	66.33	65.91	82.15	64.94	61.76	87.33	86.12	106.48	85.42
N ₂	17.25	21.84	21.05	24.17	21.08	51.88	73.03	72.61	85.06	70.65	69.13	94.86	93.66	109.23	91.72
N ₃	18.16	22.76	21.97	25.09	22.00	55.37	76.55	76.12	88.57	74.15	73.53	99.31	98.10	113.67	96.15
N ₄	18.41	23.00	22.22	23.34	21.74	56.58	77.75	77.33	83.68	73.83	74.98	100.75	99.55	107.01	95.58
N ₅	18.64	23.24	22.45	26.57	22.73	57.26	78.44	78.02	93.41	76.78	75.91	101.68	100.47	119.98	99.51
Mean	17.77	22.37	21.58	24.70	22.73	53.29	74.42	74.00	86.58	76.78	71.06	96.79	95.58	111.28	99.51
SEm±	0.41	0.47				1.36	1.58				1.39	1.79			
CD (P=0.05)	1.17	1.41				3.87	4.77				3.95	5.48			

Note : F₀ = Water spray, F₁ = 200 ppm Salicylic acid at flower initiation stage, F₂ = 200 ppm Salicylic acid at full bloom stage, F₃ = 200 ppm Salicylic acid at flower initiation and full bloom stage; N₁ = RDF (80 kg N and 40 kg P₂O₅ ha⁻¹), N₂ = 50% RDN through chemical fertilizers + 50% RDN through FYM, N₃ = 50% RDN through chemical fertilizers + 50% RDN through Vermicompost, N₄ = 50% RDN through chemical fertilizers + 50% RDN through Biogas slurry, N₅ = 1/3 RDN Each through FYM, Vermicompost and Biogas slurry

at 30 DAS in leaves (2.42, 2.45 & 2.43) and stem (0.28, 0.29 & 0.29), number of primary (8.99, 9.69 & 9.34) and secondary branches/plant (19.45, 19.78 & 19.62) were noted significantly superior under N_5 (1/3 RDN each through FYM, vermicompost and biogas slurry) as compared to rest of the treatments during 2018-19, 2019-20 and pooled data basis. It is established fact that organic manures improve physical, chemical and biological properties of soil and supplies almost all the essential plant nutrients for long term during entire crop period with slow pace while the inorganic fertilizer ensures readily available nutrients for a short period (Mandal and Sinha, 2004).

Yield : Differences among salicylic acid and nutrient sources of seed yield (q/ha), stover yield (q/ha), biological yield (q/ha) and harvest index (%) were significant (Table-3).

Foliar spray : Significantly higher seed yield (24.70, 25.62 & 25.16 q/ha), stover yield (86.58, 88.62 and 87.60 q/ha), biological yield (111.28, 114.24 & 112.76 q/ha) and harvest index (22.21, 22.44 and 22.33%) were recorded under treatment F_3 (200 ppm salicylic acid at flower initiation and full bloom stage) during 2018-19, 2019-20 and on pooled basis, respectively. It is believed that increase in the crop yield might be due to delayed senescence of plant organs (particularly leaves and flowers) in response to exogenous salicylic acid that will automatically help the plant in extending the duration of photosynthetically active sites and also prevent premature loss of flower and fruits. Similar results obtained by Gunes *et al.*, 2007.

Nutrient sources : Data revealed that nutrient source N_5 (1/3 RDN each through FYM, vermicompost and biogas slurry) proved statistical superiority seed yield (22.73, 23.28 and 23.01 q/ha), stover yield (76.78, 77.69 and 77.24 q/ha), biological yield (99.51, 100.98 and 100.24 q/ha) and harvest index (22.99, 23.23 and 23.11%) which closely followed by the application of N_3 (50% RDN through chemical fertilizers + 50% RDN through vermicompost) during both the year of study and on pooled data, respectively. It is might due to nutrient sources partly attributed to its direct influence on dry matter production of each vegetative part and indirectly through increased morphological parameters of growth. Since, biological yield is a function of seed and stover yields representing vegetative and reproductive growth of crop and also nutrient uptake. Harvest index represents the increased physiological capacity (sink capacity) to mobilize photosynthesis and translocate it to organs having economic value. These observation agreements with the findings of Singh *et al.*, 2011.

Interaction effect : Data in table-4 indicated significant interaction effect of different treatments of salicylic acid

and nutrient sources that the highest yields were recorded in F_3N_5 combination as seed yield (26.57, 27.59 and 27.08 q/ha), stover yield (93.41, 96.91 & 95.16 q/ha) and biological yield (119.98, 124.49 and 122.23 q/ha) which closely followed by F_3N_3 and F_3N_2 treatment combination during both the years of study and pooled analysis.

Conclusions

Thus, it is concluded that the application of 200 ppm Salicylic acid at flower initiation and full bloom stage (F_3) with combination of 1/3 RDN Each through FYM, vermicompost and biogas slurry (N_5) was found effective for raising a successful mustard crop, since both improved the growth parameter and yield and yield attributes during 2018-19 & 2019-20.

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Response of Biofertilizers and Split Application of Vermicompost on Total Nutrient Uptake by Wheat (*Triticum aestivum* L.) Crop

Sushila Aechra and R.H. Meena

Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan 313001

Abstract

The present study was conducted to ascertain the effect of different combinations of biofertilizers and vermicompost in wheat (*Triticum aestivum* L.) crop. The field experiments were carried out at Rajasthan College of Agriculture (Udaipur) during *Rabi* season of 2017-18 and 2018-19. Treatments consisted of five levels of biofertilizers and four levels of vermicompost were evaluated in factorial randomized block design with three replications. Among the combinations of biofertilizers, *Azotobacter* + phosphorus solubilizing bacteria (PSB) + Potash mobilizing bacteria (KMB) + Zinc solubilizing bacteria (ZnSB) resulted in the highest increased total nutrient uptake by wheat. This combination was significantly superior to all other combinations for total nutrient uptake of wheat. Application of treatment 50 % VC at sowing+50 % VC at tillering recorded maximum total nutrient uptake by wheat over the other treatments. The present study thus indicates that a combination of biofertilizers and vermicompost hold promise for improving total nutrient uptake by wheat.

Key words : biofertilizers, nutrient uptake, vermicompost, wheat.

Introduction

Wheat (*Triticum aestivum* L) is the second most important cereal crop in India, after rice, both in terms of area and production. Wheat contains more protein than other cereals and has a relatively high content of Niacin and Thiamine. It is basically concerned in providing the characteristics substance "Gluten" which is very essential for bakery. There is a decline in productivity of wheat as a result of degradation of the soil and water resources and inadequate nutrient management. Optimum nutrition is required for getting maximum yield and good quality of produce (Pandey *et al.* 2020). There is further scope to expand this area to meet the global demand for quality grain. But little work is done to improve grain quality through plant nutrition using bio- and chemical fertilizers. Biofertilizers being cheaper, effective and environmental friendly are gaining importance for use in crop production (Kachroo and Razdan 2006). Phosphate solubilising bacteria (PSB), *Bacillus subtilis* and fungi, *vesicular arbuscular mycorrhizae* (VAM) are used for supplying phosphorus to plants (Suri *et al.* 2006). The combined application of N-fixing and P-solubilizing biofertilizers may have beneficial effect. So, organic manures like vermicomposts can be a good substitute for chemical fertilizers to overcome their adverse effects. Vermicomposts are finely-divided mature peat-like materials which are produced by a non-thermophilic process involving interactions between earthworms and microorganisms (Edwards and Burrows, 1988) leading to biooxidation and stabilisation of organic material (Aira *et al.*, 2000). Evaluation of vermicomposts has generally been limited to their characterization in terms of physical and chemical properties (Kýžilkaya and Hepsen, 2007). The

suitability of vermicomposts as commercial plant growth media, their impact on plant growth and nutrient contents, and the mechanisms by which they could influence plant yield and nutrient contents have received little attention. However, studies investigating the impact of biofertilizers and vermicompost on total nutrient uptake and quality of wheat remain scarce. Taking the above into consideration, the study was conducted to examine the effect of biofertilizers and split application of vermicompost on nutrient uptake and quality of wheat.

Materials and Methods

A field experiment was conducted under clay loam soils during 2017-18 and 2018-19 at Instructional Farm, Rajasthan College of Agriculture, Udaipur. The site is situated at 24°35' North Latitude and 74°42' East Longitude with the altitude of 579.5 m above mean sea level. The region comes under agro-climatic zone IVA (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan. The wheat crop experienced maximum and minimum temperature ranged between 28.56 to 37.29 °C and 8.81 to 19.29 °C during *rabi* 2017-18, respectively. The corresponding temperature fluctuations during second year (2018- 19) of experimentation were 27.58 to 33.70 °C and 8.34 to 17.70 °C, respectively. The total amount of rainfall received in both the years as 10 and 15 mm during 2017-18 and 2018-19, respectively. The texture of soil was clay loam (sand 38.82%, silt 26.58% and clay 34.60 %). The soils were normal alkaline in reaction, medium in available nitrogen, phosphorus and high in available potassium. The study was carried out on Raj-4037 variety of wheat crop with different biofertilizers and vermicompost treatments during two consecutive *rabi* seasons. We selected 20 treatment combinations in which

five levels of biofertilizers (B_1 : Control, B_2 : *Azotobacter*, B_3 : *Azotobacter* + PSB, B_4 : *Azotobacter* + PSB + KMB and B_5 : *Azotobacter* + PSB + KMB + ZnSB) and four levels of vermicompost (V_1 : Control, V_2 : 100 % VC at sowing, V_3 : 50 % VC at sowing + 50 % VC at tillering and V_4 : 75 % VC at sowing + 25 % VC at tillering). During both the years 60 kg ha⁻¹ N and 40 kg ha⁻¹ P₂O₅ were applied in the soil as initial nutrient requirements. The ploughing and harrowing operations were done using tractor drawn cultivator and disc harrow, and inter cultivations were done at 25 and 45 days after the sowing. The wheat variety of Raj-4037 was sown at a spacing of 22.5 cm x 10 cm using a seed rate of 125 kg ha⁻¹ on 29 November during 2017-18 and 2018-19, respectively. The fertilizer sources used were urea and DAP. For the seed treatment a plastic bag was used. The bag filled with 1 kg of seeds and added required quantity of biofertilizers (@ 5 ml kg⁻¹ seed of each biofertilizers). After the seed treatment seeds were sown in each marked plots. The vermicompost (@ 4 t ha⁻¹) were applied in the field as per treatments mixed at the time of sowing (Basal application) and tillering stage. Nutrient composition of the vermicompost applied in the experiment is given in Table 1. The previous crop grown at the experimental site was sorghum and left fallow during rainy and summer. The crop was irrigated seven times (10.2 mm) at critical stages.

Table-1 : Nutrient composition of the vermicompost used in the experiment.

S. No.	Components	% on oven dry weight basis
1.	Nitrogen (N)	1.14
2.	Phosphorus (P ₂ O ₅)	1.28
3.	Potassium (K ₂ O)	1.06
4.	Zn (ppm)	26.5
5.	Fe (ppm)	172.2
6.	Mn (ppm)	96.8
7.	Cu (ppm)	4.78
8.	pH	7.0-7.5

The crop was harvested on 8-04-2018 and 10-04-2019. Crop was manually harvested, after the crop harvested, the straw and yield were air dried and weight. For analysis of soil, Soil samples up to 0-15 cm depth was drawn from different spots of field and a representative composite sample was prepared by mixing and analysis using standard methods. The experimental data on nutrient uptake and quality of wheat were subjected to Fisher's method of Analysis of variance (ANOVA) as given by Panse and Sukhatme (1985). All the data were analyzed and the results were described and discussed at a probability level of five per cent and correlation study was done as suggested by Panse and Sukhatme (1985).

Results and Discussion

Total Nutrient and Protein Uptake by Crop : The findings of the present study have been presented under following heads :

Effect of Biofertilizers : Nutrient uptake by wheat crop increased significantly with seed inoculation with different biofertilizers (Table-2). The maximum uptake of nitrogen (103.99 and 110.72 kg ha⁻¹) was recorded with the application of biofertilizers as *Azotobacter* + PSB + KMB + ZnSB during both the years, respectively over control. Seed inoculation with *Azotobacter* + PSB + KMB + ZnSB registered higher phosphorus (28.80 and 30.66 kg ha⁻¹) uptake by crop during both the years over no inoculation. Significant improvement in K uptake by wheat crop was observed with *Azotobacter* + PSB + KMB + ZnSB. The uptake of potassium (120.35 and 126.76 kg ha⁻¹) increased with the application of *Azotobacter* + PSB + KMB + ZnSB. Results further revealed that seed inoculation with biofertilizers significantly improved micronutrients uptake by wheat crop (Table 2). The maximum zinc (525.25 and 530.00 g ha⁻¹), iron (1503.74 and 1574.00 g ha⁻¹), manganese (652.22 and 688.37 g ha⁻¹) and copper (101.24 and 107.95 g ha⁻¹) uptake by wheat crop were found under the treatment *Azotobacter* + PSB + KMB + ZnSB, which was significantly higher over control. Treatment B_5 remained at par with B_4 in terms of iron, manganese and copper. Higher values of N uptake with increasing levels of S are apparently the result of favourable effect of the sulphur on N content coupled with grain and straw yield. Similar results were also reported by Singh and Singh (2020). The favourable effects of biofertilizers on N and P accumulation could be attributed to N₂ fixation by *Azotobacter* and P solubilization by PSB, also reported that dual inoculation of *Azotobacter* and PSB increased the N and P and K content and uptake in wheat due to their synergistic interaction (Sepat *et al.*, 2010; Minaxi *et al.*, 2013).

Seed inoculation with different biofertilizers increased protein uptake by wheat significantly over control during both the years. The maximum value of protein uptake by wheat (649.91 and 692.00 kg ha⁻¹) was accrued with *Azotobacter* + PSB + KMB + ZnSB and significantly higher over rest of treatment except B_4 . The increase in protein uptake by wheat may be attributed to increased grain and improvement in protein uptake due to biofertilizers application. Significant increase in grain N uptake with different combination of biofertilizers could be attributed to more nitrogen uptake by the crop and more translocation of N to grain. Similar results were reported by Singh and Singh (2017).

Effect of Vermicompost : Nutrient uptake by wheat crop improved significantly with split application of

Table-2 : Effect of biofertilizers and vermicompost on total nitrogen, phosphorus and potassium uptake by wheat crop.

Treatments	Total N uptake (kg ha ⁻¹)		Total P uptake (kg ha ⁻¹)		Total K uptake (kg ha ⁻¹)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Biofertilizers						
B ₁	74.83	79.95	19.77	21.06	87.62	92.44
B ₂	83.58	89.10	22.51	23.96	96.21	101.84
B ₃	93.89	100.08	25.74	27.38	108.91	115.57
B ₄	102.64	109.29	28.20	29.92	117.93	125.19
B ₅	103.99	110.72	28.80	30.66	120.35	126.76
SEm±	2.33	2.38	0.62	0.76	2.57	2.61
C.D. (P = 0.05)	6.68	6.81	1.79	2.17	7.37	7.47
Vermicompost						
V ₁	74.33	79.33	20.14	21.44	87.84	93.16
V ₂	84.18	89.78	23.29	24.79	99.07	105.05
V ₃	105.33	112.15	28.69	30.49	119.62	126.87
V ₄	103.29	110.05	27.89	29.66	118.30	124.36
SEm±	2.08	2.13	0.56	0.68	2.30	2.33
C.D. (P = 0.05)	5.98	6.09	1.60	1.94	6.59	6.68

Table-3 : Effect of biofertilizers and vermicompost on zinc, iron, manganese and copper uptake by wheat crop.

Treatments	Total Zn uptake		Total Fe uptake		Total Mn uptake		Total Cu uptake	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Biofertilizers								
B ₁	356.38	379.55	1092.51	1156.65	470.51	498.97	64.93	69.40
B ₂	393.09	418.55	1207.56	1278.52	520.44	551.92	75.33	80.44
B ₃	464.01	493.64	1370.92	1450.96	590.13	627.46	91.72	97.79
B ₄	492.43	524.17	1477.88	1566.34	638.32	676.68	99.56	106.53
B ₅	525.25	530.00	1503.74	1574.00	652.22	688.37	101.24	107.95
SEm±	10.59	11.02	31.43	32.60	13.61	14.12	2.16	2.21
C.D. (P = 0.05)	30.31	31.54	89.98	93.34	38.97	40.44	6.19	6.33
Vermicompost								
V ₁	365.83	389.61	1113.54	1179.18	475.67	504.40	64.28	68.83
V ₂	416.20	442.94	1256.49	1330.05	542.11	574.62	79.47	84.92
V ₃	504.66	536.75	1484.28	1570.82	644.08	682.47	101.94	108.74
V ₄	498.24	529.82	1467.78	1553.12	635.45	673.23	100.53	107.20
SEm±	9.47	9.85	28.11	29.16	12.17	12.63	1.93	1.98
C.D. (P = 0.05)	27.11	28.21	80.48	83.48	34.85	36.17	5.54	5.66

vermicompost (Table-2). Application of vermicompost as 50 % VC at sowing + 50 % VC at tillering registered higher uptake of nitrogen (105.33 and 112.15 kg ha⁻¹) during both the years, respectively over control. The maximum uptake of phosphorus by wheat crop was recorded (28.69 and 30.49 kg ha⁻¹) higher when the crop was amended with vermicompost 50% VC at sowing + 50 % VC at tillering and it was found significantly superior to control and basal dose. Soil amendment with vermicompost as 50% VC at sowing+50% VC registered maximum potassium (119.62 and 126.87 kg ha⁻¹) during both the years over control. Treatment V₃ remained at par with V₄ during both the years in terms of nitrogen, phosphorus and potassium. Results further revealed that amendment with vermicompost significantly improved micronutrients uptake by wheat crop (Table 3). The maximum zinc (504.66 and 536.75 g ha⁻¹), iron (1484.28 and 1570.82 g ha⁻¹), manganese (644.08 and 682.47 g ha⁻¹) and copper

(101.94 and 108.74 g ha⁻¹) uptake by wheat crop were found under the treatment 50% VC at sowing + 50% VC at tillering, which was significantly higher over remaining treatments except V₄. Significant increase in nutrient uptake might be due to the influence of increased yield and N content in crop with its application to soil. The results are in agreement with the findings of Kachroo *et al.* (2006). The results are in agreement with the findings of (Singh, *et al.*, 2019; Rahimabadi *et al.*, 2017).

Protein uptake by wheat crop was markedly increased due to split application of vermicompost (Table 4). Application of 50 % VC at sowing + 50% VC at tillering recorded the highest protein uptake by wheat (658.31 and 692.96 kg ha⁻¹) during both years. Treatment V₃ remained at par with V₄ during both years. This increase in protein uptake with vermicompost application could be due to the fact that the organic fertilizers increase nitrogen content in

Table-4 : Effect of biofertilizers and vermicompost on protein uptake by wheat crop.

Treatments	Protein uptake (kg ha ⁻¹) by crop	
	2017-18	2018-19
Biofertilizers		
B ₁	467.69	499.68
B ₂	522.36	556.86
B ₃	586.79	625.52
B ₄	641.50	683.09
B ₅	649.91	692.00
17 SEm±	14.59	14.88
C.D. (P = 0.05)	41.79	42.61
Vermicompost		
V ₁	464.58	495.80
V ₂	526.12	561.15
V ₃	658.31	692.96
V ₄	645.59	687.82
SEm±	13.05	13.31
C.D. (P = 0.05)	37.38	38.11

grain and straw. Similar results were reported by Singh, *et al.*, 2019.

Conclusions

On the basis of above results, it can be concluded that the application of biofertilizers and vermicompost had great effect on total nutrient uptake as well as protein by wheat crop. Thus, it can be recommended to substitute chemical fertilization to provide high availability of nutrients to plants.

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Phenotypic Diversity of Newly Developed Cytoplasmic Lines of Wheat Based on Multivariate Analysis

Vinod Kumar^{1*}, R.S. Shukla¹, Mohammad Ekram Hussain², Suneeta Pandey¹ and Amit Kumar Jha³

¹Department of Plant Breeding and Genetics, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), 482004

²Department of Genetics and Plant Breeding, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

³Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), 482004

*Corresponding Author Email : vinod.goyal90@gmail.com

Abstract

An assessment of genetic variation within diverse genotypes is needed to allow more efficient genetic improvement. The purpose of this study was to use multivariate analysis to determine the nature and magnitude of genetic divergence across twenty-two genotypes based on phenotypical variables. Based on cluster analysis, the genotypes were best fitted into six clusters. The maximum and minimum genotypes grouped in cluster II (9) and minimum were in Cluster IV (1) and cluster VI (1), respectively. Cluster V ($D^2=203.25$) had the maximum intra-cluster distance, indicating the maximum difference among the genotypes within whereas cluster IV and VI had the minimum. The maximum value of inter-cluster distance ($D^2=826.93$) was recorded between cluster IV and cluster VI, indicating that the genotypes of these clusters were highly diverse from others and might be used as divergent parents for hybridization and selection. Thus, genotypes from clusters IV and VI can be used as distant parents in any breeding program for successful wheat improvement to obtain high heterosis for recovering transgressive segregants. The first six PCs with eigen values >1 contributed 82.34% of the variability amongst genotypes. The characters contributing more positively with PC6 were days to maturity, plant height, biological yield per plant and grain yield per plant, which accounted 7.76% to the total variability. The present study results could be exploited in the future genetic improvement program of hybrid wheat in Madhya Pradesh region.

Key words : Genetic diversity, cytoplasmic lines, hierarchical clustering, hybrid wheat, principal component.

Introduction

Wheat (*Triticum aestivum* L., $2n=6x=42$) belongs to the family Gramineae (Poaceae) has been a staple food of the major civilizations for 8000 years. It is the most widely known grown cereal crop in the world, occupying 17% of crop acreage the world over, feeding about 40% of the world population and providing 20% of the total food calories and protein in human nutrition (Gupta *et al.*, 2005, Ajmal *et al.*, 2013, Getachew *et al.*, 2017, Kumar *et al.*, 2021). India is the second-largest wheat producer globally, with a production level of 109.52 million tones (Anonymous, 2020-21). In India also the larger area is under wheat cultivation. Five states, viz., Uttar Pradesh, Punjab, Haryana, Madhya Pradesh and Rajasthan, account for 90 percent of total wheat production (Shyam *et al.*, 2018). Madhya Pradesh is the second-largest producer state of wheat with an area, production, and productivity of 6.69 million hectares, 17.58 million tonnes, and 2.627 tonnes, respectively (Anonymous, 2020-21). Analyzing the targeted wheat production at the national level could be challenging to meet the demand by 2025 AD. Hence, hybrid breeding seems to be one of the alternatives to fulfill the demand. Therefore, an effort is made to develop hybrid wheat genotypes using cytoplasmic male sterile lines (Kumar *et al.*, 2021). A significant problem in the hybrid seed production of wheat

is its low cross-pollination ability. Apart from the above, there are several problems in hybrid wheat development. The lack of genetic diversity among parents for harnessing heterosis, out-crossing/natural crossing potential, complete fertility restoration, and efficient and cost-effective hybrid seed production technology are notable. (Goyal *et al.*, 2020). Therefore, exploring genetic diversity in the available germplasm is a prerequisite in a breeding program to effectively utilize the superior genotypes (Goyal and Bisen, 2017). Further a role of plant breeder is to identify the source of favorable genes to incorporate them into the breeding populations and select a combination of desirable traits that might result in the isolation of productive genotypes and cultivars. Thus, the present study is undertaken to understand the magnitude of genetic divergence to identify more diverse parents for hybrid wheat genetic improvement through hybrid vigour following cytoplasmic male sterile line approach (Goyal *et al.*, 2019).

Materials and Methods

Experimental material consists of seventeen male sterile lines, seventeen of maintainer line and seven restorer lines of wheat grown in two replications during Rabi Season, i.e. 2017-18 in RCBD design, respectively, at Seed Breeding Farm JNKVV, Jabalpur (MP). All the agronomic practices were made to raise the healthy crop

and development. The soil of the experiment is medium black with uniform topography and free from waterlogged conditions. The region has a subtropical, semi-arid climate with about 1200 mm average rainfall (Goyal *et al.*, 2020). Each plot consisted of four rows of 3.0-meter length. Observations were recorded on five competitive plants situated under the same field condition for fourteen quantitative morphological traits viz., days to heading, days to maturity, plant height, number of tillers/plant, peduncle length, ear length, ear weight, biological yield/plant, thousand-grain weight, harvest index, chlorophyll content, canopy temperature, relative water content and grain yield/plant. The pooled data from the sampled plants regarding different quantitative characters were used for various statistical analyses. The magnitude of genetic diversity among cytoplasmic lines of wheat was determined by using D^2 statistics (Mahalanobis, 1936). Hierarchical clustering using Tocher's method, as described by Rao (1952). Principal component analysis transforms the number of correlated variables into a smaller number called principal components, making complex data easier to understand. Compared to the following components, the first principal component accounts for the most variability in the data. The variation pattern was depicted using a scatter diagram. The mean values of each variable were standardized prior to cluster and principal component analysis to avoid the effects due to differences in scale.

Results and Discussion

The data obtained from the observations recorded on fourteen quantitative morphological traits were subjected to statistical analysis. Analysis of variance revealed that the mean sum of squares due to 24 lines was highly significant for all the traits (Table-2), giving a clear picture of the presence of a broad spectrum of variability among the genotypes (Supe *et al.*, (2013); Kumar and Bisen (2016), Lal *et al.*, (2011) and Georgieva *et al.*, (2016). The genetic improvement through hybridization and selection depends upon the extent of genetic diversity between parents (Hailu *et al.*, 2016, Birhanu *et al.*, 2017; Haussmann *et al.*, 2004). Although the analysis of variance revealed sufficient variability among the genotypes, the extent of genetic diversity present among the genotypes could not be explained. Therefore, cluster analysis was performed to quantify the genetic divergence between any two genotypes or groups of genotypes.

The cluster analysis sequesters genotypes into clusters that exhibit high homogeneity within a cluster and high heterogeneity between clusters (Jaynes *et al.*, 2003). Based on the relative magnitude of their Mahalanobis D^2 values using Torcher's method, all the 24 lines of wheat under study were grouped into six clusters.

The clustering patterns of pea genotypes into six clusters are presented in Table-3. Maximum number of genotypes (9) was grouped in cluster II namely: CMS-91B, CMS-94B, CMS-82B, CMS-87B, CMS-2041B, CMS-85B, CMS-90B, R-37 and R-936. Whereas cluster I and cluster III both contained five genotypes each where cluster I comprises genotypes namely: CMS-89B, CMS-97B, CMS-88B, CMS-95B and R-38; cluster III consisted of genotypes namely: CMS-92B, CMS-2046B, R-7, R-9 and R-10. Further more, cluster V comprises three genotypes: CMS-84B, CMS-96B and CMS-86B; followed by cluster IV and cluster VI, both contained one genotype each where cluster IV comprises of genotypes: R-939; and cluster VI consisted of genotypes namely: CMS-83B. The genetic diversity and geographical origin of genotypes did not reveal any parallelism in the genotype grouping pattern (Devi *et al.*, (2010); Singh *et al.*, (2007); Yadav *et al.*, (2011); Dhama *et al.*, (2009); Anandan *et al.*, (2011); Katiyar and Dixit (2009); Shrivastava *et al.*, (2012); Yadav *et al.*, (2009); Supe *et al.*, (2013) and Kumar and Kumar (2016).

The average intra and inter-cluster D^2 values with their corresponding intra and inter-cluster distance are presented in Table-4. The inter-cluster distances were greater than intra-cluster distances, which indicated the presence of a considerable amount of genetic diversity among the genotypes studied. The greater the magnitude of intra and inter cluster distance the higher the variability among the cluster and within the cluster and *vice versa* (Fig.1). The results are in concurrence with the findings of Kumar *et al.*, (2006); Singh *et al.*, (2007); Singh and Mishra (2008); Katiyar and Dixit (2009); Sen and De (2017). The least value of intra cluster distance was found in cluster IV and cluster VI ($D^2=0.0$), indicating the presence of less heterogeneous genotypes grouped in this cluster. Whereas, the maximum value of intra-cluster distance was observed in cluster V ($D^2=203.25$), revealing the existence of maximum differences among the genotypes falling in this cluster, followed by divergence ($D^2=177.13$) for cluster III, cluster II with ($D^2=153.33$) and cluster I ($D^2=107.0$) (Fig.1). Hence, selection within these clusters may be exercised based on the highest area of desirable traits.

In any breeding program where the nature of crosses is to be evaluated, the choice of diverse parents is of paramount importance as they produce superior off-springs in the segregating generation than the closely related ones. The inter-cluster distance (D^2) being the main criterion for selection of genotypes was also worked out as the crossing of genotypes within the same cluster would not produce superior off-springs. A range of 826.93 to 170.83 was observed when inter-cluster D^2 values were used to study the diversity among the clusters. The

Table-1 : List of cytoplasmic lines of wheat used in the study.

Male sterile lines	Maintainer lines	Restorer lines.
CMS-82A	CMS-82B	RES-7
CMS-83A	CMS-83B	RES-9
CMS-84A	CMS-84B	RES-10
CMS-85A	CMS-85B	RES-37
CMS-86A	CMS-86B	RES-38
CMS-87A	CMS-87B	RES-936
CMS-88A	CMS-88B	RES-939
CMS-89A	CMS-89B	
CMS-90A	CMS-90B	
CMS-91A	CMS-91B	
CMS-92A	CMS-92B	
CMS-94A	CMS-94B	
CMS-95A	CMS-95B	
CMS-96A	CMS-96B	
CMS-97A	CMS-97B	
CMS-2041A	CMS-2041B	
CMS-2046A	CMS-2046B	

divergence among wheat genotypes, similar to the findings of Ali *et al.*, (2008) and Birhanu *et al.*, (2017) who reported that cluster analysis could help find high yielding wheat genotypes. According to Rahim *et al.*, (2010) and Birhanu *et al.*, (2017), who showed that the hybrids of genotypes with maximum distance resulted in high yield, the cross between these genotypes can be used in breeding programs to achieve maximum heterosis. Therefore, more emphasis should be given on members of cluster IV with members of cluster VI; members of cluster III with members of cluster VI; members of cluster IV with members of cluster V for selecting genotypes as parents for crossing with the genotypes of cluster, which may produce new recombinants with desired traits may produce high amount of heterotic expression in the F_1 's and broad spectrum of variability in segregating (F_2) populations (Singh *et al.*, (2007); Kumar *et al.*, (2007); Shrivastava *et al.*, (2012), Getachew *et al.*, (2017); Hailegiorgis *et al.*, (2010); Degewione *et al.*, (2013); Fellahi

Table-2 : Analysis of variances for yield and yield attributing traits of cytoplasmic lines of wheat.

Characters	ANOVA Mean sums of square	Rang		Mean	Coefficient of variation (CVs)	Genetic advance as 5% of mean
		Min.	Max.			
Days to heading	9.76	60.00	73.00	65.25	4.78	9.86
Days to maturity	10.52	109.00	121.00	116.54	2.78	5.73
Plant height (cm)	36.64	97.50	120.54	106.00	5.71	11.76
Number of tillers/plant	0.63	7.50	10.25	9.37	8.50	17.52
Peduncle length (cm)	4.27	16.82	24.05	20.42	10.11	20.83
Ear length (cm)	0.96	9.49	13.35	11.40	8.59	17.70
Ear weight (g)	0.28	1.85	3.92	3.01	17.67	36.41
Biological yield/plant (g)	62.69	41.00	65.62	52.04	15.21	31.34
Thousand grain weight (g)	6.50	39.22	47.68	44.16	5.77	11.89
Harvest index (%)	12.79	32.37	46.66	37.26	9.60	19.77
Chlorophyll content (%)	7.58	41.40	55.05	48.67	5.65	11.65
Canopy temperature	1.00	18.50	22.45	20.55	4.86	10.01
Relative water content (%)	16..78	75.47	88.98	81.78	5.00	10.31
Grain yield/plant (g)	10.55	14.50	24.44	19.36	16.77	34.55

minimum value of inter-cluster distance ($D^2=170.83$) was found between clusters I and IV, indicating a close relationship and similarity for most traits among the genotypes included in these clusters. Whereas cluster IV and VI showed maximum value of inter-cluster distance ($D^2=826.93$), followed by cluster III and VI ($D^2=770.46$), IV and V ($D^2=644.33$), II and III ($D^2=602.01$), I and VI ($D^2=575.34$), III and IV ($D^2=515.52$) and II and IV ($D^2=512.61$) indicating that the genotypes included in these clusters are not so closely related showing a good amount of diversity (Fig.-1). Hence, these genetically diverse lines can be used as promising parents for hybridization.

This study showed the presence of a high genetic

et al., (2013); Ali *et al.*, (2010) and Devi *et al.*, (2010).

Diversity among the genotypes was also estimated based on the considerable variation in cluster means for different characters. Different clusters exhibited distinct mean values for almost all the fourteen characters, which reflect the genetic differences between the clusters (Table-5). It is evident from the cluster mean table that the genotypes in cluster III had the highest mean values for days to heading (68.20) and plant height (114.78). Whereas the genotypes of cluster V showed the maximum mean for days to maturity (120.33 days), number of tillers/plant (9.81), ear length (12.19), ear weight (3.48), thousand grain weight (45.74 g), relative water content (84.93), harvest index (44.71), canopy temperature

Table-3 : Clustering pattern of 24 cytoplasmic lines of wheat on the basis of their mahalanobis genetic divergence using tocher's methods.

Clusters	Number of Genotypes	Name of genotypes included
Cluster I	5	CMS-89B, CMS-97B, CMS-88B, CMS-95B and R-38
Cluster II	9	CMS-91B, CMS-94B, CMS-82B, CMS-87B, CMS-2041B, CMS-85B, CMS-90B, R-37 and R-936
Cluster III	5	CMS-92B, CMS-2046B, R-7, R-9 and R-10
Cluster IV	1	R-939
Cluster V	3	CMS-84B, CMS-96B and CMS-86B
Cluster VI	1	CMS-83B

Table-4 : Average of intra and inter cluster genetic distance.

Clusters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
Cluster I	107.07	329.63	308.51	170.83	345.84	575.34
Cluster II	329.63	153.33	602.01	512.61	302.67	223.66
Cluster III	308.51	602.01	177.13	515.52	464.05	770.46
Cluster IV	170.83	512.61	515.52	0.00	644.33	826.93
Cluster V	345.84	302.67	464.05	644.33	203.25	475.43
Cluster VI	575.34	223.66	770.46	826.93	475.43	0.00

Table-5 : Cluster wise mean values of 14 morphological traits in cytoplasmic lines of wheat.

Cluster	Characters													
	DFH	DM	PH	NTPP	PL	EL	EW	BYPP	TGW	HI	CC	CT	RWC	GYPP
Cluster I	63.80	115.80	103.16	9.49	20.90	10.79	2.84	45.93	45.10	36.38	49.20	20.49	79.37	16.69
Cluster II	64.44	116.56	103.22	9.64	19.81	11.80	3.31	59.56	44.63	36.40	48.38	20.53	81.32	21.66
Cluster III	68.20	116.00	114.78	8.47	19.35	10.94	2.45	43.22	42.87	36.57	47.80	20.57	84.02	15.81
Cluster IV	62.00	109.00	98.67	9.50	21.24	11.34	2.57	43.66	39.22	35.50	50.00	20.10	75.47	15.50
Cluster V	65.67	120.33	106.67	9.81	21.77	12.19	3.48	52.66	45.74	44.71	47.59	20.83	84.93	23.53
Cluster VI	67.00	119.00	106.83	9.50	24.05	11.00	3.07	65.62	41.90	32.37	55.05	20.70	83.78	21.24

Table-6 : Vector loadings and percentage of explained variation by the first six PCAs. PCA=Principal component axis.

Characters	Principal components (PC)					
	PC1	PC2	PC3	PC4	PC5	PC6
Days to heading	0.198	-0.243	0.494	0.075	-0.268	0.270
Days to maturity	-0.210	-0.477	-0.121	-0.035	-0.181	0.052
Plant height (cm)	0.233	-0.334	0.269	-0.289	-0.006	0.452
Number of tillers/plant	-0.282	0.352	0.253	0.037	0.079	0.231
Peduncle length (cm)	0.035	0.019	0.222	0.658	-0.335	-0.329
Ear length (cm)	-0.350	-0.125	-0.149	-0.089	0.277	0.174
Ear weight (g)	-0.442	-0.030	0.001	-0.068	0.014	-0.082
Biological yield/plant (g)	-0.340	0.113	-0.112	0.042	-0.524	0.322
Thousand grain weight (g)	-0.288	-0.019	0.218	-0.286	-0.006	-0.370
Harvest index (%)	-0.246	-0.229	0.435	0.094	0.408	-0.186
Chlorophyll content (%)	-0.057	-0.014	-0.305	0.515	0.335	0.410
Canopy temperature	-0.023	-0.392	-0.408	-0.092	-0.262	-0.219
Relative water content (%)	-0.045	-0.491	0.007	0.304	0.185	-0.049
Grain yield/plant (g)	-0.446	-0.027	0.156	0.073	-0.212	0.163
Eigen value	4.177	2.158	1.665	1.297	1.144	1.087
Variance percent	29.838	15.413	11.894	9.266	8.174	7.762
Cumulative variance percent	29.838	45.251	57.145	66.411	74.585	82.347

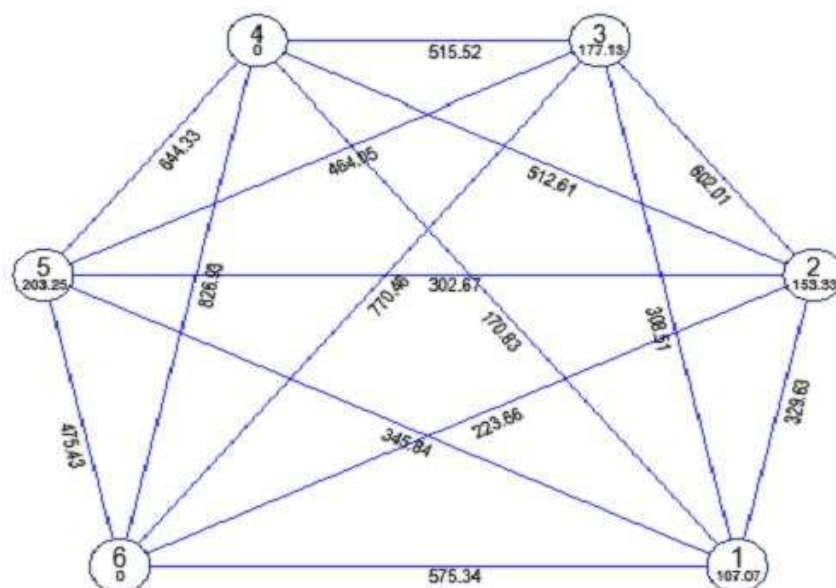


Fig-1 : Diagram showing inter and intra cluster distances of cytoplasmic lines of wheat.

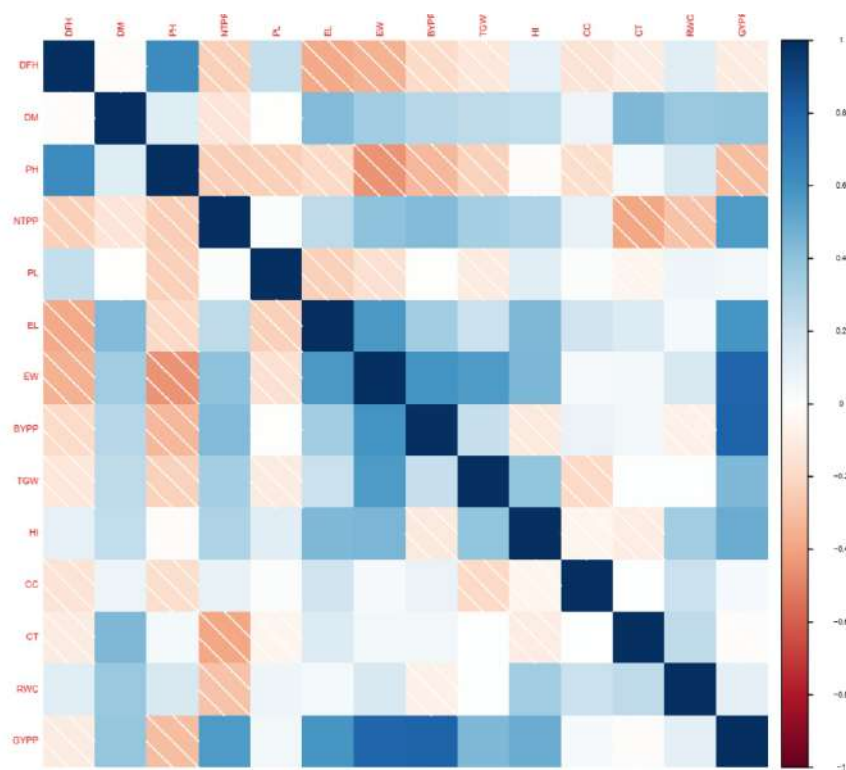


Fig-2 : Correlation between different agronomic traits of cytoplasmic lines of wheat.

(20.83) and grain yield/plant (23.53 g). The genotypes of cluster VI showed the maximum mean for peduncle length (24.05), biological yield/plant (65.62) and chlorophyll content (55.05). Comparative assessment of cluster means showed that the genotypes should be selected from the cluster having a high mean value for that particular character to improve specific characters.

This comparison indicates that clusters V and VI had better cluster means for most of the characters; therefore, these clusters might be considered better for selecting genotypes as divergent parents. Distantly placed cluster genotypes in hybridization programs to get a wide spectrum of variation among genotypes (Kumar *et al.*, (2006), Devi *et al.*, (2010), Shrivastava *et al.*, (2012),

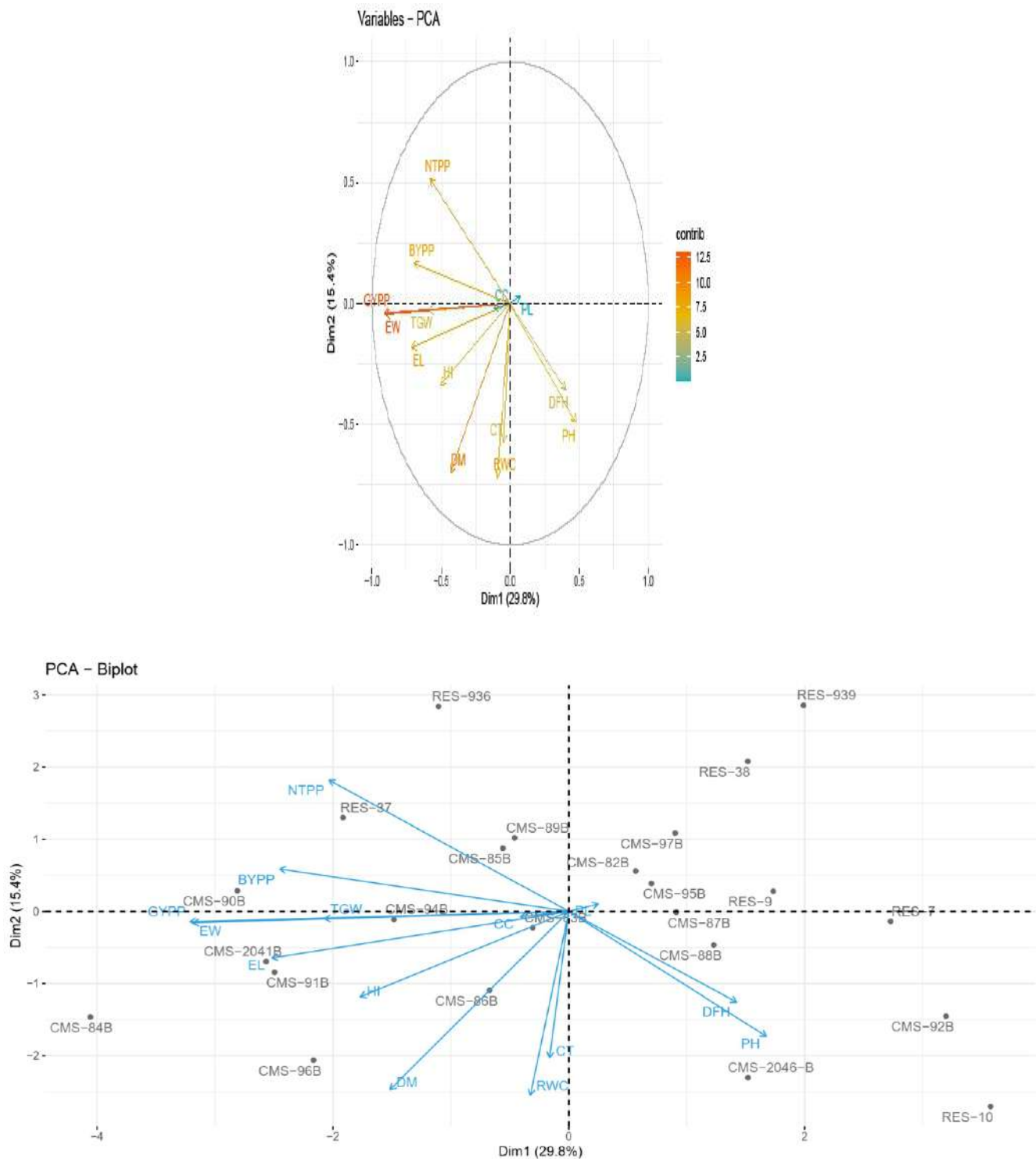


Fig 3 : Biplot based on PCA showing the relationship between the traits in cytoplasmic lines of wheat.

Yadav *et al.*, (2011), Vennila *et al.*, (2011), and Latif *et al.*, (2011).

Correlation analysis between different agronomic traits showed a significant positive association between number of tillers per plant ($r=0.56$, $p=0.01$) with grain

yield. Ear length ($r=0.58$, $p=0.01$) showed a significantly high positive correlation with grain yield. Ear weight ($r=0.79$, $p=0.01$) significantly correlated with grain yield. Similarly, biological yield per plant also had a significant positive correlation ($r=0.81$, $p=0.01$) with grain yield. Thousand-grain weight ($r=0.45$, $p=0.05$) and harvest

index ($r=0.49$, $p=0.05$) showed a significantly low positive correlation with grain yield. Selecting any of these traits would offer the opportunity for the simultaneous improvement of contributing characters. Thus, it should be kept in thought to enhance wheat yield potential. Ayer *et al.* (2017) reported that thousand seed weight, biomass yield, and harvest index showed a significant positive correlation with grain yield Fig.-2.

On the other hand, a non-significant and negative correlation with grain yield was observed for a plant height ($r=-0.31$) and days to the first heading ($r=-0.11$) (Fig.2). No significant correlation between Days to 50% heading, plant height and grain yield per plant indicates an excellent opportunity for independent improvement of both traits. Similar results were also obtained by Dabi *et al.* (2016) also reported that those days to 50% heading showed a non-significant positive correlation with grain yield. Furthermore, Aycicek and Yildirim (2006) reported that grain yield negatively correlated with days to first heading. Negative correlations indicate an inverse relationship between earliness characters, number of spikelets per spike, and desirable grain yield if stresses such as drought and terminal heat stress are fore seen.

The principal component analysis was performed based on means for the quantitative traits of lines (Table-6). Principal component analysis simplifies the complex data by transforming the number of correlated variables into a smaller number called principal components. The first principal component accounts for maximum variability in the data to succeeding components (Leilah and Al-Khateeb, 2005). The analysis had grouped the estimated wheat variables into six main components. The first six components with eigen values >1 accounted for 82.35% of the total variation of grain yield. PC1 accounted for about 29.83% of the variation in grain yield; PC2 for 15.41%; PC3 for 11.89%; PC4 for 9.26%; PC5 for 8.17% and PC6 for 7.76% (Table-6 and Fig-3).

The data presented in Table-6 showed the most contributing characters are found in the six principal component which were days to maturity, plant height, biological yield and grain yield; whereas number of tillers/plant contributed more in the second PCA; days to heading, thousand-seed weight and harvest index in the third PCA; peduncle length, chlorophyll content and relative water content in the fourth PCA; ear length and ear weight in the fifth PCA and Canopy temperature in the first PCA were the major contributing characters for variability to those principal components. Similar findings of grouping bread wheat genotypes by principal component analysis were reported (Hailegiorgis *et al.*, (2010); Degewione and Alamerew (2013) Fellahi *et al.*,

(2013). Grouping genotypes by multivariate methods in the study is of practical value for the wheat breeders. Representative genotypes may be chosen from the particular groups for hybridization programs with other approved cultivars to help breeders choose trait-specific lines in a breeding program. Further, this will aid in identification, selection and combining genotypes to obtain important traits in one line with a broad genetic base.

Conclusions

Based on Mahalanobis D^2 analysis, the newly developed cytoplasmic wheat lines in the present study can successfully plan future breeding programs. The inter-crossing of genotypes showing the more significant genetic divergence for most of the characters studied should result in superior heterotic crosses and generate valuable segregants. It is expected that better-performing varieties could be generated to increase productivity in wheat. Therefore, from the present study, genotypes of cluster IV and cluster VI based on their high values for inter-cluster distance and cluster means can be hybridized as the potential parents to produce superior off-springs in the segregating generations and improve wheat productivity.

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Economic Study of Soil Health Deterioration by Excess Use of Macro and Micro Nutrients

Ajit Singh* and S.S. Jheeba

Department of Agricultural Economics S.K.N. Agriculture College, Jobner-303329 Rajasthan

*Corresponding Author Email : ajitsingh15789@gmail.com

Abstract

Total cost for the degradation/depletion of macro-nutrients amounted to Rs. 39432.44 per hectare in Sri ganganagar and Rs.16010.37 per hectare in jaipur. The cost in terms of degradation/depletion of micro-nutrients amounted to Rs. 17770 per hectare in Sri ganganagar and Rs.23854 in Jaipur. The environmental cost for the high value cash crop was estimated to Rs. 57202.44 in Sri ganganagar and Rs. 39864.37 in Jaipur.

Key words : Macro and micronutrient, soil health, soil deterioration, human health and environmental cost

Introduction

Agrochemicals used to increase agricultural productivity, have also been associated with many direct and indirect negative impacts on human health. These effects are increasingly manifested in loss of working efficiency resulting in higher cost of production. In recent times, the effects of commercialization of agriculture on environment and human health have attracted the attention of both the scholars and policy makers (Pingali *et al*, 1997).

The severity and risks of adverse impacts are higher in developing countries where users are quite often illiterate, ill trained, and do not possess appropriate protective equipments. It is estimated that only 0.1 per cent of applied pesticides reach the target pests, leaving the bulk of pesticides (99.9 percent) to impact the environment and human health (Pimental, 1995). The emphasis on organic agriculture is the direct outcome of the increasing awareness of the adverse effects of the excessive use of agro-chemicals. The present study is a modest attempt in this direction. Against this background, the present study aims at documenting the high value cash crops cultivation led adverse changes in the natural resource base, the strategies adopted by the local people to minimize the adverse impacts, monetary valuation of environmental costs, understand their implications for the livelihoods of the local people and suggest possible solutions. Such a study is essential in estimating the true cost of the cultivation of these crops. Keeping this in view, the study has been undertaken with the following objectives :

Status and requirement of macronutrients and micronutrients in the study area.

Monetary valuation of deterioration in soil health.

Monetary valuation of total environmental costs.

Materials and Methods

Selection of study area : Out of 33 districts of the state of Rajasthan, two districts namely Sri Ganganagar and Jaipur were purposively selected for the study. The selection of the districts was influenced by two factors. First, in these districts the cultivation of high value crops namely kinnow and off- seasonal vegetable is being practiced since the late sixties and early seventies. Second, these two districts together account for more than three-fourths of the total area under fruits and vegetables

Collection and preparation of soil samples : The soil samples were separately collected from the cultivated area of each of the 200 sample households. Since kinnow was the most important crop in Sri ganganagar and vegetables in jaipur, the soil samples were collected from kinnow orchards in Sri ganganagar and vegetable fields in Jaipur. The representative soil samples were collected from 0-15 cm depth and tested under laboratory conditions. The samples were analyzed for soil PH (Jackson, 1967), Organic carbon (Walkley and Black, 1934), available P (Olsen *et al.*, 1954), available K (Mervin and Peech, 1951) and micro nutrient cations (Cu, Fe, Mn and Zn by Lindsay and Norvell, 1978). The following formula was used to classify the soils into different status :

$$\text{Overall Status of soil} = (I*1+M*2+H*3)/100$$

The values used to classify the soils into low, medium and high through soil nutrient index are given below: Low < 1.67, Medium 1.67 to 2.33 and high > 2.33 (Muhr *et al.* 1963).

The status of the availability of micro nutrients was considered sufficient if the availability was more than the following critical limits in mg per kilogram. If availability

Table-1 : Status and requirement of macronutrients and micronutrients in the study area.

Primary Macronutrients	Sri Ganganagar	Jaipur
Available Nitrogen (kg/ha)	H* (2.90)	H* (2.91)
Dose recommended as per high status (kg/ha)	1340	230
Doses applied by farmers	199.864	1320.42
Nitrogen environment status	-1140.136	1090.42
Available phosphorus (kg/ha)	H* (2.18)	H* (2.58)
Dose recommended as per high status	2837.90	176
Doses applied by farmers	101.02	637.38
Phosphorus environment status	-2736.88	561.38
Available potassium (kg/ha)	L* (0.98)	L* (1.02)
Dose recommended as per low status	1120.20	237.75
Doses applied by farmers	86.2536	280.90
Potassium environment status	-1033.95	43.15
Status and requirement of Micronutrients		
Zn	24.59 (D)	60.04 (D)
Requirement (Kg/hac)	36	36
Cu	0	6.36 (D)
Requirement (Kg/hac)	30	30
Fe	38.49 (D)	46.68 (D)
Requirement (Kg/hac)	24	25
Mn	1.08 (D)	23.46 (D)
Requirement (Kg/hac)	25	25

was less than these limits, the status was considered as deficient (Nayyar and Chhibba, 1995). Zinc = 0.60, Copper = 0.20, Iron = 4.50, Manganese = 1.00

Valuation of environmental cost : Environmental cost has been defined to include the cost of the effect on human health and soil degradation. The effect on human health is estimated to include the number of days lost, the loss in the work efficiency for those who experienced some health problems but did not take medicines, the yearly medical expenditure of the person who handled the pesticides and the value of kit. For computing monetary value of the degradation of soil health, the soil status was compared with the recommended doses in the packages of practices of horticulture and vegetable crops. If the status of a particular nutrient in the soil was high, then recommended dose, given in the package of practices, was reduced by 25 per cent. In case of medium status, the recommend was the same as given in the package of practices. If the status of a particular nutrient was low, 25 per cent was added to the recommended dose. These doses were now considered as optimum doses for a particular nutrient. Thereafter, actual dose used by the farmer was compared with the recommended dose. The difference for different nutrients from their recommended doses could either be excess or deficit. The excess or deficit amount then was converted into monetary value by multiplying the price of a particular nutrient with the excess or deficit amount. The total environmental cost then was apportioned among different crops in proportion to the area under these crops. As mentioned above, all the soil samples in Jaipur were collected from the area

under vegetable crops. Therefore, the environmental cost in Jaipur was apportioned only among vegetable crops.

Results and Discussion

Status and requirement of macronutrients and micronutrients in the study area : Table-1 shows that among macro nutrients while the status of available nitrogen and phosphorus was high in both the districts, that of potassium was low. Thus, in view of the actual availability of these nutrients in the soils, there recommended doses worked out to be 1340 kg/hectare of nitrogen, 2837.9 kg/hectare of phosphorus and 1120.20 kg/hectare of potassium in Sri Ganganagar.

The respective doses for Jaipur were 230 kg/hectare of nitrogen, 176 kg/hectare of phosphorus and 237.75 kg/hectare of potassium. In comparison, the doses of these three macro nutrients applied by the farmers were 199.86 of nitrogen, 101.02 of phosphorus, 86.36kg/hectare of potassium in Ganganagar and 1320.42 kg/hectare of nitrogen, 637.38 of phosphorus and 280.90 of potassium kg/hectare in Jaipur. In respect of micro nutrients, the results show that except copper, other nutrients like zinc, iron and mn were deficient in Ganganagar whereas in Jaipur soils were found deficient in all the four micro nutrients. The extent of soil degradation was estimated depending on the excess or deficit of macro and micro nutrients.

Table-2 shows that in monetary terms, the cost degradation of soil health, both macro and nutrients, amounted to Rs. 44,977 per hectare in Ganganagar and

Table-2 : Monitory valuation of deterioration in soil health. (Rs/ha)

Nutrients	Sri ganganagar	Jaipur
Primary Macronutrients		
Available Nitrogen	12543.96	11994.62
Available Phosphorus	17789.72	3648.97
Available potassium	9098.76	366.78
(a) Sub total	39432.44	16010.37
Micronutrients		
Zn	7920	7920
Cu	-	6084
Fe	3600	3600
Mn	6250	6250
(b) sub total	17770	23854
Total (a+b)	57202.44	39864.37

Table-3 : Monetary valuation of total environmental costs. (Rs/ha.)

Environmental cost	Sri Ganganagar	Jaipur
Cost of the adverse effect on human health	4350	1088
Cost of the degradation of soil health	57202.44	39864.37
Total cost	61552.44	40952.37

Rs. 2,98,556 in Jaipur. In terms of macro and micro nutrients, it was Rs. 32,509 and Rs. 12,468, respectively in Ganganagar and Rs. 10,188 and Rs. 19,668 respectively in Jaipur.

Monitory valuation of deterioration in soil health :

Table-3 give the total environmental including cost of the adverse effect on human health and degradation of soil. The table shows that these costs together amount to Rs. 57202.44 in Ganganagar and Rs.39864.37 in Jaipur. Among these two costs, more than 95 per cent was accounted for by the cost of degradation in soil health in both the areas.

Conclusions

High value cash crops has made a significant impact on the economic status of the farmers in terms of their income and employment. It is, therefore, no wonder that policy makers are busy devising strategies to promote agricultural diversification. However, while crop diversification has resulted in higher income and employment to the farmer households, it has also promoted indiscriminate use and unscientific handling of toxic chemicals which is causing degradation of natural resource base and also affecting human health. There is an imposing evidence to indicate that as the process of agricultural diversification towards these crops gets intensified and gains momentum, the extent, severity and

frequency of associated health problems are increasing at an alarming rate.

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Fitting of Nonlinear Statistical Models and Application of its in Agriculture Data

Chetan Kumar Saini^{1*}, Neelash Patel² and Rishabh¹

¹Department of Mathematics and Statistics, College of Agriculture, JNKVV, Jabalpur-482004

²Department of Agriculture, Rabindranath Tagore University, Raigarh-462045

*Corresponding Author Email : schetan761@gmail.com

Abstract

The present paper describes the fitting of non-statistical model on barley crop's production, productivity. model is an equation or set of equation, which represent the behaviour of a system (France and Thornley, 1984). It's can be either linear or nonlinear. models help to summarizing data, forecasting trend There we use models viz. Logistic Gompertz, molecular and Richards model. estimation of parameter of these models by Linearization (or Taylor series) and Levenberg-Marquardt method. we used three criteria to comparison among model namely (i) Adjusted R², (ii) Residual mean squares error (RMSE) and (iii) coefficient of determination (R²). The model which shows the highest R² and least RMSE, it would be best for a specific factor the result show logistic and Gompertz model best for production and productivity of barley.

Introduction

Barley (*Hordeum vulgare* L.) is cultivated as a winter season cereal crop of India ranking next to wheat. Barley occupies fourth position in world acreage and third in cereal production. In India during 2014-15 barley was cultivated in an area 27.27-million-hectare area with a production of about 26.86 million tonnes and 985 kg/ha productivity. In last 25 years the area, production and productivity have registered positive growth rate in Jaipur as well as Rajasthan.

A number of studies were undertaken to understand the growth pattern of production, productivity and area of barley The requirements of a model for mathematical completeness can provide a conceptual framework, which may help pinpoint areas where knowledge is lacking and might stimulate new ideas and experimental approaches. The economic benefit of methods suggested by research can often be investigated and highlighted by an agro-economic model, thus stimulating the adoption of improved methods of production.

Statistical Techniques : The typical form of a Nonlinear Statistical Models. can be expressed as :

$$X(t) = f(t_i) + e_i \quad i=1,2,3,\dots,n \quad (3.2.1)$$

Where,

e_i denotes the error term.

We assume that errors are identically and independently normally distributed with zero mean and constant variance, σ^2 .

Some important nonlinear deterministic growth models.

Logistic Model : Let $x(t)$ denote the variable under study like

production or area of, at a time t also let $A > 0$ denote C the carrying capacity of the environment Then this model represented by

$$y(t) = \frac{A}{1 + \exp(-t)} \\ = [-y(0)]/y(0) \text{ and } y(0) \text{ is the value of } y(t) \text{ at } t = 0.$$

Gompertz model : This model has sigmoid type of behaviour and is found quite use full in the biological work. However, unlike logistic model, this is not symmetric about its point of inflexion. This model is given by

$$y(t) = \frac{A}{1 + \exp(-t)}$$

Monomolecular model : This model describes the progress of a growth situation in which it is believed that the rate of growth at a particular time t is directly proportional to the amount of growth yet to be achieved. This model is represented by the equation

$$y(t) = -(\ln 2) \exp(-t)$$

Where, symbols have their usual meaning.

Richards model : Like mixed influence model, Richards model is also a four-parameter Growth model. It is proposed by Richards (1959) and is represented by

$$y(t) = \frac{A}{\{1 + \exp(-t)\}^{1/\alpha}}$$

The upper sign within the brackets is applicable when α is positive and lower sign when α lies in the range $-1 < \alpha < 0$. Richards model is a generalization of logistic (when $\alpha = 0$), Gompertz (when $\alpha = 0$) and monomolecular (when $\alpha = -1$).

Estimation of Parameter Nonlinear Statistical Models : Let us consider n observations (X_i, t_i) , $i = 1, 2, \dots, n$, from a nonlinear statistical model

$$X(t) = f(t_i) + e_i \quad i=1,2,3,\dots,n \quad (3.2.1)$$

Were,

X_i = i^{th} observation of the response variable.

T_i = i^{th} observation of the predictor variable.

$\beta = (\beta_0, \beta_1, \dots, \beta_p)$ the parameter vector.

e_i = i^{th} random error component.

As in linear case, in nonlinear also, parameter estimates are obtained by minimizing the residual sum of squares.

$$S(\beta) = \sum_{i=1}^n [X_i - f(T_i)]^2$$

Since X_i and t_i are fixed observations, the residual sum of squares is a function of β . We shall denote by $S(\beta)$, a least square estimates of β , that is a value of β which minimizes $S(\beta)$. Unlike the linear model situation, in nonlinear situation $S(\beta)$ may have several relative minima in addition to the absolute minimum β . Under the assumption that errors are independently and identically distributed with variance σ^2 , it is shown that under certain regularity assumptions $\hat{\beta}$ and $s^2 = S(\hat{\beta}) / (n-p)$ are consistent estimates of β and σ^2 respectively. With regularity conditions, $\hat{\beta}$ is also asymptotically normally distributed as $n \rightarrow \infty$. The proof of these results is given in Seber and Wild (1989). In addition, under the assumption that the errors are normally distributed, $\hat{\beta}$ is also the maximum likelihood estimator.

To get the least squares estimates $\hat{\beta}$ eq. (3.2.2) has to be differentiated with respect to β . This gives p normal equations, which must be solved.

When each $f(t_i)$ is differentiable with respect to β , and β is in the interior of Ω , it will satisfy.

$$S'(\hat{\beta}) / \beta_r = 0, \quad r=1, 2, \dots, p$$

Following Seber and Wild (1989) we use the notation

$$f_i(\beta) = f(t_i, \beta)$$

$$f(\beta) = [f_1(\beta), f_2(\beta), \dots, f_n(\beta)]$$

$$F(\beta) = f(\beta)'$$

$$\text{And } F' = F(\beta)'$$

Where a dot subscript denotes derivatives. Using the above notation, we can rewrite $S(\beta)$ as

$$S(\beta) = [X - f(\beta)]' [X - f(\beta)] \\ = \|X - f(\beta)\|^2$$

eq. (3.2.3) then leads to

$$\sum_{i=1}^n \{X_i - f_i(\beta)\} \cdot f_i(\beta) / \beta_r = 0, \quad r=1, 2, \dots, n$$

$$\text{or } F' \{X - \hat{f}\} = 0$$

$$\text{or } \hat{F} \cdot \hat{\beta} = 0$$

The eqs. (3.2.9) are called normal equations for the nonlinear model. As the model is nonlinear in parameters, so are the normal equations. Since it is not possible to solve nonlinear equations exactly, the only alternative is to employ iterative procedures. Two principal procedures of this kind are: (i) Linearization (or Taylor series) method (ii) Levenberg-Marquardt method.

Examination of Residuals : The residuals are defined as the difference between the observed value $X(t)$ and the fitted value $\hat{X}(t)$, and what the fitted model i.e., the amount which is unexplained by the model predicts. If our fitted model is correct, the residuals should exhibit denial of the assumptions.

Goodness of Fit of Nonlinear Statistical Models

(i) Co-efficient of determination (R^2) : The goodness of fit is examined by using the co-efficient of determination (R^2).

R_1 residual SS / corrected SS2

is the most appropriate for nonlinear statistical model. This R^2 would be used as the coefficient of determination for goodness of fit. The potential range of values of this R^2 is well defined with end points corresponding to perfect fit and complete lack of fit, such as $0 < R^2 < 1$.

(ii) Root mean square error (RMSE) :

The RMSE is defined as

$$RMSE = [\sum (X - \hat{X})^2 / n]^{1/2}$$

The smaller the value of RMSE better is the model

(iii) Mean absolute error (MAE) :

The MAE is defined as

$$MAE = \sum |X - \hat{X}| / n$$

The smaller the value of MAE, better is the model.

(iv) Mean squared error (MSE) :

The MSE is defined as

$$MSE = \sum |X - \hat{X}|^2 / (n - p)$$

Results and Discussion

Conclusions

1 In nonlinear statistical modelling of the total area under wheat in Madhya Pradesh state, we found that the logistic and Gompertz, model fit very well to data set than the Monomolecular and Richards's model.

In nonlinear statistical modelling of the total production of wheat in Madhya Pradesh state, we found that the Gompertz, and Logistic model fits very well to data set than the J Monomolecular and Richards's model.

In nonlinear statistical modeling of the productivity of

Table-1 : Results of fitting various models to the data sets regarding total area under wheat (in million hectares) crop during 1984-85 to 2008-2009.

	Logistic	Gompertz	Monomolecular	Richards
A	0.034	0.026	0.0060	0.0056
B	0.32	0.31	0.35	246.43
C	4702.11	4873.07	7605.60	-88
D				0.074
RSS	2949444.45	2953453.22	2981421.74	3010503.19
	Logistic	Gompertz	Monomolecular	Richards
No. of Runs	6	6	6	6
Z	-2.021	-2.021	-2.021	-2.021
	Logistic	Gompertz	Monomolecular	Richards
R ²	.905	.906	.910	.905
RMSE	343.47	343.71	345.49	347.01
MSE	134066.5	134247.7	135519.5	143357.4
MAX	256.00	256.77	258.93	260.40
(X, $\hat{X}$)	0.434	0.435	0.426	0.418



wheat in adh a Pradesh state, we found that the logistic model frts ery ell t data s t than the Gompertz, Monomolecular and Richards's model.

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Impact of Foliar Spray of Iron, Zinc and Boron in Quality and Economics of Strawberry (*Fragaria × ananassa* Duch.) Cv. Winter Dawn

Lokesh Kumar¹, Balkesh Kumari², H.L. Bairwa¹, L.N. Mahawer¹, Beerendra Singh³

¹Department of Horticulture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan

²Department of Horticulture, Sri Karan Narendra Agriculture University, Jobner, Jaipur

³Department of Entomology, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan

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%) recorded highest values in terms of fresh weight of fruit (12.32 g), fruit per plant (16.20), fruit yield per plant (198 g), TSS, TSS: Acid ratio, juice per cent and ascorbic acid were significantly increased while, decrease in acidity. 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 : Foliar application; strawberry; yield; quality; micro-nutrient.

Introduction

Strawberry (*Fragaria × ananassa*) is one of the most delicious fruit of the world. All the cultivated varieties of strawberry are octaploid (2n=8x=56) in nature and belongs to the family Rosaceae and native from France in 17th century and the two American diploids *Fragaria × chiloensis* and *Fragaria × virginiana* are considered as its progenitors. In India its main centers of cultivation are Nainital (district) and Dehradun in Uttarakhand, Mahabaleshwar (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. In cold climate, frost as well as winter injury seriously reduce yield of strawberry. Frost may damage centre of the open flowers, causing the characteristics black eye. The frost injury may be reduced using mulch, covering row with plastic and by creating good air drainage. Photoperiod has a marked effect on strawberry vegetative growth, plant morphology and yield. Strawberry plant grows best in sandy loam 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. The plants should be set in the soil with their roots going straight-down. The soil around the plant should be firmly packed to exclude air. The growing point of the plant should be just above the soil surface.

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. It used for preparation of ice cream and Jam on account of its rich aroma. It is a soft and a highly perishable fruit, often shipped in frozen condition in Western countries.

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).

In India the total area of strawberry is 1000 ha with production of 5000 MT (Anonymous, 2018). In India, Maharashtra is the leading state in production of strawberry fruits. The nutrition status of strawberry plant

Table-1 : Response of micronutrient on fresh weight of fruit, number of fruit per plant and fruit yield per plant.

Notations	Treatments	Fresh weight of fruit (g)	Number of fruit plant ⁻¹	Fruit yield plant ⁻¹ (g)
S ₁	RDF + Control (Water spray)	10.88	14.91	162.22
S ₂	RDF + Borax (0.1%)	10.89	15.00	163.30
S ₃	RDF + ZnSO ₄ (0.2%)	10.90	15.13	164.85
S ₄	RDF + FeSO ₄ (0.2%)	10.91	15.33	167.29
S ₅	RDF + Borax (0.2%)	10.91	15.52	169.37
S ₆	RDF + ZnSO ₄ (0.4%)	10.90	15.61	169.93
S ₇	RDF + FeSO ₄ (0.4%)	10.92	15.55	169.79
S ₈	RDF + Borax (0.1%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	10.93	15.66	171.13
S ₉	RDF + Borax (0.1%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	10.94	15.87	173.60
S ₁₀	RDF + Borax (0.2%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	10.97	16.21	177.96
S ₁₁	RDF + Borax (0.2%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	10.95	16.00	175.23
	SEm ±	0.19	0.18	3.51
	CD at 5%	NS	0.56	10.29
	C.V.	3.05	2.13	3.59

Table-2 : Response of micronutrient on TSS, titratable acidity, TSS acid ratio, Juice content, Ascorbic acid, Gross return ha⁻¹, Net return ha⁻¹ and B:C.

Notations	Treatments	TSS (OB)	Titratable acidity (%)	TSS : Acid	Juice content (%)	Ascorbic acid (mg 100 g ⁻¹)	Gross return ha ⁻¹ (Rs.)	Net return ha ⁻¹ (Rs.)	B : C
S ₁	RDF + Control (Water spray)	11.10	1.00	11.10	57.76	57.75	649633	307633	0.90
S ₂	RDF + Borax (0.1%)	11.14	0.93	11.98	61.15	57.89	653219	311173	0.91
S ₃	RDF + ZnSO ₄ (0.2%)	11.25	0.93	12.07	61.60	58.16	660617	318428	0.93
S ₄	RDF + FeSO ₄ (0.2%)	11.82	0.90	13.13	62.47	58.82	673183	330868	0.97
S ₅	RDF + Borax (0.2%)	11.32	0.93	12.17	60.35	59.11	677903	335273	0.98
S ₆	RDF + ZnSO ₄ (0.4%)	11.10	0.93	11.93	60.38	59.31	677540	335285	0.98
S ₇	RDF + FeSO ₄ (0.4%)	11.47	0.90	12.74	61.90	59.86	679316	336806	0.98
S ₈	RDF + Borax (0.1%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	11.58	0.90	12.87	62.18	59.99	683764	341100	1.00
S ₉	RDF + Borax (0.1%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	11.25	0.90	12.50	62.88	60.19	696437	353202	1.03
S ₁₀	RDF + Borax (0.2%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	11.99	0.87	13.89	64.56	60.80	715439	372680	1.09
S ₁₁	RDF + Borax (0.2%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	11.90	0.87	13.79	63.95	60.62	704111	360782	1.05
	SEm ±	0.21	0.02	0.43	1.21	0.70	12514.38	12514.38	0.04
	CD at 5%	0.63	0.07	1.27	3.56	2.04	36700.13	36700.13	0.11
	C.V.	3.23	4.25	5.97	3.40	2.03	3.19	6.44	6.43

plays a vital role in determining the yield and yield attributing parameters since, it is a very sensitive plant to nutritional balance (Mohamed *et al.*, 2011).

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 P₂O₅ kg

ha⁻¹ (17.1) and Available K₂O 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 + ZnSO₄ (0.2%), S₄ i.e. RDF + FeSO₄ (0.2%), S₅ i.e. RDF + Borax (0.2%), S₆ i.e. RDF + ZnSO₄ (0.4%), S₇ i.e. RDF + FeSO₄ (0.4%), S₈ i.e. RDF + Borax (0.1%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%), S₉ i.e. RDF + Borax (0.1%) + ZnSO₄ (0.4%) + FeSO₄ (0.4%), S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%), S₁₁ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.4%) + FeSO₄ (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

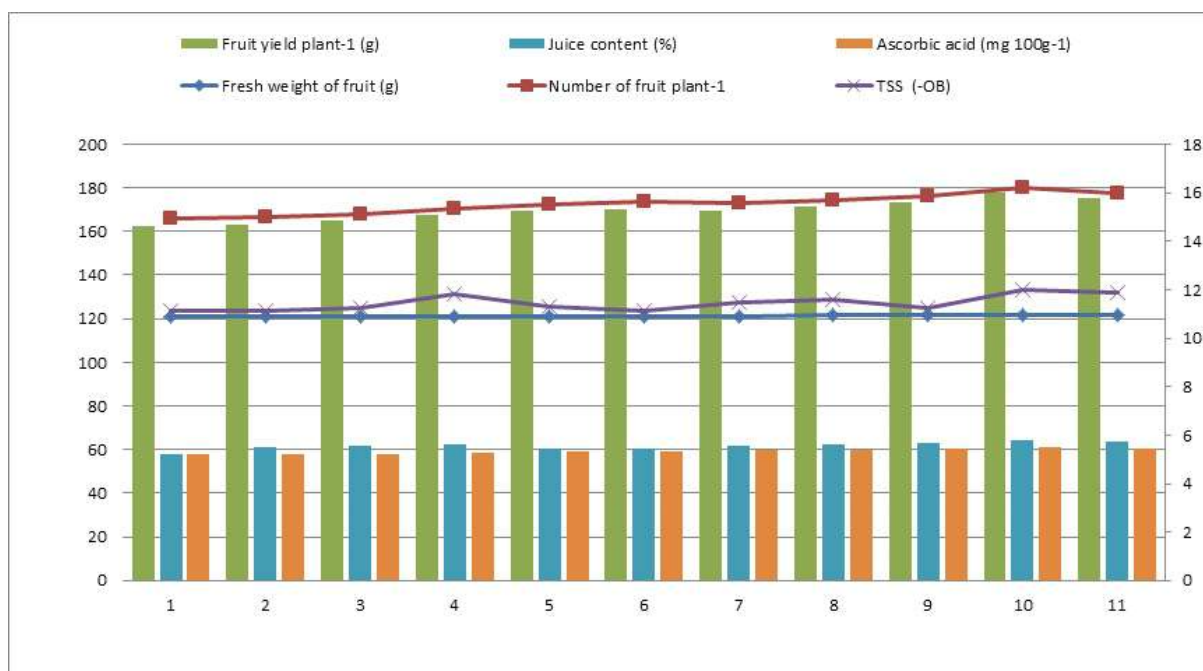


Fig.-1 : Response of micronutrient on fruit yield plant⁻¹, Juice content, Ascorbic acid, fresh weight of fruit, number of fruit plant⁻¹ and TSS.

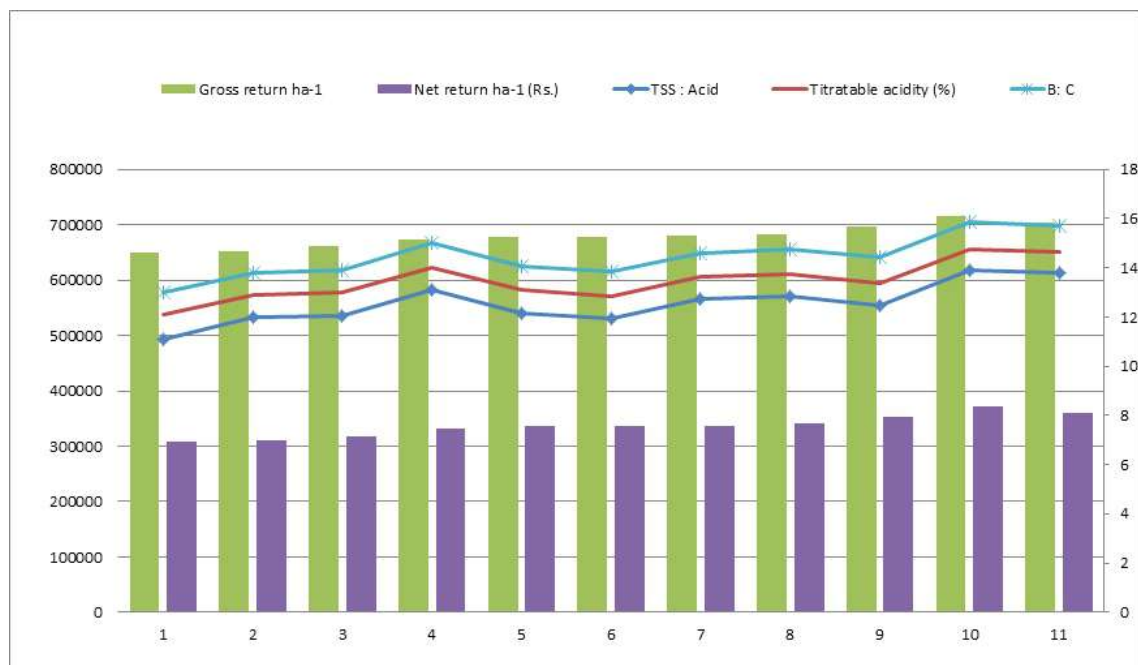


Fig.-2 : Response of micronutrient on gross return ha⁻¹, net return ha⁻¹, TSS: Acid, titratable acidity and B:C.

concentrations, respectively. Iron and zinc solution was prepared from same procedure. 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, Digital hand refractometer was used to calculate total soluble solid, Standard N/10 NaOH solution and phenolphthalein as an indicator were used to determine the titratable acidity of strawberry fruit juice until faint pink color appeared, The ripe strawberry fruits were crushed and pass through muslin cloth. The weight of

strawberry juice was measured with electronic balance and the percentage of juice was worked out on the basis of total weight of fruit taken for juice extraction, calculation of ascorbic acid/100 ml juice by using below formula (Sadasivam and Theymoli, 1987).

Results and Discussion

The maximum fresh weight of fruit, fruit per plant and fruit yield per plant (10.97 g, 16.21 and 177.96 g respectively) was 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, 14.91 and 162.22 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 Bakshi *et al.* (2013), Kazemi *et al.* (2014), and Mehraj *et al.* (2015) in strawberry, Thorat *et al.* (2018) 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, Cakici and Arslan (2012), Bakshi *et al.* (2013), Mehraj *et al.* (2015) in strawberry. The maximum TSS (11.99 °Brix) was 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 TSS (11.10 °Brix). The increase in TSS might be due to hydrolysis of the polysaccharides, conversion the organic acids to the soluble sugars and improved solubilization of insoluble starch and pectin are present in cell wall as well as middle lamella. In conformity of its similar observations were reported by Chaturvedi *et al.* (2005) in strawberry, Kumar *et al.* (2010) in strawberry, Bakshi *et al.* (2013), Thorat *et al.* (2018) in sweet orange and Pawar *et al.* (2019) in mandarin. It is clear from the mean data showed that treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) were recorded minimum titratable acidity of the fruit (0.87%) whereas, S₁ i.e. RDF + Control (Water spray) recorded maximum titratable acidity (1.0%). The decrease in acidity might be due to the metabolic changes with fast conversion of organic acids to the sugars and its derivatives and utilization as the respiratory substrate during growth and development of the fruits, which was stimulated by zinc and iron foliar spray. These finding are collaborates with the findings of Chaturvedi *et al.* (2005) in strawberry, Kumar *et al.* (2010), Pathak *et al.* (2011) in banana, Bakshi *et al.* (2013), Thorat *et al.* (2018) in sweet lemon. The highest TSS Acid ratio (13.89) was recorded treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas S₁ i.e. RDF + Control (Water spray) recorded lowest TSS Acid ratio (11.10). The

increase in TSS Acid ratio might be due to the increase in TSS content and decrease in acidity of the fruit and this change have stimulated by ZnSO₄ and FeSO₄ foliar spray. These finding are collaborates with the findings of Kumar *et al.* (2010), Bakshi *et al.* (2013), Chaturvedi *et al.* (2005) in strawberry, Pathak *et al.* (2011) in banana, Pawar *et al.* (2019) in mandarin. The highest juice content (64.56 %) were recorded under the combined treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas S₁ i.e. RDF + Control (Water spray) recorded lowest juice content (57.76%). The increase in juice per cent might be due to the metabolic changes with fast conversion of organic acids in to sugars and its derivatives and utilization as the respiratory substrate during growth and development of the fruits, which was stimulated by zinc and iron foliar spray. These finding are collaborates with the findings of Chaturvedi *et al.* (2005) in strawberry, Kumar *et al.* (2010) and Singh *et al.* (2012). Highest ascorbic acid content (60.80 mg 100g⁻¹ pulp) was recorded in combined treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas S₁ i.e. RDF + Control (Water spray) recorded lowest ascorbic acid content (57.75 mg 100g⁻¹ pulp). In conformity of its similar observations were well reported by Chaturvedi *et al.* (2005) in strawberry, Kumar *et al.* (2010), Pathak *et al.* (2011) in banana, Bakshi *et al.* (2013) and Pawar *et al.* (2019) in mandarin. 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.

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 × 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 fresh weight of fruit, fruit per plant, fruit yield per plant, TSS, TSS Acid ratio, juice content and ascorbic acid content gross return, benefit cost ratio while, decrease in titratable acidity. The treatment S₁₀ i.e. RDF (100: 80: 80 NPK) + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) were found increase in term of TSS, TSS Acid ratio, juice content and ascorbic acid content while, decrease in titratable acidity. 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. It is mentioned that results of the present investigation are only indicative and based on one year of experimentation and suggested that to confirmation trial for one more year is needed to develop technology.

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Influence of Density-Dependent (*Mustard Aphid*) and Independent Factors on Coccinellids Population under Mustard Agro Eco-System

R. Bajia^{1,2*} and N.N. Singh¹

¹Department of Entomology and Agricultural Zoology, Institute of Agricultural Sciences, BHU, Varanasi-221 005 U.P.

²Vivekananda Global University, Jaipur-302012, Rajasthan

*Email : bajiaento@gmail.com

Abstract

Present study revealed the effect of density-independent (abiotic) and density-dependent (biotic) factors on coccinellids (viz., *Coccinella septempunctata* L., and *Coccinella transversalis* Fab.) population under mustard agro eco-system, that the occurrence of aphid population starts from January 26th, 2012 with 3.72 aphids per 10cm terminal shoot and coccinellids population was recorded 0.01 per plant. The aphid population reached to its peak recorded 117.96 aphids per 10cm terminal shoot on February 19th, 2012 and the coccinellids population was recorded 1.48 per plant. Thereafter, a decline in coccinellids population was recorded as low as 0.38 per plant during first week of March corresponding to decrease in aphid population (2.98 aphids per 10cm terminal shoot). The correlation analysis revealed that temperature had a positive correlation with coccinellids population, whereas a significant negative correlation was observed with relative humidity at 0.05 per cent level.

Key words : Coccinellids, abiotic and biotic (aphid) factors, mustard.

Introduction

Mustard aphid (*Lipaphis erysimi* Kalt.) is a key pest of rapeseed and mustard crop. Under the condition of severe infestation it may cause 100 per cent crop loss. For successful cultivation, crop needs repeated application of insecticides which leads to several ill effects.

Among several bio-agents of mustard aphid, lady bird beetles (Coccinellidae: Coleoptera) are important biological control agents, as majority of them *Coccinella septempunctata* and *C. transversalis* are predaceous on several groups of insect pests, including aphids, coccids, adelgids and aleyrodids. Ninety percent of the known 4200 coccinellid species are predaceous ^[1] and Indian coccinellid diversity includes 119 predaceous species ^[2] of these, *Micraspis discolor* (Fabricius) is native to India ^[3,4]. The beetle has distinct sexual dimorphism ^[5] and a wide range of aphid prey provides effective biological control of certain aphid species, viz., *Aphis gossypii* Glover and *A. craccivora* Koch. ^[6,7,8]. These predatory beetles can be used in biological control based IPM programme against mustard aphid. For most agricultural systems, the augmentative releases and conservation techniques for ladybird beetle are greatly emphasized to maximize their uses in biological control ^[9].

The present work was conducted with a view to study the impact of weather conditions on population of predators and its effectiveness in pest management especially mustard aphid, *Lipaphis erysimi* in Varanasi region.

Growth and distribution of aphid population and its

natural enemies in the field are greatly influenced by abiotic factors (density independent) viz., temperature, temperature range, relative humidity, sunshine and rainfall. The present scenario of change in climatic condition, over the globe has affected the occurrence, of the pest species as well as their natural enemies. Hence, present investigation was carried out to study the effect of abiotic and biotic factors on coccinellids population under mustard agro ecosystem as well as study was carried out to find out the influence of various weather parameters on population fluctuation of coccinellids in mustard crop and to influence of abiotic and biotic factors on coccinellids population.

Materials and Methods

To study the influence of abiotic and biotic factors on coccinellids population under mustard agro ecosystem, commonly cultivated 'Varuna' variety of mustard was grown under Randomized Block Design (RBD) with 4 Replications at the Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experimental plot was as big as 600m² in area, row to row and plant to plant distance was maintained at 40cm and 15cm, respectively, having a border area of 1 meter between the two blocks for irrigation channel. Field border of 2 meter also maintained to segregate the experimental area from other crops in the near vicinity ^[10]. The crop was sown on the 9th December 2011, during the year of experiment. The observation on aphid population and coccinellids were recorded from their occurrence till harvesting of the crop on 5 randomly selected plants.

Table-1 : Influence of abiotic and biotic (aphid) factors on the population dynamics of mustard Coccinellids during Rabi season 2012.

Factors	Coefficient	Std. Error	't' Value	95% C.I. lower bound	95% C.I. upper bound
Y	-0.1971	0.8577	-0.2298	-2.9270	2.5327
X ₁	0.0294	0.0413	0.7116	-0.1022	0.1611
X ₂	-0.2296	-0.2728	-0.1698	-0.2436	0.0382
X ₃	0.0822	0.0840	0.9786	-0.1851	0.3496
X ₄	-0.0231	0.0128	-1.8050	-0.0639	0.0176
X ₅	0.0382	0.0283	1.3488	-0.0519	0.1284
X ₆	-0.1463	0.1117	-1.3102	-0.5019	0.2091
X ₇	0.0101	0.0020	5.0011	0.0036	0.0166

$R^2 = 0.572$

Y-Population of mustard aphid

X₁-Maximum temperature (°C)

X₃-Temperature range (°C)

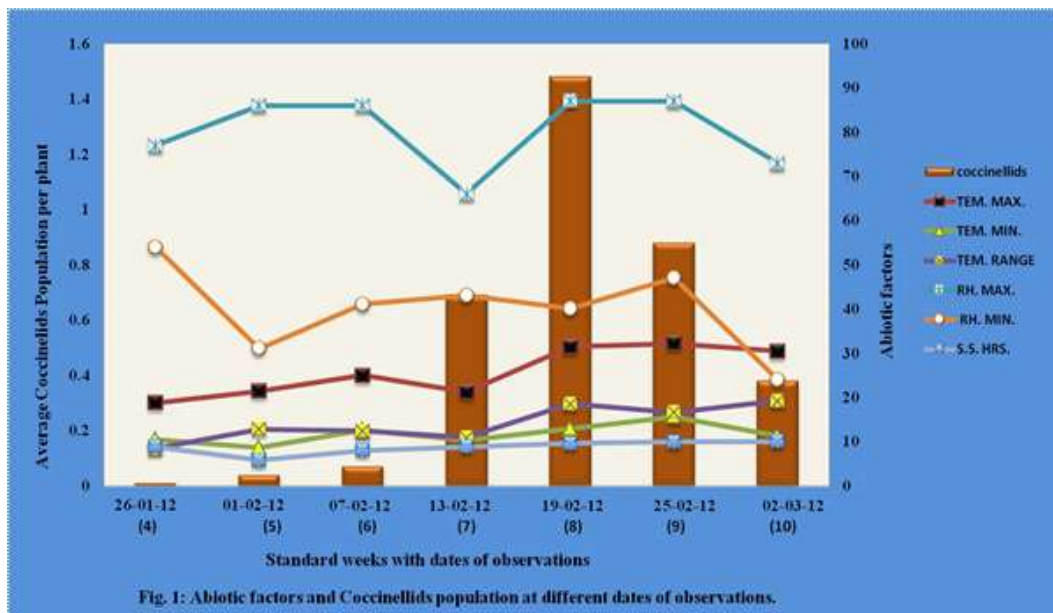
X₅-Relative humidity minimum (%)

X₂-Minimum temperature (°C)

X₄-Relative humidity maximum (%)

X₆-Sunshine (hrs.)

X₇-Coccinellids population



The aphid population was recorded at 3 days intervals while coccinellids population at 6 days intervals starting with their first appearance till harvesting of crop. The aphid population was recorded from top 10 cm. of terminal shoot, whereas, whole plant was considered for coccinellids population.

The meteorological data during entire experimentation were recorded from meteorological department of Banaras Hindu University, Varanasi.

The correlation coefficient and regression analysis was applied to determine the relation between: Mustard aphid (*Lipaphis erysimi* Kalt.), *C. septempunctata* and *C. transversalis* and abiotic factors i.e., temperature, temperature range, humidity, sunshine hours, rainfall etc., following the statistical package ^[11].

Results and Discussion

Abiotic and biotic (Aphid) factors existing in defined ecosystem play a significant role in growth and development of coccinellids population and its life history and number of generation in a unit period of time are significantly influenced by various abiotic and biotic factors in niche. The present endeavour was made to study the influence of abiotic and biotic factors on a seasonal occurrence and abundance of coccinellids in Varanasi region.

The impact of major abiotic factors on the growth and development of coccinellids in 'Rabi' season of 2011-2012, particularly during January and March months are given in Table-1.

It can be visualized from Fig.-1 that the coccinellids

Table-2 : Average population of aphid and coccinellids with different abiotic factors during experimental period (January - March 2012) under Mustard ecosystem.

S. No.	Date of observation	S.W.	Average* Coccinellids population/plant	Aphid population/ 10 cm terminal shoot	Temperature (°C)		Temperature Range (°C)	Relative Humidity (%)		Sunshine (hrs.)
					Max.	Min.		Max.	Min.	
1.	26-01-12	4	0.01	3.72	18.8	10.4	8.4	77	54	8.8
2.	01-02-12	5	0.04	13.65	21.4	8.6	12.8	86	31	5.8
3.	07-02-12	6	0.07	26.94	25	12.6	12.4	86	41	8.0
4.	13-02-12	7	0.69	59.24	21.2	10.3	10.9	66	43	8.8
5.	19-02-12	8	1.48	117.96	31.4	12.9	18.5	87	40	9.6
6.	25-02-12	9	0.88	33.95	32.2	15.6	16.6	87	47	9.9
7.	03-03-12	10	0.38	2.98	30.4	11.2	19.2	73	24	10

S.W. – Standard Week, * = Average of 20 plants

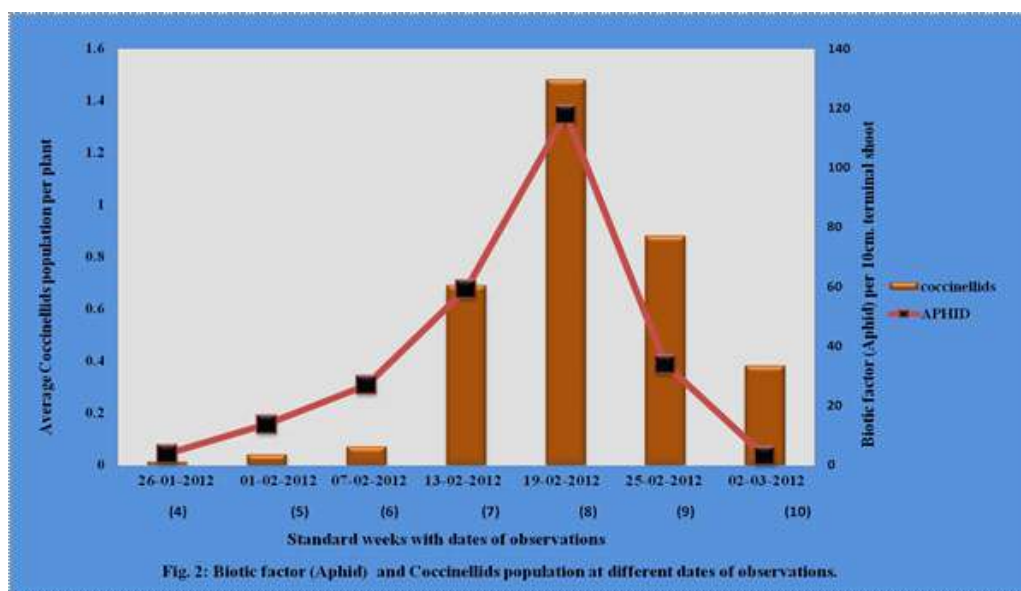


Fig. 2: Biotic factor (Aphid) and Coccinellids population at different dates of observations.

attained its peak during fourth week of February recording 1.48 coccinellids per plant. Thereafter, the population declined gradually with minimum population of 0.38 coccinellids per plant. Aphid occurrence starts from fourth week of January and peaked during fourth week of February with 117.96 aphids per 10cm terminal shoot. The numbers of coccinellids were comparatively less when the temperature was 30.4°C. Through the occurrence of initial population of the coccinellids was noted during second week of January, but the population was not recorded due to its very low number. However, the population increased significantly after the fourth week of January and a mean population is 0.01 coccinellids per plant were recorded with maximum and minimum temperature 18.8°C and 10.4°C, maximum and minimum relative humidity was 77 per cent and 54 per cent, respectively. The population of coccinellids increased gradually till 4th week of February reaching to peak of 1.48 coccinellids per plant, during this period the variation in minimum and maximum temperature were

observed about 2°C which remains congenial for multiplication of coccinellids. Variation in maximum and minimum relative humidity was ± 10 per cent, respectively with sunshine of 9.6 hours.

The population of coccinellids starts decreasing with significant decrease in relative humidity. The period of sunshine hours also increased reaching maximum of 10 hours. The coccinellids population decrease to 0.38 individuals per plant with a maximum and minimum temperature of 30.4°C and 11.2°C and relative humidity of 73 per cent and 24 per cent, respectively. Prior to this observation the temperature increased to as high as 32.2°C recording a mean population of coccinellids 0.88 per plant at the time of harvesting of the crop.

Two coccinellids species, *C. septempunctata* and *C. transversalis* were observed to be active in mustard ecosystem in this region. The initial population of coccinellids was observed during first week of February when the mean aphid population varied between 13.65

Table-2 : Correlation matrix of various weather parameters and biotic factor (aphid) on coccinellids population.

	Y	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇
Y	1							
X ₁	0.6777	1						
X ₂	0.5545	0.7670	1					
X ₃	0.6131	0.9333	0.4856	1				
X ₄	0.1385	0.3803	0.4330	0.2759	1			
X ₅	0.0614	-0.3087	0.3080	-0.5929	0.0579	1		
X ₆	0.5806	0.6350	0.6615	0.4951	-0.2398	0.1684	1	
X ₇	0.8835	0.3834	0.3184	0.3443	0.1787	0.1329	0.2766	1

* Correlation is significant at the 0.05 level ($r=0.754$)

Y-Population of mustard coccinellids

X₁-Maximum temperature (°C)

X₂-Minimum temperature (°C)

X₃-Temperature range (°C)

X₄-Relative humidity maximum (%)

X₅-Relative humidity minimum (%)

X₆-Sunshine (hrs.)

X₇-Aphid population

and 117.96 aphids per 10cm terminal shoot. During 1st week of February the mean coccinellids population was observed 0.04 per plant on 01-02-2012.

On successive days of observation at an interval of 6 days the coccinellids population have an increasing trend till 02-03-2012 and reached to its peak (with average) population of 1.48 per plant. Similarly at an interval of 3 days the aphid population gradually increased till 02-03-2012 and reached to its peak with average population of 117.96 per plant.

The significant increase in temperature and decrease in relative humidity with increase in sunshine hours does not affect the coccinellids population but have great influence on aphid population (Table-2 and Fig-2). It appears that coccinellids population is mainly host dependent and with the increase in host population, the coccinellids population was also found increasing. The increase in coccinellids population along with increase in temperature causes remarkable reduction in aphid population. This reduction in aphid population, with increase in coccinellids population coupled with unfavourable abiotic factors like increased in temperature, sunshine hours and decrease in relative humidity leads to reduction of coccinellids population.

Relative abundance of aphid, *Lipaphis erysimi* (Kaltenbach) and predator, *Coccinella septempunctata* (L.) colonies on *Brassica oleracea* var. botrytis. They observed that the numerical density of the predator increased in response to increase in density of aphid prey in the field ^[12]. That the aphid population was non significant negatively correlated with maximum and minimum temperature and with mean relative humidity it was significant negative correlation. The predatory activity of the coccinellids, *C. septempunctata* also began in the first week of February and the adult of coccinellids had a significant positive correlation with aphid population ^[13]. The correlation analysis showed highly significant

positive correlation ship between predator and aphid species. Temperature, relative humidity and rainfall correlated negatively with predator and prey population whereas sunshine and wind speed correlated positively.

Thus the present experiment showed that the combined effect of increase in temperature and coccinellids population leads to decline of aphid population. Such condition of growth and multiplication of coccinellids is normally experienced during the 3rd and 4th week of February in Varanasi region. After fourth week of February, temperature has raising trend and relative humidity has decreasing trend. Hence, during second fortnight of February when temperature starts increasing with increase coccinellids population, there is no need of insecticides application as coccinellids population will take care of aphid population in mustard ecosystem.

The present study was in confirmation with the previous work revealed that the combined effect of both biotic and abiotic factors influenced on *L. erysimi* density and showed that *Coccinella septempunctata* and *Ischiodon scutellaris* were the established predator of mustard aphid ^[14]. Further, the maximum temperature had a negative and significant relationship with the aphid population, but was positive for *C. septempunctata*.

Present finding is also in conformation with the findings[15,16,17] that feeding potential of coccinellids increases with increase in temperature. Relative Humidity and sunshine have are positively correlated with coccinellids population size ^[18]. But, rainfall has a negative correlation with coccinellids ^[19]. Biotic factors such as aphid have initial positive correlation with ladybeetles ^[20,21]. Increase in ladybeetle population reduces the aphid population, thereby establishing a negative correlation ^[22].

Conclusions

The findings of present investigations revealed that

coccinellids population was greatly influenced by different abiotic and biotic factors. The maximum and minimum temperature, and temperature range showed a positive correlation with the coccinellids population, whereas relative humidity had a negative correlation. The coccinellids population as a predator was also influenced by the aphid population. The sunshine hours and aphid population had shown the positive correlation with the test insect.

A significant impact of temperature and relative humidity were also observed with the predatory coccinellids population. The temperature and sunshine hours had a positive correlation with abundance of coccinellids in mustard agro ecosystem. In such conditions growth and multiplication of coccinellids normally experienced during the 3rd and 4th week of February in this region. After fourth week of February temperature was raised regularly and relative humidity was further decrease.

Hence, during second fortnight of February month when temperature starts increasing with increased coccinellids population, no need of insecticides application as coccinellids population will take care of aphid population under mustard agro eco-system.

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Attitude and Extent of Pesticide using Behavior of Paddy Growers at Khambhat Taluka of Anand District in Gujarat

Raju Singh Jakhar^{1,2*}, A.S. Saiyad¹, Foumy N. Rafeeq² and Vinod Bhateshwar²

¹Department of Extension Education, B.A. College of Agriculture, AAU, Anand, Gujarat- 388110

²Department of Agriculture, Vivekananda Global University, Jaipur, Rajasthan-303012

*Corresponding Author Email : raju.jakhar2@gmail.com

Abstract

The pesticide using behavior of paddy crop may differ from individual to individual because of their differences in age, education, size of land holding, type of family, social participation and socio-economic status. Pesticide using behavior is a mental process. It involves selection of goals to be attained and also alternative means to be evaluated for their efficiency in the attainment of the selected goals. Therefore, "A Study on Pesticide using Behavior of Paddy Growers in Khambhat Taluka of Anand District" was undertaken with the following specific objectives: To study the attitude of respondents towards use of pesticides and to study the extent of pesticide using behavior of paddy growers. The present investigation was purposively carried out in Khambhat taluka of Anand district, where paddy crop is cultivated in larger area as compared to other talukas. Ten villages were randomly selected from Khambhat taluka having the larger area under paddy cultivation. A list of paddy growers who were cultivating paddy crop from each of the selected villages was obtained from the concerned Gram Panchayat. Twelve paddy growers were randomly selected from each village. Thus, the sample consisted of 120 respondents for the study. The independent and dependent variables were measured by using suitable scales and procedures adopted by various researchers. The interview schedule was prepared keeping in view the objectives of the study. The data so collected were classified, tabulated and analyzed in order to make the findings meaningful. The statistical measures such as percentage, mean score, standard deviation and coefficients of correlation were used.

Key words : Pesticide, paddy, farmer, behavior.

Introduction

India is predominantly an agrarian country. Its economy is based on agriculture of which plant protection is a significant component. Adequate plant protection measures are one of the important parameters of crop husbandry. To keep pace with population growth, there is a continuing need to increase food production, particularly in the developing countries of Asia, Africa and Latin America. Most of the increased food production has to come from increased yield of major crops grown on existing arable lands. One of the practical means of crop production is to minimize the pest associated losses, which are currently estimated at 14.00 per cent of the total agricultural production [1].

However, if an average per hectare consumption of pesticide is compared of various countries and ours, it, would be found that it is perhaps amongst the lowest in the world. Notably, the crop yield per hectare is also among the lowest. The damage due to various crop pests and diseases are estimated to be around 30.00 per cent of the total agricultural production. Thus, the pesticides industry plays a vital role in safe guarding the crops and thereby increasing the country's agricultural production. Annual crop losses in India due to pests are estimated at around 30,000 crores of which diseases account for

28.00 per cent costing approximately. As per recent estimates, India is losing annually Rs.1,40,000 crores [2].

At present, the share of insecticide consumption in the country is 19.80 per cent, that of fungicide 10.00 per cent, weedicide 6.40 per cent and others 3.40 per cent. The major crops which consume maximum pesticides are cotton and paddy, which is about 54.00 per cent and 17.00 per cent, respectively of the total pesticides consumed in the country [3]. The rate of pesticide consumption in India is low i.e., 438 gm/ha as compared to 14 kg/ha in USA and 10-12 kg/ha in Japan. So, it is fact that pesticide consumption in India is much low as compared to several other countries. As far as state-wise contribution to total consumption of pesticides in India is concerned, Gujarat stands on 4th position with 15.20 per cent to total contribution [4].

Keeping this in view, plant protection measures are most effective practices in agriculture. Poor plant protection is a major cause for low yield in paddy. It is essential that after using all the inputs such as hybrid seeds, irrigation, fertilizers, insecticides, pesticides, fungicides etc., we should protect our crops from ravage of pests [5]. Therefore, the judicious use of pesticides against control of insect, pest and diseases are very important.

Table-1 : Distribution of the respondents according to their attitude towards the use of pesticides.

n=120

S. No.	Category	Frequency	Per cent
1.	Less favorable (below 60.10 score)	21	17.50
2.	Moderately favorable (in between 60.10 to 74.81 score)	74	61.67
3.	Highly favorable (above 74.81 score)	25	20.83
	Total	120	100.00

Mean = 67.456

S.D. = 7.363

Table-2 : Distribution of the paddy growers according to their extent of pesticide using behaviour.

n=120

Sr. No.	Category	Frequency	Per cent
1.	Below recommendation (below 46.21 score)	15	12.50
2.	As per recommendation (in between 46.21 to 73.25 score)	75	62.50
3.	Above recommendation (above 73.25 score)	30	25.00
	Total	120	100.00

Mean = 59.728

S.D. = 13.521

The problem has recently attracted the attention of some extension researchers, but very limited work has been done in this regard. The knowledge of different categories of farmers towards pesticides and lack of knowledge regarding pesticides in combination with personal and socio-psychological characteristics of the farmers are expected to lead to difference in perception of the problem. The present study aims at determining the attitude and extent of pesticide using behavior of paddy growers which contribute to proper use of pesticides.

Research Methodology

The present study was carried out in the Anand district of Gujarat state. This district was purposively selected as paddy was a major crop grown in the district, as the climatological factors are suited for growth of paddy crop and main paddy research station is located in this district. The study was confined to "ex- post facto" research design as the independent variables is already operated in study area. Anand district is comprised of eight talukas. Keeping the time and other resources available with the investigator in view, only one taluka i.e., Khambhat taluka was purposively selected where paddy crop is cultivated in larger area as compared to other talukas. Thereafter, ten villages having the larger area under paddy cultivation were selected by random sampling method with the help of random table. A list of paddy growers was obtained from the Village Level Worker and concerned Gram Panchayat. Thereafter, twelve paddy growers from each village were selected by random sampling method. In this way, the sample consisted of 120 respondents. The variables under the study were selected on the basis of extensive review of literature related to the topic of research in consultation with experts. Only those variables which were found to have most relevance to the present investigation were finally selected for the study. Thereby, 16 independent variables and 1 dependent variable were selected. A well-structured and pre-tested

interview schedule was prepared for collecting the data. The collected data were tabulated, analysed by using suitable statistical tools.

Results and Discussion

The collected information was classified, tabulated and analyzed in light of the objectives of the study. The facts and findings derived after analyzing the information have been presented.

Attitude of Respondents Towards use of Pesticides :
Attitude of the cultivator is very important for the use of any new agricultural technology. If the cultivator has positive attitude or positive behaviour about new technology, they can easily adopt or properly use the pesticides. Here, an attempt has been made to study the attitude of paddy growers towards the use of pesticides in paddy crop. The data in this regard are presented in Table-1.

The data presented in Table-1 show that slight more than three-fifth (61.67 per cent) of the respondents were having moderately favorable attitude towards the use of pesticides in paddy crop, followed by 20.83 per cent with highly favorable attitude and only 17.50 per cent of the respondents had less favorable attitude towards the use of pesticides.

It can be concluded that a vast majority (82.50 per cent) of the paddy growers had moderately to highly favorable attitude towards the use of pesticides. This might be due to the reason that majority of the respondents had obtained secondary to higher secondary level of education, which in turn might have played a major role in building up favorable attitude among paddy growers towards use of pesticides.

Extent of pesticide using behaviour of paddy growers : The adoption process is the mental process through which an individual passes from first hearing of an innovation to its final adoption. Thus, adoption is a

decision to continue full use of an innovation. With a view to find out the level of use of recommended plant protection measures of paddy crop, the respondents were asked to indicate at what extent they used recommended plant protection measures. The data in this regard are presented in Table-2.

The data presented in Table-2 indicate that majority (62.50 per cent) of the paddy growers had used the pesticides as per recommendation, followed by 25.00 per cent of them had used the pesticides at the rate of above recommendation. Whereas, only 12.50 per cent of them had used the pesticides below recommendation.

From the above results, it can be concluded that nearly two-third (62.50 per cent) of the paddy growers had used the pesticides as per recommendation. The probable reason might be due to the facts that majority of the paddy growers were young to middle age group and well-educated having ability to read, understand and concretize the ideas leads to unique power of decision making which is reflected into recommended use of pesticides.

Conclusions

Plant protection measures are most effective practices in agriculture. Poor plant protection is a major cause for low yield in paddy. A great majority (82.50 per cent) of the respondents had moderately to highly favorable attitude

towards the use of pesticides. Nearly two-third (62.50 per cent) of the paddy growers had used the pesticides as per recommendation. The most important constraints faced by the paddy growers were: non-availability of chemicals at affordable rates, poor quality of chemicals and non-availability of pest resistance varieties of paddy crop. The major suggestions requested by most of the paddy growers were that: plant protection chemicals should be provided at reasonable rates, credits should be provided at reasonable rates, pest and disease resistance varieties of paddy crop should be developed and method demonstrations should be conducted on farmers' fields to develop skill for proper use of chemicals.

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Problems Faced by the Paddy Growers in Utilization of Canal Irrigation Water in Paddy Crop of Anand District in Gujarat

Raju Singh Jakhar^{1,2*}, A.S. Saiyad¹, Foumy N. Rafeeq² and Ramesh Chand Choudhary²

¹Department of Extension Education, B.A. College of Agriculture, Anand Agricultural University, Gujarat-388110

²Department of Agriculture, Vivekananda Global University, Jaipur, Rajasthan-303028

*Corresponding Author Email : raju.jakhar2@gmail.com

Abstract

Agriculture as the largest private enterprise in India has been and will continue to be the life line of the Indian economy least in foreseeable future. It contributes nearly 22 per cent to national G.D.P In food sector alone, agriculture contributes about 250 thousand crore rupees annually. Also provide direct employment to about 234 million people. India account for 16 per cent of the world human population and 30 per cent of the cattle and the country is endowed with just 4 per cent of water resource. Out of total water resources available, only 3 per cent goes into irrigation and a major portion to public supply, so even in full irrigation potential is exploited about more than 50 per cent of the country's cultivated area will remain unirrigated. Command Area Development is directed to maximum utilization of the resources of land and water both is limited in our country. This requires a multi-disciplinary approach, involving water management, its engineering and crop husbandry. The objective is to reduce loss of water through seepage, bring maximum area under irrigation and agronomic practices, which increase the intensity of cropping and yield per unit of water and land. These problems are observed on canal of Mahi project, while on sub-minor it is very little. Anand district was chosen for the study. Anand and Umreth talukas of Anand district were purposively selected, because these talukas have more canal irrigation water area as compared to other talukas. Eight paddy growing villages were randomly selected from those two talukas. For this study 120 paddy growers who had minimum 3 years of experience in paddy cultivation were selected randomly and analyzed the constraints faced by the them and provided suitable suggestions as mentioned by the farmers.

Key words : Paddy growers, canal irrigation, problem, village.

Introduction

Agriculture as the largest private enterprise in India has been and will continue to be the life line of the Indian economy least in foreseeable future. It contributes nearly 22 per cent to national G.D.P In food sector alone, agriculture contributes about 250 thousand crore rupees annually. Also provide direct employment to about 234 million people. India account for 16 per cent of the world human population and 30 per cent of the cattle and the country is endowed with just 4 per cent of water resource. Out of total water resources available, only 3 per cent goes into irrigation and a major portion to public supply, so even in full irrigation potential is exploited about more than 50 per cent of the country's cultivated area will remain unirrigated.

The management of irrigation in India differs conceptually from that practiced in those developed countries where limited water is not a constraint. Good management, efficient operation and well-executed maintenance of irrigation systems are essential to the success and sustainability of irrigated agriculture. They result in better performance, better crop yields and sustained production. One of the key objectives of the management of an irrigation system is to provide levels of

service as agreed with the relevant government authorities and the consumers at the minimum achievable cost. Irrigation development in India gained momentum after Independence. The net irrigated area in 1950-51 was 20.85 million ha. with 1.71 million ha. irrigated during more than one crop season. The gross irrigated area was 22.6 million hectares [1].

The target now is to achieve by the year 2010 the ultimate irrigation potential of 113.5 million ha. from all sources of water. About 58.5 million under large and medium sized projects and 55 million under smaller projects. This means adding some 1.7 million ha per year to the larger irrigation projects [2]. The canal system transfers water from its source to one or more points of diversion downstream. A canal's recovery characteristics - the speed and manner in which the canal recovers to a steady state flow after a flow change depend on the method of pool operation.

The feasibility study undertaken in March 1982 by the French consulting firm GERSAR (Groupe d'Etudes, de Recherches et de Sauvegarde de l'Art Rupestre), on improving the operation of the Mahi right bank canal concluded that it would be possible to improve the efficiency of the system with automation. According to the

Table-1 : Constraints faced by respondents in utilization of canal irrigation water in paddy crop.

n=120

S. No.	Constraints	Number	Per cent	Rank
1.	Due to more land holding, it is not possible to irrigate all area	106	88.33	I
2.	Technical guidance is not available in time	105	87.50	II
3.	There was, shortage of irrigation water at critical stage of paddy crop	102	85.00	III
4.	Due to lack of bridge on canal difficulties for transporting the agriculture implements and animals	101	84.16	IV
5.	Farmer those who are near to out-let of canal used more irrigation water	100	83.33	V
6..	Employees are not following the proper distribution system of water	99	82.50	VI
7.	Canal irrigation is not economical for the rainfed crops	98	81.66	VII
8.	Water supply is not regular	98	81.66	VII
9.	Irrigation authority are not informed while giving the water in canal	97	80.83	VIII
10.	Water supply is not enough	96	80.00	IX
11.	Due to lack of money less area was covered under irrigation	94	78.33	X
12.	Field channel were not prepared in time	92	76.66	XI
13.	Soil are deteoriated due to irrigation	91	75.83	XII
14.	Rotation register is not maintained properly	88	73.33	XIII
15.	Other farmers got discouraging results	85	70.83	XIV
16.	Land is situated at the tail end of the canal	84	70.00	XV
17.	Alternate irrigation sources is not available	82	68.33	XVI
18.	Mode of payment of water charges is not satisfactory	80	66.66	XVII
19.	Topography of land	79	65.83	XVIII
20.	Neighboring farmers do not use irrigation water	77	64.16	XIX

Table-2 : Suggestions given by respondents to overcome the constraints faced by them.

n = 120

S. No.	Suggestions	Number	Per cent	Rank
1.	Timely technical guidance should be provided to the farmers	108	90.00	I
2.	Water supply should be timely.	105	87.50	II
3.	More water should be provided for irrigation	104	86.66	III
4.	Guidance should be provided for using irrigation method	101	84.16	IV
5.	Proper distribution system should be established	98	81.66	V
6.	Irrigation rate of produce should be regulated.	95	79.16	VI

study, the efficiency of the network at the time was 23 per cent. The irrigation authority proposed to introduce Warabandhi in the command area without any improvement in regulation. This would increase efficiency to 28 per cent. The pilot project was selected to cover 100 km of the main canal and 4 400 ha. of the distribution network. The cost of automation was estimated at the rate of Rs 500/- per ha on the main canal and at the rate of Rs. 1700/- per ha in the distribution network as of 1982. [3].

In Gujarat, the average area for the year 2007-2008 and 2008-2009 under paddy crop is 2,93,876 hectares with average annual production of about 3,51,543 metric tons [4]. The major paddy growing districts in Gujarat state are Anand, Gandhinagar, Kheda, Mehsana, Bharuch, Ahmedabad, Dahod, Navsari, Surat, Baroda and Sabarkantha which together contributes to about 87.00 per cent and 87.50 per cent of total area and total production.

Command Area Development is directed to maximum utilization of the resources of land and water both are limited in our country. This requires a multi-disciplinary approach, involving water management, its engineering and crop husbandry. The objective is to reduce loss of water through seepage, bring maximum area under irrigation and agronomic practices, which increase the intensity of cropping and yield per unit of water and land. Equitable distribution of water and service the principle of social justice in relation to the small and marginal farmers and tail ender, while simultaneously helping in increasing overall productivity.

Encouraging adoption of water saving method would help sustain irrigated agriculture, where water supplies are diminishing curb and ecological damage to over taxed river and stream which helps in controlling rising water table. These problems are observed on canal of Mahi project, while on sub- minor it is very little. Irrigation methods applied by the farmers are very

important. Much more irrigation water being wasted by the farmers in Mahi command area which directed to undertake this study by considering the problems faced by the paddy growers in utilization of canal irrigation water in paddy crop and to seek the suggestions from the farmers to overcome the constraints faced by them.

Research Methodology

Anand district was chosen for the study. Anand and Umreth talukas of Anand district were purposively selected, because these talukas have more canal irrigation water area as compared to other talukas. Eight paddy growing villages were randomly selected from those two talukas. For this study 120 paddy growers who had minimum 3 years of experience in paddy cultivation were selected randomly. 120 paddy growers were considered as a sample and as respondents. To know the various characteristics of paddy growers a scale developed by [5] was used with some modifications. Measurements of knowledge about utilization of canal irrigation water in paddy crop done by using teacher made test. A measurement of extent of utilization of canal irrigation water in paddy crop by the respondents was done by using scale developed by [6] with slight modification. The data were collected with the help of well-structured, pre-tested, Gujarati version interview scheduled through personal contact and data were compiled, tabulated and analyzed to get proper answers for objectives of the study. A simple ranking technique was applied to measure the constraints faced by respondents. The statistical tools used were percentage, mean score, standard deviation and coefficient of correlation value.

Results and Discussion

The major constraints faced by the farmers were collected, tabulated and analyzed as follows:

Constraints in adoption of new technology never end. However, they can be minimized. The respondents were requested to express the constraints faced by them in utilization of canal irrigation water of paddy crop. Frequency and percentage for each constraint were calculated and on that basis of that, the constraints were ranked and presented in Table-1.

As seen from the table major constraints faced by respondents are due to more land holding, it is not possible to irrigate all area (88.33 per cent), technical guidance are not available in time (87.50 per cent), shortage of irrigation water at critical stage of crop (85.00 per cent), due to lack of bridge on canal difficulties for transporting the agriculture implements and animals (84.16 per cent), farmer those who are near to out-let of canal used more irrigation water (83.33 per cent),

employees are not following the proper distribution system of water (82.50 per cent), water supply is not regular and canal irrigation is not economical for the rainfed crops (81.66 per cent), irrigation authority are not informed while giving the water (80.83 per cent), water supply is not enough (80.00 per cent), due to lack of money area is covered under irrigation (78.33 per cent), field channel were not prepared in time (76.66 per cent), soil are deteriorated due to irrigation (75.83 per cent), rotation register is not maintained properly (73.33 per cent), other farmers got discouraging results (70.83 per cent), land is situated at the tail end of the canal (70.00 per cent), alternate irrigation sources is not available (68.33 per cent), mode of payment of water charges is not satisfactory (66.66 per cent), topography of land (65.83 per cent) and neighboring farmers do not use irrigation water (64.16 per cent).

Suggestions Made by Respondents to overcome the Constraints Faced by them : An attempt was also made to ascertain suggestions from respondents to overcome various constraints faced by them in utilization of canal irrigation water in paddy crop. The respondents were requested to offer their valuable suggestions against difficulties faced by them in the utilization of canal irrigation water in paddy crop. The data were collected and summarized in table-2.

Valuable suggestions given by respondents are presented in Table 2. It can be concluded from the Table 2 that the respondents suggested that timely technical guidance should be provided to the farmers (90.00 per cent), water supply should be timely (87.50 per cent), more water provided should be for irrigation (86.66 per cent), proper distribution system should be established (81.66 per cent) and irrigation rate should be regulated (79.16 per cent).

It can be concluded that major suggestions given by respondents where timely technical guidance should be provided to the farmers, water supply should be timely, more water provided should be for irrigation, rate of produce should be regulated, proper distribution system should be established and irrigation rate should be regulated.

Conclusions

Out of total water resources available, only 3 per cent goes into irrigation and a major portion to public supply, so even in full irrigation potential is exploited about more than 50 per cent of the country's cultivated area will remain unirrigated. Encouraging adoption of water saving method would help sustain irrigated agriculture, where water supplies are diminishing curb and ecological damage to over taxed river and stream which helps in controlling rising water table. These problems are observed on canal

of Mahi project, while on sub- minor it is very little. Irrigation methods applied by the farmers are very important.

Major constraints faced by respondents those who are due to more land holding it is not possible to irrigate all area, technical guidance is not available in time, shortage of irrigation water at critical stage of crop, due to lack of bridge on canal difficulties for transporting the agriculture implements and animals, farmer those who are near to out-let of canal used more irrigation water and employees are not following the proper distribution system of water.

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To Study the Instability and Causes of Instability of Major Pulse Crops in Karnataka

Harkesh Kumar Balai^{1*}, Kailash Chand Bairwa², Hari Singh³, M.L. Meena⁴ and G.L. Meena⁴

¹Department of Agricultural Economics, College of Agriculture, Indore-452001, Madhya Pradesh

²Department of Agricultural Economics, College of Agriculture, Baytu-344034, Barmer, Rajasthan

³Department of Agricultural Economics and Management, Rajasthan College of Agriculture, Udaipur-313001, Rajasthan

⁴Department of Horticultural, College of Agriculture, Baytu-344034, Barmer, Rajasthan

*Corresponding Author Email : harkeshbalai15@gmail.com

Abstract

The study was conducted the growth of area, production and productivity of major pulse crops i.e. gram, black gram, green gram and pigeon pea crops in Karnataka. The study was based on secondary data from 1988-89 to 2017-18. Instability in area, production and productivity of selected pulse were worked out for entire period of analysis by Cuddy- Della Valle index and to measure the cause of instability with respect of selected pulse crops i.e. gram, black gram, green gram and pigeon pea in Karnataka, acreage response function (log linear function) and yield response function have been used. The study revealed that production of selected crops were highly instable in Karnataka. In case of area, gram was highly instable and black gram was less instable while green gram and pigeon pea were medium instable. In the mean time, productivity of gram and pigeon pea were medium instable while productivity of black gram and green gram were highly instable. Green gram growers in Karnataka showed contrary response to lagged area under its competing crop i.e. the decrease in area of competing crop in last year season, thereby that was tendency to increase the area under green gram in Karnataka. while quite responsive to lagged area under gram, black gram and pigeon pea crop in Karnataka. It means the increase in area of gram, black gram and pigeon pea crops in last year season, there is tendency to increase the area under gram, black gram and pigeon pea in Karnataka. The time trend factor showed positive influence on productivity of gram and pigeon pea crops while negative influence on productivity of black gram and green gram crops in Karnataka. Further, seasonal rainfall was recorded positive impact on gram crop while negative influence on productivity of black gram green gram and pigeon pea crops in Karnataka.

Key words : *Instability, acreage response function and yield response function.*

Introduction

One of the most important segment of Indian agriculture after oilseeds and cereals is pulse production. The pulses comprise Chickpea, Pigeon pea, Lentil, Green gram, Black gram and Field pea. Being an important crop commodity they provide high quality protein. Moreover they complement other cereal crops thus helping the population of the country by providing nutritious diet. Pulses are popularly known as "Poor man's meat" and "rich man's vegetable" as a result of being a major source of proteins, vitamins and minerals especially for vegetarian diets in India (Singh *et al.*, 2016). Pulses are also capable of taking upcoming and changing environmental challenges. About 9-10 per cent share is of the pulses to the total food grain having important and valuable plant based proteins, vitamins and minerals. As they are inexpensive and protein rich they form an essential part of the meal about 20-25 per cent. Pulses are also useful from health point of view helping fight, malnutrition, diabetes etc. (Source: Ministry of Agriculture and Farmers Welfare, DAC and FW, 2018)

Pulses prove to be a boom for mankind as they are highly nutritive important gift of nature. They not only increase the fertility of the soil by nitrogen fixation but also

increase the porosity of the soil due to their invasive top root system due to the low requirement of water and ability to withstand serves revealed that decline in pulses consumption lead to increase in malnutrition due to decline in protein intake. (Shalendra *et al.*, 2013). India is still a home for about 24 per cent of under nourished people in the world (Sharma *et al.*, 2016 and Ahlawat *et al.*, 2016).

Almost 50 per cent of world pulse output is concentrated in Asia (India, Myanmar, China and Turkey), followed by 22 per cent in Africa (Nigeria, Tanzania, Niger and Ethiopia), 19 per cent in the America (Canada, Brazil, USA and Mexico), 9 per cent in Europe and the remaining 4 per cent in Oceania. Low Income Food Deficit Countries (LIFDCs) account for 48 per cent of world production and Least Developed Countries (LDCs) about 23 per cent substantiating the importance of these crops in the most economically disadvantaged countries. As per the data for the past 30 years is concerned, India finds its place in doubly as the largest producer of pulses, consequently producing two-three times more than any other country. (Food outlook, biannual report 2016, Food and Agriculture Organization).

Table-1 : Instability in area, production and productivity of selected pulse crops in Karnataka (1988-89 to 2017-18).
(In Per cent)

Crops	Area	Production	Productivity
Gram	31.83	32.70	15.65
Black gram	13.93	48.82	44.84
Green gram	26.67	54.10	37.48
Pigeon pea	15.66	35.34	23.68

Source : Author's own commutation from compiled time series data.

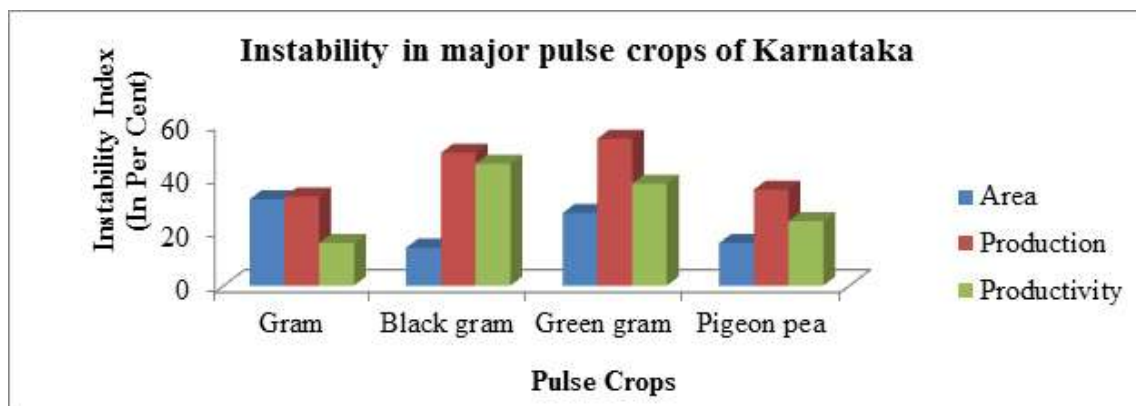


Figure-1 : Instability in area, production and productivity of Major pulse crops in Karnataka.

Pulses were cultivated over more than 29 million hectare area with productivity of 841 kg/ha. Ten states were the major producers contributing more than 90 per cent pulses. These were Madhya Pradesh (> 8 mt), Rajasthan (>3 mt), Maharashtra (>3 mt) Uttar Pradesh (>2 mt) Karnataka (2 mt) and Andhra Pradesh (>1 mt) producing more than one million tones each followed by Gujarat, Jharkhand, Tamil Nadu, and Chhattisgarh producing <1.0 mt each (Anonymous, 2018). Under individual crop category, gram recorded a highest ever production of 11.23 mt at a record productivity level of 1063 kg/ha in an area of 10.56 million hectares. Major 07 states that contributed > 90 per cent in gram production have been Madhya Pradesh (4.60 mt), Maharashtra (1.78 mt), Rajasthan (1.67 mt), Karnataka (0.72 mt), Andhra Pradesh (0.59mt), Uttar Pradesh (0.58 mt) and Gujarat (0.37 mt) (Anonymous, 2018).Pigeon pea remained at second position in total pulse production with 4.25 mt under acreage of 4.43 million hectare with the productivity of 960 kg/ha, the ever highest yield. Major states to record the success had been Maharashtra (1.07 mt), Madhya Pradesh (0.84 mt), Karnataka (0.77 mt), Gujarat (0.34 mt), Uttar Pradesh (0.33 mt), Telangana (0.26 mt) and Jharkhand (0.22 mt). Urad (Black gram), showed to be the 3rd important pulse crop which was cultivated over an area of 5.44 million hectare (kharif + rabi) and recorded a production of 3.56 mt at a productivity level of 655 kg/ha. Major contributing states had been Madhya Pradesh, Rajasthan, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Maharashtra, Jharkhand and Gujarat (Anonymous, 2018).

Stagnant pulses production between 15 and 25.23 million tones with significant growth was observed in the country between 2010 and 2017. Even after the production of the highest quantity of pulses, import would become necessary in order to bridge the gap between demand and supply. To meet the domestic demand, the country is importing about 5–6 million tones pulses. The growth rate of pulses production was stagnant as compared to population growth rate of 1.44 per cent and has led to progressive decline in per capita availability of pulses (Anonymous, 2018) the last decade has seen, a progressive decline in pulse consumption, especially among the poorer segments of the population due to high purchase prices.

Materials and Methods

The study was based on secondary data collected from different sources i.e. Directorate of Agriculture and cooperation, GOI, Directorate of pulses development Bhopal, various issues of Agriculture Statistical Year Book and Agriculture Statistics at a Glance, etc. The time series data of area, production and productivity of selected pulse crops have been taken for 30 years from 1988-89 to 2017-18. Instability in area, production and productivity of selected pulse were worked out for entire period of analysis by Cuddy- Della Valle index and to measure the cause of instability with respect of selected pulse crops i.e. gram, black gram, green gram and pigeon pea in Karnataka, acreage response function (log linear function) and yield response function have been used.

Table-2 : Estimated acreage response function (log linear form) of selected crops in Karnataka (1988-89 to 2017-18).

Variables	Gram	Black gram	Green gram	Pigeon pea
Constant (B_0)	0.371 (0.394)	1.086 (1.344)	7.452 (2.195)	2.002 (1.524)
$A_{(t-1)}$	0.925 (0.135)	0.603* (0.169)	0.270 (0.181)	0.910 (0.171)
C_t	-	-	-	-
$C_{(t-1)}$	-1.148 (0.702)	0.708 (0.887)	-2.434 (1.449)	-0.897 (1.035)
S	-0.234 (0.112)	-0.174 (0.202)	-0.448 (0.347)	0.211 (0.257)
$S_{(t-1)}$	0.139** (0.111)	-0.157 (0.293)	-1.262 (0.462)	-0.571** (0.309)
R^2	0.721	0.461	0.441	0.658

Source : Author's own commutation from compiled time series data.

Note : Figures in parenthesis are standard error of Coefficient

*, ** Significant at 1 and 5 % levels of significance, respectively

Table-3 : Estimated yield response function (log linear form) of selected crops in Karnataka (1988-89 to 2017-18).

S. No.	Variable	Gram	Black gram	Green gram	Pigeon pea
1.	Constant (B_0)	-14.898 (3.401)	7.290 (11.268)	23.629 (10.046)	-18.393 (5.877)
2.	T (Time)	0.009 (0.002)	-0.002 (0.005)	-0.010** (0.005)	0.011* (0.003)
3.	S	0.022 (0.059)	-0.001 (0.397)	-0.076 (0.354)	-0.056 (0.207)
4.	R^2	0.507	0.100	0.179	0.432

Source : Author's own commutation from compiled time series data.

Note : Figures in parenthesis are standard error of Coefficient

*, ** Significant at 1 and 5% levels of significance, respectively

Instability : Instability index was calculated by using of Cuddy-Della Valle index (Cuddy and Della, 1978).

$$\text{Instability index} = CV * \sqrt{1 - R^2}$$

$$C.V. = \frac{\text{Standard Deviation}}{\text{Arithmetic Mean}} \quad 100$$

R^2 = ESS/TSS i.e. ratio of explained variation to total variation.

Where,

CV = Coefficient of Variation

R^2 = Coefficient of Determination

ESS = Variation explained by explanatory variable.

TSS = Total Variation.

The ranges of instability are as follows (Sihmar 2014):

Low instability = Between 0 to 15

Median instability = Greater than 15 and lower than 30

High instability = Greater than 30

Causes of Instability

(i) Causes of Instability in Area : The relative change in the area target from one year to the next, thus depends solely on the area of its competitive crops. In order to examine the causes of instability in the area of pulse crops, following model was used.

$$\text{Log} A_t = B_0 + B_1 \text{Log} A_{t-1} + B_2 \text{Log} C_t + B_3 \text{Log} C_{t-1} + B_4 \text{Log} S_t + B_5 \text{Log} S_{t-1}$$

Where;

A_t = Pulse crops area in period t

Where,

B_0 = Constant

$A_{(t-1)}$ = Lagged area of Main Crop

C_t = Area of Competitive Crop

$C_{(t-1)}$ = Lagged area of Competitive Crop

S = Seasonal Rainfall

$S_{(t-1)}$ = Lagged Seasonal rainfall

Note : Competitive crop of gram was wheat while of black gram green, gram and pigeon pea was paddy in Karnataka

Causes of Instability in Yield : The following model was used to estimate the impact of seasonal rainfall changes on pulse crops yield variability.

$$\text{Log } Y_t = B_0 + C_1.T + C_2. \text{Log } S$$

Where,

Y_t = Pulse crops yield in period t

Where,

B_0 = Constant

C_1 and C_2 = Regression coefficient

S = Seasonal Rainfall

Results and Discussion

Instability : The instability in area, production and productivity of selected major pulse crops i.e. gram, black gram, green gram and pigeon pea for the study period from 1988-89 to 2017-18 were calculated. The result of

instability for selected pulse crops of Karnataka were presented in the table-1 to 3.

Instability analysis of major pulse crops in Karnataka

Gram : The instability in area, production and productivity of gram in Karnataka are presented in the Table-1 and figure-1. It was revealed from the table that among area, production and productivity of gram, the maximum variability was found in production at 32.70 per cent followed by area (31.83 per cent) and productivity (15.65 per cent) in the state. Similar findings were also presented by Kathale *et al.* (2015) in Nagpur division of Maharashtra.

Black gram : The variability in area, production and productivity of black gram in Karnataka are presented in the Table-1 and figure-1. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in production of black gram was found highest at the rate of 48.82 per cent followed by productivity (44.84%) and area (13.93%) in the state. Similar findings were also presented by Bairwa *et al.* (2020) in area, production and productivity of black gram crop in Rajasthan.

Green gram : The instability in area, production and productivity of green gram are depicted in Table-1 and figure-1. It was observed from the table that highest CDVI index of green gram was recorded in production (54.10%) followed by productivity (37.48%) and area (26.67%) in the state. Similar findings were also presented by Netharvadi and Yeledhalli (2016) in area, production and productivity of sesame crop in Bengaluru Division.

Pigeon pea : The results of instability in area, production and productivity of pigeon pea are shown in Table-1 and figure-1. It was revealed from the table that during entire study period (1988-89 to 2017-18), the instability in production of pigeon pea was found highest at the rate of 35.34 per cent followed by productivity (23.68%) and area (15.66%) in the state.. Similar findings were also presented by Netharvadi and Yeledhalli (2016) in area, production and productivity of tur crops in Bengaluru Division.

Causes of instability in acreage of selected pulse crops in Karnataka

Gram : The output of causes of instability in gram area is presented in Table 2. It was revealed from the findings that lagged area of gram (A_{t-1}) was found to be 0.925, lagged acreage of competitive crop (C_{t-1}) wheat was found to be -1.148, rainfall was found to be -0.234 and lagged rainfall was found to be 0.139, variables were together explained 72.1 per cent of variability in gram area in Karnataka. The coefficient of all variables namely rainfall, lagged area of gram and lagged area of competing crop were statistically non-significant. Though, lagged rainfall was statistically significant and positive. Similar findings

were also presented by Tuteja *et al.* (2006) of gram crops in India

Black gram : The output of causes of instability in black gram area is presented in Table 2. It was revealed from the findings that lagged area of black gram (A_{t-1}) was found to be 0.603, lagged acreage of competitive crop (C_{t-1}) paddy was found to be 0.708, rainfall was found to be -0.174 and lagged rainfall was found to be -0.157, variables were together explained 46.1 per cent of variability in black gram area in Karnataka. The coefficient of all variables namely rainfall, lagged rainfall and lagged area of competitive crop (C_{t-1}) were statistically non-significant. Though, and lagged area of black gram were statistically significant but positive. Similar findings were also presented by Tuteja *et al.* (2006) of urad crops in India.

Green gram : There two independent variables namely A_{t-1} and C_t showed higher correlation indicating presence of multicollinearity. Therefore, only one of these two variables i.e. A_{t-1} , which reported highly correlation with dependent variable was retained in the fitted model. The output of causes of instability in green gram area is presented in Table 2. It was revealed from the findings that lagged area of green gram (A_{t-1}) was found to be 0.270, lagged acreage of competitive crop (C_{t-1}) paddy was found to be -2.434, rainfall was found to be -0.448 and lagged rainfall was found to be -1.262 variables were accounted as high as 44.1 per cent of variability in green gram area in Karnataka. The coefficient of lagged area of green gram (A_{t-1}) was positive and statistically non-significant. Though lagged area of competing crop, rainfall and lagged rainfall were also non-significant but negative. Similar findings were also presented by Gajja *et al.* (2008) of Sesame crops in Rajasthan

Pigeon pea : The output of causes of instability in pigeon pea area is presented in Table 2. It was revealed from the findings that lagged area of pigeon pea (A_{t-1}) was found to be 0.910, lagged acreage of competitive crop (C_{t-1}) paddy was found to be -0.897, rainfall was found to be 0.211 and lagged rainfall was found to be -0.571, variables were together explained 65.8 per cent of variability in pigeon pea area in Karnataka. The coefficient of all variables namely lagged area of competing crop C_{t-1}) were negative and statistically non-significant while lagged rainfall was negative and statistically significant. Though, area of pigeon pea crop (A_{t-1}) and rainfall was non-significant but positive. Similar findings were also presented by Tuteja *et al.* (2006) of Arhar crops in India.

Causes of instability in productivity of selected pulse crops in Karnataka

Gram : The results of factors responsible for instability in productivity of gram are presented in Table-3. It was revealed from the table that rainfall and time trend

variables together explained 50.7 per cent of instability in productivity of gram. The coefficient of seasonal rainfall and time trend were 0.022 and 0.009 respectively, showing positive and non significant. The productivity of black gram was augmented due to increase in seasonal rainfall over the year in Karnataka.

Black gram : The results of factors responsible for instability in productivity of black gram are presented in Table-3. It was revealed from the table that rainfall and time trend variables together explained 10 per cent of instability in productivity of black gram. The coefficient of seasonal rainfall and time trend were -0.001 and -0.002 respectively, showing negative and statistically non significant. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall gram in Karnataka.

Green gram : The results of factors responsible for instability in productivity of pigeon pea are presented in Table-3. It was revealed from the table that rainfall and time trend variables together explained 17.9 per cent of instability in productivity of pigeon pea. The coefficient of seasonal rainfall was -0.076 showing negative and significant. Subsequently, the impact of time trend was -0.010, which was also negative but significant on the productivity of green gram in Karnataka. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall in Karnataka.

Pigeon pea : The results of factors responsible for instability in productivity of pigeon pea are presented in Table-3. It was revealed from the table that rainfall and time trend variables together explained 43.2 per cent of instability in productivity of pigeon pea. The coefficient of seasonal rainfall was -0.056 showing negative and non significant. Subsequently, the impact of time trend was 0.011, which was also positive but significant on the productivity of pigeon pea in Karnataka. The excess rainfall in cropped season recorded negative impact on the productivity; it might be due to heavy rainfall in Karnataka.

Conclusions

The study revealed that production of selected crops were highly instable in Karnataka. In case of area, gram was highly instable and black gram was less instable while green gram and pigeon pea were medium instable. In the mean time, productivity of gram and pigeon pea were medium instable while productivity of black gram and green gram were highly instable. Green gram growers in Karnataka showed contrary response to lagged area under its competing crop i.e. the decrease in area of competing crop in last year season, thereby that was tendency to increase the area under green gram in Karnataka. while quite responsive to lagged area under

gram, black gram and pigeon pea crop in Karnataka. It means the increase in area of gram, black gram and pigeon pea crops in last year season, there is tendency to increase the area under gram, black gram and pigeon pea in Karnataka. The time trend factor showed positive influence on productivity of gram and pigeon pea crops while negative influence on productivity of black gram and green gram crops in Karnataka. Further, seasonal rainfall was recorded positive impact on gram crop while negative influence on productivity of black gram green gram and pigeon pea crops in Karnataka.

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Effect of Legitimate Outcome and Fungicides for Powdery Mildew of Ber (*Oidium erysiphoides* f. sp. *Ziziphi*.)

Meera Choudhary* and R.P. Ghasolia

Department of Plant Pathology, S.K.N. College of Agriculture (SKNAU), Jobner-303329, Jaipur, Rajasthan

*Corresponding Author Email : meera.ranwa@gmail.com

Abstract

Indian jujube or ber (*Ziziphus mauritiana* Lamk.) is one of the most common fruit in Rajasthan, indigenous to an area joined from India to China. Powdery mildew of ber incited by *Oidium erysiphoides* f. sp. *Ziziphi*, Yan and Wang is the most important disease that causes maximum reduction in yield and quality of ber fruits. Exclusive reliance on fungicides for the control of disease in various crops resulted in residue and environmental hazards. Therefore, in recent years, efforts are being diverted to employ higher plants, natural products and their derivatives as a tool for integrated disease management because they do not cause bio-accumulation, bio-magnification and environmental pollution. In present investigation six natural products (buffalo milk, cow milk, garlic extract, neem oil, mustard oil, butter milk/chhach) were evaluated for their efficacy against powdery mildew of ber. The jujube or ber is an ancient fruit of India and China. It was one of the prominent fruits on which the sages in ancient India lived during the Vedic age and lived even today. Ber is a hardy crop which grown in arid conditions of Rajasthan, characterized by sandy soils, scanty rainfall (400-600mm), thermal oscillations (5-35 °C) and low relative humidity. Therefore, the area of cultivation is increasing in this zone (arid and semi arid) and is expected that in near future ber will be a leading fruit crop of arid zone. The cultivation of ber required the least input and care. In natural products maximum intensity over control was observed with garlic extract followed by neem oil, mustard oil, cow milk, buffalo milk and least effective was butter milk. Among the five systemic and non systemic fungicides (difenoconazole, dinocap, hexaconazole, tridemorph and wettable sulphur) tested against powdery mildew of ber, the maximum reduction in disease intensity over control was observed in dinocap (0.1%) with lowest per cent disease intensity (9.60) followed by hexaconazole, wettable sulphur, tridemorph and least effective was difenoconazole.

Key words : Ber, *Ziziphus mauritiana*, powdery mildew, natural products and fungicides,

Introduction

Indian jujube or ber (*Ziziphus mauritiana* Lamk.) is one of the most common fruit, indigenous to an area joined from India to China. The genus *Ziziphus* has been derived from 'Zizaif' which is the Arabic name of the fruit (Bailey, 1947). The ber belongs to the family *Rhamnaceae* which has about 50 genera and more than 600 species (Pareek, 1983). In India, ber is being cultivated on an area of about 4,845 hectares with production of 66,296 metric tonnes and productivity of 13.68 metric tonnes (Anonymous, 2014). Ber is a hardy crop which grown in arid conditions of Rajasthan, characterized by sandy soils, scanty rainfall (400-600mm), thermal oscillations (5-35 °C) and low relative humidity. Powdery mildew of ber incited by *Oidium erysiphoides* f. sp. *ziziphi*, Yan and Wang is the most important disease that causes maximum reduction in yield and quality of ber fruits (*Ziziphus mauritiana* Lamk.). Due to powdery mildew recorded per cent disease index 17-71 at fruiting stage of ber (*Oidium* sp.) in Bijapur, India (Jamadar *et al.*, 2009). Ber is attacked by many of the diseases caused by fungi and other pathogenic agents. Among these, powdery mildew is one of the most important, wide spread and easily recognized diseases. Among these, powdery mildew caused by

Oidium erysiphoides f. sp. *ziziphi*, Yan and Wang (*Microsphaera alphitoides* f. sp. *ziziphi* Griffon and Maublanc) is a major disease of jujube in India (Jamadar *et al.* 2009). Due to powdery mildew (*Oidium* sp.) per cent disease index recorded 17-71 at fruiting stage of ber in Bijapur, India (Jamadar and Desai, 1996).

Materials and Methods

Disease Control through natural products : In lieu of organic produce for the consumers, the following natural products were used to test their efficacy against powdery mildew of ber on ten years old susceptible variety Gola. The concentration of natural products was decided as per available information in literature.

Neem oil, mustard oil, cow milk, buffalo milk and butter milk (Chhach) were applied as per required concentration while garlic extract was prepared as follows.

Hundred gram garlic cloves were taken with 100 ml of water and then grinded in juicer mixer grinder and filtered through double layered muslin cloth. This was considered as 100 per cent concentration and sprayed (10 %) on ber trees (Sindhan *et al.*, 1999).

The experiment was conducted at Asalpur Farm,

Jobner in RBD with four replications. Two sprays of each natural product was applied, first spray at the time of disease initiation and second at fifteen days interval. Observation for disease intensity was recorded at fifteen days after second spray (as per 3.2). Per cent disease control over check was calculated as follows.

Per cent disease control =

$$\frac{\begin{array}{l} \text{\% disease intensity in control} \\ - \text{\% disease intensity in treatment} \end{array}}{\text{\% disease intensity in control}} \times 100$$

Disease control through fungicides : The following five systemic and non systemic fungicides were evaluated by applying as foliar spray in RBD with four replications on ten year old susceptible variety Gola. Two sprays of each fungicide were applied, first spray at the time of disease initiation and next at fifteen days interval. Observation and calculation of per cent disease intensity and per cent disease control were as per followings.

Common Name of fungicide	Trade Name	Dose (%)
Wettable sulphur	Sulfex 80% WP	0.2
Dinocap	Karathane 48% EC	0.1
Tridemorph	Calixin 80% EC	0.1
Hexaconazole	Contaf 5% EC	0.1
Difenoconazole	Score 25% EC	0.1

Results and Discussion

Disease control through natural products : It is evident from the Table-1 and 2 that out of six natural products (buffalo milk, cow milk, butter milk, garlic extract, mustard oil and neem oil) the maximum reduction in disease intensity was observed with garlic extract (44.69%) followed by neem oil (39.94%), mustard oil (29.89), cow milk (18.43%) and buffalo milk (16.45%) and butter milk (9.33%) was found least effective in reducing disease intensity over check. However buffalo milk and cow milk were found at par with each other. Bettiol et al. (2008) have also been tested effectiveness of whey against powdery mildew (*Podosphaera xanthii*) of cucumber and zucchini squash in greenhouse. Plants were sprayed once or twice a week with whey at concentrations of 5, 10, 15, 20, 25, and 30 per cent in water. Disease progress was more slowly in plants treated with 25-30 per cent whey than lower concentration was used. Surwase et al. (2009) also reported that NSKE was found most effective and economic against *Erysiphe polygoni* causing pea powdery mildew and gave better seed yield.

Disease control through fungicides : Out of five (difenoconazole, dinocap, hexaconazole, tridemorph and wettable sulphur) systemic and non-systemic fungicides tested (Table-1), the maximum reduction in disease intensity was observed with dinocap (73.18%) followed by

Table-1 : Efficacy of natural products against powdery mildew (*Oidium erysipoides* f. sp. ziziphi) of ber.

Natural products	Concentration (%)	Per cent disease intensity*	Per cent disease control
Buffalo milk	10	29.91 (33.21)	16.45
Cow milk	10	29.2 (32.58)	18.43
Garlic extract	10	19.8 (26.57)	44.69
Neem oil	0.5	21.5 (27.97)	39.94
Mustard oil	0.5	25.1 (30.00)	29.89
Butter milk (Chhach)	10	32.46 (34.45)	9.33
Check	-	35.8	-
(Without any spray)	-	(36.87)	-
SEm +	-	0.28	-
CD (p =0.05)	-	0.85	-

*Average of four replications

Figures given in parentheses are angular transformed values

Table-2 : Efficacy of fungicides against powdery mildew (*Oidium erysipoides* f. sp. ziziphi) of ber.

Fungicides	Concentration (%)	Per cent disease intensity*	Per cent disease control
Difenoconazole	0.1	16.26 (23.58)	54.58
Dinocap	0.1	9.6 (17.95)	73.18
Hexaconazole	0.1	12.15 (20.27)	66.06
Tridemorph	0.1	14.8 (22.79)	58.67
Wettable sulphur	0.25	14.4 (22.38)	59.78
Check	-	35.8	-
(Without any spray)	-	(36.87)	-
SEm +	-	0.45	-
CD (p = 0.05%)	-	1.40	-

*Average of four replications

Figures given in parentheses are angular transformed values

hexaconazole (66.06%), wettable sulphur (59.78%) and tridemorph (58.67%) and difenoconazole (54.58%) was found least effective in reducing disease intensity over check. However wettable sulphur and tridemorph were found at par with each other in controlling each other. The results are in agreement with several workers (Das, 1994, Reddy et al., 1996, Dang et al., 1997, Jamadar and Desai, 1998 and Jamadar et al., 2009) who reported dinocap as most effective in reducing powdery mildew. Similar result have also been observed excellent with dinocap in controlling powdery mildew of ber (Gupta et al. 1977). It

have also been obtained good control of ber powdery mildew with various fungicides including dinocap and sulfex (Das *et al.* 1994, Desai 1998 and Thind and Kaur 2006).

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Assessment of Metabolic Premise of Resistance in Ber for Powdery Mildew

Meera Choudhary* and R.P. Ghasolia

Department of Plant Pathology, S.K.N. College of Agriculture (SKNAU), Jobner-303329, Jaipur, Rajasthan

*Corresponding Author Email : meera.ranwa@gmail.com

Abstract

Indian jujube or ber (*Ziziphus mauritiana* Lamk.) is one of the most common fruit in Rajasthan as well as India. Powdery mildew of ber incited by *Oidium erysiphoides* f. sp. *ziziphi*, Yan and Wang is the most important disease that causes maximum reduction in yield and quality of ber fruits. Young and small sized fruits are more prone to attack in comparison to large sized. In view of this, some biochemical were evaluated to see their impact on disease development. In healthy fruits, the level of total soluble solids (TSS) and ascorbic acid were increased that played a very important role in disease control. In case of diseased fruits, decrease in TSS was recorded maximum at peanut stage (27.79 - 41.30%) then immature stage (5.65 - 13.52%) over healthy fruits whereas ascorbic acid from 14.34 - 30.37% and 7.06 - 12.91%, respectively. Increase in total phenols was higher in diseased fruits at peanut stage (28.81 - 51.65%) then immature stage (17.39 - 43.90%) over healthy fruits. Similar trend in these metabolics were also observed at tender and maturing stages of leaves. Metabolic changes in total soluble solids, ascorbic acid and total phenol content were played a very important role in imparting resistance against this disease.

Key words : Ber, *Ziziphus mauritiana*, powdery mildew, total soluble solids, total phenol, ascorbic acid.

Introduction

Indian jujube or ber (*Ziziphus mauritiana* Lamk.) is one of the most common fruit, indigenous to an area joined from India to China. The genus *Ziziphus* has been derived from 'Zizaif' which is the Arabic name of the fruit [1]. The ber belongs to the family *Rhamnaceae* which has about 50 genera and more than 600 species [2]. In India, ber is being cultivated on an area of about 4,845 hectares with production of 66,296 metric tonnes and productivity of 13.68 metric tonnes [3]. Ber is hardy crop which grown in arid conditions of Rajasthan, characterized by sandy soils, scanty rainfall (400-600mm), thermal oscillations (5-35 °C) and low relative humidity. Powdery mildew incited by *Oidium erysiphoides* f. sp. *ziziphi*, Yan and Wang is the most important disease that causes maximum reduction in yield and quality of ber (*Ziziphus mauritiana* Lamk.). In India, the intensity of powdery mildew disease has been recorded from 17 to 71 per cent at fruiting stage of ber (*Oidium* sp.) in Bijapur [4].

Materials and Methods

The content of total soluble solids (TSS), ascorbic acid and total phenols were estimated in fruits and leaves (except ascorbic acid in leaves) of healthy and infected fruits and leaves of moderately susceptible (Kaithali and Mehroon) and susceptible (Gola and Thornless) varieties of ber at peanut and immature stages of fruits and tender and maturing stages of leaves of ber.

Estimation of ascorbic acid : Ascorbic acid (vitamin C) content in fresh ber fruits was determined by diluting the known weight of pulp with 3 per cent metaphosphoric acid

to appropriate volume and titrating it with 2, 6-dichlorophenol indophenols dye solution after standardization till the faint pink colour was obtained. The average values were expressed as mg ascorbic acid per 100 g fresh fruit pulp [5].

Estimation of TSS : Fresh fruits and leaves from selected ber varieties were taken and macerated separately for juice extraction and total soluble solids (TSS) of the extract was determined by using a hand refractometer of 0-32 per cent range. In this case, one drop of fruit pulp and leaf juice was put separately on the prism of the refractometer and per cent TSS was recorded directly. The values were corrected at 20 °C and expressed as per cent total soluble solids of the fruits and leaves juice [5].

Estimation of total phenol : The content of total phenol present in the fruits and leaves was estimated as per standard protocol [6]. According to this, weighed 0.5g of fresh leaves without midrib and fresh fruit pulp (0.5 g) and ground these separately with mortar and pestle in 10 ml of 80 per cent ethanol. Thus, homogenate or extract obtained was centrifuged at 8000 rpm for 10 minutes. Extraction was repeated four times with 5 ml of 80 per cent ethanol each time and supernatants were collected into same beaker. Volume of the extract was made to 50 ml with 80 per cent ethanol. One ml of supernatant was taken and evaporated to dryness in water bath. One ml of millipore water in each test tube and 0.5 ml of Folin and Ciocalteu reagent (1:1 with water) was added and kept for three min. After this, 2 ml of 20 per cent Na₂CO₃ was added and mixed thoroughly. The tubes were placed in boiling water for exactly one minute and cooled in ice

Table-1 : Biochemical changes in healthy and infected (*Oidium erysipoides* f. sp. ziziphi) fruits of different varieties of ber at peanut and immature stages.

Cultivars	Disease Reaction	Stages	Category	TSS (%)*	% decrease in TSS over healthy	Ascorbic acid (mg/ 100 g)*	% decrease in ascorbic acid over healthy	Total Phenol (mg/g)*	% Increase in phenol over healthy
Kaithali	MS	Peanut	H	7.03		45.73		0.086	-
			D	4.30	38.83	39.16	14.34	0.126	46.51
		Immature	H	15.53		58.86		0.074	-
			D	13.43	13.52	54.31	7.73	0.101	36.49
Mehroon	MS	Peanut	H	9.03		40.97		0.091	-
			D	5.30	41.30	32.17	21.47	0.138	51.65
		Immature	H	15.40		66.14		0.082	-
			D	13.43	12.79	61.47	7.06	0.118	43.90
Gola	S	Peanut	H	11.86		41.00		0.062	-
			D	8.26	30.35	32.16	21.56	0.081	30.64
		Immature	H	15.93		56.14		0.047	-
			D	15.03	5.65	50.37	10.28	0.058	23.40
Thornless	S	Peanut	H	10.90		40.07		0.059	-
			D	7.87	27.79	27.90	30.37	0.076	28.81
		Immature	H	18.16		70.47		0.046	-
			D	15.50	14.65	61.37	12.91	0.054	17.39
SEm +			0.79	3.18		0.005	-		
CD (p = 0.05)			2.44	9.80		0.015	-		

*Average of three replications, TSS = Total soluble solids, H = Healthy, D = Diseased, Peanut stage = 45-50 days after fruit setting, Immature stage = 65-70 days after fruit setting, MS = Moderately susceptible, S = Susceptible

Table-2 : Biochemical changes in healthy and infected (*Oidium erysipoides* f. sp. ziziphi) leaves of different varieties of ber at tender and maturing stages.

Cultivars	Disease reaction	Stages	Category	TSS (%)*	% decrease in TSS over healthy	Total Phenol (mg/g)*	% Increase in phenol over healthy
Kaithali	MS	TL	H	3.27		0.882	
			D	2.57	21.41	0.981	11.22
		ML	H	4.74		0.767	
			D	3.83	19.19	0.828	7.95
Mehroon	MS	TL	H	4.23		0.662	
			D	2.76	34.75	0.748	12.99
		ML	H	5.47		0.430	
			D	4.31	21.21	0.469	9.07
Gola	S	TL	H	3.82		0.705	
			D	2.23	41.62	0.765	8.5
		ML	H	5.63		0.413	
			D	4.46	20.78	0.433	4.84
Thornless	S	TL	H	3.97		0.691	
			D	2.31	41.81	0.744	7.67
		ML	H	5.63		0.546	
			D	4.43	21.31	0.574	5.13
SEm +			0.26	-	0.042	-	
CD (p = 0.05)			0.80	-	0.121	-	

*Average of three replications, TSS = Total soluble solids, TL = Tender leaves, ML = Maturing leaves, MS = Moderately susceptible, S = Susceptible, H = Healthy, D = Diseased

water. The absorbance was read at 650 nm against a reagent blank.

Results and Discussion

Changes in the content of total soluble solids (TSS), ascorbic acid and total phenols were estimated in fruits and leaves of healthy and infected fruits and leaves of Kaithali, Mehroon, Gola and Thornless varieties of ber at peanut and immature stages and tender and maturing stages of leaves of ber.

TSS : It is evident from the data (Table-1) that with the advancement of fruit development stages of ber, the level of TSS was increased in healthy fruits of Kaithali, Mehroon, Gola and Thornless from peanut stage (7.03%, 9.03%, 11.86% and 10.90%, respectively) to immature stage (15.53%, 15.40%, 15.93% and 18.16%, respectively). It played an important role in reducing disease intensity at advanced stages of fruits. Our results are in the agreement with findings of earlier worker [7]. They observed increased level of TSS and ascorbic acid in healthy fruits of resistant and susceptible genotype of ber at unripe and ripe stages. After infection by *Oidium erysiphoides* f. sp. *Ziziphi* at peanut nad immature stages of ber fruits, reduction in quantity of TSS and ascorbic acid (vitamin-C) were recorded that qualitatively deteriorates the nutritive value and quality of ber fruits. Decrease in total soluble solids was recorded maximum in diseased fruits at peanut stage (27.79 to 41.30%) as compared to immature stage (5.65 to 13.52%) over healthy fruits whereas ascorbic acid from 14.34 to 30.37% and 7.06 to 12.91%, respectively in all the varieties under test.

Ascorbic acid : It is evident from the data (Table-1) that with the advancement of fruit development stages of ber, the level of ascorbic acid was also increased in healthy fruits of Kaithali, Mehroon, Gola and Thornless from peanut stage (45.73 mg/g, 40.97 mg/g, 41.00 mg/g and 40.07 mg/g, respectively) to immature stage (58.86 mg/g, 66.14 mg/g, 56.14 mg/g and 70.47 mg/g, respectively). Due to increased acidity, large sized fruits at advance stages might have lower chances of infection by the powdery mildew pathogen. These results are supported by the findings of earlier scientists [8, 9]. The Vitamin-C content of many fruits such as sour orange, cashew apple, mango, pineapple, orange and guava is higher when they are slightly immature and decline as they hits peak ripeness [10]. After infection by *Oidium erysiphoides* f. sp. *ziziphi*, the level of ascorbic acid (Table-1) was decreased with an advancement of fruit development stages of Thornless susceptible variety (30.37 %) followed by Gola (21.56 %) at peanut stage and 12.91 per cent and 10.28 per cent at immature stage, respectively while in case of moderately susceptible varieties (Mehroon and Kaithali), the ascorbic acid level was also reduced at peanut (21.47% and 14.34 %) and at immature stage (7.06% &

7.73%, respectively). Due to this increased acidity, large sized fruits might not be infected by the powdery mildew pathogen. These results are supported by the findings of earlier researchers [8, 9]. The Vitamin-C content of many fruits such as sour orange, cashew apple, mango, pineapple, orange and guava is higher when they are slightly immature and decline as they hits peak ripeness [10].

Total phenol : The total phenol was higher in healthy fruits (Table-1) of moderately susceptible varieties i.e. Kaithali and Mehroon (0.086 and 0.091 mg/g, respectively) of ber at peanut stage while at immature stage it was 0.074 mg/g and 0.082 mg/g, respectively whereas the level of total phenol was lower in healthy fruits of susceptible varieties i.e. Gola & Thornless of ber at peanut and immature stages (0.062–0.047 mg/g and 0.059–0.046 mg/g, respectively). Total phenol was also estimated at tender and maturing stages of both healthy and infected leaves of ber (Table-2). Similar trend in level of total phenol was observed in healthy and infected leaves of ber at tender and maturing stage of leaves. In the present investigation, the concentration of total phenol was slightly higher at peanut stage where as immature stage it was decreased. However, after infection the phenol content was significantly increased in leaves and fruits of ber as compared to healthy ones. It is also observed that per cent increase in phenol content was maximum (36.49 to 51.65%) in moderately susceptible varieties (Kaithali and Mehroon) than susceptible ones (Gola, 23.40 – 30.64% and Thornless, 17.39 – 28.81%). Our results are parallel to the findings of earlier workers [11, 12]. They recorded concentration of phenol content at increased level among phenolic substances in different host-pathogen system after infection. Rapid increase in phenolic synthesis due to infection has been correlated with disease resistance in many host-pathogen interactions [13]. Powdery mildew colonized (*Oidium erysiphoides* f. sp. *ziziphi*) immature and mature fruits and tender, maturing and old leaves of ber accumulated significantly more phenol, which may be attributed to the defense mechanisms [14].

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Extent of Utilization of Irrigation Water in Paddy Crop by the Paddy Growers of Mahi Command Area of Anand District in Gujarat

Raju Singh Jakhar^{1,2*}, A.S. Saiyad¹, Foumy N. Rafeeq² and Ramesh Chand Choudhary²

¹Department of Extension Education, B.A. College of Agriculture, AAU, Anand, Gujarat-388110

²Department of Agriculture, Vivekananda Global University, Jaipur, Rajasthan-303012

*Corresponding Author Email : raju.jakhar2@gmail.com

Abstract

Agriculture, being country's biggest private industry, has always been and will remain to be the Indian economy's backbone for the years ahead. It contributes almost 22% of the country's gross domestic product (GDP). Agriculture provides roughly 250 thousand crore rupees yearly to the food industry alone. Approximately three percent of total available water goes to irrigation, with the majority going to public supply, therefore even if the irrigation potential is fully utilised, more than half of the country's agricultural land will continue unirrigated. Command Area Development is directed to maximum utilization of the resources of land and water both are limited in our country. The goal of Command Area Development is to make the most of both land and water resources. This needs a multi-disciplinary strategy that includes water management, engineering, and agricultural management. In central Gujarat, Anand district accounts for around 52.00 percent of total land and 49.00 percent of total paddy output. The district of Anand was selected for this research. The talukas of Anand and Umreth in the Anand district were purposefully chosen as they had greater canal irrigation water area than other talukas. From the two talukas, eight paddy-growing villages were chosen at random. For this investigation, 120 rice producers with at least three years of experience in paddy farming were chosen at random and examined the restrictions they encountered, as well as providing appropriate recommendations based on the farmers' input thereby, a detailed investigation about the extent of utilization of irrigation water in paddy crop by the paddy growers of Mahi command area of Anand district were collected, tabulated and analyzed with the suitable statistical tools and drawn the conclusion.

Key words : *Irrigation water, paddy, farmer, water resource.*

Introduction

Agriculture, being India's largest private industry, has been and will continue to be the Indian economy's backbone for the conceivable future. It accounts for about 22% of national G.D.P. Agriculture provides roughly 250 thousand crore rupees yearly to the food industry alone. About 234 million people are directly employed as a result of this. India has 16 percent of the world's human population and 30% of the world's livestock, yet it only has 4% of the world's water resources. Only 3% of total available water goes to irrigation, with the rest going to public supply, therefore even with maximum irrigation capacity, more over half of the country's cultivated land is irrigated [1].

Irrigation management in India is fundamentally different from that in industrialised nations where water scarcity is not an issue. Irrigation system management, efficiency, and well-executed maintenance are critical to the viability and sustainability of irrigated agriculture [2]. They lead to improved performance, higher crop yields, and longer-term production. One of the main goals of irrigation system management is to deliver agreed-upon service levels to the necessary government bodies and consumers at the lowest possible cost. Immediately after

independence, India's irrigation development accelerated. In 1950-51, the net irrigated area was 20.85 million ha, with 1.71 million ha irrigated throughout several farming season. A total of 22.6 million hectares were irrigated [3].

The goal today is to reach the full irrigation potential of 113.5 million hectares by 2010 from any and all water sources. Around 58.5 million will be allocated to big and medium-sized projects, while 55 million will be allocated to smaller initiatives. This entails the addition of 1.7 million hectares to the main irrigation projects each year [4]. The canal system transports water from its place of origin to one or more downstream diversion locations. The pace and manner in which a canal rebounds to a flow regime following a flow change are determined by the pool operating technique [5].

The goal of Command Area Development is to make the best use of our country's limited land and water resources. This necessitates a multi-disciplinary strategy that includes water management, engineering, and agricultural management. The goal is to limit water loss via leakage, put as much land as possible under irrigation, and use agronomic approaches that increase cropping intensity and yield per unit of water and land.

In agriculture, an efficient water resource utilisation management approach is maximising the use of freshwater resources for agricultural output. For effective and economic use of water resources with optimum return, strive for timely and appropriate irrigation with minimal losses and little or no lingering adverse impacts on the soil. Promotion of the use of water-saving techniques would assist to maintain irrigated agriculture in areas where water resources are dwindling, as well as reduce ecological harm to overburdened rivers and streams that aid in the management of rising water levels [6]. Farmers in Mahi command area are wasting a lot of irrigation water; therefore, this research was commissioned to look into the extent of utilization of irrigation water in paddy crop by the paddy growers of Mahi Command Area of Anand District.

Research Methodology

The district of Anand was selected for this research. The talukas of Anand and Umreth in the Anand district were purposefully chosen because they had greater canal irrigation water area than other talukas. From the two talukas, eight paddy-growing villages were arbitrarily chosen. A total of 120 rice producers with at least three years of experience in paddy farming were chosen at random for this study. A total of 120 paddy producers were used as a sample and respondents. A scale created by [7] was utilised with slight changes to determine the various features of rice producers. Teacher-made tests were used to assess knowledge of how to use canal irrigation water in rice crops. The level to which respondents used canal irrigation water in paddy crops was measured using a scale devised by [8] with minor modifications. The data was obtained using a well-structured, pre-tested Gujarati version interview that was planned by personal contact, and the data was assembled, tabulated, and evaluated to obtain appropriate responses for the study's objectives. The respondents' restrictions were measured using a simple ranking approach. Percentage, mean score, standard deviation, and coefficient of correlation value were the statistical tools employed.

Results and Discussion

Keeping in view of the objectives of the study, information was collected from the respondents, classified, tabulated, analyzed and presented. Utilization of canal irrigation water is a decision to continue the use of canal irrigation in their paddy crop. In this study it means acceptance of full use of canal irrigation water by paddy growers in their paddy field very effectively. It is rigidly stated that utilization of canal irrigation water for making paddy farming a better and more profitable enterprise. In this context it is also stressed that taking scientific knowledge

regarding irrigation management practices to the door of sixty million farm families in India is possible only through intensive training of farmers, regarding specialized technique of irrigation management are given in Table-1.

Table-1 : Distribution of respondents according to their overall utilization of canal irrigation water for paddy crop.
n=120

Sr. No.	Level of utilization	Number	Percent
1.	Low utilization (below 11.60 score)	14	11.67
2.	Medium utilization (Between 11.60 to 16.46 score)	83	69.16
3.	High utilization (above 16.46 score)	23	19.17
Total		120	100.00

Mean = 14.03

S.D. = 2.43

It is clear from table-1 that majority of the respondents (69.16 per cent) had found with medium utilization of canal irrigation water in paddy crop, followed by 19.17 per cent and 11.67 per cent of the respondents with high and low utilization of canal irrigation water in paddy crop, respectively.

Conclusions

Central Gujarat accounts for 52.25 percent of the state's total land area and 53.12 percent of paddy productivity. Anand district accounts for around 52.00 percent of total area and 49.00 percent of total paddy output in central Gujarat. Only 3% of overall groundwater sources are used for irrigation, with the majority going to different supply, therefore even if the whole irrigation potential is used, more than half of the country's agricultural land will stay unirrigated. Advancement of the use of water-saving techniques would assist to maintain irrigated agriculture in areas where water resources are dwindling, as well as reduce ecological harm to overburdened rivers and streams that aid in the management of rising water tables.

Most of paddy producers (69.16%) used canal irrigation for rice crop in a medium way, whereas 19.17 percent and 11.67 percent of paddy growers used canal irrigation water for paddy crop in high and low ways, respectively.

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An Economic Analysis of Environmental and Total Costs of Kinnow Crop

Ajit Singh^{1*}, S.S. Jheeba², Soumitra S. Das³ and Ingle Dipak Shyamrao¹

¹Department of Agricultural Economics, Birsa Agricultural University, Jharkhand

²Department of Agricultural Economics, Sri Karan Narendra Agriculture University, Jobner, Rajasthan

*Corresponding Author Email : ajitsingh15789@gmail.com

Abstract

The total cost was calculated to be Rs. 1110000.52 ha⁻¹, of which variable cost accounted for Rs. 485970.32 ha⁻¹ (43.84 per cent of total cost) and fixed cost accounted for Rs. 624030.20 ha⁻¹ (55.16 per cent of total cost). The sum of the stream of cost has been estimated to be Rs. 1110000.52 ha⁻¹ whereas sum for the stream of gross returns was estimated to be Rs. 2745502 ha⁻¹. Similarly the sum of the stream of net returns and production were estimated to be Rs 1635501.48 ha⁻¹ and 299576 kg ha⁻¹, respectively.

Introduction

The state of Rajasthan is considered to be the potential area for fruit growing. The fruits like mango, banana, orange, dateplam, ber, grape and guava are grown in various regions of the state. The climatic conditions of state are also suitable for cultivation of these fruits. In Rajasthan, kinnow occupies 5.7 thousand hectare under cultivation and Sriganganagar district is well known for its area and production. Sriganganagar district occupied 5.1 thousand hectare of area under kinnow cultivation in the year 2016-17, which was 84.11 per cent of the total area under kinnow in Rajasthan. The production of kinnow in Sriganganagar was 2.30 lac metric tonnes which was 89 per cent of total production in the state (Krishi Pant Bhawan, Jaipur). Thus looking to the importance of kinnow in citrus fruits in general and Sriganganagar district in particular, the present investigation was carried out in Sriganganagar district of Rajasthan.

Studies have shown that excessive use of chemical fertilizers and pesticides has impacted adversely on the soils. For example, according to (Oldeman *et al.*, 1991) globally a total of 239 M ha is affected due to excessive and or imbalanced use of agro-chemicals. Out of such lands, 135 M ha is degraded due to loss of nutrients, 76 M ha is affected by salinity, 22 M ha is affected by chemical pollution and 6 M ha of land is affected by acidity. These estimates give a rough idea about the extent of chemical-related soil degradation worldwide. The adoption of monoculture by the farmers and the use of high yielding varieties in place of traditional varieties in commercialized agriculture have led to a significant loss of genetic diversity. The contribution of monoculture and intensification towards the loss of nutrients, chemical pollution and acidification is, however, not known. here are growing concerns of pesticide risks to human health, natural environment and ecosystems (Atreya *et al.*,

2012). These effects are increasingly manifested in loss of working efficiency of farm workers resulting in higher cost of production. The increased use of pesticides, deteriorating ecosystem health has advocated the need to change traditional and external input use in agriculture towards safe and sustainable production (Bhurtyal *et al.*, 2016). In this context, the present study was aimed at measuring the extent of use of pesticides in commercial vegetable production and its direct impact on health.

Materials and Methods

Selection of study area : Sri Ganganagar district in Rajasthan state was purposively selected for the study because of maximum area and commercial production of selected vegetables (cabbage, cauliflower, tomato and peas). These vegetables are being cultivated since late sixties and early seventies until now in the study area. In the second stage, two blocks namely Ganganagar and Raisingnagar were selected based on highest area and production. From these two blocks, 18 villages were selected using stratified proportional sampling method. Hundred farm households were selected randomly from these 18 villages in proportion to the area under vegetables in each village (Table 1). Cauliflower, cabbage, tomato and peas were cultivated by 50, 42, 37 and 34 farm households respectively among these 100 farm HHs. Interview schedule was developed specifically for the study keeping in view the objectives of the study. Primary data were collected from 2016 to 2019 using personal interview method on vegetable cultivation practices, plant protection techniques and other variables. The primary data were corroborated/ validated through focussed group discussions with key informants in each village and scientists from Krishi Vigyan Kendra and agriculture officers working in Sri Ganganagar district. Published secondary sources were also used.

The cumulative square root frequency method

Table-1 : Sampling plan in Sri Ganganagar district of Rajasthan.

Block	Study villages	Number of respondent households	Number of respondent households cultivating different vegetables			
			Cauliflower	Cabbage	Tomato	Peas
Ganganagar	8a	6	4	0	2	0
	7h	3	1	2	3	2
	8LNP	5	5	2	0	2
	9Y	7	4	3	0	3
	9Z	4	2	4	2	4
	Shankaj Nehar Kotha	6	3	3	2	0
	Dungarsingh Pura	7	3	2	5	2
	Shankaj Nehar Pakki	6	4	3	3	3
Raising Nagar	6TK	8	3	2	0	2
	60NP	5	1	3	3	0
	60RB	3	2	2	1	2
	63NP	5	3	2	3	0
	3BWM	5	2	3	4	3
	3LPM(A)	6	2	2	0	2
	Bhagsar	4	2	2	2	2
	Haripura	6	3	2	3	2
	Lakhmisar	7	4	3	4	3
	Luhara	7	1	2	0	2
	Total	100	50	42	37	34

Table-2 : Cumulative square root frequency method used for construction of strata.

Class No.	Class interval (bighas)	Frequency (n)	$\sqrt{n}$	Cumulative square root frequency	Strata
A	1 to 5	58	7.61	7.61	First strata
B	6 to 10	17	4.12	11.73	
C	11 to 15	6	2.44	14.17	
D	16 to 20	4	2.00	16.17	Second strata
E	21 to 25	4	2.00	18.17	
F	26 to 30	4	2.00	20.17	
G	31 to 35	2	1.41	21.58	
H	36 to 40	1	1	22.58	
I	41 to 45	2	1.41	23.99	
J	46 to 50	1	1	24.99	
K	51 to 55	1	1	25.99	

Table-3 : Classification of farm households based on farm size (ha).

Category	Land holding (ha.)	Sample size		
		Ganganagar	Raisingh Nagar	Total
Small	Up to 2.5	38	43	81
Large	> 2.5	6	13	19
Total	-	44	56	100

(Singh and Mangat, 1995) was used for the construction of strata as stated in Table-2.

The households were divided into two strata :

$$\text{First strata} = \frac{\sqrt{x} + \sqrt{b} + \dots + \sqrt{m}}{2} \times (\text{say})$$

$$\text{First strata} = 25.99/2 = 12.95$$

X lies in between Class interval 11-15 in class C. Therefore, all respondents owning up to 15 bighas of land

fall under first strata. The remaining households fall in the second strata.

The classification of households into small and large categories based on table 2 and their number in respective category and the basis for classification is presented in table 3.

The small farmers were those who had land up to 2.5 ha and the large farmers having land more than 2.5 ha.

Table-4 : Total Cost of Kinnow Orchards.

S. No.	Particulars	Cost (Rs. /ha.)	Percentage
1.	Variable cost		
A.	Planting cost*	7000.00	0.6.3
B.	Hoeing and weeding	26324.35	2.39
C.	Training and pruning	47353.32	4.30
D.	Manure and fertilizer	41000.00	3.69
E.	Irrigation charges	29823.66	2.68
F.	Plant protection charges	30912.15	2.78
G.	Transportation	9000.84	0.81
H.	Watching and harvesting cost	294556.00	26.53
	Total variable cost	485970.32	43.78
2.	Fixed cost		
A.	Interest on fixed capital	70310.00	6.33
B.	Depreciation	23310.67	2.10
C.	Rental value of land	530410.20	47.78
	Total fixed cost	624030.20	56.21
3.	Total cost	1110000.52	100.00

*Planting cost included expenditure on ploughing farm layout, digging of pits, filling of pits and cost of plants.

Table-5 : Costs and Returns of kinnow orchards.

Age in year	Production Of kinnow (kg./ha.)	Total costs of cultivation (Rs./ha.)	Gross returns (Rs./ha.)	Net returns (Rs./ha.)
1	0.00	21556.62	0.00	-21556.62
2	0.00	10020.16	0.00	-10020.16
3	0.00	8788.49	0.00	-8788.49
4	0.00	201115	0.00	-201115
5	4443.00	41000.56	41330.00	330
6	5085.00	40234.16	54765.00	14530.40
7	6120.00	39315.56	55872.00	16557.44
8	11362.00	48990.09	129258.00	80268
9	13765.00	50811.33	132885.00	82073.67
10	14583.00	51340.89	143847.00	92506.11
11	15998.00	42690.89	143982.00	101291.11
12	16890.00	56780.83	144050.00	87269.17
13	17845.00	43450.16	160775.00	117324.84
14	18654.00	58970.03	165186.00	106215.97
15	19987.00	47879.09	188883.00	141003.91
16	20867.00	45000.76	178803.00	133803.09
17	19649.00	50340.03	194841.00	144500.97
18	18987.00	53555.43	206883.00	153327.57
19	16876.00	54573.79	187884.00	133310.21
20	19974.00	61822.53	179766.00	117943.47
21	15876.00	50345.13	178884.00	128538.87
22	11478.00	28425.56	103302.00	74876.44
23	6784.00	28930.38	59097.00	30166.62
24	5960.00	27222.13	51306.00	24083.87
25	4393.00	24417.13	43901.00	19483.87
Total	299576	1110000.52	2745502	1635501.48

Table-6 : Monetary valuation of deterioration in soil health.

Nutrients	Sri Ganganagar
1. Primary nutrients	
Available Nitrogen	14530
Available Phosphorus	85670
Available Potassium	17665
Sub total	117865
2. Micronutrients	
Zn	4700
Cu	3420
Fe	8320
Mn	7650
Sub total	24090
Total	141955

Table-7 : Monetary valuation of total environmental costs. (Rs/ha.)

Environmental cost	Sri Ganganagar
Cost of the adverse effect on human health	17896
Cost of the degradation of soil health	141955
Total cost	159851

Table-8 : Return over cost of production and environmental cost.

Particulars	Kinnow
Cost of production	1110000.52
Environmental cost	159851
Total returns	2745502
Returns over cost of production	1635501.48
Returns over environmental cost	2585651
Returns over cost of production + Environmental cost	1475650.48

Cost and returns analysis : The cost and returns were worked out following farm management cost concepts like Cost A1, cost A2, cost C1, Cost C2 and Cost C3. The definitions of these concepts have been explained below:

Cost A1:

1. Value of human labour
2. Value of Bullock labour
3. Value of seed
4. Value of manure
5. Value of fertilizer
6. Value of chemicals
7. Machinery
8. Depreciation of farm equipment, calculated as 10 per cent of total value of farm equipment, annually
9. Irrigation charges
10. Land revenue
11. Interest on working capital for half of the growth period of the crop

Cost A2: A1 + rent paid for leased-in land.

Cost B1: Cost A1 + imputed interest on owned fixed capital (excluding land).

Cost B2: Cost A2 + imputed rental value of owned land (less land revenue) + imputed interest on owned fixed capital (excluding land).

Cost C1: Cost B1 + imputed value of family labour.

Cost C2: Cost B2 + imputed value of family labour.

The net returns from different crops were estimated over different costs. The calculations were made on per hectare basis. The details of procedure followed to compute the returns are explained below.

The net returns of the crop were calculated by using following method.

$NR = GR - \text{Costs}$

Where,

NR = Net returns over cost

$GR = YMPM + YBPB$

Where,

GR = Gross returns per hectare of the crop

YM = Yield level of the main product of the crop

PM = Price per quintal of the main product of the crop

YB = Yield level of the by-product of the crop

PB = Price level of the by-product of the crop

PB = Price per quintal of the by-product of the crop and different costs over which net returns have been worked out and it include Cost A1, Cost A2, Cost B1, Cost B2, Cost C1 and Cost C2.

Valuation of environmental cost : Environmental cost has been defined to include the cost of the effect on human health and soil degradation. The effect on human health is estimated to include the number of days lost, the loss in the work efficiency for those who experienced some health problems but did not take medicines, the yearly medical expenditure of the person who handled the pesticides and the value of kit. For computing monetary value of the degradation of soil health, the soil status was compared with the recommended doses in the packages of practices of vegetable crops. If the status of a particular nutrient in the soil was high, then recommended dose, given in the package of practices, was reduced by 25 per cent. In case of medium status, the recommend was the same as given in the package of practices. If the status of a particular nutrient was low, 25 per cent was added to the recommended dose. These doses were now considered as optimum doses for a particular nutrient.

Thereafter, actual dose used by the farmer was compared with the recommended dose; the difference for different nutrients from their recommended doses could either be excess or deficit. The excess or deficit amount then was converted into monetary value by multiplying

the price of a particular nutrient with the excess or deficit amount. The total environmental cost then was apportioned among different crops in proportion to the area under these crops. As mentioned above, all the soil samples in Jaipur were collected from the area under vegetable crops. Therefore, the environmental cost in Jaipur was apportioned only among vegetable crops.

Results and Discussion

Total Cost : On the whole, the total cost was calculated to be Rs. 1110000.52 ha⁻¹, of which variable cost accounted for Rs. 485970.32 ha⁻¹ (43.78 per cent of total cost) and fixed cost accounted for Rs. 624030.87 ha⁻¹ (56.22 per cent of total cost).

Costs and Returns of Kinnow orchards : The age wise costs and returns have been presented in table-4 The table shows the stream of total cost, gross returns, net returns and production. The sum of the stream of cost has been estimated to be Rs. 1110000.52 ha⁻¹ whereas sum for the stream of gross returns was estimated to be Rs. 2745502 ha⁻¹. Similarly the sum of the stream of net returns and production were estimated to be Rs. 1635501.81 ha⁻¹ and 299576 kg ha⁻¹, respectively.

Monitory valuation of deterioration in soil health : Table-6 shows that in monetary terms, the cost degradation of soil health, both macro and micro nutrients, amounted to Rs.141955 per hectare in Sri Ganganagar.

Monetary Valuation of total environmental cost : Table-7 and 8 showed that total cost due to soil health degradation accounted 159851 and return over cost of production plus environmental cost accounted 1475650.48.

Conclusions

The total cost was calculated to be Rs. 1110000.52 ha⁻¹, of which variable cost accounted for Rs. 485970.32 ha⁻¹ (43.84 per cent of total cost) and fixed cost accounted for Rs. 624030.20 ha⁻¹ (55.16 per cent of total cost). The sum of the stream of cost has been estimated to be Rs. 1110000.52 ha⁻¹ whereas sum for the stream of gross returns was estimated to be Rs. 2745502 ha⁻¹. Similarly the sum of the stream of net returns and production were estimated to be Rs 1635501.48 ha⁻¹ and 299576 kg ha⁻¹, respectively. And total environmental cost accounted Rs. 159851.

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Effect of Non-Genetic Factors on Production Performance of Gir Cow under Semi-arid Condition of Rajasthan

Mahesh Datt*, Om Prakash Choudhary and Sheshpal Choudhary

Department of Livestock Production Management, Sri Karan Narendra Agriculture University, Jobner, Rajasthan

Corresponding Author Email : omprakashchoudhary9365@gmail.com

Abstract

The data on 96 lactation of 32 Gir cow at dairy farm, S.K.N college of Agriculture, Jobner, Jaipur (February 2017- January 2021) were collected to document the production performance of Gir cattle under RKVY-14 "Conservation, Improvement and Production Performance of Indigenous Milch Breed of Cow under Semi-arid Condition of Rajasthan" with respect to period of calving, month of calving and lactation order. A least square model was used to determine the effect of various non genetic factors on performance traits of Gir cow. The total lactation milk yield, 300 days milk yield, peak milk yield, lactation length and calving interval averaged 1779.66 ± 46.97 kg, 1750.38 ± 32.42 kg, 9.13 ± 0.18 kg, 308.49 ± 7.05 days, 75.65 ± 6.23 days and 384.58 ± 9.53 days, respectively. Production traits like total lactation milk yield, 300 days milk yield and peak milk yield were significantly affected ($p < 0.01$) by period of calving and lactation order and other productive traits like a lactation length and calving interval were not affected by period of calving, month of calving and lactation order. The Gir cow most frequently calving in rainy season follows by winter and summer season. The milk yield found to be constant throughout the year. The phenotypic correlation for total lactation milk yield, 300 days milk yield, peak milk yield, lactation length, calving interval of Gir cow were significantly correlated with each other. Improvement in feeding, breeding and culling practices on productivity may improve the performance of Gir cattle.

Key words : Non-genetic, Gir cow, production, performance, semi-arid.

Introduction

Livestock in India has a very important role in the agricultural sector, Indian economy and consequently in its rural economy. About 20.5 million people depend upon livestock for their livelihood. Livestock contributed 16% to the income of small farm households as against an average of 14% for all rural households. India has 192.49 million cattle population, which includes 50.52 million cross-bred/exotic and 142.11 million Indigenous cattle (Anonymous 2019).

Gir is a famous milch breed of Indigenous cattle. The native trait of this breed is Gir forest of Kathiawar including Junagadh, Bhavnagar, Rajkot and Amreli districts of Gujarat and also found in some parts of Maharashtra and Rajasthan. Cattle of this breed are famous for their higher tolerance to stress conditions and resistant to various tropical diseases. Estimation of systematic environmental source of variation such as period of calving, month of calving and lactation order on performance traits can help in developing models to predict future genetic ability of the animals. Most of the studies on Indigenous breed were based on small data sheets restricted to a specific herd and thus differed significantly in establishing performance pattern of the breed for traits of economic importance. Lactation milk yield, for example has been reported to vary from 1153 kg (Pereria and Prasad, 1986) to 1635.4 ± 26.50 kg (Gosavi,

1987) 300 days milk yield from 1048.3 ± 30.5 kg (Sing *et al.*, 1982) to 1534 ± 32.2 kg (Dsouza *et al.*, 1979) lactation length from 296 days (Bhatnagar *et al.*, 1972) +382.3 days (Buragohain and Sharma, 1980), dry period from 57 days (Basu *et al.*, 1978) to 195 ± 14 days (Pundir *et al.*, 2007) calving interval upto 485 ± 13 days (Pundir *et al.*, 2007) reported for Indigenous cattle. The objective of present study aimed at establishing the productive performance of Gir cow in semi-arid condition of Rajasthan and documents the behaviour of various performance traits with respect to period of calving, month of calving and lactation order.

Materials and Methods

The data on performance traits of Gir cow for this investigation were collected from RKVY-14 Project "Conservation, Improvement and Production Performance of Indigenous Milch Breed of Cow under Semi-arid Condition of Rajasthan" at dairy farm, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan). The performance traits examined were total lactation milk yield; 300 days milk yield, peak milk yield, lactation length and calving interval of Gir breed.

The data on the various performance traits were analyzed to evaluate the magnitude of various non genetic factors of variation. Incomplete lactation for any recorded reason or lactations ending with abortion or other normally were not utilized. Lactation records of less

than 60 days were not considered in the analysis. In order to eliminate the effects of short dry period on subsequent production, a dry period of less than 40 days were omitted. The records of cows which had aborted or missed a year due to sickness or other reasons were eliminated. Initially 96 lactation records of 32 cows sired by different males were available.

The year was divided into twelve months. Statistical methods were used for analyzing data as least square suggested by Harvey 1990. Following model was used to evaluate the effect of various non-genetic factors on performance traits.

$$Y_{ijk} = \mu + A_i + B_j + C_k + e_{ijk}$$

Where,

μ = overall mean

y_{ijk} = performance record of individual at i^{th} period of calving of j^{th} month of calving and k^{th} lactation order i.e. parity.

A = Effect of i^{th} period of calving

B = Effect of j^{th} month of calving

C_k = Effect of lactation order i.e. parity

e_{ijk} = random error SN ($0,6^2$)

The standard error of μ was calculated from the inverse matrix.

Results and Discussion

Total lactation milk yield : The average lactation milk yield in this investigation was 1779.67 ± 97 kg. It was highest (2041.69 ± 6408 kg) in cows calved during period P3 (2020-2021) and lowest (1476.22 ± 112.94 kg) in period P1 (2017-2018). The previously reported lactation milk yield (1635.4 ± 26.50 kg) was also confirmed by the finding of present study Gosavi (1987). However the quite lower lactation milk yield (1532 ± 88 kg) was estimated by Pundir *et al.*, (2007) whereas highest total lactation milk yield (3571.68 kg) was observed by Kale (1984) it was significantly affected by period of calving ($p < 0.01$) and lactation order. The highest milk yield (1985.12 ± 117.74 kg) was attained in the 4th parity.

300 days milk yield : The average 300 days milk yield in the present study was 1750.39 ± 32.42 kg. It was highest (1978.28 ± 44.23 kg) in cows calved during period P3 (2020-2021) followed by period P2 (2019-2020) 1835.94 ± 51.41 kg and lowest during period P1 (2017-2018), 1488.21 ± 77.96 kg. The phenotypic correlation of 300 days milk yield with peak milk yield were found to be positively significant ($p < 0.01$). It was significantly affected by period of calving and lactation order.

The quite lower 300 days milk yield (1534 ± 32.2 kg) than present study was estimated by Dsouza *et al.*, (1979) in Red Sindhi cows and highest 300 days milk yields by Kale (1984) 3521.21 kg in Jersey $\times$ Gir crossed bred cows.

Peak milk yield : The average peak milk yield in the present study was 9.13 ± 0.18 kg. It was highest (10.21 ± 0.24 kg) in cows calved during period P3 (2020-2021) and lowest during period P1 (2017-2018) 7.50 ± 0.43 kg it was significantly affected by period of calving lactation order, month of calving exerted non-significance result on peak milk yield. Phenotypically peak milk yield was significantly correlated with total lactation milk yield 300 days milk yield.

Lactation length : The average lactation length in present investigation was 308.49 ± 7.05 days. It was in shortest cows calved during period P2 (2019-2020) and largest calving interval was observed in cows calved during period P1 (2017-2018). The effect of period of calving month of calving and lactation order was found to be non-significant on lactation length under present study. The decreasing trend of lactation length with increasing subsequent lactation order was observed after 4th lactation order. The phenotypic correlation among lactation length and calving interval was found highly significant ($p < 0.01$) and with dry period was non-significant.

Calving interval : The average calving interval 384.58 ± 9.53 days was found under present study the period of calving, month of calving and lactation order had exerted non-significance effect on calving interval the longest calving interval was found in period P1 (2017-2018) 391.70 ± 22.93 days and shortest calving interval was found during period P2 (2019-2020) 369.84 ± 15.12 days. It was found longest January-February (411.91 ± 21.32 days) and shortest in October-November month (358.43 ± 23.58 days) the decreasing trend of calving interval with subsequently increasing lactation order was found in present study after 4th lactation order.

The phenotypic correlation of calving interval with total lactation milk yield and dry period ($p < 0.01$) was found. A reduction in calving interval is desirable to produce more number of calves ultimately improving overall productivity (Dahalin *et al.* 1998). The longer calving interval (428 to 506 days) in Sahiwal cows have been reported earlier (Jadhav *et al.*, 2000).

Conclusions

The performance traits in Gir cow were affected by period of calving and lactation order, i.e. total lactation milk yield,

300 days milk yield and peak milk yield. Cattles differences which represent management differences affected all the traits. More number of calving was observed during rainy season followed by winter and summer season, so they are regular breeder. In July month total milk yield, 300 days milk yield and peak milk yield was found to be highest over other months due to ample availability of green fodder than in summer. The differences in lactation length were stable through the year as compared to month calving. The dry period in June month, were found to be longest and shortest dry period found in July month, it was reduced down with increase lactation order. The calving interval trend was found decreasing with increasing lactation number.

The phenotypic trend for various productive traits was deteriorated over the years and needs serious effects to receive the economic viability of the breed. There is a lot of variation within cattle which promises for scope in the productivity of this important national milch breed.

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Adoption of Control Measure Practices of Major Insect Pests in Rice Crop

Somendra Singh, K.K. Shrivastava and P.K. Pandey

Department of Agricultural Extension, IGKV, Raipur, Chhattisgarh

Email : somendras940@gmail.com

Abstract

The present study was conducted on adoption of control measure practices of major insect pests by in rice crop during the year 2021-22. The results were Showed that the maximum number of respondents (63.00 per cent) belonged to medium level of adoption category regarding control measures of insect pests in rice crop. In case of various insect pest wise adoption *i.e.*, brown plant hopper, stem borer, gundhi bug, leaf folder, case worm, gall midge, hispa, were also medium level of adoption regarding control measure practices of rice crop.

Introduction

Rice (*Oryza sativa*) is India's most significant grain crop. It accounts for roughly 23.3 percent of the country's gross cropped area. During the 2018 agricultural season, 392.15 million hectares were planted, yielding 834.02 million tons with a productivity of 2127 kg per hectare. Anonymous (2018). With a total rice production of 146.05 lakh tones from West Bengal, it stand first with an output of 2600 kg/ hectare in the harvest season of 2018 with Uttar Pradesh stand second with total production of 140.22 lakh tones. With total production of 128.95 lakh tones Andhra Pradesh stood third in position. Rice is Chhattisgarh's most significant food grain crop. The state's net sown area is 37.27 lakh hectares, with an average annual rainfall of about 1400 mm. Productivity of 1402 kg/ha Anonymous (2017). Hundreds of insect pests causes harm to rice crops. The most common pest includes stem borers, gall midge, plant hoppers, leaf fodders, rice hispa, gundhi bug, and case worm. The biology and ecology of these paddy crop insect pests have been studied. (Pathak and Khan, 1994) Stem borer is a highly damaging pest that may be found in nearly every area of the world. Hopper burn" is a characteristic of brown plant hoppers (Bisen *et al.*, 2019). Leaf folder larvae eat on delicate leaves without folding them, whereas older larvae feed inside folded leaves. Gall midge is a pest that belongs to the order Diptera and the family Ceccidomyiidae. Its damage symptoms include "onion leaf" and "silver shoot." Incidence of insect pest outbreak and there varied resulting yield loss majorly depend upon the basis of crop growth stages. The crop's growth stage between 30 and 60 days after transplanting was the most vulnerable for stem borer, gall midge, leaf folder and brown planthopper, resulting in significant output losses (20-68 percent) (Krishnaiah and Varma, 2011).

Materials and Methods

The study was conducted in northern hill zone of Chhattisgarh namely surguja district, out of One block ambikapur was selected purposively. Out of total villages of Ambikapur block. 10 villages were selected randomly for the present study. Each village has ten rice growers were randomly chosen. Karji, Bartikra, Nawabandh, Saraitikra, Jagdishpur, Rampur, Jogibandh, Kerakachar, Shivpur & Libra village were selected. The respondent's farmers were interviewed with the help of pretested interview schedule prepared for the present study. The statistical tools like Mean, Standard deviation, frequency, percentage, correction were used to analyse the data.

Results and Discussion

Adoption level of rice growers regarding recommended control measure practices of major insect-pests in rice crop : Data presented in table-1 Showed that the maximum number of respondents (63.00 per cent) belonged to medium level of adoption category regarding control measures of insect pests in rice crop. In case of 22.00 per cent respondents belonged to low level of adoption and only 15.00 per cent respondents were having high level of adoption regarding insect pests control measure in rice crop. It can be concluded that majority of respondents having medium level of adoption regarding control measures of major insect pests in rice crop.

The data reported in the table-2 indicated that the majority of farmers belonged to medium level of adoption regarding control measure of various insect pests in rice crop *i.e.*, brown plant hopper (61.00%), stem borer (59.00%), gundhi bug (54.00%), leaf folder (53.00%), case worm (51.00%), gall midge (50.00%), hispa (49.00%). In case of low adoption category; hispa (41.00%), gall midge (38.00%), and case worm (35.00%) reported by the respondents. Among the respondents

Table-1 : Distribution of respondents according to their overall adoption level regarding control measures practices of major insect pests in rice crop. (n=100)

Sl. No.	Categories	Frequency	Percentage
1.	Low (up to 33 score)	22	22.00
2.	Medium (34 to 41 score)	63	63.00
3.	High (above 41 score)	15	15.00
	Mean = 36.92	S.D. = 4.62	

Table-2 : Distribution of respondents according to their insect-pest wise level of adoption regarding control measure practices of major insect pests in rice crop. (n = 100)

Sl. No.	Insect-pests	Adoption level	Frequency	Percent
1.	Stem borer	Low (up to 8)	3	23.00
		Medium (9 to 12)	9	59.00
		High (above 12)	8	18.00
		Mean = 10.19		S.D. = 2.03
2.	Brown plant hopper	Low (up to 3)	0	20.00
		Medium (4 to 6)	1	61.00
		High (above 6)	9	19.00
		Mean = 4.96		S.D.= 1.58
3.	Leaf folder	Low (up to 3)	2	32.00
		Medium (4 to 5)	3	53.00
		High (above 5)	5	15.00
		Mean = 4.23		S.D. = 1.51
4.	Gundhi bug	Low (up to 3)	0	30.00
		Medium (4 to 6)	4	54.00
		High (above 6)	6	16.00
		Mean = 4.65		S.D. = 1.68
5.	Case worm	Low (up to 2)	5	35.00
		Medium (3 to 4)	1	51.00
		High (above 4)	4	14.00
		Mean = 3.19		S.D. =1.07
6.	Rice Hispa	Low (up to 4)	1	41.00
		Medium (5 to 7)	9	49.00
		High (above 7)	0	10.00
		Mean = 5.24		S.D.= 1.73
7.	Gall midge	Low (up to 3)	38	38.00
		Medium (4 to 6)	50	50.00
		High (above 6)	12	12.00
		Mean = 4.46		S.D. =1.58

with higher adoption category, such as brown plant hopper (19.00%), stem borer (18.00%), gundhi bug (16.00%).

It can be concluded that maximum number of respondents adopted the medium level of control measures for major of rice pests such as brown plant hopper, stem borer, gundhi bug, leaf folder, case worm, gall midge, hispa. In case of low adoption category for major rice pests namely hispa, gall midge, only 19.00 per cent and 18.00 per cent of respondents belonged to higher adoption category regarding control measure in rice crop.

The results in the Table-3 showed that majority of the rice growers adoption index of cultural practices of rice stem borer was 59.23 per cent, followed by Chemical practices (34.50 %), mechanical practices 4.00 per cent and biological practices (1.50%). In case of brown plant hopper adoption index of the respondents regarding

cultural practices (44.55%), followed by chemical practices (32.30%), mechanical practices (1.25%), and (2.25%) biological practices. With regard to leaf folder adoption index of the respondents towards cultural practices (46.25%), followed by Chemical practices (19.20 %), mechanical practices (00.00%), and 0.00% biological practices. In the case of gundhi bug adoption index of the respondents regarding cultural practices (49.50%), followed by chemical practices 31.50 per cent, mechanical practices (2.50%), and (00.00 %) biological practices, as regard to case worm adoption index of the respondents towards cultural practices 14.50 per cent, followed by chemical practices 18.25 per cent, 00.00 per cent mechanical practices, and (0.00 %) biological practices. In the case of hispa adoption index of the respondents regarding cultural practices (30.45%), followed by chemical practices 16.50 per cent, 00.00 % mechanical practices and (0.00 %) biological practices, as regard to gall midge adoption index of the respondents

Table-3 : Distribution of the respondents according to their insect pest wise level of adoption index regarding control measure of major insect pests in rice crop. (n=100)

Sl. No.	Insect pest	Adoption index (%)			
		Cultural	Mechanical	Chemical	Biological
1.	Stem borer	59.23	4.00	34.50	1.50
2.	Brown plant hopper	44.55	1.25	32.30	2.25
3.	Leaf folder	46.25	00.00	19.20	00.00
4.	Gundhi bug	49.50	2.50	31.50	00.00
5.	Caseworm (banki)	14.50	00.00	18.25	00.00
6.	Rice Hispa	30.45	00.00	16.50	00.00
7.	Gall midge	49.00	00.00	26.50	0.50
	Overall A.I. (%)	41.92	1.10	25.53	0.60

towards cultural practices 49.00 per cent, followed by chemical practices 26.50 per cent, 0.0 per cent mechanical practices, and (0.50 %) biological practices.

Overall adoption index of the respondents regarding cultural practices of insect pests was (41.92%), followed by 25.53 per cent chemical practices, 1.10 per cent mechanical practices and (0.60%) of biological practices of major insect pests of rice crop.

Conclusions

Results clearly showed the overall level of adoption of control measures of rice crop, maximum number of respondents 63.00 per cent were medium level, in case of insect pest wise adoption of control measure in rice crop, majority of farmers belonged to medium level of adoption *i.e.*, brown plant hopper (61.00%), stem borer (59.00%), gundhi bug (54.00%), leaf folder (53.00%), case worm (51.00%), gall midge (50.00%), hispa (49.00%).

In case of overall adoption index of the respondents regarding cultural practices of insect pests was (41.92%), followed by 25.53 per cent chemical practices, 1.10 per cent mechanical practices and only 0.60% of biological practices the control of major insect pests of rice crop.

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In the Phulera Block of Jaipur District, Rajasthan, a Socio Survey was Conducted on the Milking Management Practices Constraints and Suggestion of Buffalo Farmers

Jhabar Mal Tatarwal^{1*}, Ramesh Pandey¹, Goatm Chopra², Om parkash Choudhury², Subhash Yadav² and Priyanka Kayath²

¹Department of Animal Husbandry and Dairying, SHUATS, Prayagraj, U.P.

³Department of Animal Production, Rajasthan College of agriculture, MPUAT, Udaipur, Rajasthan

*Corresponding Author Email : j6350260110@gmail.com.

Abstract

The current investigation is being carried out in the Jaipur district of Rajasthan. One Tehsils Phulera selected from the northwestern region has been selected. For each tehsil, four villages were selected. Twenty buffalo farmers were selected from each district making a sample of 80 buffalo breeders. The results of existing milk management procedures showed that 78.75 percent of respondents followed the milking process. The majority of 66.25 percent were following the removal at the end of milking and 76.25 percent of respondents used to milk buffalo in the same area. All respondents used precautionary measures before milking, such as hand washing, breast and breast cleansing, and 86.25 respondents milked their buffalo twice a day. It was found that 81.25% of respondents used milk exchange. None of the respondents used a scientific milking bowl to milk and wiped the udder and nipples immediately after milking. About 63.75% of respondents use sand and clean water to clean milking dishes. All (25%) respondents allowed the calf to suckle both before and after milking. Most of the 93.75 respondents in the respondent provided concentrations and feed if the buffalo did not reduce milk after the calf's death and about oxytocin used only 6.25 percent of respondents who injected to reduce milk intake after calf death. None of the respondents followed dry hand milking and the closure of the udder at the end of breastfeeding. Basically the combined RBQ negligence in vaccinating animals was one of the main obstacles buffalo owners face in Phulera tehsils. Followed by a repeating breeder. It is ranked as the second most difficult issue.

Key word : buffalo, milking, respondents, concentrate, animals.

Introduction

The livestock industry plays a major role in the country's economy and its growth rate is growing. As a result of liberal policies and international trade, demand for livestock products has increased. Increased per capita income, urbanization and lifestyle, women's participation in the labor market and changes in taste and choice are important reasons for the growth of livestock-related products. Demand for animal-related products such as milk, meat, wool and eggs have grown rapidly in India. Demand for livestock products has increased not only in cities but also in rural areas. The domestic and export business needs to put a lot of pressure on supply.

At the national level, the livestock industry plays an important role in terms of employment, revenue, exports and renewable energy sources. The country's Introduction revenue is growing steadily in India. Livestock products provide income, job opportunities and security for rural households. The livestock sector has both forward and backward communication. Farmers often sell expensive animal products and buy other food and non-food items on the market.

The number of livestock in India has almost shown

growth since the country gained independence. Livestock plays an important role in agriculture and the rural economy in developing countries. They not only produce direct food, they also provide essential resources for crop farming. Many farms in developing countries are too small to justify having a tractor or use, and one that can be done by animal power or human activity.

In the past, farmers were able to restore the fertility of their soil by letting it sleep for several years or more. But as population dynamics increase, mourning times decrease or disappear and different approaches are needed to maintain food production. Animals are an important link in the nutrient cycle, replenishing nutrients in the soil in ways that plants can easily use. They can bring in nutrients from different pastures and areas and concentrate on the vegetation area through their manure and urine. Animal manure and urine that people in developed countries consider to be the most important fertilizer in developing lands. Few smallholder farmers can afford enough mineral fertilizer.

Animals give farmers the reason to plant legumes as pastures and cover crops that protect the soil and restore structure and fertility. India is the world's largest milk producer by producing 187 million tons of milk in the year

Table-1 : Existing milking management practices.

Practices	Households (Herd size)			Overall	² Value
	Small	Medium	Large		
1. Method of milking :					
a. Full hand	0	0	0	00	—
b. Knuckling	8	30	25	63 (78.75)	
c. Stripping	4	8	5	17 (21.25)	
2. Stripping at the end of milking :					
a. Yes	8	25	20	53 (66.25)	0.23NS
b. No	5	13	9	27 (33.75)	
3. Place of milking :					
a. Milking at the same place	9	30	22	61 (76.25)	0.45NS
b. Milking at separate and dry place	4	9	6	19 (23.75)	
4. Frequency of milking					
a. Two times	9	38	22	69 (86.25)	0.25NS
b. Three times	2	6	3	11 (13.75)	
5. Clean udder and teats before milking :					
a. Yes	15	35	30	80 (100)	—
b. No	0	0	0	00	
6. Wash hand before milking					
a. Yes	11	35	24	70 (87.50)	0.41NS
b. No	1	6	3	10 (12.50)	
7. Change milker :					
a. Yes	12	33	20	65 (81.25)	0.09NS
b. No	3	8	4	15 (18.75)	
8. Type of milking pail :					
a. Open mouth bucket	15	35	30	80 (100)	—
b. Scientific milking pail	0	0	0	00	
9. Cleaning of milking utensils with :					
a. Sand and clean water	7	27	17	51 (63.75)	—
b. Ash and water	6	15	8	29 (36.25)	
c. Cleaning agent and water	0	0	0	00	
10. Wipe to clean the udder and teats just after milking :					
a. Yes	0	0	0	00	—
b. No	15	38	27	80(100)	
11. Calf is allowed to suckle					
a. Before milking	7	20	15	42(52.50)	0.061NS
b. After milking	4	7	7	18(22.50)	
c. Both time (a+b)	4	8	8	20(25.00)	
12. If the buffalo do not let down milk after the death of calf, Practice followed					
a. Offer concentrate and feed	13	32	30	75(93.75)	0.03NS
b. Apply oxytocin injection	1	2	2	05(6.25)	
13. Dry hand milking					
a. Yes	0	0	0	00	—
b. No	15	35	30	80(100)	

20018-19 (FAO). The number of buffalo in India is estimated at 109.85 million, comprising about 57 percent of the world's total buffalo.

Animal husbandry is a major economic activity for rural people, especially in the arid and desert regions of Rajasthan. Livestock development has a significant impact on job creation and poverty reduction in rural areas. Livestock contributes the bulk of the agricultural

potential, with about half the cattle and 25 percent of buffalo being used for farming and farming.

About 8 percent of G.D.P. Rajasthan is sponsored by the Livestock sector only. The sector has great potential for self-employment in rural areas where investment is very low per unit. Therefore, livestock development is an important means of prosperity in rural areas. According to the 2020 Livestock Census of 2019,

Table-2 : Rank Based Quotient (RBQ) Values of Different Constraints.

Constraints	Constraint Code	Values	Rank
Repeat breeder	1	57.75	2
Distant location of vet. hospital	2	52.12	8
Lack of A.I. centers, ill equipped and poor service at A.I. center	3	54.68	3
Lack of knowledge about concentrate feeding according to milk production	4	53.87	4
Lack of proper marketing of milk	5	51.12	10
Lack of knowledge about deworming practices	6	53.50	5
Lack of good breed able buffalo bulls	7	51.43	9
Lack of knowledge about full hand milking	8	52.18	7
Farmers negligence in vaccinating the animals	9	62.12	1
Lack of knowledge about proper sanitation and hygiene	10	52.50	6

Table-3 : Vaccination schedule for adult animals.

Vaccine	Months
Foot and mouth	January to February
Abortion causing brucellosis	March to April
Anthrax disease	April to may
Foot and mouth disease(twice a year)	June to July
Black quarter	August to September(before monsoon)
Hemorrhagic septicemia	September to October

there are 56.8 million livestock (including cattle, buffaloes, sheep, goats, horses and ponies, mules, donkeys, camels and pigs) and 14.6 million chickens (Department of Animal Husbandry, Government. Rajasthan , Livestock Census 2019 (Temporary).

The buffalo has a very strong promise of food security and sustainable development in the 21st century as these animals form an integral part of the traditional farming system in India. In India, buffalo have been the backbone of the rural economy. It is the mainstay of butter and ghee production. Not only this, buffalo is considered to be very useful due to its high fat milk content, the ability to use agricultural products effectively and require a small amount of kilos.

Calories to produce 1kg of milk. Buffalo is a big bank and is a friend of small farmers. It is a good companion for Indian farmers, who grow older with their buffaloes that develop high compatibility. Like many pets kept by domestic families, there is a social and cultural connection with buffalo.

As a three-purpose animal that provides milk, meat and dung, the buffalo's contribution to the country's economy is enormous. Although buffalo are smaller in number than cattle, they currently produce an estimated 60 million tons of milk, which is 55% of the total milk produced in the country. Despite changes in diet patterns the number of vegetarians is still high and milk and dairy products are a great source of good quality protein in their diet. Therefore, the buffalo is very important as a dairy animal in India.

Given the fact that the climatic conditions of India are very different from one region to another, a clear strategy will be developed for breeding, feeding and management in each area. Due to the lack of detailed information on existing breeding, feeding, housing and other management practices used in the various livestock sectors, it is not possible for policymakers to pay full attention to these important aspects of buffalo production. Proper management is required to increase milk production. Effective management requires a solid website.

Efforts should be made to gather and integrate all available information. Few efforts are known to provide systematic study of buffalo management in rural areas. Available information and general text on the topic are based on speculation, general observations, information and reports of specific experts and professional staff. This is not enough to serve as a basis on which practical guidelines for developing systems for introducing advanced and scientific management processes and problem-solving problems encountered.

Research Methodology

The total area of Rajasthan is 3, 42,239 square kilometers, with a population of 6, 86, 21,012 and a population of 57.9 million people, and a total of 11.09 million buffalo. The state is divided into 33 states for administrative purposes. The current study was conducted in Phulera, Jaipur district of Rajasthan.

Jaipur County is located in the northeastern part of

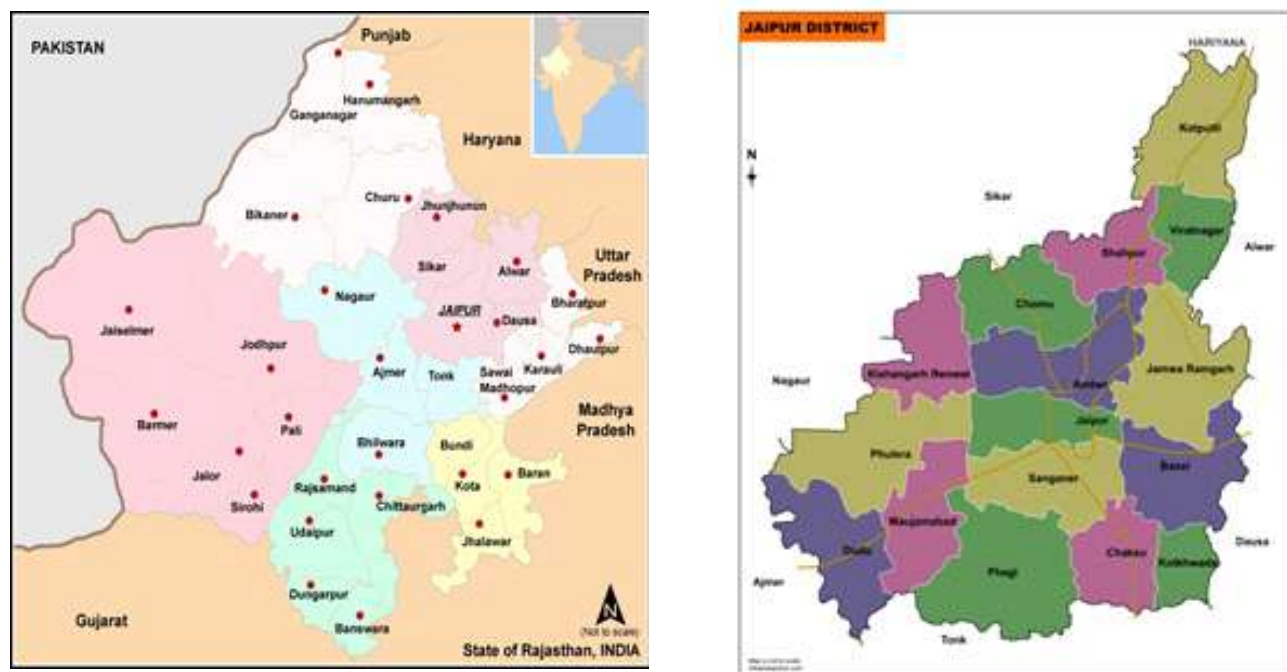


Fig-1 : Survey area.

Rajasthan between 260 92 'and 750 82' northeast areas. Regional temperatures vary between 350C in summer and 300C in winter. The total area of ??the region is 200.4 km². The region has a tropical climate with an average rainfall of more than 650 mm per year. It has a medium-sized irrigation center, most of which are well supplied with a well-opened tube.

The study was conducted in Phulera tehsil, Jaipur district of Rajasthan, deliberately selected. The district is made up of 13 tehsils, from which one tehsils were selected. In addition, four selected districts have been identified in tehsil. In each district, 20 respondents were selected. Thus, the entire sample contains 80 respondents from four selected districts in Phulera tehsils district.

Based on the standards provided to farmers, the renk based quotient (RBQ) for each block is calculated at the local level on the basis of the formula (Sabarathnam and Vennila 1996).

Results and Discussion

Existing milking management practices : Findings regarding milk management procedures followed by respondents are presented in Table-1. It was found that the majority of 78.75 percent of respondents followed the milking process. Only 21.25 percent of respondents followed the milking process. The results of the present study are almost identical to the earlier findings of Singh

and Singh (1999), Khupse *et al.* (1980), Garg *et al.* (2005) Mathur *et al.* (2001) and Rathore *et al.* (2009).

About 76.25% of respondents milked buffalo in one place and 23.75% milked in a separate dry area. Chi-square figures are 0.4468. The p-value is .799808. The result is not relevant to $p < .05$. The majority of 66.25 percent of respondents followed a break at the end of milking. The results contradict those of Verma (1989), who reported that none of the respondents were accustomed to undressing after breastfeeding. 86.25% of respondents milked their buffalo twice a day and this finding is consistent with reports of Dubey and Kumar (1981) but in contrast to Sarkar and Pal (1980), who suggest that it be milked three times a day. Chi-square figures are 0.2472. The p-value is .883727. The result is not relevant to $p < .05$. All respondents cleaned the breasts and nipples and washed their hands before milking. These findings are consistent with the earlier findings of Hazarika and Anand (1984), Nataraju and Channegowda (1986), Verma (1989) and Garg *et al.* (2005).

About 81.25% of respondents changed milk from time to time because some buffalo would give someone milk if the milk was not changed. Chi-square figures are 0.0994. The p-value is .951517. The result is not relevant to $p < .05$. None of the respondents used a scientific milking vessel to milk. A similar observation was reported by Garg *et al.* (2005). The majority (63.75 percent) of buffalo breeders used sand and clean water to clean

milking vessels followed by 36.25 percent ash and water and none of the respondents were found using cleaning equipment and water. Ranjan, S.K. and Pathak, N.N. (1999), Roy A., D.S. Brar and S.K. Jha (2007).

It was noted in the research results; that no respondent wiped the udder and breast immediately after milking. 25.00% of respondents in buffalo breeders allowed the calf to suckle both before and after milking. Chisquare figures are 0.6132. The p-value is .961591. The result is not relevant to $p < .05$. Approximately 93.75 percent of the respondents provided a concentrated milk reduction diet after the calf's death and only 6.25 percent of the respondents included an oxytocin injection to reduce milk intake in the study. Chi-square figures are 0.0269. The pvalue is .986645. The result is not relevant to $p < .05$. The results obtained from the present study are similar to those found by Singh and Singh (1999), and Garg *et al.* (2005)

From the results, it turned out that although the majority of respondents followed one or more effective ways of managing milking, there were still gaps in the acceptance of certain critical procedures by some of the respondents. Milking is a flawed process but it is present in the area to a large extent.

Constraints in the adoption of recommended buffalo management practices in the Phulera block, Jaipur : According to the renk based quotient (RBQ) values ??the researcher easily identified the most critical obstacle at the regional level. Obstacles with a high RBQ value can be displayed as the most difficult obstacles. The RBQ values ??for the Phulera block presented in Table-2.

As can be seen from the results, the farmer's negligence in vaccinating animals was one of the challenges buffalo farmers faced on a compact RBQ basis. The RBQ value for this restriction was 62.12.

The repeating breeder is ranked second as a critical constraint, with a total RBQ of 57.75. Based on the distribution of RBQ values, this restriction is placed second in the Phulera block.

Lack of A.I. institutions, ill-equipped and poor service in A.I. The center was the third with critical issues in the tested area. It had an RBQ value of 54.68. This figure is ranked fifth in the Phulera block.

Lack of information about a concentrated feed in terms of milk production was the fourth most significant barrier identified (aggregate RBQ, 53.87) in the study area. Based on RBQ values, the limit is placed seventh in the Phulera block.

Lack of knowledge about how to kill worms has been a fifth-ranked obstacle in the study area.

Jaipur

Colostrum feeding : Colostrum is the first milk that comes out after birth. It contains a large number of anti-body gamma globulins produced by the cow against the antigens during its lifetime including those that are resistant to many pathogens. Colostrum is a very strong source of nutrients with 7 times the protein and twice the total amount of normal milk, thus providing instant energy and solid food. It contains high levels of minerals and vitamin A that are essential in fighting disease. Ingestion of colostrum significantly increases calf survival.

The absorption of these antibodies gives the calf an umbrella of the immune system. Colostrum provides a laxative effect that is useful in extracting muconium (primary stool). It will be very helpful to inject colostrum for the first 15-30 minutes followed by a second dose for about 10-12 hours. For the first ½ to 12 hours of life, the calf should be given colostrum for its 5-8% weight. Then day 2 and 3, it should be 10% of its body weight. Excess colostrum can be stored in the refrigerator and can be used on other calves or orphans.

Weaning : Separation of a calf and making it independent of its mother for food is known as weaning. Nowadays, early weaning is recommended for better management. Under the early weaning program, weaned calves are housed separately and in a scientific feeding system and management procedures. In this way, the cow is not allowed to suckle her calf after colostrum. Instead, the cow is milked completely and the required amount of whole milk or skim milk is fed to the calf. Suckling calves should be trained to drink bottled milk / milk to make it easier to handle food. Weaned calves should be weighed every week and the amount of milk to be fed is calculated accordingly.

Disbudding : Catching a growing horn at a young age, when the horn root is in the germination stage is called disbudding. This is especially true of rare and diverse cattle breeds. Cattle with horns are the only ones that can lead to severe economic losses. Animals with horns are dangerous to the operator and without horns, handling becomes easier. Abortion is important to reduce the animal's size in sheds. Abortion should be done on the calf in the age of 15-20 years itself. It is made using hot metal and chemicals. Hot iron is a bloodless method that can be used at any time of the year. The electric-fired metal has an automatic control that maintains a temperature of about 10000 F, using it on the horn sprout 10 seconds is enough to destroy the horn tissue. Caustic potash or caustic soda is a common chemical used for extraction. These are available in the form of an attachment or solution. Cut hair on the horns of the horns

and surrounding areas, Vaseline ring to protect the eyes from chemicals. Apply the chemical on top of the buds until they bleed.

Quarantine : A quarantine is a process of distinguishing healthy animals (especially an animal that is introduced into the herd or land for the first time) that has been exposed to the risk of infection. The timing of the separation depends on the duration of the infection. In fact, a minimum of 30 to 40 days is accepted as the appropriate time; but in the case of diseases such as rabies this period lasts up to 6 months. Newly purchased animals and animals returning from the exhibition should be kept in an enclosed shed. The shed should be built at the entrance to the farm. They must be immersed or sprayed on 25/26 to remove ectoparasites.

Isolation of sick animals : Isolation is the process of separating infected and affected animals from those that appear healthy, in the event of an infectious disease. Such isolated animals should be housed in a separate shed away from the common kennel. If there is no separate shed for the animals to be separated they should be kept at the end of the shed away from the animals that appear to be healthy. Guardians and property of sick animals should be properly disassembled. If for good reason this does not happen, sick animals should be visited only when they are healthy. The materials must be disinfected completely after use in the isolation group. The worker should wash his hands, feet, and gumboots with disinfectant and change his clothes. Live animals are reintroduced to a healthy herd only after they have fully recovered and the chance of transmitting the Infection has been eliminated.

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Conclusions

The results of existing milk management procedures showed that 78.75 percent of respondents followed the milking process. The majority of 66.25 percent were following the removal at the end of milking and 76.25 percent of respondents used to milk buffalo in the same area. All respondents used precautionary measures before milking, such as hand washing, breast and breast cleansing, and 86.25 respondents milked their buffalo twice a day. It was found that 81.25% of respondents used

milk exchange. None of the respondents used a scientific milking bowl to milk and wiped the udder and nipples immediately after milking. About 63.75% of respondents use sand and clean water to clean milking dishes. All (25%) respondents allowed the calf to suckle both before and after milking. Most of the 93.75 respondents in the respondent provided concentrations and feed if the buffalo did not reduce milk after the calf's death and about oxytocin used only 6.25 percent of respondents who injected to reduce milk intake after calf death. None of the respondents followed dry hand milking and the closure of the udder at the end of breastfeeding.

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Effect of Neem (*Azadirachta indica*) Supplementation on Growth Performance of Kuroiler Chicks

Priyanka Kayath^{1*}, Mahesh Datt², Lekhu Kumar², Goatm Chopra¹ and Jhabar Mal Tatarwal³

¹Department of Animal Production, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

²Department of Livestock Production Management, Shri Karan Narendra Agriculture University, Jobner, Rajasthan

³Department of Animal Husbandry and Dairying, SHUATS, Prayagraj, U.P.

*Corresponding Author Email : priyankakayath0666@gmail.com

Abstract

The present investigation was conducted to detect the effect of Neem (*Azadirachta indica*) supplementation on growth rate of Kuroiler chicks. One hundred twenty unsexed Kuroiler chicks (day old) were used on a completely randomized design (CRD) in 4 treatments with 3 replicates, each consisting of 10 chicks. The treatments involved the control group (T₁) fed with chick starter feed and other group were fed on basal diet mixed with neem powder @ 2g, 4g, 6g in T₂, T₃, T₄ respectively. All other management practices were followed as per recommendation throughout the investigational period of 8 weeks. The feed consumption and body weight of chicks was recorded weekly for further analysis. The average body weight, body weight gain, feed consumption, feed conversion ratio (FCR), significantly higher in T₄ group (6g/kg of neem leaves powder) than all other treatments. The average body weight was significantly ($p < 0.05$) higher in T₄ (1170.63 ± 3.48) as compare to T₃ (1161.13 ± 12.2), T₂ (1147.03 ± 4.45) and control group T₁ (1129.37 ± 1.610). Average body weight gain was significantly ($p < 0.05$) higher in T₄ (204.50 ± 5.40) as compare to control group and other treatment groups. Average feed consumption ratio was significantly ($P < 0.05$) higher in T₁ (756.67 ± 3.9) group as compare to treated groups and control group.

Key words : Body weight, growth, kuroiler chicks and neem, feed consumption, body weight, FCR.

Introduction

India ranks 3rd in the world production of eggs and 5th in the production of broiler. (DHAD 2017-18). The poultry sector is one of the rare examples of socio-economic development, which attained its present advanced stage without much international aid and investment from the Five-Year-Plans.

Chicken meat and egg are gaining popularity because of having high nutritional value, universal taste appeal, no religious taboo and being comparatively economical. Egg is one such food commodity, which cannot be adulterated and contains protein of very high biological value. Poultry meat is an ideal food for children, young, adult, old people and those attempting to control their weight. It is easy to digest and contains high quality protein having abundance of all the essential amino acids required for optimum human nutrition.

The Kuroiler is a hybrid breed of chicken developed by the Kegg Farms Group in Gurgaon, Haryana. Kuroilers, a dual-purpose breed producing meat and eggs, can live on a diet of kitchen and agricultural waste. Due to its unique genetic features, the Kuroiler is resistant to diseases. The Kuroiler chick is a potential bio-converter of no cost agricultural, household and natural waste abundant in villages into human protein food and substantial incomes for rural households.

Feed additives are the substances used in animal nutrition for purpose of refining the quality and quantity of products from origin and the health of animals. Growth promoter are commonly added in poultry diets for increasing the growth and egg production. The main feed spices used in poultry feeds are antibiotics, coccidiostat, antistress, probiotic, prebiotic, symbiotic, enzymes, organic acids, venom binders, hormones, arsenicals.

Azadirachta indica, generally known as neem, nim tree or Indian lilac, is a tree in the mahogany family Meliaceae. It is one of two species in the genus *Azadirachta*, and is native to the Indian subcontinent, i.e., India, Nepal, Pakistan, Bangladesh, Sri Lanka, and Maldives. It is typically grown in tropical and semi-tropical regions. Neem trees also grow in islands located in the southern part of Iran. Its fruits and seeds are the source of neem oil.

Scientists are again focused on the use of our primeval medicinal system to find beneficial herbs and plants, which can be safely used to increase the production. Many plants also produce secondary metabolites such as phenolic compounds, essential oils and Saponins (Chesson et al., 1982; Wallace et al., 1994; Kamel, 2001). Herbs usually used are picorhiza, garlic, cloves, slippery elm, neem fruit and leaves, sophora flavescens, nutmeg, cinnamon, ginger, peppermint, sage, thyme, mustard and fenugreek. These

plants are used as digestive stimulants, antidiarrheic, antiseptic, anti-inflammatory, antiparasitic and appetite stimulants in human beings as well as animals. It is conceivable that herbal agents could serve as safer alternatives as growth promoters due to their suitability and preference, lower cost of production, reduced risks toxicity and minimum health hazards. One of such plants, neem (*Azadirachta indica*) is an indigenous plant of Asian subcontinent acknowledged for its useful medicinal properties like antibacterial, antiviral, antifungal, antiprotozoal, hepatoprotective, immunomodulator and various other properties without showing any adverse effects (Kale et al., 2003; Sadekar et al., 1998). Neem promotes growth and feed efficiency of birds because of its antibacterial and hepatoprotective properties (Padalwar, 1994). Neem provisions fed to laying hens have been reported by Sadre *et al.*, (1984). Recent biological trials of certain herbal creations in India as growth have shown encouraging results and some of the reports have demonstrated improvement with respect to weight gain, feed efficiency, lowered mortality, increased immunity and increased livability in poultry birds (Kumar, 1991). Neem (*Azadirachia indica*) dry leaves powder as medical herbs could be beneficial in immunosuppressant diseases of poultry. Low dose of neem leaves powder has an inhibitory action on wide spectrum of microorganisms (Talwar *et al.*, 1997) and immunomodulator actions that induce cellular immune reaction (Devakumar and Suktt, 1993). Considering the vast benefits of neem on poultry health and management the present study was aimed to evaluate the growth performance of broilers supplemented with neem leaf powder.

Materials and Methods

The experiment was conducted at Poultry farm, S.K.N. College of Agriculture, Jobner District Jaipur, (Rajasthan, India). Geographically Jobner is located 45.0 km west of Jaipur at 26°05' North latitude, 75°28' East longitude and at an altitude of 427 meter above the mean sea level. The area falls in agro-climatic zone III-A (Semi-arid eastern plain zone of Rajasthan). The climate of this region is a typically semi-arid, characterized by extremes of temperature during both summers and winters. The present investigation was conducted to study the effect of neem feeding on growth rate of Kuroiler chicken from (day old) to 8 weeks of age. For the present study 120, day old chicks of Kuroiler chicken were procured from department of Livestock Production and management. The chicks were randomly distributed into four treatment groups each having 30 chicks and each group were further divided into three replicates of 10 chicks each (Table 1). Neem leaf were dried in sunshine and crushed to make

fine powder were mixed at appropriate concentration in feed as specified for different treatments.

Housing and management : The chicks were reared under strict + disinfected conditions in the brooder house of the college poultry farm. Before housing the chicks, experimental brooder rooms, equipment's and utensils were cleaned and disinfected thoroughly with 2.5% phenol and subsequently fumigated with formaldehyde gas (40ml of commercial formalin and 20g potassium permanganate per hundred cubic feet volume). The corners of brooder rooms were rounded by using the cardboard to avoid any piling up of chicks. The chicks (day old) were weighed at the beginning of the experiment and divided into groups randomly. Saw dust was used as litter material which was procured from the local market and filtered through a sieve to separate the coarse particles. The thickness of bedding material was kept 2 inches initially which was subsequently increased by 0.5 inch on 15th and 30th day of the experiment. The chicks were vaccinated against NCD (F1 strain) and IBD on 5th and 12th day of the experiment through intra-ocular route. Standard management practices such as brooding, proper lighting, raking of litter, cleaning of feeders, waterers, etc. were followed.

Feeding and watering : The chicks were offered all crumbled chick starter feed ad libitum, purchased from a private poultry feed manufacturing factory according to BIS (2007) specifications. Initially the feed was offered by putting the newspapers on ground and after 3 days horizontal feeder was used to feed the chicks upto the age of two weeks. After two weeks the chick feeder was used and continued during whole experimental period. The feeders were kept at shoulder height of birds and were filled only two third to minimum the feed wastage. The birds were offered clean and fresh drinking water ad libitum using chick waterers during the whole experimental period.

Body weight : The birds belonging to all the experimental groups were closely observed throughout the experiment, starting from day old till the end of the experiment *i.e.*, 8 weeks, for body weight gain. The chicks were weighed individually at the beginning of the experiment and later on at weekly intervals using an electronic balance to calculate the weekly gain in body weight.

Feed consumption : Weekly record of feed consumption was maintained for each experimental group and their replicates weekly record of the feed offered and feed weigh back was maintained during the experimental period of 8 weeks for the calculation of feed consumption, feed conversion ratio, performance index, protein and energy efficiency.

Table-1 : Details of Treatments.

Groups	Treatment
T ₁ (Control feed)	Standard chick starter feed
T ₂	Dry neem leaves powder 2 g/kg standard feed
T ₃	Dry neem leaves powder 4 g/kg standard feed
T ₄	Dry neem leaves powder 6 g/kg standard feed

Table-2 : Treatment means of average body weight (g/bird) during different growth periods.

Age of chicks (days)	Treatments			
	T ₁	T ₂	T ₃	T ₄
0	31.00±0.17 ^a	31.00±0.11 ^{ab}	30.83±0.32 ^{ab}	30.80±0.2 ^{ab}
7	72.50±2.3 ^d	81.23±0.66 ^{abc}	82.90±0.2 ^{ab}	84.90±0.4 ^a
14	126.97±1.74 ^d	140.53±0.57 ^c	145.13±1.0 ^b	153.07±1.46 ^a
21	208.27±4.90 ^d	221.37±1.90 ^{bc}	230.37±3.09 ^{ab}	239.47±0.26 ^a
28	347.03±0.88 ^d	353.50±1.90 ^c	361.27±1.71 ^b	376.17±1.01 ^a
5	536.13±2.09 ^d	547.07±3.47 ^{bc}	551.20±0.85 ^{ab}	556.53±3.18 ^a
42	731.50±0.764 ^d	741.37±3.98 ^c	752.20±2.05 ^b	760.87±1.02 ^a
49	932.70±1.15 ^d	947.27±5.78 ^c	959.07±0.81 ^b	966.17±2.04 ^a
56	1129.37±1.61 ^{cd}	1147.03±4.45 ^{bc}	1161.13±12.2 ^{ab}	1170.67±3.48 ^a

Each value is a mean of three replicates.

Means bearing different superscripts, differ significantly (P<0.05) row wise.

Table-3 : Effect of neem on mean weekly weight gain (g/bird) of Kuroiler chicken.

Week	Treatments			
	T ₁	T ₂	T ₃	T ₄
1	41.50±2.20 ^d	50.23±0.50 ^{bc}	52.07±0.40 ^{ab}	54.10±0.30 ^a
2	54.47±3.34 ^{cd}	59.30±0.60 ^{bc}	62.23±0.80 ^{ab}	68.17±1.10 ^a
3	81.30±6.52 ^{abcd}	80.83±2.50 ^{abc}	85.23±2.10 ^{ab}	86.40±1.30 ^a
4	138.77±5.65 ^a	132.13±1.50 ^{abc}	130.90±2.20 ^{abcd}	136.70±1.20 ^{ab}
5	189.10±2.94 ^{abc}	193.57±3.30 ^a	189.93±1.50 ^{ab}	180.37±4.20 ^{bcd}
6	195.37±2.76 ^{abc}	194.30±0.750 ^{bcd}	201.00±2.70 ^{ab}	204.33±4.10 ^a
7	201.20±0.40 ^a	205.90±2.40 ^{ab}	206.87±2.50 ^a	205.30±1.40 ^a
8	196.67±1.20 ^a	199.77±2.50 ^a	202.07±12.90 ^a	204.50±5.40 ^a

Each value is a mean of three replicates.

Means bearing different superscripts, differ significantly (P<0.05) row wise.

Feed conversion ratio : Feed conversion ratio is a measure of efficiency of utilization of feed for body weight gain. The weekly and overall feed conversion ratio (FCR) for each group was calculated by following formula.

$$FCR = \frac{\text{Total feed consumed}}{\text{Body weight gain}}$$

Statistical analysis : Data obtained were subjected to statistical analysis as per Snedecor and Cochran (1994) using Completely Randomized Design (CRD). All the data were subjected to ANOVA using the General Linear Models procedure. The mean difference among different treatments were separated by Duncan's multiple range tests. Consequently, a level of (P<0.05) was used as the criterion for statistical significance (Duncan, 1955).

Results and Discussion

Growth performance

Body weight : In present investigation the chicks of one day old were selected and the weekly body weight of chicks was recorded. The initial body weight of chicks in group (T₁), (T₂), (T₃) and (T₄) were recorded as 31.00, 31.00, 30.83 and 30.80 g at an age of one day old and final body weight of chicks at the end of experiment as 1129.37, 1147.03, 1161.13 and 1170.67g, respectively. There was a progressive increase in body weight in all the groups. The weekly body weight of chicks of different groups is presented in table-2.

The result of body weight in investigation were found similar reported by Pagrut *et al.* (2018). Similar trend was reported by Deka *et al.* (2019) and Kharde and Soujanya

Table-4 : Effect of neem on mean weekly feed intake (g/bird) of Kuroiler chicken.

Weeks	Treatments			
	T ₁	T ₂	T ₃	T ₄
1	52.33±0.2 ^a	52.00±0.20 ^{ab}	50.53±0.30 ^c	48.93±0.60 ^d
2	110.33±1.10 ^{bc}	102.00±1.10 ^a	96.83±0.60 ^d	110.40±0.30 ^b
3	180.33±1.30 ^b	159.33±1.80 ^c	153.00±0.60 ^d	194.00±2.30 ^a
4	314.73±2.60 ^a	290.00±3.00 ^c	285.67±2.80 ^{cd}	312.33±2.80 ^{ab}
5	500.67±6.00 ^a	479.00±5.20 ^{bcd}	471.33±6.60 ^{bc}	486.00±4.60 ^{ab}
6	603.00±2.60 ^{ab}	573.00±3.00 ^{bc}	567.67±3.10 ^{bcd}	603.68±4.00 ^a
7	680.00±6.40 ^b	679.67±0.90 ^{bc}	658.00±2.50 ^d	694.00±2.90 ^a
8	729.67±4.50 ^b	716.67±6.10 ^{bc}	703.33±5.20 ^{cd}	756.67±3.90 ^a

Each value is a mean of three replicates.

Means bearing different superscripts, differ significantly (P<0.05) row wise.

Table-5 : Effect of neem on mean weekly Feed conversion ratio of Kuroiler chicken.

Week	Treatment			
	T ₁	T ₂	T ₃	T ₄
1	1.27±0.07 ^a	1.04±0.01 ^b	0.97±0.01 ^c	0.90±0.015 ^d
2	2.04±0.14 ^a	1.72±0.02 ^b	1.56±0.01 ^{bcd}	1.62±0.02 ^{bc}
3	2.25±0.21 ^{ab}	1.97±0.04 ^{bc}	1.80±0.05 ^{cd}	2.25±0.06 ^a
4	2.28±0.10 ^{ab}	2.20±0.03 ^{abc}	2.18±0.05 ^{abcd}	2.28±0.01 ^a
5	2.65±0.07 ^{ab}	2.48±0.02 ^{bc}	2.48±0.05 ^{bcd}	2.70±0.09 ^a
6	3.09±0.05 ^a	2.95±0.01 ^{abc}	2.83±0.05 ^{bcd}	2.96±0.08 ^{ab}
7	3.38±0.03 ^{ab}	3.30±0.04 ^c	3.18±0.04 ^d	3.38±0.02 ^a
8	3.71±0.04 ^{ab}	3.59±0.07 ^{abc}	3.51±0.25 ^{abcd}	3.71±0.10 ^a

Each value is a mean of three replicates.

Means bearing different superscripts, differ significantly (P<0.05) row wise.

(2014) and Nnenna *et al.* (2013) and Karangiya *et al.* (2016). These Values are in agreement with findings by Wankar *et al.* (2009), Durrani *et al.* (2008), Abujradah *et al.* (2018) and Ansari *et al.* (2012) recorded the similar effect of the levels of *Azadirachta indica* dried leaf meal as phytogetic feed additive on the growth performance broiler chicks.

Weekly body weight gain : The weekly body weight Gain in gram (Table-3) was recorded at the age of one week, the weight gain in T₄ group was found significantly higher than other. The weekly weight gain is highest in 7th week rang from (201.20 to 205.50) than the other treatment group. However, the minimum growth was recorded in T₃ at 4th week, in T₄ at 5th week and maximum growth was recorded in T₁ at 4th (138.77g) and in T₃ at 5th week (193.57g).

The weekly body weight was constantly high of T₄ and the result of body weight gain were similar trend reported by Anurag *et al.* (2018), Wankar *et al.* (2009), Alam *et al.* (2015) and Khatun *et al.* (2013). Similar trend reported by Ansari *et al.* (2012), Dhansing *et al.* (2006) and Beg *et al.* (2018).

Feed consumption : The mean feed consumption per bird at weekly intermission under different treatments is present in table-4. the mean feed consumption of Kuroiler chicken during 8th week of experiment continue significantly lower treatment group T₃ as compare to other groups control or treatment group T₂ and T₄. However, the minimum feed consumption in T₄ at 1st week and the maximum in T₁ at the age of 4th week (314.73g) and 5th week (500.67g). There was significantly higher feed consumption in T₄ as compare to other treatment groups.

Similar results reported by Deka *et al.* (2019), Wankar *et al.* (2009), Abujradah *et al.* (2018) and Devender (2016). These Values are in agreement with findings by Pagrut *et al.* (2018) and Anurag *et al.* (2018) found the similar feed consumption. However, Karangiya *et al.* (2016) recorded similar results of feed consumption.

Feed conversion ratio : In the present investigation weekly feed conversion ratio (FCR) of Kuroiler chicken provided chicks feed with supplementation of neem (*Azardirechtra indica*) is presented in table-5. The feed conversion ratio of T₁ is significantly higher than the other treatment groups. The data of FCR for T₁ group were

1.27, 2.04, 2.25, 2.28, 2.26, 3.09, 3.38 and 3.71. The FCR of T₃ group is comparatively lowest than other groups during all week of age. The minimum FCR ratio of T₄ at age of 1 week as compare to control and other treatment groups, after 1 week the FCR of T₄ was constantly increasing and the data of FCR for T₄ group were 0.90, 1.62, 2.25, 2.28, 2.70, 2.96, 3.38 and 3.71.

The result of feed conversion ratio in the investigation were found similar reported by Abujradah *et al.* (2018), Ansari *et al.* (2012), Pagrut *et al.* (2018), Borgohain *et al.* (2017), Durrani *et al.* (2008), and Devender (2016), respectively.

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Conclusions

Thus, it concluded that, Average body weight gain was significantly ($p < 0.05$) higher in T₄ (204.50±5.40) as compare to control group and other treatment groups. Average feed consumption ratio was significantly ($P < 0.05$) higher in T₁ group as compare to treated groups and control group. The feed conversion ratio was significantly ($P < 0.05$) higher in T₄ and control group T₁ as compare to treated group T₂ and T₃ groups. The supplementation of neem @ 6g/kg level was found advantageous in improving body weight, weekly weight gain, feed conversion ratio.

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Constraints Faced by Sheep Farmers in Tonk District of Rajasthan

Goatm Chopra^{1*}, Ramesh Pandey², Jhabar Mal Tetarwal², Om Prakash Chaudhary¹, Subhash Yadav¹ and Priyanka Kayath¹

¹Department of Animal Husbandry and Dairying, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

²Department of Animal Production, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, 313001

*Corresponding Author Email : goutamchopra997@gmail.com

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. The results of the study showed that technical and input were the major constraints, with the first rank, followed by social constraints and institutional constraints with rank second and third respectively. The major constraints are poor availability of good quality rams under technical constraints, lack of water under inputs, low wool prices under institutional and low literacy rates of farmers under social constraints.

Key words : sheep, constraints, farmers, Tonk.

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.

Rajasthan state has livestock population of 56.80 million (11 per cent) of India contributing nearly 41.5 million Kg. of wool and 187 million tons of milk and 7.4 million tons of meat production to the country during year 2019. In Rajasthan, livestock population comprises large and small ruminants. Cattle and buffaloes are the main large animals while sheep and goats are the major small ruminants. According to estimates of the recent Livestock census, the share of cattle population was about 21 per cent and buffaloes constitutes about one-fifth of the total population.

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 adoptable to a wide range of environmental conditions. 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".

The Rajasthan state has 7.9 million sheep as per 20th livestock census and ranks 4th in India. During 2001-02 wool production stands at the modest level of 19.67 million kg and from that year to present year (2012-13) there was a continue decrease (14.07 million kg) in the wool production. Because there was continues decrease in the sheep population in the state and demand for the sheep meat is increasing day by day. Sheep forms a key component of Indian livestock biodiversity. They are lifeline for many marginal farmers and landless labourers surviving in adverse climatic

Table-1 : Technical Constraints.

S. No.	Technical Constraints	Constraints faced by sheep farmers (Per cent)				Score	Rank
		4	3	2	1		
1.	Poor availability of good quality rams	29	40	31	0	2.98	1
2.	Low conception rate	6	32	59	3	2.41	4
3.	Lack of knowledge on nutrition	0	12	79	9	2.03	5
4.	Poor knowledge of disease management	20	41	39	0	2.81	2
5.	High rate of abortion	6	50	34	10	2.52	3

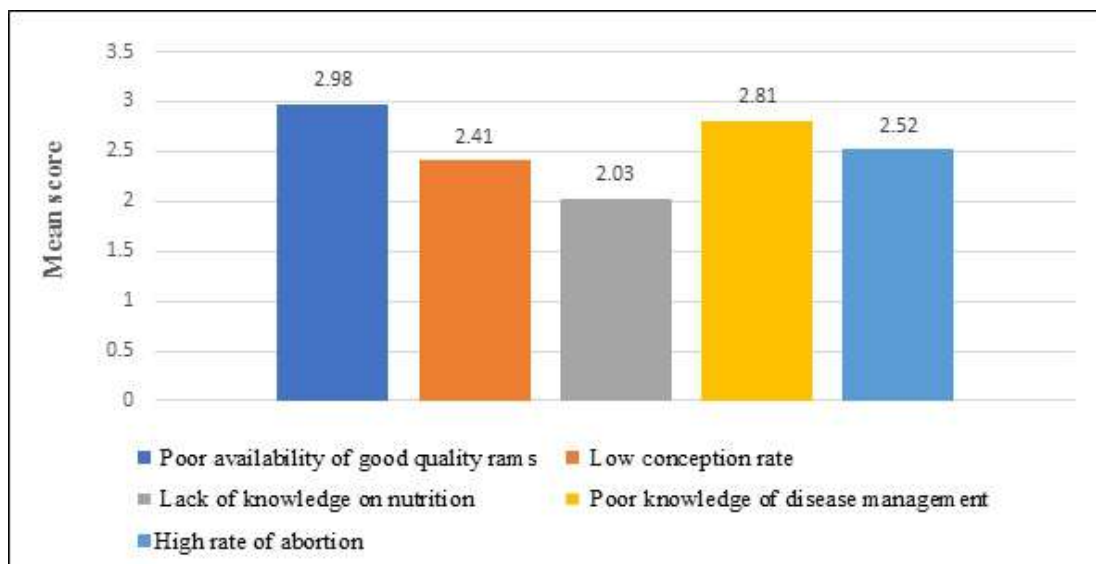


Fig.-1 : Technical constraints.

conditions (Arora et al. 2011). The production of wool, meat and manure provides different sources of income generation to the shepherd.

Most of the farmers faced hurdles in sheep rearing because of lack of awareness about scientific management practices and lack of access to veterinary services.

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.

Constraints faced by sheep farmers the major constraints in sheep rearing were identified based on

literature and discussion with scientists and progressive farmers. The constraints were classified into four groups: technical, input, institutional and social.

To analysis the collected information, several basic statistical tools and methods were used. The following statistical treatments were used for interpretation of data :

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

Mean score ranking : This technique was used to evolve the constraints faced by the sheep rearers in sheep rearing. In this method the respondent were asked to score the problem according to the occurrence of the problem. Like always, very often, sometimes and never and the magnitude for these were 4,3,2 and 1. After giving score by all respondent mean score of that problem was calculated and the problem was ranked, higher rank was given to a problem having higher score.

Rank : Ranks were accorded in the descending order according to the mean per cent score obtained. This was used to find out the constraint's severity in order of priority.

Results and Discussion

Constraints faced by sheep farmers : The major

Table-2 : Input constraints

S. No.	Input constraints	Constraints faced by sheep farmers (Per cent)				Score	Rank
		4	3	2	1		
1.	High cost of feed	3	30	50	17	2.19	4
2.	Fodder scarcity	20	58	22	0	2.98	2
3.	Unavailability of medicine	6	40	43	11	2.41	3
4.	High cost of medicine	6	29	43	22	2.19	4
5.	Water scarcity	36	31	30	3	3.00	1

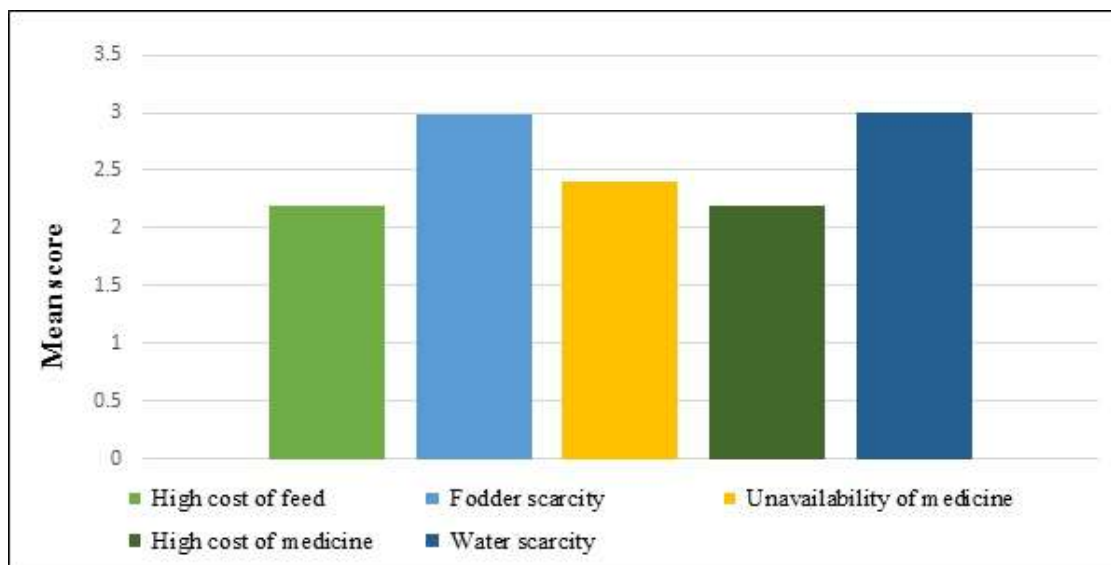


Fig-2 : Input constraints.

constraints in sheep rearing were identified based on literature and discussion with scientists and progressive farmers. The constraints were classified into four groups: technical, input, institutional and social. The major constraints under the technical category were poor availability of superior quality of breeding rams, poor conception rate of ewes, lack of knowledge on feed management, inadequate knowledge on disease management and high rate of abortion. Low availability of water, high cost of feed, lack of fodder availability, poor availability of medicine and high cost of medicine were included under the input category. The constraints under the institutional factors were low price of wool, absence of wool grading during marketing, lack of market for sheep milk, poor credit facility for undertaking sheep farming, high interest rate of non-institutional credit, poor sale value of sheep milk, absence of market for live animals, poor marketing infrastructure for live sheep and poor market information. The social category constraints were low literacy of farmers, poor extension facility and low prestige associated with the sheep farming. Mean score ranking technique was used to identify and rank the problems associated with the sheep farmers. The farmers were asked to rank these problems on a four-point continuum of always, very often, sometimes and never, which carried weight ages of 4, 3, 2 and 1, respectively.

The intensity of the problems was highest with the highest score.

Technical Constraints : Technical Constraints faced by the sheep farmer were analyzed and are presented in the table-1 and fig.-1.

The major constraints under technical category were found to be problem of good quality breeding rams with 2.98 score got highest rank followed by poor knowledge of disease management with 2.81 score, high rate of abortion with 2.52, low conception rate with 2.41 score and lack of knowledge on nutrition with 2.03 score.

These findings are in line with the findings of Dinesh Kumar *et al.* (2006), Suresh *et al.* (2008) and Rajanna *et al.* (2012).

Input constraints : The results showing various input constraints faced by the farmers were analyzed and are presented in the table-2 and fig.-2. Among the input constraints, the problem of water scarcity was reported by 36per cent of the farmers which is always occurring in the area under study. Another major problem found to be poor availability of green and dry fodder which was reported by 20per cent respondent. The above problems used to occur very often as reported by 31 and 58per cent of farmers respectively. As far as ranking is concerned Water scarcity

Table-3 : Institutional constraints.

S. No.	Institutional constraints	Constraints faced by sheep farmers (Per cent)				Score	Rank
		4	3	2	1		
1.	Low wool price	28	41	27	4	2.86	1
2.	Poor sale value of sheep milk	0	4	71	25	1.79	5
3.	No regular market for live sheep	0	21	57	22	1.99	4
4.	Poor infrastructure for marketing	6	55	24	15	2.52	3
5.	Lack of market information	27	34	34	9	2.75	2

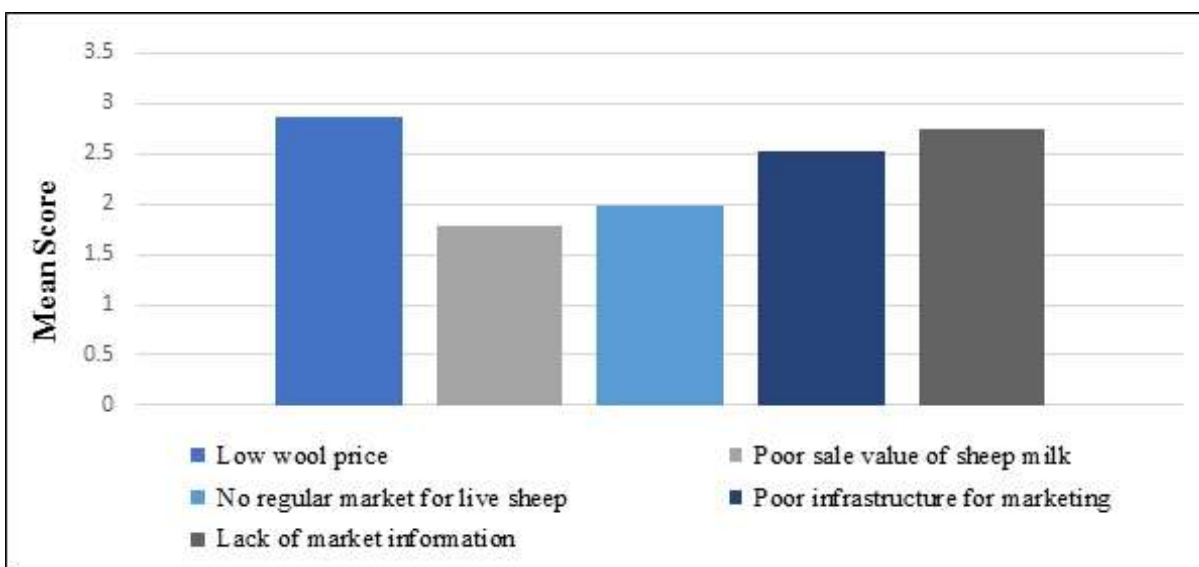


Fig-3 : Institutional constraints.

got highest ranking followed by fodder scarcity, unavailability of medicines, high cost of medicine and high cost of feed. The most important source of fodder is the common grazing land. The area under the common grazing land was declining due to overgrazing and conversion of these lands for other purpose. These finding are supported by Selvakumar (2003) and Singh *et al.* (2006).

Institutional constraints : Institutional constraints faced by the farmers were analyzed and are presented in the table-3 and fig.-3. The major constraints under institutional category were poor infrastructure for marketing, low wool price and lack of market information as these problems occurs very often and reported by 55, 41 and 30 per cent of sheep farmers respectively. As far as ranking is concerned low wool price got highest rank followed by lack of market information, poor infrastructure for market, unavailability of regular market for sheep and poor sale value of sheep milk. These finding are supported by Kuldepporwal *et al.*, (2006) Singh *et al.* (2006) and Rajanna *et al.* (2012).

Social constraints : Social constraints faced by the farmers were analyzed and are presented in the table-4 and fig.-4. The major constraint under social constraints was the low literacy of the farmers which is reported by 46

per cent of sheep farmers and always occurring in the study area. The literacy rate is a factor, which helps the farmers to acquire knowledge regarding improved practices. It is proved to impart significant influence on the technology adoption process. Another major constraint according to ranking is concerned were the lower priority attached to sheep in extension services compared to that offered to large ruminants like buffalo and cattle and low prestige associated with sheep rearing as these constraints are reported very often by 20 and 21 per cent of sheep farmers. Moreover, the sheep production is generally considered as the occupation of the weaker section of the society and draws poor prestige. Therefore, the younger generation is gradually getting disinterested in this profession. These findings are in accordance with the findings obtained by Suresh *et al.* (2008).

Overall constraints : Overall constraints faced by the farmers were analyzed and are presented in the table-5 and fig.-5. The results of the study showed that technical and input were the major constraints, with the first rank, followed by social constraints and institutional constraints with rank second and third respectively. These finding are supported by Selvakumar (2003), Singh *et al.* (2006) and Rajanna *et al.* (2012).

Table-4 : Social constraints.

S. No.	Social constraints	Constraints faced by sheep farmers (Per cent)				Score	Rank
		4	3	2	1		
1.	Low literacy rate of farmers	46	31	20	3	3.20	1
2.	Impaired access to extension facility	13	20	45	22	2.24	2
3.	Low prestige associated with sheep rearing	0	21	60	19	2.02	3

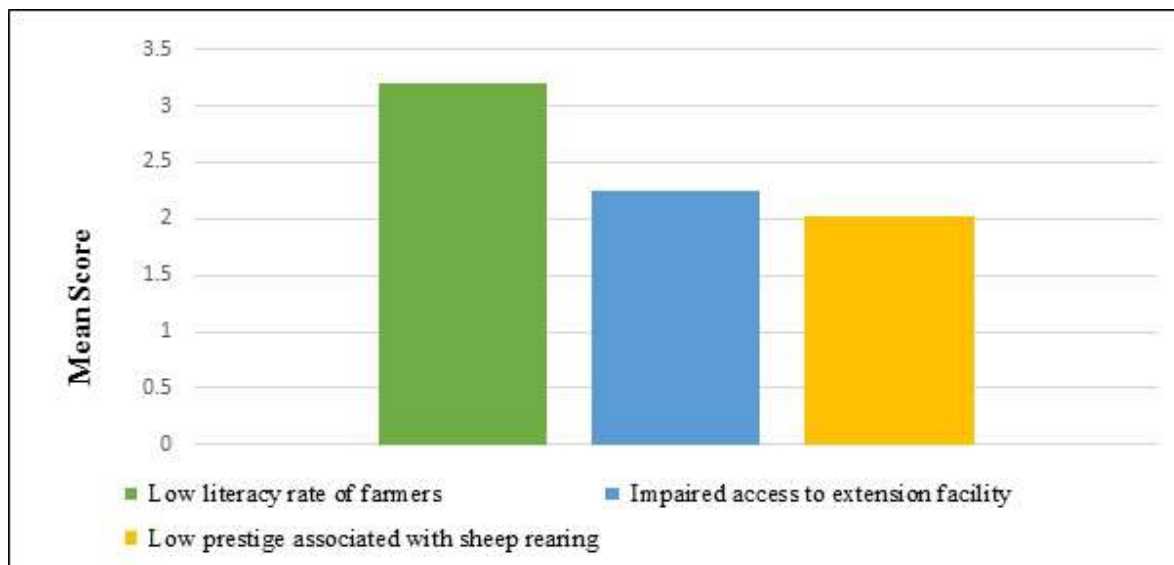


Fig-4 : Social constraints.

Table-5 : Overall constraints.

S. No.	Constraints	Constraints faced by sheep farmers (Per cent)				Score	Rank
		4	3	2	1		
1.	Technical Constraints	12.2	35	48.4	4.4	2.55	1
2.	Input constraints	14.2	37.6	37.6	10.6	2.554	1
3.	Institutional	12	31	42	15	2.40	3
4.	Social constraints	19.67	24	41.67	14.67	2.49	2

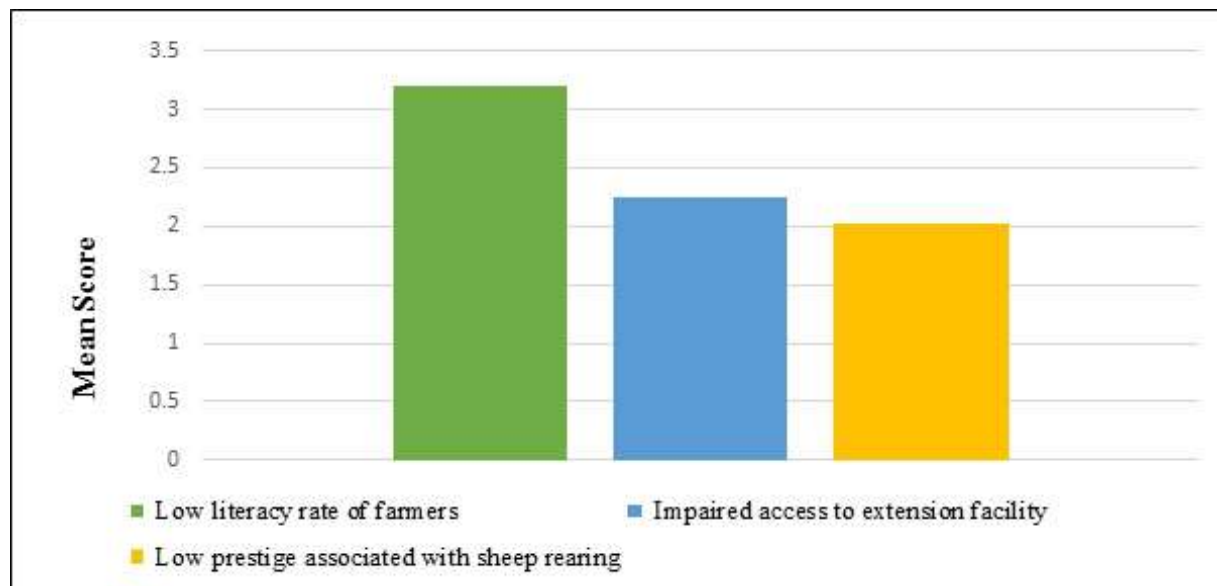


Fig-4 : Social constraints.

Conclusions

It can be concluded from the results of the present study that most of the shepherds faced technical and input constraints as they were following the traditional methods of sheep rearing in the absence of any scientific management practices and access to veterinary services.

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Genetic Variability, Heritability and Character Association Studies for Yield and its Attributing Traits in Rice (*Oryza Sativa* L.)

Rajpal Singh^{1*}, Manoj Kumar², Sandhya², Yamini Tak³, B.L. Nagar⁴ and Ravi Kishan Soni¹

¹Department of Genetics and Plant Breeding, College of Agriculture, Ummadganj, Kota (AU, Kota Rajasthan)

²Department of Genetics and Plant Breeding, Agriculture Research Station, Ummadganj, Kota (AU, Kota Rajasthan)

³Department of Biochemistry, College of Agriculture, Ummadganj, Kota (AU, Kota Rajasthan)

⁴Department of Horticulture, Agriculture Research Station, Ummadganj, Kota (AU, Kota Rajasthan)

*Corresponding Author Email : manoj.vishnoi108@gmail.com

Abstract

An experiment was conducted to estimate genetic variability, correlation and path coefficient in 30 diverse genotypes of rice (*Oryza sativa* L.) grown in Randomized Block Design during *Kharif*2020. The analysis of variance indicated the existence of significant differences among all the genotypes for all the characters studied. Highest GCV and PCV were recorded for grain yield per plant followed by test weight (g), number of effective tillers per plant, bran oil content (%) and number of grains/ panicle (g) indicating the presence of good amount of genetic variability for these characters so, direct selection for these characters would be effective. Higher heritability with high genetic advance as per cent mean recorded for the traits like test weight (g), bran oil content (%) and grain yield per plant (g) indicating the involvement of additive gene action in the inheritance of these traits hence simple selection would be rewarding. The results of character association study indicated that grain yield per plant had higher significant and positive correlation with test weight, number of grains/ panicle, number of panicles/ m², number of effective tillers per plant and panicle length. The path analysis revealed that the traits like test weight, number of grains/ panicle, days to 50% flowering and number of effective tillers per plant showed direct and positive effect on seed yield per plant.

Key words : Genetic variability, heritability, correlation, path analysis, grain yield, *Oryza sativa*.

Introduction

Rice is the backbone of livelihood for millions of rural families and plays an essential role in the country's food security, so the term "rice is life" is most suitable in case of India (Mahajan *et al.*, 2017 and Dhillon *et al.*, 2021). "Rice is life" was the famous theme of International Year of Rice, 2004 indicating importance of rice as an over whelming item of food and commerce. It is a central part of many Indian cultures also. It has influenced its consumer's cultures and dietary habits due to which few countries credit rice cultivation as the development of their civilization. Rice contains 80% carbohydrates, 7-8% protein and also fat and dietary fibre (Juliano, 1985). It can contribute, nutritionally, significant amounts of thiamine, riboflavin, niacin, and zinc. Rice is the second most important pillar of food security for the humankind, next to wheat. Green revolution resulted in increase in rice production and productivity across the globe endowing us with semi-dwarf and high yielding varieties. Rice production of world during 2020-21 was 782 million tone in the area of 167.1 million hectares with the productivity of 4679 kg/ha. In India rice is grown in an area of about 43.78 million hectares which accounts about 26 per cent of the world's total acreage with the production of 118.43 million tones and productivity 2705 kg/ha. (Anonymous 2020-21).

Knowledge of genetic variability existing among different genotypes for different characters is important for crop improvement. Correlation and path coefficient analysis are also important tools to understand the interrelationship of various characters, which helps in selection programme to be adopted by a plant breeder for rapid genetic enhancement.

Materials and Methods

The present study was carried out during *Kharif*, 2020 at Agricultural Research Station, Ummadganj, Agriculture University, Kota (Raj.) The experiment was laid out in a Randomized Block Design with three replications. Each genotype transplanted in plot of 10 m² having ten rows of five-meter length. Row to row (20cm) and plant to plant (10cm) distance was maintained, respectively. The observations were recorded on five randomly selected plants per plot for characters *viz.*, plant height (cm), number of effective tillers per plant, panicle length (cm), number of panicles/ m², number of grains/ panicle, test weight (g), amylose content (%), bran oil content (%), and grain yield per plant (g) whereas, the observations for days to 50 % flowering and days to maturity was recorded on plot basis. Analysis of variance for the design of experiment was done using the method suggested by Panse and Sukhatme (1985). Genotypic and phenotypic

Table-1 : Analysis of variance for yield and its attributing traits in rice genotypes.

Source of variation	Degree of freedom	Mean sum of square										
		Days to 50% Flowering	Days to maturity	Plant height (cm)	Number of effective tillers Per Plant	Panicle length (cm)	Number of panicles/ m ²	Number of grains/ panicle	Test weight (g)	Amylose content percent	Bran oil content percent	Grain yield per plant (g)
Replication	2	2.21	5.41	4.59	0.34	1.51	914.74	43.54	0.07	0.65	0.47	0.08
Genotypes	29	27.46**	64.14**	139.17**	5.33**	11.02**	865.21**	960.03**	43.57**	4.72 **	5.40**	77.84**
Error	58	4.84	7.64	7.54	0.58	0.87	336.98	215.54	0.31	0.35	0.11	3.32

*,** Significant at 5 and 1 per cent level, respectively.

Table-2 : Genetic variability parameters for yield and its attributing traits in rice genotypes.

Sr. No.	Characters	Range	Mean	GCV (%)	PCV (%)	Heritability % (bs)	Genetic advance	Genetic Advance as % of mean
1.	Days to 50% flowering	94.33-104.33	99.15	2.76	3.54	60.89	4.41	4.45
2.	Days to maturity	124-140.00	131.54	3.31	3.91	71.96	7.62	5.79
3.	Plant height (cm)	91.66-119.56	109.09	6.03	6.55	84.68	12.47	11.44
4.	No. of effective tillers per plant	8.33-13.66	11.31	11.12	13.01	72.97	2.21	19.56
5.	Panicle length (cm)	21.06-27.80	24.39	7.54	8.45	79.44	3.37	13.84
6.	Number of panicles/m ²	219.66-285	251.81	5.33	8.94	35.62	16.53	6.56
7.	Number of grains/panicle	124-185.33	155.87	10.10	13.81	53.51	23.74	15.23
8.	Test weight (g)	14.73-28.06	23.12	16.40	16.58	97.88	7.73	33.43
9.	Amylose content (%)	22.26-26.76	25.20	4.78	5.34	80.17	2.22	8.82
10.	Bran oil content (%)	10.76-16.50	12.86	10.32	10.65	93.95	2.65	20.61
11.	Grain yield per plant (g)	11.50-28.63	19.91	25.03	26.65	88.20	9.64	48.42

correlation coefficients were worked out by a method described by Singh and Chaudhary (1979). The estimates of direct and indirect effects were calculated by the path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

Results and Discussion

The analysis of variance showed highly significant differences among the 30 genotypes in respect of all the 11 characters under study indicating presence of good amount of variability in the genotypes used for present investigation (Table-1). In the present investigation, the phenotypic coefficient of variation was found to be higher in magnitude than the genotypic coefficient of Variation with small differences, which indicate less environmental influence on the expression of all the traits (Table-2). These results were similar with the earlier results of Babu *et al.* (2012) and Jadhav *et al.* (2020). The highest PCV and GCV were recorded for grain yield per plant in the agreement of the findings reported by Nayak *et al.* (2016) and Gour *et al.* (2017). Moderate GCV and PCV was observed in test weight (g) followed by number of effective tillers per plant, Number of grains/panicle and bran oil content percent whereas low GCV and PCV were reported for characters like day to 50% flowering, day to maturity, plant height (cm), panicle length (cm) and amylose content (%) these results are with similar of earlier finding

of Babu *et al.* (2012), Dhakal *et al.* (2020), Keerthiraj and Biju (2020) and Parmar *et al.*, (2021)

Higher heritability was recorded in test weight (g), followed by bran oil content percent, grain yield per plant (g), plant length (cm), and amylose content (%) similar finding was earlier reported by Babu *et al.* (2012), Nayak *et al.* (2016) and Jadhav *et al.* (2020). High genetic advance as per cent of mean was expressed by grain yield per plant followed by test weight (g) and amylose content percent. This finding was in agreement with Nayak *et al.* (2016), Jadhav *et al.* (2020) and Nath and Kole (2021). Moderate genetic advance as per cent of mean was expressed by plant height (cm), number of effective tillers per plant, panicle length (cm) and number of grains/panicle. This finding was in agreement with Jadhav *et al.* (2020), Dhakal *et al.* (2020) and Singh *et al.* (2020).

The efficiency of selection can be increased, if it is simultaneously practiced for characters which are correlated with yield. In the quantitative traits, the genotype is influenced by the environment, thereby, affecting the phenotypic expression as well as association and consequently direction of association between the characters. The knowledge of magnitude and direction of correlation is used for judging how improvement in one character will bring simultaneous change in the other

Table-3 : phenotypic (P) and genotypic (G) correlation coefficient among different traits in rice genotypes.

Characters	Days to 50% flowering	Days to Maturity	Plant height (cm)	Number of effective tillers per plant	Panicle length (cm)	Number of panicles/m ²	Number of grains/panicle	Test weight (g)	Amylose content (%)	Bran oil content (%)	Grain yield per plant (g)
Days to 50% flowering	1.000	0.934**	0.175	-0.169	0.150	0.003	-0.111	-0.184	-0.054	0.003	-0.195
Days to maturity	1.000	0.974**	0.304**	-0.263*	0.141	-0.004	-0.183	-0.226*	-0.104	0.045	-0.240*
Plant height (cm)		1.000	0.168	-0.228*	0.135	-0.004	-0.156	-0.197	-0.015	0.017	-0.268*
			0.248*	-0.305**	0.128	-0.045	-0.276**	-0.236*	-0.056	0.050	-0.330**
			1.000	0.010	0.353**	-0.054	0.051	-0.029	0.113	-0.049	0.024
			1.000	0.024	0.431**	-0.002	0.073	-0.027	-0.115	-0.060	0.035
Number of effective tillers/plant				1.000	0.293**	0.411**	0.400**	0.462**	-0.371**	-0.094	0.594**
				1.000	0.655**	0.632**	0.632**	0.552**	0.426**	-0.110	0.741**
Panicle length (cm)					1.000	0.150	0.035	0.521**	-0.307**	-0.219*	0.282**
						0.105	-0.005	0.600**	-0.393**	-0.222*	0.324**
Number of panicles/m ²						1.000	0.685**	0.385**	0.276**	0.135	0.612**
							1.039	0.625**	-0.450**	0.283**	0.943**
Number of grains/panicle							1.000	0.366**	-0.132	0.049	0.758**
								0.487**	-0.182	0.066	0.886**
Test weight (g)								1.000	-0.310**	-0.116	0.761**
									-0.352**	-0.120	0.789**
Amylose content (%)									1.000	-0.242*	-0.332**
										-0.256*	-0.376**
Bran oil content (%)										1.000	-0.045
											-0.050

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

characters. High magnitude of positive correlation coefficient at genotypic level between component characters and yield is important for indirect selection for yield. Since, suitable test for significance of genotypic correlation coefficients is not available, therefore, major emphasis has been put on phenotypic correlation coefficients.

In general, the genotypic correlation coefficients were higher than the respective phenotypic correlation coefficients which might be from the modifying effect of environment on the association of characters at phenotypic level. Selection of yield as such may not be effective since there may be number of genes for yield per se and yield may be resultant of interaction among various components. Knowledge of relation between yield and its components is essential and selection for one component may bring about as imultaneous change in the other. Therefore, a rational approach to improve yield is to collect information on character association. Hence, under the present investigation, the phenotypic and genotypic correlation coefficients were worked out for grain yield and yield related characters

The correlation coefficients between grain yield per plant and its component characters were estimated at genotypic and phenotypic levels (Table-3). The genotypic correlation coefficient was higher than phenotypic correlation coefficient for all the traits thus suggested that the observed relationship among the characters was due to genetic factors or it might be due to modified effect of environment on character association at the genetic level. Grain yield/plant exhibited positive and significant association with number of effective tillers per plant, panicle length (cm), number of panicles/m², number of grains/panicle and test weight (g) at the phenotypic and genotypic levels, indicates that grain yield of rice can be improved by selecting genotypes having higher performances for these characters. These results were in accordance with the result of Nayak *et al.* (2016), Rathod *et al.* (2017), and Lakshmi *et al.* (2020) Kumar and Kumar (2021).

In the present study, path coefficient analysis was computed both at genotypic and phenotypic levels for all the characters. Path coefficient analysis was carried out by taking grain yield per plant as dependent variable to partition the correlation coefficient into direct and indirect effect in order to determine the contribution of different characters towards the grain yield per plant. Direct and indirect effect of various characters on grain yield per plant indicated that there is agreement between direction and magnitude of direct effect of various characters and correlation with grain yield per

Table-4 : Phenotypic and genotypic path coefficient for grain yield per plant in rice.

Characters		Days to 50% flowering	Days to Maturity	Plant height (cm)	No. of effective tillers/plant	Panicle length (cm)	Number of panicles/m ²	Number of grains/panicle	Test weight (g)	Amylose content (%)	Bran oil content (%)	Correlation with grain yield per plant
Day to 50% flowering	P	0.2484	-0.2749	0.0074	-0.0182	-0.0125	0.0001	-0.0519	0.09772	0.0040	-0.0001	-0.195
	G	0.4992	-0.5317	-0.0163	-0.0192	0.0094	-0.0001	-0.1039	0.0827	0.0072	-0.0019	-0.240*
Day to maturity	P	0.2321	-0.2943	0.0070	-0.0247	-0.0113	-0.0001	-0.0728	-0.1045	0.0011	-0.0005	-0.268*
	G	0.4860	-0.5461	-0.0133	-0.0223	0.0086	-0.0012	-0.1563	-0.0865	0.0038	-0.0022	-0.330*
Plant height (cm)	P	0.0435	-0.0494	0.0421	0.0010	-0.0295	-0.0021	0.0236	-0.0150	0.0085	0.0016	0.024
	G	0.1515	-0.1356	-0.0537	0.0017	0.0289	-0.00006	0.0414	-0.0099	0.0080	0.0026	0.035
Number of effective tillers/plant	P	-0.0419	0.0672	0.0004	0.1081	-0.0194	0.0162	0.1874	0.2445	0.0279	0.0030	0.594**
	G	-0.1312	0.1666	-0.0013	0.0732	0.0196	0.0188	0.3580	0.2022	0.0297	0.0048	0.741**
Panicle length (cm)	P	0.0372	-0.0398	0.0149	0.0251	-0.0835	0.0059	0.0161	0.2760	0.0232	0.0071	0.282**
	G	0.0705	-0.0700	-0.0231	0.0215	0.0671	0.0030	-0.0028	0.2201	0.0274	0.0098	0.324**
Number of panicles/m ²	P	0.0008	0.0012	-0.0022	0.0444	-0.0125	0.0395	0.3204	0.2037	0.0208	-0.0044	0.612**
	G	-0.0020	0.0244	0.0001	0.0479	0.0070	0.0287	0.5888	0.2291	0.0314	-0.0124	0.943**
Number of grains/panicle	P	-0.0275	0.0457	0.0021	0.0432	-0.0028	0.0271	0.4681	0.1940	0.0099	-0.0015	0.758**
	G	-0.0915	0.1506	-0.0039	0.0463	-0.0003	0.0298	0.5666	0.1786	0.0126	-0.0029	0.886**
Test weight (g)	P	-0.0456	0.0581	-0.0012	0.0499	-0.0435	0.0152	0.1715	0.5294	0.0233	0.0037	0.761**
	G	-0.1127	0.1288	0.0014	0.0404	0.0403	0.0179	0.2760	0.3666	0.0245	0.0053	0.789**
Amylose content (%)	P	-0.0133	0.0042	-0.0047	-0.0400	0.0256	-0.0109	-0.0617	-0.1640	-0.0754	0.0079	-0.332**
	G	-0.0518	0.0304	0.0062	-0.0311	-0.0264	-0.0129	-0.1028	-0.1289	-0.0698	0.0112	-0.376**
Bran oil content (%)	P	0.0008	-0.0049	-0.0020	-0.0101	0.0182	0.0053	0.0227	-0.0612	0.0182	-0.0325	-0.045
	G	0.0223	-0.0274	0.0032	-0.0080	-0.0149	0.0081	0.0375	-0.0441	0.0178	-0.0441	-0.050

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

plant. Thus, a significant improvement in grain yield per plant can be expected through selection in the component traits with high positive direct effect (Table-4). The highest positive direct effect on grain yield per plant was expressed by traits such as test weight followed by number of grains/ panicle, number of panicles/m², number of effective tillers per plant, and panicle length. Hence, selection for this character could bring improvement in yield and yield components. These results are in agreement to the earlier finding of Rahman *et al.* (2014), Rashmi *et al.* (2017) and Perween *et al.* (2020).

The residual effect was very low at both genotypic and phenotypic levels (0.01905 and 0.11923) which indicated appropriate choice of characters in the study that accounted for maximum variation available in the genotypes.

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Suggestions Offered by Postgraduate Students in Using Social Media

Annu Devi Gora¹, S.S. Sisodia¹ and J.L. Choudhary²

¹Department of Extension Education, RCA, MPUAT, Udaipur, Rajasthan

²Department of animal production, RCA, MPUAT, Udaipur, Rajasthan

Abstract

The present study was conducted in agriculture university of Rajasthan by selecting three agriculture colleges i.e. RCA, Udaipur, SKNCOA, Jobner and COA, Bikaner purposively. Among these three colleges selected 240 students were selected randomly. The all suggestions were tabulated on the basis of mean per cent score and further ranking of different suggestion was made with the help of its percentage score. The results of study revealed that the major suggestions offered by postgraduate students were; computers with printers should be provided in the hostels (92.50 MPS), proper internet facilities should be maintained among departments (88.47 MPS) and availability of Wi-Fi facilities on campus and hostel (87.63 MPS) got first, second and third rank respectively.

Key words : *Suggestions, social media, postgraduate students.*

Introduction

Social media are modern interactive communication channels through which people connect to one another, share ideas, experiences, pictures, messages and information of common interest. Social media provide tools by which people can communicate, share information and create new relationships. Penuel and Riel (2007) define social networking as “a set of people and the relationships between them”. This definition is found today in the social networking services that promote the development of online communities of people. These sites allow user to make new friends, chatting with friends and family, sharing pictures and ideas that they cannot do offline.

Research Methodology

The present study was conducted in Rajasthan which means “Land of Maharajas”. The state of Rajasthan consists five Agricultural Universities, out of which three agricultural universities namely Maharana Pratap University of Agriculture and Technology, Udaipur, Sri Karan Narendra Agriculture University, Jobner and Swami Keshwanand Rajasthan Agriculture University, Bikaner were selected on the basis of post graduate programmes (M.Sc. and Ph.D. in Agriculture) are running for more than 20 years in various discipline. Therefore, the selected colleges are Rajasthan College of Agriculture (MPUAT, Udaipur), SKN College of Agriculture Jobner (SKNAU, Jobner) and College of Agriculture (SKRAU, Bikaner) for the present study. From the list so prepared, 80 post graduate scholars were selected from each identified college with the help of random sampling technique. Thus, a total of 240 post graduate students were included in the

sample of study. For analyses the collected information, following statistical methods were used for interpretation.

Mean Score : It was obtained by total score of each aspect divided by total number of respondents:

$$\text{Mean Score} = \frac{\text{Total score obtained by respondents}}{\text{Total number of respondents}}$$

Results and Discussion

Suggestions from postgraduate students in using social media : Suggestions offered by postgraduate students for more effective use of social media. Each suggestion was calculated mean per cent score and assigned rank accordingly.

Data presented in table-1 revealed that “computers with printers should be providing in the hostels” as suggested by the majority of the postgraduate students were ranked first with overall 92.50 MPS. The similar ranking pattern in RCA, Udaipur, SKNCOA, Jobner and COA, Bikaner, it stands at first ranked with 90.16, 90.83 and 90.50 MPS respectively. The added reason behind due to students need to take hard copy for study purpose, we can't read everything in soft format only and even single hostel there was no facility of printer.

The next important suggestion reported that “proper internet facilities should be maintained among departments” and “availability of wi-fi facilities on campus and hostel” which was second and third ranked with 88.47 MPS and 87.63 MPS, respectively. This reason might be due to there was no availability of internet among department and hostel, now a day's students took online classes, seminar and training.

Analysis of data show that “antivirus and other

Table-1 : Suggestion of postgraduate students for more effective use of social media in academic activities.

S. N.	Suggestion	RCA Udaipur (n1=80)		SKNCOA Jobner (n2=80)		COA Bikaner (n3=80)		Overall (n=240)	
		MPS	RANK	MPS	RANK	MPS	RANK	MPS	RANK
1.	For making social media more effective, there is a need of improved software	80.00	IX	77.91	XIII	83.33	VI	80.41	IX
2.	Social media should be used to collect technical information	77.08	XIV	77.08	XV	80.00	VIII	78.05	XII
3.	Proper internet facilities should be maintained among departments	87.91	V	85.83	III	91.66	II	88.47	II
4.	Frequent awareness programmes should be organized for the users to educate them about social media	77.50	XIII	75.83	XVII	79.16	IX	77.50	XV
5.	Security of personal information on social media should be taken in account	90.00	IV	80.00	IX	77.91	XI	82.63	VI
6.	Reliability should be taken care of information available on social media	76.25	XVI	77.08	XV	78.75	X	77.36	XVI
7.	Students may be educated to use social media for academic communication	79.16	X	80.41	VIII	79.16	IX	79.58	XI
8.	Availability of academic groups on social media should be formulated, where faculty and students can share their academic information with each other.	76.66	XV	80.83	VII	81.66	VII	79.72	X
9.	The online and face-to face course components should be balanced with each other.	77.91	XII	77.50	XIV	78.75	X	78.05	XII
10.	Computer terminals should be installed to provide fast access to social media.	81.25	VIII	78.75	XI	81.66	VII	80.55	VIII
11.	The library should have a separate 24 x7 open social media section	84.16	VI	80.00	IX	79.16	IX	81.11	VII
12.	Updated information should be available on social media	77.08	XIV	78.33	XII	77.08	XII	77.50	XV
13.	Social media should be beneficial to students who are using it for academics	78.33	XI	76.25	XVI	78.75	X	77.77	XIV
14.	More research work is required on use of social media for academic use by students	76.66	XV	79.16	X	77.91	XI	77.91	XIII
15.	Availability of Wi-Fi facilities on campus and hostel	91.66	II	85.00	IV	86.25	IV	87.63	III
16.	Important sites should be opened for all the students	82.08	VII	86.25	II	88.33	III	85.55	V
17.	Antivirus and other software should be installed in the library computers	90.41	III	84.58	V	83.75	V	86.25	IV
18.	Headphones should be provided in the computer laboratory of library	77.50	XIII	83.33	VII	77.91	XI	79.58	XI
19.	Computers with printers should be provide in the hostels	94.16	I	90.83	I	92.50	I	92.50	I

software should be installed in the library computers”, “important sites should be opened for all the students”, “security of personal information on social media should be taken in account”, “the library should have a separate 24 x7 open social media section”, “computer terminals should be installed to provide fast access to social media with overall 86.25, 85.55, 82.63, 81.11 and 80.55 MPS, respectively by postgraduate students.

Further reported that the “for making social media more effective, there is a need of improved software”, “availability of academic groups on social media should be formulated, where faculty and students can share their academic information with each other”, “students may be

educated to use social media for academic communication”, “the online and face-to face course components should be balanced with each other” and “Social media should be used to collect technical information” were seen by the postgraduate students as suggestion for effective using social media with 80.41, 79.72, 79.58, 78.05 and 78.05 MPS, respectively.

Least favorable suggestion offered by students “more research work is required on use of social media for academic use by students”, “social media should be beneficial to students who are using it for academics”, “updated information should be available on social media” and “reliability should be taken care of information

available on social media” with the overall extent 77.91, 77.77, 77.50 and 77.36 MPS, respectively.

Separate analysis of data for each colleges that the least favorable suggestion offered by students of RCA, Udaipur were “reliability should be taken care of information available on social media” (76.25 MPS) followed by SKNCOA, Jobner had “frequent awareness programmes should be organized for the users to educate them about social media” (75.83 MPS) and COA Bikaner “updated information should be available on social media” (77.08 MPS) which were assigned last ranked of students.

The findings are somewhat similar to the finding of panday (2012) and doddamani (2020).

Conclusions

It can be concluded that the major suggestion were; computers with printers should be provided in the hostels , proper internet facilities should be maintained among departments and availability of Wi-Fi facilities on campus and hostel got first, second and third rank respectively.

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Effect of Different Levels of NPK and Rhizobium on Physico-Chemical Properties of Soil in Cowpea (*Vigna unguiculata* L.) var. Pusa Komal

Dinesh Kumar Sharma¹, Tarence Thomas¹, Shankar Lal Yadav², Rohan Serawat¹, Shishpal Kantwa¹, Sanwar Mal Yadav¹ and Akshay Kumar Tiwari³

¹Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj, U.P.

²Department of Soil Science and Agricultural Chemistry, RVSKVV, Gwalior, M.P.

³Department of Agronomy, RCA, MPUAT, Udaipur, Rajasthan

Abstract

A field study was conducted on the "Effect of different levels of NPK and Rhizobium on Physico-Chemical properties of soil in Cowpea (*Vigna unguiculata* L.) var. Pusa Komal" at the Soil Science and Agricultural Chemistry Research Farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during Kharif season 2018. The soil of experimental area falls in order Inceptisol and soil texture was sandy loam treatment combination $T_3-N_2R_2$ [@ 100% NPK ha⁻¹ + 100% Rhizobium ha⁻¹] combined use of NPK resulted in significant increase on enrichment of soil fertility status. Rhizobium in combination resulted in a slight increase in pH 7.64, EC 0.50dSm⁻¹. In post soil of NPK fertilizers observations were resulted in significant increase in OC 0.82%, Particle density 2.72 g cm⁻³, Bulk density 1.44 g cm⁻³, Pore space 53.05% and available N 221.45 kg ha⁻¹, P 24.10 kg ha⁻¹, K 147.82 kg ha⁻¹ as compared to T_0 (control).

Key words : Cowpea, NPK, rhizobium, physico-chemical properties of soil.

Introduction

Pulses are the main source of protein particularly for vegetarians and contribute about 14% of the total protein of average Indian diet. Production of pulses in the country is far below the requirement to meet even the minimum level per capita consumption. The per capita availability of pulses in India has been continuously decreasing which is 32.52 g day⁻¹ against the minimum requirement of 80 g day⁻¹ per capita prescribed by Indian Council of Medical Research (ICMR). Therefore, it is necessary for agricultural scientists to evolve strategy to increasing production of pulses to meet the protein requirements of increasing population of the country. Cowpea (*Vigna unguiculata* L.) is a self-pollinated leguminous crop which is grown during kharif as well as summer seasons in arid and semi-arid regions of India. It is tolerant to drought and can be grown successfully on drained loamy to sandy loam soil in areas of erratic rainfall. Cowpea is primarily a rainy season crop but with the development of early maturing varieties, it has also proved to be an ideal crop for spring and summer season. It has protein content about 24.6 % and rich source of calcium and iron. Cowpea production in Rajasthan is about 11644 tonnes from an area about 124407 hectare.

Cowpea [*Vigna unguiculata* (L.)] is also known as black eye pea, southern pea and crowder pea. It is an important legume vegetable crop. The crop is used for variety of ways, as vegetable it is grown for its long tender

green pods which are used as a vegetable. Mature but green seeds are also used as a vegetable purpose. Commonly it is used for soil fertility improvement through biological nitrogen fixation, green manuring, forage yield, production of high quality hay and silage, synthesis of nutritional products, suppression of weeds, food, and a source of protein and income generation

Materials and Methods

The investigation on "Effect of different levels of NPK and Rhizobium on Physico-Chemical properties of soil in Cowpea (*Vigna unguiculata* L.) var. Pusa Komal" comprise of a field experiment which was carried out at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during kharif season 2018-19. The details about the experiment site, soil and climate is described in this chapter together with the experimental design, layout plan, culture practice, particulars of treatments, planting material and techniques employed for the parameters.

It is situated at 25°24'23" N latitude, 81°50'38" longitude and at the altitude of 98 meter above the sea level. The area of Prayagraj 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.

Experiment will be laid out in 3x3 factorial randomized block design with three levels of NPK and Rhizobium plot size was 2x2 m² for crop seed rate is 15-20 kg ha⁻¹ (*Vigna unguiculata* L.) var. Pusa Komal. Cowpea sowing was done on in 21th July 2018 and the source of NPK and Rhizobium were Urea, SSP, MOP and Rhizobium respectively. Dose of fertilizer was applied in respective plots according to treatment allocation uniform furrows opened by about 5 cm. All the agronomic practices were carried out uniformly to raise the crop. The crop was harvested on October 2018.

Physical and Chemical analysis of soil samples

Particular	Method used
Bulk density (Mg m ⁻³)	Graduated measuring cylinder (Black 1965)
Particle density (Mg m ⁻³)	Graduated measuring cylinder (Black 1965)
Soil PH (1:2) soil water suspension (w/v)	Digital PH meter (Jackson 1958)
Soil Colour	Munshell Colour Chart
Organic carbon (%)	(Walkley and Black method 1947)
Available Nitrogen (Kg ha ⁻¹)	(Subbiah and Asija 1956)
Available Phosphorous (Kg ha ⁻¹)	Colorimetric method (Olsen et al.)
Available Potassium (Kg ha ⁻¹)	Flame photometric method (Toth and Prince 1949)

Source : Soil water and plant analysis manual practical (P.C. Jaiwal 2006).

Results and Discussion

Bulk density (gm/cm³) : Bulk density (gm/cm³) of soil as influenced by NPK fertilizers and Rhizobium. The response Bulk density (gm/cm³) of soil was found to be non-significant in levels of NPK and Rhizobium. The maximum Bulk density (gm cm⁻³) of soil was recorded 1.44 gm cm⁻³ in treatment T₀ (control) and minimum Bulk density (gm cm⁻³) of soil was recorded 1.14 gm cm⁻³ in treatment T₈ (100% NPK + 100% Rhizobium). Similar results were also reported by Kumar *et al.*, (2008) and Reddy *et al.*, (2005)

Particle density (gm/cm³) : Particle density (gm/cm³) of soil as influenced by NPK fertilizers and Rhizobium. The response Particle density (gm/cm³) of soil was found to be non-significant in levels of NPK and Rhizobium. The maximum Particle density (gm cm⁻³) of soil was recorded 2.72 gm/cm³ in treatment T₈ (@100%NPK+100% Rhizobium) and minimum Particle density (gm/cm³) of soil was recorded 2.39 Mg/m³ in treatment T₆ (@100%NPK + 0% Rhizobium). Similar results were also reported by Kumar *et al.*, (2008) and Reddy *et al.*, (2005).

Pore space (%) : Percentage Pore space of soil as influenced by NPK fertilizers and Rhizobium. The response of soil pore space was found to be significant in

levels of NPK and Rhizobium. The maximum soil pore space was recorded 53.05 % in treatment T₈ (@100NPK + 100% Rhizobium) and minimum soil pore space was recorded 42.28% in treatment T₀(control). Similar results were also reported by Kumar *et al.*, (2008) and Reddy *et al.*, (2005).

Soil pH (1:2) w/v : pH of soil as influenced by NPK fertilizers and Rhizobium. The response of soil pH was found to be significant in levels of NPK and Rhizobium. The maximum soil pH was recorded 7.64 in treatment T₆ (@ 50 % NPK @ +100% Rhizobium) and minimum soil pH was recorded 7.22 in treatment T₇ (@100%NPK+50% Rhizobium). Similar results were also reported by Milivojevic *et al.*, (2011) Takase *et al.*, (2011) and Cakmak *et al.*, (2010).

EC (dSm⁻¹) : EC (dS m⁻¹) of soil as influenced by NPK fertilizers and Rhizobium. The response of EC (dS m⁻¹) of soil was found to be non-significant in levels of NPK and Rhizobium. The maximum EC (dS m⁻¹) of soil was recorded 0.50 dS m⁻¹ in treatment T₅ (@100%NPK+100% Rhizobium) and minimum EC (dS m⁻¹) of soil was recorded 0.25 dS m⁻¹ in treatment T₀ (control). Similar results were also reported by Takase *et al.*, (2011), Nawlakhe and Mankar (2009).

Percentage Organic carbon : Percentage Organic carbon in soil as influenced by NPK fertilizers and Rhizobium. The % Organic carbon in soil increased significantly with the increase in levels of NPK and Rhizobium. The maximum % Organic carbon in soil was recorded 0.82 % in treatment T₈ (@100% NPK + 100% Rhizobium) which was significantly higher than any other treatment combination and the minimum % Organic carbon in soil was recorded 0.58 % in treatment T₀ (control). Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as cowpea. Similar findings were recorded by Kumar *et al.*, (2008), Reddy *et al.*, (2005).

Available Nitrogen (Kg ha⁻¹) : Available Nitrogen in soil as influenced by NPK fertilizers and Rhizobium. The available Nitrogen in soil increased significantly with the increase in levels of NPK and Rhizobium. The maximum available Nitrogen in soil was recorded 221.45 (Kg ha⁻¹) in treatment T₈ (@100%NPK+100% Rhizobium) which was significantly higher than any other treatment combination and the minimum available Nitrogen in soil was recorded 201.16 (Kg ha⁻¹) in treatment T₀ (control). The increase in available Nitrogen in soil after crop harvest by NPK fertilizers and Rhizobium might be due to increased efficiency of Nitrogen fixing capacity and nodule formation. Legumes have potential to improve soil nutrients status through biological nitrogen fixation and

Table-1 : Effect of different level of NPK and Rhizobium on physical parameters of soil in Cowpea.

Treatment	Bulk density (gm cm ⁻³)	Particle density (gm cm ⁻³)	Pore space (%)
T ₀	1.14	2.40	42.28
T ₁	1.35	2.48	46.30
T ₂	1.42	2.62	48.82
T ₃	1.32	2.60	47.94
T ₄	1.35	2.55	45.80
T ₅	1.33	2.70	47.00
T ₆	1.38	2.39	48.47
T ₇	1.32	2.55	50.25
T ₈	1.44	2.72	53.05
F-test	NS	NS	S
S. Em+	0.11	0.14	0.19
C.D. (P= 0.05)	0.33	0.43	0.58

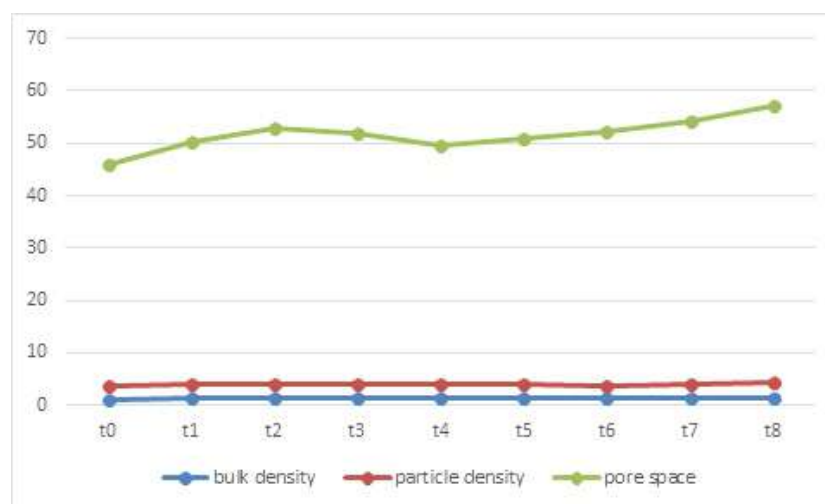


Fig.-1 : Effect of different level of NPK and Rhizobium on physical parameters of soil in Cowpea.

incorporation of biomass in to the soil as green manure. Similar findings were also recorded by Kumar *et al.*, (2008) and Umesha *et al.*, (2013).

Available Phosphorus (Kg ha⁻¹) : Available Phosphorus in soil as influenced by NPK fertilizers and Rhizobium. The available Phosphorus in soil increased significantly with the increase in levels of NPK and Rhizobium. The maximum available Phosphorus in soil was recorded 24.10 (Kg ha⁻¹) in treatment T₈ (@100%NPK+100% Rhizobium) which was significantly higher than any other treatment combination and the minimum available Phosphorus in soil was recorded 16.00 (Kg ha⁻¹) in treatment T₀ (control). 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 also recorded by Datt *et al.*, (2013), Kumar *et al.*, (2008) and Reddy *et al.*, (2005).

Available Potassium (Kg ha⁻¹) : Available Potassium in soil as influenced by NPK fertilizers and Rhizobium. The available Potassium in soil increased significantly with the

increase in levels of NPK and Rhizobium. The maximum available Potassium in soil was recorded 147.82 (Kg ha⁻¹) in treatment T₈ (@100%NPK+100% Rhizobium) which was significantly higher than any other treatment combination and the minimum available Potassium in soil was recorded 115.94 (Kg ha⁻¹) in treatment T₀ (control). 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 also recorded by Khanday *et al.*, (2012) and Reddy *et al.*, (2005).

Conclusions

In the present investigation, it was apparent that application of NPK and Rhizobium fertilizer in treatment T₈ (20 Kg N, 60 Kg P, 40 Kg P and Rhizobium) was found on physical and chemical parameters of soil such as bulk density, particle density, % pore space, EC, pH, Organic carbon, Available NPK than other treatment combinations. Bulk density, Particle density and EC are non-significant. Rhizobium in combination resulted in a slight increase in

Table-2 : Effect of different level of NPK and Rhizobium on chemical parameters of soil in Cowpea.

Treatment	pH (1:2) w/v	EC (dS m ⁻¹)	Organic carbon (%)	Nitrogen (Kg ha ⁻¹)	Phosphorus (Kg ha ⁻¹)	Potassium (Kg ha ⁻¹)
T ₀	7.45	0.25	0.58	201.16	16	115.94
T ₁	7.44	0.36	0.64	201.28	16.58	123.03
T ₂	7.52	0.42	0.70	202.22	17.47	127.80
T ₃	7.38	0.43	0.65	204.30	17.65	130.00
T ₄	7.40	0.42	0.63	211.44	19.55	126.50
T ₅	7.55	0.50	0.68	212.13	20.18	134.52
T ₆	7.64	0.49	0.67	213.54	21.08	139.81
T ₇	7.22	0.47	0.73	215.88	22.85	143.90
T ₈	7.38	0.41	0.82	221.45	24.10	147.82
F-test	S	NS	S	S	S	S
S. Em+	0.02	0.02	0.01	0.02	0.10	0.10
C.D. (P= 0.05)	0.06	0.06	0.04	0.05	0.29	0.30

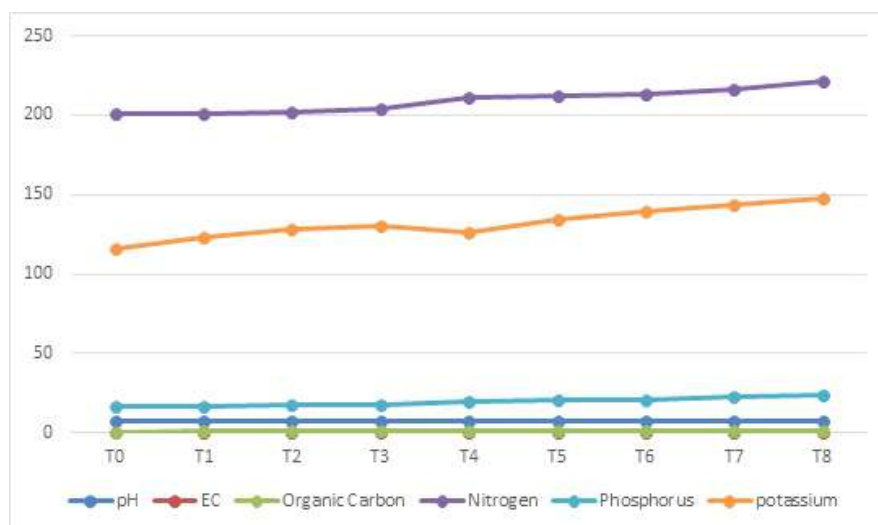


Fig-2 : Effect of different level of NPK and Rhizobium on chemical parameters of soil in Cowpea.

pH 7.64, EC 0.50dSm⁻¹. In post soil of NPK fertilizers observations were resulted in significant increase in OC 0.82 %, Particle density 2.72 g cm⁻³, Bulk density 1.44 g cm⁻³, Pore space 53.05% and available N 221.45 kg ha⁻¹, P 24.10 kg ha⁻¹, K 147.82 kg ha⁻¹ as compared to T₀ (control).

Thus it can be concluded that different levels of NPK and Rhizobium fertilizer improved soil available nutrient, increased soil available nitrogen, phosphorus, potassium and electrical conductivity. However, pH of soil decreased and also among the treatments T₈ recorded the best treatment which increased the availability of nutrient and influenced on physical properties of soil as well.

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Assessment of Yield Criteria in Wheat through Correlation and Path Analysis

Madhu Yadav*, Sita Ram Kumhar, Ramesh Choudhary, Shankar Yadav and Govind Goyal

Department of Genetics and Plant Breeding College of Agriculture, Mandor, Jodhpur.

*Email : [ymadhu147@gmail.com](mailto:yadhu147@gmail.com)

Abstract

The present investigation entitled "Assessment of yield criteria in wheat through Correlation and Path Analysis" has been carried out at Agricultural Research Station, Mandor, Jodhpur during *rabi* 2016-17 to evaluate thirty one genotypes of wheat to assess extent of nature and magnitude of correlation and path coefficient for grain yield and contributing character. The material was planted in randomized block design with three replications and observations were recorded on individual plant basis. In the present investigation, genotypic and phenotypic correlation of grain yield was found to be positive and highly significant correlated with days to heading. Further this character exhibited positively significant correlation with peduncle length, number of tillers per plant and days to maturity. This character had positive non significant association with plant height, spike length and flag leaf area. Path coefficient analysis suggested that the highest positive direct effect on grain yield per plant was exerted by days to heading followed by peduncle length, number of tillers per plant and protein content. In contrast, harvest index, flag leaf area, days to maturity, spike length, 1000 grain weight and plant height contributed considerable negative direct effect on grain yield.

Key words : *Wheat, heritability, genetic advance, correlation and path coefficient.*

Introduction

Wheat (*Triticum* sp.), a crop of poaceae family, is a major staple food crop of the world. It is primarily grown in temperate region, at higher altitude and also at medium altitude of tropical climate. Nutritional value per 100 g of wheat (germ crude) provides Protein 26.7g, Carbohydrate 44.7g, Starch 28.7 g, Fat 9.2g, Vitamin E 22 mg, Niacin 45 mg, Thiamine 2.01 mg, Riboflavin 0.72mg (Kumar *et al.* 2011). Proteins are mainly consists of the 'Glutins'. Wheat proteins are of special significance because the Glutins provides the frame work of spongy cellular texture of bread and baked products and also very versatile in the culinary arts. Wheat Straw is used as fodder, padding materials and mulching materials. At national level total area under wheat is 30.23 million ha with the production of 93.50 million tons and a productivity of 3.09 tons per ha. Wheat contributes about 34% of total food grain production of the country (Anonymous, 2016).

Correlation studies along with path analysis provide a better understanding of the association of different characters with grain yield. Correlation is useful in disclosing the magnitude and direction of the relationship between various yield contributing traits and yield. While path coefficient (or) standardized partial regression coefficient that measures the direct effect of a predictor variable upon its response variable and the second component being the indirect effect(s) of a predictor variable (Dewey and Lu, 1959).

Materials and Methods

The field experiment entitled "Assessment of yield criteria in wheat through Correlation and Path Analysis" was conducted during *Rabi* season of 2016-17 at Agricultural Research Station, Mandor-Jodhpur. In this experiment, 31 wheat cultivars viz., WH1105, GW 11, GW 366, GDW 1255, PBW 644, WH 1080, HD 3043, JW 3269, MP 3288, MP 1201, MP 3336, DBW 71, DBW 88, DBW 90, DBW 107, DBW 110, Bilara selection, HD 2967, HD 2985, HD 2987, WHD 948, WH 1124, HD 3059, HD 3086, HD 3090, HD 3118, HI 8713, HI 8737, HI 1563, RAJ 4083 and RAJ 3765 were grown in randomized block design with three replications during *Rabi*, 2016-17 under irrigated conditions at experimental field of ARS Mandor, Jodhpur. Each entry was grown in 30 m row spacing. Each genotype was planted in an experimental plot size of (4m×3m). The recommended package of practices will be adopted to raise a healthy crop. The observations were recorded on individual plant basis on ten randomly selected plants from each replication for 11 characters viz., Days to heading, days to maturity, plant height (cm), number of tillers per plant, peduncle length (cm), spike length (cm), flag leaf area (cm²), grain yield per plant (g), harvest index (%), protein content (%) and 1000-grain weight (g) were recorded.

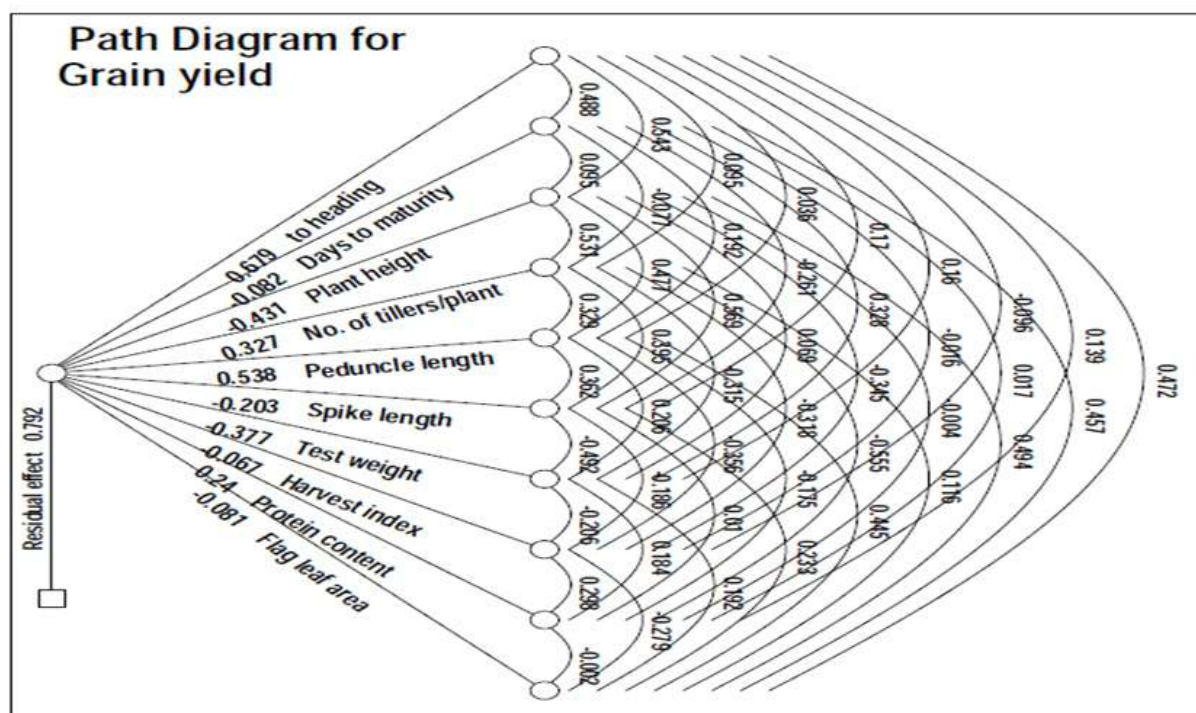
Correlation Analysis : The phenotypic and genotypic correlation coefficients were computed from the phenotypic and genotypic variance and co-variances as according to Searle (1961).

Table-1 : Phenotypic and genotypic correlation coefficient between different characters in wheat.

Characters	Level	Days to heading	Days to maturity	Plant height (cm)	Number of tillers per plant	Peduncle length (cm)	Spike length (cm)	Flag leaf area (cm ²)	Grain yield (g per plant)	Harvest index (%)	Protein content (%)	1000-grain weight (g)
Days to heading	G	1.0000										
	P	1.0000										
Days to maturity	G	0.5328**	1.0000									
	P	0.3986**	1.0000									
Plant height (cm)	G	0.5825**	0.1309	1.0000								
	P	0.4799**	0.0323	1.0000								
Number of tillers per plant	G	0.0986	-0.0778	0.5769**	1.0000							
	P	0.0895	-0.0624	0.4608**	1.0000							
Peduncle length (cm)	G	0.0388	0.2350	0.5057**	0.3664**	1.0000						
	P	0.0276	0.1625	0.4278**	0.2737*	1.0000						
Spike length (cm)	G	0.1786	-0.2476*	0.6258**	0.4173**	0.4033**	1.0000					
	P	0.1563	-0.2308	0.4825**	0.3591**	0.3087**	1.0000					
Flag leaf area (cm ²)	G	0.5048**	0.5118**	0.5471**	0.1226	0.4738**	0.2303					
	P	0.4187**	0.3610**	0.4151**	0.1059	0.4058**	0.2375*	1.0000				
Grain yield (g per plant)	G	0.3807**	0.2372*	0.2333	0.2806*	0.2932*	0.2146	0.1746	1.0000			
	P	0.3359**	0.1673	0.1584	0.2350	0.1884	0.1676	0.1532	1.0000			
Harvest index (%)	G	-0.0999	0.0002	-0.3740**	-0.3500**	-0.3747**	-0.1974	-0.3026*	-0.1016	1.0000		
	P	-0.0886	0.0064	-0.2995*	-0.2627*	-0.3121**	-0.1661	-0.2405*	-0.0137	1.0000		
Protein content (%)	G	0.1457	0.0473	-0.0053	-0.6234**	-0.1589	0.0180	0.0203	-0.0290	0.3257**	1.0000	
	P	0.1316	-0.0348	-0.0027	-0.4572**	-0.1840	-0.0010	-0.0339	-0.0315	0.2582*	1.0000	
1000- grain weight (g)	G	0.1604	0.3591**	0.1093	-0.3415**	0.2289	-0.5490**	0.1922	-0.1889	-0.2307	0.1874	1.0000
	P	0.1613	0.2336	0.0085	-0.2720*	0.1618	-0.4063**	0.1917	-0.1483	-0.1645	0.1796	1.0000

Table-2 : Path coefficient analysis for 11 characters in wheat-grain yield is as dependent character.

Characters	Days to heading	Days to maturity	Plant height (cm)	Number of tillers per plant	Peduncle length (cm)	Spike length (cm)	Flag leaf area (cm ²)	Harvest index (%)	Protein content (%)	1000-grain weight (g)
Days to heading	0.6792	0.3316	0.3686	0.0648	0.0248	0.1153	0.3209	-0.0652	0.0946	0.1090
Days to maturity	-0.0398	-0.0816	-0.0077	0.0063	-0.0156	0.0213	-0.0373	0.0013	-0.0014	-0.0268
Plant height (cm)	-0.2341	-0.0408	-0.4314	-0.2292	-0.2057	-0.2454	-0.2130	0.1488	0.0018	-0.0297
Number of tillers per plant	0.0312	-0.0252	0.1736	0.3267	0.1076	0.1290	0.0379	-0.1040	-0.1815	-0.1030
Peduncle length	0.0196	0.1031	0.2565	0.1771	0.5379	0.1946	0.2396	-0.1913	-0.0939	0.1107
Spike length (cm)	-0.0345	0.0529	-0.1155	-0.0802	-0.0735	-0.2030	-0.0473	0.0378	-0.0021	0.0999
Flag leaf area (cm ²)	-0.0381	-0.0368	-0.0398	-0.0094	-0.0359	-0.0188	-0.0807	0.0225	0.0002	-0.0155
Harvest index (%)	0.0064	0.0011	0.0231	0.0213	0.0238	0.0124	0.0186	-0.0668	-0.0199	0.0137
Protein content (%)	0.0334	0.0041	-0.0010	-0.1331	-0.0418	0.0025	-0.0006	0.0714	0.2396	0.0440
1000-grain weight (g)	-0.0605	-0.1238	-0.0260	0.1188	-0.0776	0.1855	-0.0723	0.0775	-0.0692	-0.3769
Grain yield	0.3628	0.1845	0.2003	0.2632	0.2438	0.1935	0.1660	-0.0681	-0.0318	-0.1745
Partial R ²	0.2464	-0.0151	-0.0864	0.0860	0.1311	-0.0393	-0.0134	0.0045	-0.0076	0.0658



Path Coefficient Analysis : The direct and indirect effects were estimated through path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

Results and Discussion

Genotypic and phenotypic correlation of grain yield was found to be positive and highly significant correlated with days to heading (0.3359**). This character had negative non significant association with harvest index (-0.0137), protein content (-0.0315) and 1000-grain weight (-0.1483), whereas, remaining traits had positive non significant association with grain yield. Days to heading was found to be positive and highly significant correlated with plant height (0.5825**), days to maturity (0.5328**), flag leaf area (0.5048**) and grain yield (0.3807**) at genotypic level. Days to maturity was found to be positive and highly significant correlated with days to heading (0.5328**), flag leaf area (0.5118**) and 1000 grain weight (0.3591**) at genotypic level. Number of tillers per plant was found to be positive and highly significant correlated with plant height (0.5769**), spike length (0.4173**) and peduncle length (0.3664**). Peduncle length was found to be positive and highly significant correlated with plant height (0.5057**), flag leaf area (0.4738**), spike length (0.4033**) and number of tillers per plant (0.3664**). Spike length was found to be positive and highly significant correlated with plant height (0.6258**), number of tillers per plant (0.4173**) and peduncle length (0.4033**). Protein content was found to be positive and

highly significantly correlated with harvest index (0.3257**). Path coefficient analysis suggested that the highest positive direct effect on grain yield was exerted by days to heading (0.6792) followed by peduncle length (0.5379), number of tillers per plant (0.3267) and protein content (0.2396). In contrast, harvest index (-0.0668), flag leaf area (-0.0807), days to maturity (-0.0816), spike length (-0.2030), 1000 grain weight (-0.3769) and plant height (-0.4314) contributed considerable negative direct effect on grain yield per plant. It has also been observed by previous workers, such as Ali *et al.* (2008), Degewione *et al.* (2013), Kalimullah *et al.* (2012), Khan *et al.* (2010), Koul and Singh (2011), Saxena *et al.* (2007), Singh *et al.* (2008), Singh *et al.* (2006) and Vamshikrishna *et al.* (2013).

Conclusions

Genotypic and phenotypic correlation of grain yield was found to be positive and highly significant correlated with days to heading. Further this character exhibited positively significant correlation with peduncle length, number of tillers per plant and days to maturity. These associations indicated that improvement in grain yield can be achieved by improving above characters. Path coefficient analysis suggested that the highest positive direct effect on grain yield per plant was exerted by days to heading followed by peduncle length, number of tillers per plant and protein content. In contrast harvest index, flag leaf area, days to maturity, spike length, 1000 grain weight and plant height contributed considerable negative direct effect on grain yield.

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Constraints Faced and Suggestions Provided by Wheat Growers among Different Categories of Farmers in Malwa Region of Madhya Pradesh

Mangi Lal Jat^{1*}, D.K. Jaiswal¹ and Y.S. Saharawat²

¹Department of Extension Education, JNKVV, Jabalpur, M.P.

²IFDC, New Delhi

Corresponding Authors Email : mangilalgodara9546@gmail.com

Abstract

The present study was conducted for finding out the constraints faced and suggestions provided by wheat growers among different categories of farmers in Malwa region of Madhya Pradesh. 324 wheat growers, 9 farmers (3 big, 3 medium and 3 small farmers) were selected randomly from each (thirty six) selected village of nine blocks of Hosangabad, Harda, and Sehore districts. The sample farmers were further categorized, based on their operational land holding, as small, medium and large farmers. The analysis of information collected by personal interview method and found that small farmers have 85.18 per cent risk in adoption of improved wheat production technology; medium farmers 82.40 per cent have irregular supply of electricity; big farmer's 77.77 per cent have no availability of good quality pesticide and overall farmers 83.02 per cent constraints have faced irregular supply of electricity. The important suggestions reported by the wheat growers for taking higher yield of crop were availability of sufficient water from canal and adequate supply of electricity so that farmers can prepare their fields in time however late sowing causes low productivity. Further, availability of good quality seeds, fertilizers and insecticides be made in time were important suggestions reported by farmers.

Key words : Constraints, suggestions, wheat growers, production technology, analysis.

Introduction

Wheat (*Triticum aestivum*) is an important and strategic cereal crop for the majority of world's populations. It is the most important staple food of about two billion people (36% of the world population). It exceeds in acreage and production of every other grain crop (including rice, maize, etc.) and is therefore, the most important cereal grain crop of the world, which is cultivated over a wide range of climatic conditions. Wheat offers ease of grain storage and ease of converting grain into flour for making edible, palatable, interesting and satisfying foods. Wheat is the most important source of carbohydrate in a majority of countries. Wheat also contains a diversity of minerals, vitamins and fats (lipids). With a small amount of animal or legume protein added, wheat-based meal is highly nutritious. It is consumed in various forms by more than one thousand million human being in the World, In India, it is the second important staple food crop rice being the first. In areas where wheat is the staple cereal food it is consumed in the form of Chapatti's. It provides about 20 per cent of the total food calories required for the human race. Besides staple food for human beings wheat straw is good source of food for large population of cattle in our country. Wheat competes well with other important cereals in its nutritive values and also contains higher protein as compared to other cereals. In India wheat is grown over area of 30.60 million hectares with total

production of 98.38 million tonnes with the average yield is 3216 kg/hectares and in Madhya Pradesh, it is grown over an area of 6.03million hectares with total production of 17.94 million tonnes with the average yield 2976 kg/ha (DAC & FM, 2017). In Hoshangabad district, wheat is grown over area of 0.26 million hectares with total production of 1.11 million tonnes with the average yield is 4440 kg/hectares (FWADD, 2017). In Harda district, wheat is grown over area of 0.17 million hectares with total production of 0.66 million tonnes with the average yield is 3843 kg/hectares (FWADD, 2017). In Sehore district, wheat is grown over area of 0.25 million hectares with total production of 0.90 million tonnes with the average yield is 3645 kg/hectares (FWADD, 2017). The extension service in the country has a huge net work of professional extension workers at national, state district, sub-division, and block and village level. Several programmers motivating the farmers in adoption of new technologies are in operation throughout the country. But still there is wide gap between the technology available with the researchers and its adoption in farmer's field particular in wheat. There is urgency particularly in wheat to minimize the technological gap and to ensure that the developed technology should be transmitted speedily to the farmers for increasing yield through reorganized agricultural extension system. The adoption of improved technology of wheat crop by the farmers is not uniform due to several reasons. Hence, also to find out various answer of the

questions like what type of farmers grow wheat crop? What is the technological knowledge of farmers? What package of practices they adopt? What problems do they face in increasing production level? Keeping this view in mind an effort has been made in this study to find out the constraints faced and suggestions provided by wheat growers among different categories of farmers in Hoshangabad, Harda and Sehore district (MP).

Research Methodology

The *ex post facto* research design was followed in this study. This study was carried out in Hoshangabad, Harda and Sehore districts of Madhya Pradesh State during 2018-19 to know the constraints faced and suggestions provided by recommended wheat production practices among different categories of wheat growers. A total of 36 villages were selected with the help of a stratified random sampling method from 9 blocks namely Hoshangabad, Pipariya, Itarsi, Harda, Timarni, Khirkiya, Sehore, Ichhawar and Narsullaganj (4 villages from each block) on account of the maximum area covered under wheat crop. A total of 324 wheat growers, 9 farmers (3 big, 3 medium and 3 small farmers) were selected with simple random sampling from each selected village under the study. The primary data was collected personally through group discussion and a pre-tested interview schedule which was prepared on the basis of objectives of the study. The data pertaining to constraints has been collected through statements of the structured schedule and tabulated on the basis of frequency and percentage scores and further ranking was made with help of its percentage scores. Respondents were free to express their suggestions in order to eliminate the constraints encountered by them in improved wheat production technology. All the suggestions borne out through systematic observation had been recorded by the researcher.

Results and Discussion

The major constraints faced by wheat growers in adoption of improved wheat production technology were irregular supply of electricity, non-availability of pesticides of good quality, more risk in adoption of improved technology, lack of knowledge regarding improved technology, non-availability of improved seeds and fertilizers at proper time, inadequate irrigation facilities, termite problem, non-availability of extension workers at the time of inquiry lack of credit facilities/loan low price of grains and late sowing in order of importance. Such type of constraints was also reported by Tripathi (2010), Chaudhari (2011), Raghuwanshi *et al.* (2014), Hussain *et al.* (2018).

Table-1 presents the constraints of farmers which they faced in adoption of improved wheat production technology. It is evident from the table that 81.84 per cent

small farmers reported about non-availability of fertilizer at proper time, 82.40 lack of knowledge of improved technology, 85.18 more risk in adoption of improved technology while, 64.81 percent stated the problems with respect to non-availability of improved seed at proper time and 75.92 per cent termite problem, 84.25 per cent due to inadequate irrigation facilities, 74.07 per cent non-availability of pesticide of good quality and 78.70 per cent irregular supply of electricity, 60.18 per cent felt due to the low price of grains, 69.44 per cent lack of credit facilities/loan and 65.74 per cent non-availability of extension worker at the time of enquiry and 46.29 per cent due to late sowing. In case of medium farmers reported the problems like 57.40 per cent due to non-availability of fertilizer at proper time, 64.81 per cent lack of knowledge regarding improved technology, where as 62.96 per cent due to non-availability of improved seed at proper time, 50.92 per cent inadequate irrigation facilities, 82.40 per cent irregular supply of electricity, 65.74 per cent due to lack of credit facilities/loan, 69.44 per cent due to more risk in adoption of improved technology, 72.22 per cent non-availability of pesticides of good qualities, 72.22 per cent low price of grains and 65.74 per cent due to termite problems, 57.40 per cent non-availability of extension worker at the time of enquiry for getting agricultural information's, and 50.92 per cent due to late sowing. The big farmers reported the problems like 44.44 per cent due to non-availability of fertilizer at proper time, 60.18 per cent lack of knowledge regarding improved technology, where as 57.40 per cent due to non-availability of improved seed at proper time, 46.29 per cent inadequate irrigation facilities, 87.96 per cent irregular supply of electricity, 38.88 per cent due to lack of credit facilities/loan, 64.81 per cent due to more risk in adoption of improved technology, 77.77 per cent non-availability of pesticides of good qualities, 40.74 per cent low price of grains and 37.96 per cent due to termite problems, 53.70 per cent non-availability of extension worker at the time of enquiry for getting agricultural information's, and 60.18 per cent due to late sowing. Thus, the overall farmers reported the constraints which they faced in adoption of improved wheat production technology were 61.11 per cent non-availability of fertilizer and 61.72 per cent improved seeds at proper time, 60.49 per cent inadequate irrigation facilities, 69.13 per cent lack of knowledge regarding improved technology, 58.02 per cent lack of credit facilities/loan, 73.14 per cent more risk in adoption of improved technology, 74.69 per cent non-availability of pesticides of good quality, 83.02 per cent irregular supply electricity, 57.71 per cent low price of grains and 58.95 per cent non-availability of extension worker at the time of enquiry, 59.87 per cent due to termite problems and 52.46 per cent

Table-1 : Percentage distribution of different categories of farmer according to constraints faced in adoption of improved wheat production technology.

S. No.	Constraints	Small farmers n=108	Medium farmers n=108	Big farmers n=108	Overall farmers n=324	Rank
		Freq.	Freq.	Freq.	Freq.	
1.	Non-availability of fertilizer at proper time	88 (81.48)	62 (57.40)	48 (44.44)	198 (61.11)	VI
2.	Non-availability of improved seed at proper time	70 (64.81)	68 (62.96)	62 (57.40)	200 (61.72)	V
3.	Inadequate irrigation facilities	91 (84.25)	55 (50.92)	50 (46.29)	196 (60.49)	VII
4.	Lack of knowledge regarding improved technology	89 (82.40)	70 (64.81)	65 (60.18)	224 (69.13)	IV
5.	Lack of credit facilities/loan	75 (69.44)	71 (65.74)	42 (38.88)	188 (58.02)	X
6.	More risk in adoption of improved technology	92 (85.18)	75 (69.44)	70 (64.81)	237 (73.14)	III
7.	Non-availability of pesticides of good qualities	80 (74.07)	78 (72.22)	84 (77.77)	242 (74.69)	II
8.	Irregular supply of electricity	85 (78.70)	89 (82.40)	95 (87.96)	269 (83.02)	I
9.	Low price of grains	65 (60.18)	78 (72.22)	44 (40.74)	187 (57.71)	XI
10.	Non-availability of extension worker at the time of enquiry	71 (65.74)	62 (57.40)	58 (53.70)	191 (58.95)	IX
11.	Due to termite problem	82 (75.92)	71 (65.74)	41 (37.96)	194 (59.87)	VIII
12.	Due to late sowing	50 (46.29)	55 (50.92)	65 (60.18)	170 (52.46)	XII

(Figures in parenthesis are percentage)

Table-2 : Percentage distribution of different categories of farmers on the basis of suggestion.

S. No.	Suggestions	Small farmers n=108	Medium farmers n=108	Big farmers n=108	Overall farmers n=324	Rank
		Freq.	Freq.	Freq.	Freq.	
1.	Procedure of credit facilities should be made easy	60 (55.55)	47 (43.51)	40 (37.03)	147 (45.37)	VI
2.	Supply of good quality of fertilizers and pesticides at proper time	52 (48.14)	65 (60.18)	74 (68.51)	191 (58.95)	IV
3.	Adequate supply of electricity	53 (49.07)	66 (61.11)	87 (80.55)	206 (63.58)	II
4.	Availability of sufficient water for irrigation	76 (70.37)	82 (75.92)	96 (88.88)	254 (78.39)	I
5.	Technical knowledge regarding the control of pest and diseases	51 (47.22)	74 (68.51)	67 (62.03)	192 (59.25)	III
6.	Technical guidance and supervision of extension agency	61 (56.48)	49 (45.37)	54 (50.00)	164 (50.61)	V
7.	Adequate transport facilities	32 (29.62)	43 (39.81)	62 (57.40)	137 (42.28)	VII

(Figures in parenthesis are percentage)

due to late sowing for wheat production was perceived by all the categories of farmers.

The important suggestions reported by the wheat growers for taking higher yield of crop were availability of sufficient water from canal and adequate supply of electricity so that farmers can prepare their fields in time

however late sowing causes low productivity. Further, availability of good quality seeds, fertilizers and insecticides be made in time were important suggestions reported by farmers. The other suggestions were on simplification of loaning procedure, and lack of continuous contact of extension workers for proper guidance. It was also pointed out by the farmer that, in the area wheat crop

is severely affected by the termite which causes low production of the crop hence; the extension personnel should provide appropriate technical guidance for controlling the problems of termites in time. Such type of suggestion was also reported by Kumbhare and Singh (2011), Ambulakar and Dixit (2014), Maraddi *et al.* (2014).

Table-2 presents the suggestion of the small farmers which they faced in adoption of improved wheat production technology. It is evident from the table suggested that 55.55 per cent procedure of credit facilities should be made easy, 48.14 per cent supply of good quality of fertilizers and pesticides at proper time, 49.07 per cent adequate supply of electricity, 70.37 per cent availability of sufficient water for irrigation, 47.22 per cent technical knowledge regarding the control of pest and diseases, 56.48 per cent technical guidance and supervision of extension agency, and 29.62 per cent adequate transport facilities. In case of medium farmers suggested that like 43.51 per cent procedure of credit facilities should be made easy, 60.18 per cent supply of good quality of fertilizers and pesticides at proper time, 61.11 per cent adequate supply of electricity, 75.92 per cent availability of sufficient water for irrigation, 68.51 per cent technical knowledge regarding the control of pest and diseases, 45.37 per cent technical guidance and supervision of extension agency, and 39.81 per cent adequate transport facilities. The big farmers suggested that like 37.03 per cent procedure of credit facilities should be made easy, 68.51 per cent supply of good quality of fertilizers and pesticides at proper time, 80.55 per cent adequate supply of electricity, 88.88 per cent availability of sufficient water for irrigation, 62.03 per cent technical knowledge regarding the control of pest and diseases, 50.00 per cent technical guidance and supervision of extension agency, and 57.40 per cent adequate transport facilities. Thus, the overall farmers suggested that like 45.37 per cent procedure of credit facilities should be made easy, 58.95 per cent supply of good quality of fertilizers and pesticides at proper time, 63.58 per cent adequate supply of electricity, 78.39 per cent availability of sufficient water for irrigation, 59.25 per cent technical knowledge regarding the control of pest and diseases, 50.61 per cent technical guidance and supervision of extension agency, and 42.28 per cent adequate transport facilities.

Conclusions

As a result of the findings, it is suggested that farmers be given location-specific information rather than broad information for the whole region. For greater uptake and usage, farmers should be given information about the entire package of practices via various extension approaches. In conclusion, the present study to identify

the problem, and an effort was made to address the many issues raised by wheat producers in Madhya Pradesh in terms of productivity, economics, technology, and policy formulation. Based on their perceptions of the restrictions they face, measures for increasing wheat productivity and profitability were proposed, with the goal of improving wheat producers' socioeconomic conditions. Indeed, there is a current need to raise awareness and interest among producers in order to alleviate the limits they face and encourage them to use wheat production technology as their primary activity in order to double their farm revenue. The major constraints faced by wheat growers in adoption of improved wheat production technology were irregular supply of electricity, non-availability of pesticides of good quality, more risk in adoption of improved technology, lack of knowledge regarding improved technology, non-availability of improved seeds and fertilizers at proper time, inadequate irrigation facilities, termite problem, non-availability of extension workers at the time of inquiry lack of credit facilities/loan low price of grains and late sowing in order of importance. The important suggestions reported by the wheat growers for taking higher yield of crop were adequate supply of electricity and availability of sufficient water from canal so that farmers can prepare their fields in time however late sowing causes low productivity. Further, availability of good quality seeds, fertilizers and insecticides be made in time were important suggestions reported by farmers. The other suggestions were on simplification of loaning procedure, and lack of continuous contact of extension workers for proper guidance. It was also pointed out by the farmer that, in the area wheat crop is severely affected by the termite which causes low production of the crop hence; the extension personnel should provide appropriate technical guidance for controlling the problems of termites in time.

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Heterosis for Yield and Other Traits in Wheat (*Triticum aestivum* L.) Over the Environments

Meenakshi Dhoot^{1*}, Hemlata Sharma¹, Rupal Dhoot² and R.B. Dubey¹

¹Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, MPUAT, Udaipur-313001, Rajasthan

²Department of Genetics and Plant Breeding, College of Agriculture, Agriculture University, Jodhpur-342304, Rajasthan

*Corresponding Author Email : dhootakshi9@gmail.com

Abstract

In this study, heterosis was evaluated by 42 crosses developed by line x tester design (14 lines and 3 testers) along with 2 checks in RBD with 3 replications in wheat for days to 50 per cent flowering, number of effective tillers per plant, number of spikelets per plant, biological yield per plant, total protein content in grains, heat injury, proline content and total chlorophyll content on pooled basis. The pooled analysis for above eight characters revealed that mean squares due to environments, genotypes, parents, crosses as well as parents v/s. crosses were significant indicating presence of overall heterosis for these traits. Out of forty two crosses, number of crosses which showed significant heterobeltiosis ranged from 01 (heat injury) to 14 (biological yield per plant) over the environments. In case of economic heterosis, 1 different cross for days to 50 per cent flowering, number of spikelets per plant, heat injury and proline content, 2 crosses for number of effective tillers per plant and 3 different crosses for biological yield per plant and total protein content in grains showed desirable significant economic heterosis.

Key words : Biological yield, heterobeltiosis, economic heterosis, wheat.

Introduction

Bread wheat [*Triticum aestivum* (L.) em. Thell] is the most important food crop in the world which belongs to genus *Triticum* and family Poaceae. Bread wheat is considered as a staple food source for a large human population of the world and provides required carbohydrates and proteins in the diet (Kumar and Rai, 2014). Heterosis is mainly accredited to cross pollinated crops but now-a-days this is common in self-pollinated crops such as wheat, providing an option for commercial utilization of wheat (Singh *et al.*, 2004). Manipulation of heterosis is an important strategy for increasing the yield potential of wheat.

Materials and Methods

The experimental material comprised of seventeen wheat genotypes (14 lines and 3 testers) and two check varieties viz., MP 3288 and HI 1544. These genotypes were crossed in Line x Tester design to develop a total forty two crosses during *rabi* 2016-17. All the 61 genotypes (17 parents, 42 crosses and 2 checks) were evaluated in a randomized block design with three replications in three different environments during *rabi* 2017-18 at department of Genetics and Plant Breeding, Rajasthan College of Agriculture (RCA), MPUAT, Udaipur. Each genotype was accommodated in one row plot of 3 meter length. Row to row and plant to plant distances were 22.5 cm and 10 cm, respectively. Heterobeltiosis and economic heterosis, expressed as per cent deviation toward desirable direction over better parent and standard check, respectively.

Heterobeltiosis and economic heterosis were calculated according to the method suggested by Fonseca and Patterson (1968) and Meredith and Bridge (1972), respectively.

Results and Discussion

Mean squares due to genotype x environment interactions were significant for all the eight characters, reflecting influence of different environments on the expression of genotypes (Table-1). The mean squares due to crosses x environments were significant for above seven characters except biological yield per plant indicating that crosses interacted differentially with different environments for these characters. The mean squares due to parents x environments were significant for only four characters (number of effective tillers per plant, biological yield per plant, proline content and total chlorophyll content) out of above eight characters. This suggested that parents performed differentially in different environments for these characters. The mean squares due to parents v/s crosses x environments were significant for only three characters (number of effective tillers per plant, number of spikelets per plant and proline content) out of above eight characters suggested that the average performance of crosses was different from that of the parents in different environments and existence of overall heterosis for these traits. Similar results were also reported by Ameen 2012, Barot *et al.*, 2013, Lohithaswa *et al.*, 2014, Singh *et al.*,

Table-1 : Pooled mean squares for days to 50 per cent flowering, number of effective tillers per plant, number of spikelets per plant, biological yield per plant (g), total protein content in grains (%), heat injury, proline content (μg per 100 mg) and total chlorophyll content (mg/g).

S. No.	Source	Df	Days to 50 per cent flowering	Number of effective tillers per plant	Number of spikelets per plant	Biological yield per plant (g)	Total protein content in grains (%)	Heat injury (%)	Proline content (μg per 100 mg)	Total Chlorophyll content (mg/g)
1.	Environment	2	2170.86**	557.36**	241116.02**	712.50**	7.94**	1200.76**	2589.19**	3.23**
2.	Rep./Env	6	1.33	0.64	308.47	1.67	0.06	5.86	0.60	0.01
3.	Genotype	60	12.29**	9.47**	4612.91**	69.96**	2.62**	158.61**	59.75**	0.96**
	Parent	16	4.96**	5.60**	2511.03**	34.31**	1.51**	116.86**	55.76**	0.68**
	Tester	2	4.78**	3.44	444.12**	18.67**	0.35**	48.69**	13.94**	0.01
	Line	13	2.85**	5.82**	2998.86**	39.03**	1.80**	127.27**	66.47**	0.51**
	P v/s C	1	154.36**	5.98*	11224.78**	283.65**	9.50**	721.03**	14.05**	0.06**
	Cross	41	11.48**	10.59**	4618.54**	76.28**	2.87**	158.70**	62.60**	0.94**
4.	G x E	120	4.46**	1.93**	548.74**	5.39*	0.11**	6.04**	4.08**	0.02**
	P x E	32	2.19	1.93*	481.36	7.18*	0.07	6.20	3.27**	0.02**
	T x E	4	0.89	4.61**	760.59	2.99	0.08	2.05	2.02**	0.03**
	L x E	26	2.39	1.58	387.20	8.33**	0.06	6.62*	3.14**	0.02**
	P v/s C x E	2	3.97	9.96**	1418.81*	8.14	0.07	2.22	11.28**	0.01
	Cross x E	82	5.47**	1.76*	573.94**	4.82	0.13**	6.33**	3.93**	0.01**
5.	Pooled Error	360	2.85	1.24	385.74	4.24	0.08	4.31	0.38	0.01

*, ** Significant at 5 and 1 per cent, respectively.

Table-2 : Maximum desirable significant heterobeltiosis and economic heterosis on pooled basis.

S. No.	Characters	Heterobeltiosis	Economic heterosis
1.	Days to 50 per cent Flowering	HS-547 x RAJ 4037 (-3.95)	HS-547 x RAJ 4037 (-1.71)
2.	Number of effective tillers per plant	PBW-701 x RAJ 4120 (34.85)	KBRL 82-2 x RAJ 4037 (11.24)
3.	Number of spikelets per plant	KBRL 82-2 x RAJ 4037 (49.34)	KBRL 82-2 x RAJ 4037 (12.56)
4.	Biological yield per plant	DBW-179 x RAJ 4037 (17.4)	DBW-179 x RAJ 4037 (6.31)
5.	Total protein content in grains	DBW-71 x RAJ 4120 (7.51)	PBW-701 x RAJ 4037 (5.79)
6.	Heat injury	HS-595 x RAJ 4037 (-8.58)	HPW-360 x RAJ 4120 (-4.39)
7.	Proline content	HUW 677 x RAJ 4037 (14.97)	HS 595 x RAJ 4120 (2.95)
8.	Total chlorophyll content	PBW 701 x RAJ 4120 (19.05)	-

2014, Ismail 2015, Jat *et al.*, 2015, Kumar *et al.*, 2017 and Singh *et al.*, 2018.

The estimates of heterobeltiosis for days to 50 per cent flowering revealed that out of forty two crosses, 6 crosses exhibited negative significant heterobeltiosis with maximum negative magnitude (HS-547 x RAJ 4037) -3.95% on pooled basis (Table 2). The magnitude of heterobeltiosis for this trait varied from -3.95% (HS-547 x RAJ 4037) to -2.26 % (HUW-677 x RAJ 4079). The negative significant economic heterosis for days to 50 per cent flowering was expressed by cross HS-547 x RAJ 4037 (-1.71%) over the earliest check HI-1544 on pooled basis.

For number of effective tillers per plant; 7 crosses exhibited significant and positive heterobeltiosis, magnitude of which varied from 13.25% (DBW-93 x RAJ 4120) to 34.85% (PBW 701 x RAJ 4120). Cross KBRL 82-2 x RAJ 4037 expressed significant positive economic

heterosis on pooled basis. Likewise, cross KBRL 82-2 x RAJ 4120 also exhibited significant positive economic heterosis on pooled basis. While the magnitude of economic heterosis was varied from 6.74% (KBRL 82-2 x RAJ 4120) to 11.24% (KBRL 82-2 x RAJ 4037) for Number of effective tillers per plant over the best check HI-1544 on pooled basis.

On pooled basis, positive significant heterobeltiosis was expressed by 8 crosses with range varied from KBRL 82-2 x RAJ 4037 (49.34%) to HUW 677 x RAJ 4037 (15.58%) for number of spikelets per plant. The economic heterosis for number of spikelets per plant was positive significant for only one cross KBRL 82-2 x RAJ 4037 (12.56%) over the environments.

Fourteen crosses showed positive significant heterobeltiosis over the environment for biological yield per plant. The ranged of heterobeltiosis on pooled basis varied from 5.94% (DBW-179 x RAJ 4079) to 17.40 %

(DBW-179 x RAJ 4037). The estimates of economic heterosis were positive significant for 2 crosses viz., DBW-179 x RAJ 4037 and DBW-129 x RAJ 4120 on pooled basis. Similarly, cross HPW-360 x RAJ 4037 also exhibited significant positive economic heterosis on pooled basis. While the magnitude of economic heterosis was over the best check HI-1544 on pooled basis varied from 2.50% (HPW-360 x RAJ 4037) to 6.31% (DBW-179 x RAJ 4037) for biological yield per plant.

On pooled basis, positive significant heterobeltiosis for total protein content in grains was ranged from 2.51 % (DBW-17 x RAJ 4037) to 7.51 % (DBW-71 x RAJ 4120). On the pooled basis, significant positive economic heterosis was expressed by 3 crosses viz., PBW-701 x RAJ 4037 (5.79%), PBW-701 x RAJ 4079 (3.31%) and GW-463 x RAJ 4120 (2.85%) over the best check MP 3288 for total protein content in grains.

Heterobeltiosis was negative significant for cross HS-595 x RAJ 4037 over the environments with magnitude of -8.58% for heat injury. The negative significant economic heterosis was exhibited by only one cross HPW-360 x RAJ 4120 (-4.39%) over the best check MP 3288 for this trait on pooled basis.

In case of Proline content, 2 crosses viz., HUW 677 x RAJ 4037 (14.97 %) and PBW-701 x RAJ 4120 (3.82 %) expressed positive significant heterobeltiosis. Cross HS 595 x RAJ 4120 (2.95 %) also showed positive significant economic heterosis for proline content over the best check MP 3288. Heterobeltiosis was significant for 3 crosses on pooled basis for total chlorophyll content with maximum magnitude of 19.05% (PBW 701 x RAJ 4120) for this trait. None of the crosses was showed significant economic heterosis for this trait in any of the environments.

Similar results were also reported by Saxena and Rawat 2011, Jain and Sastry 2012, Beche et al. 2013, Desale and Mehta 2013, Barot et al. 2014, Gogas and Sotiriou 2014, Kumar and Kerkhi 2014, Ismail 2015, Kalhoro et al. 2015, Desale et al. 2016, Thomas et al. 2017, Yadav et al. 2017, Patel 2018, Rajput and Kandalkar 2018, Saini et al. 2018 and Saren et al. 2018.

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Heterosis for Grain Yield and Related Traits in Wheat [*Triticum aestivum* (L.) in Normal and Heat Stressed Environments

Meenakshi Dhoot^{1*}, Hemlata Sharma¹, Rupal Dhoot² and H.K. Jain³

¹Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, MPUAT, Udaipur-313001, Rajasthan

²Department of Genetics and Plant Breeding, College of Agriculture, Agriculture University, Jodhpur-342304, Rajasthan

³Department of Statistics, Rajasthan College of Agriculture, MPUAT, Udaipur-313001, Rajasthan

*Corresponding Author Email : dhootakshi9@gmail.com

Abstract

Present investigations were carried out to exploit further breeding for heat tolerant cultivars. Heterosis was evaluated by 42 crosses developed by line x tester design (14 lines and 3 testers) along with 2 checks in RBD with 3 replications in wheat for number of effective tillers per plant, spike length, number of spikelets per plant, length of awns, number of grains per spike, flag leaf area, 1000 grain weight, biological yield per plant, grain yield per plant and harvest index in normal sown and late sown (heat stressed) environments. The mean squares due to genotypes, parents, crosses were significant indicating presence of overall heterosis for these traits in both the environments. Variable number of crosses exhibited significant heterobeltiosis in desirable direction for different component. Number of crosses showing desirable significant heterobeltiosis ranged from 02 (number of effective tillers per plant, number of spikelets per plant, flag leaf area) to 14 (grain yield per plant) in normal sown and 01 (length of awns, flag leaf area) to 16 (grain yield per plant) in late sown condition. The positive significant heterobeltiosis for grain yield per plant was ranged from 11.75 % (DBW-129 x RAJ 4120) to 40.82 % (DBW-179 x RAJ 4037) in stressed condition. The economic heterosis for grain yield per plant was significant for 4 and 6 crosses over the best check HI 1544 in normal and stressed environments, respectively.

Key Words : Heterosis, grain yield, normal sown and late sown (heat stressed) environment.

Introduction

Wheat, a self-pollinated temperate crop belongs to family Poaceae, is major cereal crop grown world wide for staple food. Common bread wheat is used in whole world due to its nutritional components like, protein, gluten and starch. However, the productivity of wheat is affected during recent years due to unfavourable environmental conditions prevailing at the time of grain filling stage. Thus, to understand the effect of increasing temperature on wheat in general and terminal heat in particular, it became important to improve the yield and quality of wheat for warm as well as temperate countries (Nandha *et al.*, 2018). Heterosis breeding provides the way to overcome the yield barriers. Exploitation of heterotic effects is mainly accredited to cross pollinated crops but now-a-days the incidence is common in self-pollinated crops such as wheat, providing an option for commercially utilizing wheat (Kumar *et al.*, 2011).

Materials and Methods

The experimental material comprised of seventeen wheat genotypes (14 lines and 3 testers) and two check varieties viz., MP 3288 and HI 1544. These genotypes were crossed in Line x Tester design to develop a total forty two crosses during *rabi* 2016-17. All the 61 genotypes (17

parents, 42 crosses and 2 checks) were evaluated in a randomized block design with three replications in different environments, normal sown and late sown during *rabi* 2017-18 at Department of Genetics and Plant Breeding, Rajasthan College of Agriculture (RCA), MPUAT, Udaipur. Each genotype was accommodated in one row plot of 3 meter length. Row to row and plant to plant distances were 22.5 cm and 10 cm, respectively. Heterobeltiosis and economic heterosis, expressed as per cent deviation toward desirable direction over better parent and standard check, respectively. Heterobeltiosis and economic heterosis were calculated according to the method suggested by Fonseca and Patterson (1968) and Meredith and Bridge (1972), respectively.

Results and Discussion

Significant differences among genotypes, parents and crosses for all the concern characters suggested presence of considerable amount of genetic variation in the material (Table 1) Similar results were reported by Nour *et al.* 2011, Ameen 2012, Hossain *et al.* 2013, Barot *et al.* 2014, Ismail 2015, Mahpara *et al.* 2015, Baloch *et al.* 2016 and Patel 2018.

Total-2 and 5 crosses exhibited significant and positive heterobeltiosis for number of effective tillers per plant in normal sown and late sown, respectively (Table

Table-1 : Mean squares for different characters in wheat (*Triticum aestivum*) in different environments.

S. No.	Characters	E	Rep. [2]	Genotype [60]	Check [1]	Par-ents [16]	Crosses [41]	Tester [2]	Lines [13]	L X T [26]	Error [120]
1.	Number of effective tillers per plant	N	0.4	3.57*	0.67	2.96**	3.95**	2.33	3.27**	3.89**	1.24
		S	0.59	4.72**	1.5	2.75**	5.23**	6.33**	2.23*	4.97**	1.17
2.	Spike length (cm)	N	1.66	3.51*	0.43	2.72	3.62**	1.33	3.09*	2.64*	1.63
		S	0.02	3.16*	0.33	3.16**	3.34**	1.37	3.52**	4.05**	1.1
3.	Number of spikelets per plant	N	171.71	2023.29*	10.94	1888.35**	1974.76**	831.09	2014.28**	1816.11**	437.03
		S	286.17	1634.2**	16.37	778.88**	1702.02**	772.66	823.07**	1465.98**	301
4.	Length of awns (cm)	N	0.03	1.50*	0.38	1.59**	1.18**	0.53	1.66**	1.06*	0.6
		S	0.01	1.65*	0.04	1.67**	1.55**	0.10	1.77**	1.43**	0.37
5.	Number of grains per spike	N	4.63	71.63**	24.00**	112.29**	45.78**	7.00	131.66**	19.63**	2.97
		S	5.97	63.97**	0.67	107.14**	43.01**	4.78	128.07**	15.95**	8.06
6.	Flag leaf area (cm ²)	N	0.56	28.15*	2.9	16.74**	30.91**	3.31	18.54**	10.24	6.87
		S	0.39	24.57**	1.87	16.71**	26.20**	7.92	16.69**	11.68**	5.85
7.	1000-grain weight (g)	N	0.15	23.90**	8.17	22.14**	20.94**	8.11	25.30**	6.85*	3.73
		S	5.75	18.87*	4.17	10.60*	18.75**	12.00	11.11*	8.2	5.22
8.	Biological yield per plant (g)	N	2.01	34.16**	20.17*	22.17**	35.30**	3.41	26.48**	11.32**	4.73
		S	2.09	21.47**	1.71	14.38**	22.29**	3.52	17.02**	13.74**	3.9
9.	Grain yield per plant (g)	N	0.12	29.30**	7.64*	17.66**	31.10**	3.75	21.05**	9.15**	1.31
		S	0.32	19.15**	0.48	10.31**	21.28**	1.72	11.95**	10.56**	0.95
10.	Harvest index (%)	N	3.52	78.56**	1.5	65.18**	79.76**	16.78	77.43**	31.54**	14.14
		S	0.7	78.33**	0.17	48.89**	88.25**	4.33	55.01**	49.21**	7.66

*, ** Significant at 5 and 1 per cent, respectively. N= Normal, S=Stressed

2). The maximum magnitude of heterobeltiosis was expressed by DBW-179 x RAJ 4079 (22.22%) in normal sown and DBW-17 x RAJ 4120 (52.94 %) in late sown environment. Cross KBRL 82-2 x RAJ 4037 expressed significant positive economic heterosis in both environments over the best check HI-1544. For spike length positive significant heterobeltiosis was exhibited by 4 and 2 crosses for normal sown and late sown environment, respectively. The magnitude of heterobeltiosis ranged from 18.92 % (HS-595 x RAJ 4079) to 33.33 % (HPW-368 x RAJ 4079) in normal sown and 18.03 % (HPW-368 x RAJ 4079) to 20.44 % (HPW-360 x RAJ 4120) in late sown environment for spike length. None of the crosses showed significant economic heterosis for this trait in any of the environments. Heterobeltiosis for number of spikelets per plant was positive significant for 2 and 6 crosses in normal sown and late sown environment, respectively (Table-3). The maximum heterobeltiosis was expressed by HS-547 x RAJ 4079 (25.89 %) in normal sown and PBW-701 x RAJ 4120 (77.84 %) in late sown environment. The economic heterosis for number of spikelets per plant was positive significant for only one cross KBRL 82-2 x RAJ 4037 in both environments, 11.14% in normal sown, 11.51% in late sown. Heterobeltiosis was significant for cross VL-1003 x RAJ 4079 in late sown environment with magnitude of 15.21% for length of awns. None of the crosses expressed significant economic heterosis for this trait in any of the environments. The magnitude of

heterobeltiosis ranged from 5.45 (GW-463 x RAJ 4037) to 22.64 % (KBRL 82-2 x RAJ 4120) in normal sown and 8.92% (KBRL 82-2 x RAJ 4079) to 12.67 % (KBRL 82-2 x RAJ 4120) in late sown environment for number of grains per spike. Heterobeltiosis was significant for 10 and 6 crosses in normal sown and late sown environment, respectively (Table-4). None of the crosses showed significant economic heterosis for this trait in any of the environments. Positive significant heterobeltiosis was expressed by 2 and 1 crosses in normal sown and late sown environments, respectively for flag leaf area. The maximum magnitude of heterobeltiosis was observed DBW-17 x RAJ 4120 (11.04 %) and DBW-129 x RAJ 4120 (11.04 %) in normal sown and DBW-129 x RAJ 4120 (14.13%) in late sown environment. The economic heterosis was positive significant only for one cross DBW-17 x RAJ 4120 (8.43 %) in normal sown environment over the best check MP 3288 for this trait (Table-5). For 1000-grain weight, positive significant heterobeltiosis exhibited by 6 and 8 crosses in normal sown and late sown environment, respectively. The maximum estimates of heterobeltiosis were 13.69 % (HPW-368 x RAJ 4120) and 15.32 % (DBW-17 x RAJ 4079) in normal sown and late sown environment, respectively. Two crosses exhibited positive significant economic heterosis in late sown viz., HPW-360 x RAJ 4120 (6.67 %) and DBW-17 x RAJ 4079 (6.67 %) was for 1000-grain weight over the best check HI 1544. The magnitude of heterobeltiosis for biological yield per plant

Table-2 : Extent of heterobeltiosis (HB) and economic heterosis (EH) for number of effective tillers per plant and spike length.

S. No.	Crosses	Number of effective tillers per plant				Spike length			
		HB		EH		HB		EH	
		N	S	N	S	N	S	N	S
1.	DBW-129 x RAJ 4120	10.7	25.00	-	-	8.57	-	-	-
2.	DBW-17 x RAJ 4120	9.38	52.94**	0.00	-	-	-	-	-
3.	DBW-93 x RAJ 4120	12.5	27.27*	2.86	3.70	-	-	-	-
4.	DBW-71 x RAJ 4120	-	11.76	-	-	4.19	-	-	-
5.	HPW-368 x RAJ 4120	-	-	-	-	-	-	-	-
6.	DBW-179 x RAJ 4120	-	-	-	-	6.42	-	-	-
7.	KBRL 82-2 x RAJ 4120	12.5	27.27*	2.86	3.70	-	-	-	-
8.	GW-463 x RAJ 4120	-	-	-	-	-	-	-	-
9.	HS-547 x RAJ 4120	14.8	17.65	-	-	-	0.63	-	-
10.	HS-595 x RAJ 4120	-	-	-	-	7.14	1.23	-	-
11.	HUW-677 x RAJ 4120	-	-	-	-	-	3.77	-	-
12.	VL-1003 x RAJ 4120	3.12	20.00	-	-	-	3.77	-	-
13.	HPW-360 x RAJ 4120	3.85	-	-	-	21.43*	20.44*	2.16	4.08
14.	PBW-701 x RAJ 4120	20.69*	50.00**	0.00	-	25.71**	6.92	5.77	-
15.	DBW-129 x RAJ 4037	17.86	9.52	-	-	8.75	6.45	-	-
16.	DBW-17 x RAJ 4037	0	4.76	-	-	1.83	-	-	-
17.	DBW-93 x RAJ 4037	-	-	-	-	-	6.80	-	-
18.	DBW-71 x RAJ 4037	-	-	-	-	4.75	-	-	-
19.	HPW-368 x RAJ 4037	-	0.00	-	-	-	-	-	-
20.	DBW-179 x RAJ 4037	3.22	-	-	-	-	-	-	-
21.	KBRL 82-2 x RAJ 4037	19.36	31.82**	5.71*	7.41*	-	-	-	-
22.	GW-463 x RAJ 4037	3.7	-	-	-	-	8.47	-	-
23.	HS-547 x RAJ 4037	3.7	0.00	-	-	-	5.08	-	-
24.	HS-595 x RAJ 4037	10.71	-	-	-	5.14	-	-	-
25.	HUW-677 x RAJ 4037	9.68	19.05	-	-	-	3.81	-	-
26.	VL-1003 x RAJ 4037	-	-	-	-	-	-	-	-
27.	HPW-360 x RAJ 4037	11.54	-	-	-	12.12	15.92	-	-
28.	PBW-701 x RAJ 4037	0	-	-	-	33.33**	18.03*	5.77	-
29.	DBW-129 x RAJ 4079	7.41	-	-	-	5.41	-	-	-
30.	DBW-17 x RAJ 4079	14.81	-	-	-	4.44	-	-	-
31.	DBW-93 x RAJ 4079	3.70	-	-	-	-	13.27	-	-
32.	DBW-71 x RAJ 4079	-	-	-	-	1.08	-	-	-
33.	HPW-368 x RAJ 4079	11.11	0.00	-	-	10.53	3.90	0.96	-
34.	DBW-179 x RAJ 4079	22.22*	-	-	-	4.05	-	-	-
35.	KBRL82-2 x RAJ 4079	14.81	-	-	-	-	-	-	-
36.	GW-463 x RAJ 4079	-	-	-	-	5.26	8.47	-	-
37.	HS-547 x RAJ 4079	18.52	-	-	-	5.94	-	-	-
38.	HS-595 x RAJ 4079	18.52	-	-	-	18.92*	1.23	5.77	-
39.	HUW-677 x RAJ 4079	7.41	-	-	-	4.32	2.81	-	-
40.	VL-1003 x RAJ 4079	3.7	0.00	-	-	-	-	-	-
41.	HPW-360 x RAJ 4079	11.5	-	-	-	-	-	-	-
42.	PBW-701 x RAJ 4079	-	-	-	-	0.00	3.28	-	-

*, ** Significant at 5 and 1 per cent, respectively. N= Normal, S=Stressed

Table-3 : Extent of heterobeltiosis (HB) and economic heterosis (EH) for number of spikelets per plant and length of awns.

S. No.	Crosses	Number of spikelets per plant				Length of awns			
		HB		EH		HB		EH	
		N	S	N	S	N	S	N	S
1.	DBW-129 x RAJ 4120	1.36	41.44*	-	-	7.84	-	1.85	-
2.	DBW-17 x RAJ 4120	4.43	46.24**	-	-	5.88	-	0.00	-
3.	DBW-93 x RAJ 4120	11.66	30.66*	2.95	0.95	5.88	-	0.00	-
4.	DBW-71 x RAJ 4120	-	17.82	-	-	-	-	-	-
5.	HPW-368 x RAJ 4120	-	-	-	-	0.39	11.84	-	4.08
6.	DBW-179 x RAJ 4120	-	-	-	-	1.96	3.07	-	-
7.	KBRL 82-2 x RAJ 4120	11.83	74.00**	3.11	3.31	0.00	-	-	-
8.	GW-463 x RAJ 4120	-	-	-	-	-	-	-	-
9.	HS-547 x RAJ 4120	-	20.59	-	-	-	-	-	-
10.	HS-595 x RAJ 4120	-	-	-	-	1.96	-	-	-
11.	HUW-677 x RAJ 4120	-	-	-	-	-	-	-	-
12.	VL-1003 x RAJ 4120	-	-	-	-	0.00	-	-	-
13.	HPW-360 x RAJ 4120	-	-	-	-	-	-	-	-
14.	PBW-701 x RAJ 4120	14.73	77.84**	5.79	-	-	-	-	-
15.	DBW-129 x RAJ 4037	-	4.49	-	-	3.20	-	-	-
16.	DBW-17 x RAJ 4037	-	4.59	-	-	8.57	-	-	-
17.	DBW-93 x RAJ 4037	-	-	-	-	-	-	-	-
18.	DBW-71 x RAJ 4037	-	5.91	-	-	8.16	1.36	-	-
19.	HPW-368 x RAJ 4037	-	-	-	-	-	-	-	-
20.	DBW-179 x RAJ 4037	-	-	-	-	9.80	1.32	3.70	-
21.	KBRL 82-2 x RAJ 4037	25.07**	60.91**	11.14*	11.51*	2.04	-	-	-
22.	GW-463 x RAJ 4037	-	-	-	-	3.67	-	-	-
23.	HS-547 x RAJ 4037	-	6.40	-	-	-	-	-	-
24.	HS-595 x RAJ 4037	-	-	-	-	12.65	-	2.22	-
25.	HUW-677 x RAJ 4037	10.25	16.07	-	-	-	-	-	-
26.	VL-1003 x RAJ 4037	-	-	-	-	-	-	-	-
27.	HPW-360 x RAJ 4037	-	-	-	-	2.04	-	-	-
28.	PBW-701 x RAJ 4037	-	-	-	-	-	-	-	-
29.	DBW-129 x RAJ 4079	0.42	-	-	-	5.60	-	-	-
30.	DBW-17 x RAJ 4079	-	-	-	-	13.11	7.62	2.22	-
31.	DBW-93 x RAJ 4079	-	-	-	-	3.91	10.60	-	-
32.	DBW-71 x RAJ 4079	-	-	-	-	0.00	-	-	-
33.	HPW-368 x RAJ 4079	-	-	-	-	0.00	-	-	-
34.	DBW-179 x RAJ 4079	0.90	-	-	-	-	-	-	-
35.	KBRL82-2 x RAJ 4079	12.15	15.87	-	-	-	-	-	-
36.	GW-463 x RAJ 4079	-	-	-	-	-	-	-	-
37.	HS-547 x RAJ 4079	25.89*	-	-	-	2.17	-	-	-
38.	HS-595 x RAJ 4079	9.38	-	-	-	-	-	-	-
39.	HUW-677 x RAJ 4079	-	-	-	-	-	-	-	-
40.	VL-1003 x RAJ 4079	-	-	-	-	9.57	15.21*	-	2.04
41.	HPW-360 x RAJ 4079	7.19	12.10	-	-	-	0.00	-	-
42.	PBW-701 x RAJ 4079	-	-	-	-	13.48	-	-	-

*, ** Significant at 5 and 1 per cent, respectively. N = Normal, S = Stressed

Table-4 : Extent of heterobeltiosis (HB) and economic heterosis (EH) for number of grains per spike and flag leaf area.

S. No.	Characters	Number of grains per spike				Flag leaf area			
		HB		EH		HB		EH	
		N	S	N	S	N	S	N	S
1.	DBW-129 x RAJ 4120	-	-	-	-	11.04*	14.13**	4.13	5.29
2.	DBW-17 x RAJ 4120	-	-	-	-	11.04*	4.77	8.43*	-
3.	DBW-93 x RAJ 4120	0.63	-	-	-	-	-	-	-
4.	DBW-71 x RAJ 4120	-	-	-	-	6.73	-	-	-
5.	HPW-368 x RAJ 4120	1.25	-	-	-	5.12	4.76	-	-
6.	DBW-179 x RAJ 4120	-	-	-	-	5.04	3.25	-	-
7.	KBRL 82-2 x RAJ 4120	22.64**	12.67**	4.28	0.60	7.27	0.43	-	-
8.	GW-463 x RAJ 4120	6.92*	4.67	-	-	-	-	-	-
9.	HS-547 x RAJ 4120	-	1.33	-	-	6.52	2.21	-	-
10.	HS-595 x RAJ 4120	-	-	-	-	6.48	3.45	-	-
11.	HUW-677 x RAJ 4120	-	-	-	-	9.88	9.06	-	-
12.	VL-1003 x RAJ 4120	1.82	-	-	-	3.31	-	-	-
13.	HPW-360 x RAJ 4120	0.61	0.65	-	-	-	-	-	-
14.	PBW-701 x RAJ 4120	18.24**	11.33*	0.53	-	-	-	-	-
15.	DBW-129 x RAJ 4037	3.43	0.62	-	-	6.14	-	-	-
16.	DBW-17 x RAJ 4037	-	-	-	-	6.87	7.99	4.35	2.79
17.	DBW-93 x RAJ 4037	-	-	-	-	-	-	-	-
18.	DBW-71 x RAJ 4037	-	0.00	-	-	-	-	-	-
19.	HPW-368 x RAJ 4037	0.61	4.64	-	-	-	-	-	-
20.	DBW-179 x RAJ 4037	-	-	-	-	4.18	-	-	-
21.	KBRL 82-2 x RAJ 4037	9.70**	12.58**	-	1.19	0.16	-	-	-
22.	GW-463 x RAJ 4037	5.45*	3.31	-	-	-	-	-	-
23.	HS-547 x RAJ 4037	-	1.32	-	-	-	6.35	-	0.86
24.	HS-595 x RAJ 4037	-	-	-	-	-	-	-	-
25.	HUW-677 x RAJ 4037	-	-	-	-	4.11	-	-	-
26.	VL-1003 x RAJ 4037	6.67*	3.12	-	-	2.63	-	-	-
27.	HPW-360 x RAJ 4037	-	-	-	-	-	-	-	-
28.	PBW-701 x RAJ 4037	0.61	5.30	-	-	-	-	-	-
29.	DBW-129 x RAJ 4079	-	-	-	-	-	-	-	-
30.	DBW-17 x RAJ 4079	1.76	3.16	-	-	-	0.71	-	-
31.	DBW-93 x RAJ 4079	4.76	6.37	-	-	-	-	-	-
32.	DBW-71 x RAJ 4079	-	-	-	-	-	-	-	-
33.	HPW-368 x RAJ 4079	-	-	-	-	-	-	-	-
34.	DBW-179 x RAJ 4079	-	-	-	-	0.86	0.34	-	-
35.	KBRL82-2 x RAJ 4079	7.74**	8.92*	-	1.79	1.12	-	-	-
36.	GW-463 x RAJ 4079	5.95*	10.83*	-	3.57	-	-	-	-
37.	HS-547 x RAJ 4079	-	-	-	-	-	-	-	-
38.	HS-595 x RAJ 4079	-	-	-	-	-	-	-	-
39.	HUW-677 x RAJ 4079	-	-	-	-	5.06	-	-	-
40.	VL-1003 x RAJ 4079	-	-	-	-	-	-	-	-
41.	HPW-360 x RAJ 4079	12.50**	11.46*	1.07	4.17	0.05	-	-	-
42.	PBW-701 x RAJ 4079	6.55*	7.64	-	0.60	-	-	-	-

*, ** Significant at 5 and 1 per cent, respectively. N= Normal, S=Stressed

Table-5 : Extent of heterobeltiosis (HB) and economic heterosis (EH) for 1000-grain weight and biological yield per plant.

Characters		1000- grain weight				Biological yield per plant			
S. No.	Crosses	HB		EH		HB		EH	
		N	S	N	S	N	S	N	S
1.	DBW-129 x RAJ 4120	10.30**	11.43*	4.50	4.00	7.24	7.21	5.48*	2.99*
2.	DBW-17 x RAJ 4120	7.83*	9.91	5.64	1.67	3.00	-	-	-
3.	DBW-93 x RAJ 4120	-	-	-	-	0.71	-	-	-
4.	DBW-71 x RAJ 4120	1.28	1.39	-	-	-	-	-	-
5.	HPW-368 x RAJ 4120	13.69**	8.87	1.13	4.33	3.05	-	-	-
6.	DBW-179 x RAJ 4120	7.45*	9.83*	3.01	5.25	14.29**	-	-	-
7.	KBRL 82-2 x RAJ 4120	5.07	12.29*	-	2.00	-	2.32	-	-
8.	GW-463 x RAJ 4120	-	-	-	-	-	-	-	-
9.	HS-547 x RAJ 4120	0.00	4.63	-	-	-	-	-	-
10.	HS-595 x RAJ 4120	4.96	8.33	-	-	-	6.35	-	-
11.	HUW-677 x RAJ 4120	2.56	7.41	-	-	-	6.03	-	-
12.	VL-1003 x RAJ 4120	7.26	7.59	-	-	0.65	5.29	-	-
13.	HPW-360 x RAJ 4120	4.44	14.39**	-	6.67*	12.56*	2.94	-	-
14.	PBW-701 x RAJ 4120	-	-	-	-	-	-	-	-
15.	DBW-129 x RAJ 4037	5.79	-	0.23	-	-	-	-	-
16.	DBW-17 x RAJ 4037	2.07	0.00	0.00	-	-	14.20*	-	-
17.	DBW-93 x RAJ 4037	-	-	-	-	0.59	1.36	-	-
18.	DBW-71 x RAJ 4037	-	-	-	-	-	0.56	-	-
19.	HPW-368 x RAJ 4037	0.00	-	-	-	5.44	-	-	-
20.	DBW-179 x RAJ 4037	-	4.35	-	0.00	24.29**	10.34*	6.97*	3.70*
21.	KBRL 82-2 x RAJ 4037	-	0.70	-	-	17.65**	-	-	-
22.	GW-463 x RAJ 4037	-	-	-	-	-	11.36*	-	-
23.	HS-547 x RAJ 4037	-	-	-	-	8.44	8.79	-	-
24.	HS-595 x RAJ 4037	-	-	-	-	3.36	6.74	-	-
25.	HUW-677 x RAJ 4037	-	0.00	-	-	-	10.80	-	-
26.	VL-1003 x RAJ 4037	2.14	-	-	-	9.96	3.76	-	-
27.	HPW-360 x RAJ 4037	-	6.14	-	0.83	23.30**	6.47	4.10*	0.56
28.	PBW-701 x RAJ 4037	-	-	-	-	5.04	6.14	-	-
29.	DBW-129 x RAJ 4079	1.59	10.71*	-	3.33	0.83	-	-	-
30.	DBW-17 x RAJ 4079	2.46	15.32**	0.38	6.67*	4.89	16.36**	0.16	-
31.	DBW-93 x RAJ 4079	0.42	2.94	-	-	-	-	-	-
32.	DBW-71 x RAJ 4079	6.78	-	-	-	-	-	-	-
33.	HPW-368 x RAJ 4079	8.54*	-	-	-	16.89**	5.85	0.41	-
34.	DBW-179 x RAJ 4079	-	0.00	-	-	11.43*	1.97	-	-
35.	KBRL82-2x RAJ 4079	5.63	2.75	-	-	21.57**	11.11*	1.64	1.85
36.	GW-463 x RAJ 4079	6.78	9.18	-	-	-	-	-	-
37.	HS-547 x RAJ 4079	5.08	3.92	-	-	-	-	-	-
38.	HS-595 x RAJ 4079	-	-	-	-	-	-	-	-
39.	HUW-677 x RAJ 4079	8.90*	1.87	-	-	-	0.44	-	-
40.	VL-1003 x RAJ 4079	5.25	14.42**	-	-	6.12	-	-	-
41.	HPW-360 x RAJ 4079	4.27	2.77	-	-	10.68*	8.33	-	2.31
42.	PBW-701 x RAJ 4079	-	11.76*	-	-	-	-	-	-

*, ** Significant at 5 and 1 per cent, respectively. N= Normal, S=Stressed

Table-6 : Extent of heterobeltiosis (HB) and economic heterosis (EH) for grain yield per plant and harvest index.

S. No.	Character Crosses	Grain yield per plant				Harvest index			
		HB		EH		HB		EH	
		N	S	N	S	N	S	N	S
1.	DBW-129 x RAJ 4120	16.27**	11.75*	11.47*	5.36*	7.65	4.72	4.79*	-
2.	DBW-17 x RAJ 4120	12.83*	14.44*	1.56	-	10.00	8.76	1.99	8.76*
3.	DBW-93 x RAJ 4120	-	-	-	-	-	-	-	-
4.	DBW-71 x RAJ 4120	-	-	-	-	-	0.93	-	-
5.	HPW-368 x RAJ 4120	5.93	-	-	-	2.92	-	-	-
6.	DBW-179 x RAJ 4120	10.42	6.25	-	-	-	13.11*	-	0.73
7.	KBRL 82-2 x RAJ 4120	0.85	-	-	-	1.46	-	-	-
8.	GW-463 x RAJ 4120	-	-	-	-	-	-	-	-
9.	HS-547 x RAJ 4120	-	-	-	-	-	-	-	-
10.	HS-595 x RAJ 4120	4.22	14.97*	-	-	0.00	-	-	-
11.	HUW-677 x RAJ 4120	-	18.64**	-	-	-	12.73*	-	-
12.	VL-1003 x RAJ 4120	-	9.16	-	-	-	2.78	-	-
13.	HPW-360 x RAJ 4120	24.62**	12.00*	-	-	9.77	6.78	-	-
14.	PBW-701 x RAJ 4120	-	-	-	-	-	-	-	-
15.	DBW-129 x RAJ 4037	-	-	-	-	-	-	-	-
16.	DBW-17 x RAJ 4037	2.60	-	-	-	4.64	-	-	-
17.	DBW-93 x RAJ 4037	-	-	-	-	-	-	-	-
18.	DBW-71 x RAJ 4037	1.29	6.38	-	-	3.31	3.92	-	-
19.	HPW-368 x RAJ 4037	9.55	-	-	-	5.11	-	-	-
20.	DBW-179 x RAJ 4037	30.23**	40.82**	11.44*	24.11**	3.31	27.87**	3.31	13.87**
21.	KBRL 82-2 x RAJ 4037	15.87*	1.51	-	-	-	11.11	-	-
22.	GW-463 x RAJ 4037	20.51**	26.60**	-	-	21.19**	13.86*	-	-
23.	HS-547 x RAJ 4037	19.07**	21.09**	-	-	11.86	10.48	-	-
24.	HS-595 x RAJ 4037	16.63*	14.49*	-	-	15.83*	8.26	-	-
25.	HUW-677 x RAJ 4037	10.37	21.88**	-	-	10.17	10.00	-	-
26.	VL-1003 x RAJ 4037	19.32**	18.95*	-	-	7.03	17.48**	-	-
27.	HPW-360 x RAJ 4037	33.96**	21.20**	0.30	2.71*	9.02	13.56*	-	-
28.	PBW-701 x RAJ 4037	9.54	14.83	-	-	7.63	10.89	-	-
29.	DBW-129 x RAJ 4079	1.27	-	-	-	0.00	-	-	-
30.	DBW-17 x RAJ 4079	13.47**	18.69**	2.14*	-	7.86	-	0.00	-
31.	DBW-93 x RAJ 4079	-	-	-	-	-	-	-	-
32.	DBW-71 x RAJ 4079	-	-	-	-	9.76	-	-	-
33.	HPW-368 x RAJ 4079	29.64**	23.79**	1.84*	5.17*	11.68	16.39**	1.32	3.65
34.	DBW-179 x RAJ 4079	-	9.38	-	-	-	8.20	-	-
35.	KBRL82-2 x RAJ 4079	38.15**	28.97**	4.57*	6.57*	11.68	17.09**	1.32	0.00
36.	GW-463 x RAJ 4079	-	2.84	-	-	1.54	5.83	-	-
37.	HS-547 x RAJ 4079	-	-	-	-	-	-	-	-
38.	HS-595 x RAJ 4079	-	-	-	-	0.00	-	-	-
39.	HUW-677 x RAJ 4079	5.80	2.12	-	-	3.74	-	-	-
40.	VL-1003 x RAJ 4079	7.47	1.11	-	-	-	1.94	-	-
41.	HPW-360 x RAJ 4079	30.81**	28.85**	-	9.19*	19.55**	16.95**	5.30*	0.73
42.	PBW-701 x RAJ 4079	-	-	-	-	-	-	-	-

*, ** Significant at 5 and 1 per cent, respectively. N = Normal, S = Stressed

ranged from 10.68% (HPW-360 x RAJ 4079) to 24.29 % (DBW-179 x RAJ 4037) in normal sown and 10.34 % (DBW-179 x RAJ 4037) to 16.36 % (DBW-17 x RAJ 4079) in late sown environment. Heterobeltiosis was significant and positive for 9 and 5 in normal sown and late sown environment, respectively for biological yield per plant. The estimates of economic heterosis were positive significant for 3 crosses in normal sown and 2 crosses in late sown environment over the best check HI 1544. The positive significant heterobeltiosis for grain yield per plant was ranged from 12.83 % (DBW-17 x RAJ 4120) to 38.15 % (KBRL 82-2 x RAJ 4079) in normal sown and 11.75 % (DBW-129 x RAJ 4120) to 40.82 % (DBW-179 x RAJ 4037) in late sown environment (Table 6). The positive heterobeltiosis was significant for 14 and 16 crosses in normal sown and late sown environment, respectively.

The economic heterosis for grain yield per plant was significant for 4 and 6 crosses in normal sown and late sown environment, respectively. The maximum economic heterosis was exhibited by cross DBW-129 x RAJ 4120 (11.47 %) in normal sown and cross DBW-179 x RAJ 4037 (24.11 %) in late sown environment over the best check HI 1544. For harvest index, positive significant heterobeltiosis was expressed by 3 and 9 crosses in normal sown and late sown environment, respectively. The maximum positive heterobeltiosis was depicted by cross DBW-179 x RAJ 4037 in (27.87 %) late sown, while GW 463 x RAJ 4037 (21.19 %) in normal sown environment for harvest index. Two different crosses in each environment exhibited positive significant economic heterosis over the best check HI 1544. The highest economic heterosis was 5.30 % (HPW-360 x RAJ 4079) in normal sown and 13.87 % (DBW-179 x RAJ 4037) in late sown environment for harvest index. Similar results were reported by Nour *et al.* 2011, Ameen 2012, Hossain *et al.* 2013, Barot *et al.* 2014, Ismail 2015, Mahpara *et al.* 2015, Baloch *et al.* 2016, Thomas *et al.* 2017, Yadav *et al.* 2017, Patel *et al.* 2018, Rajput and Kandalkar 2018, Saini *et al.* 2018 and Saren *et al.* 2018.

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Standardized Precipitation Index (SPI) for Identification and Characterization of Drought for Rajasthan (Great Indian Desert)

Poonam^{1,2*}, Aradhana thakur², V.K. Chandola² and A.K. Lohani³

¹Dept. of Watershed Development and Soil Conservation, Lakshmangarh, Siakr, Rajasthan

²Department of Farm Engineering, IAS, Banaras Hindu University, Varanasi, U.P.

³National Institute of Hydrology, Jalvigyan Bhawan, Roorkee, Uttarakhand

*Corresponding Author Email : poonammahla11@gmail.com

Abstract

Rajasthan suffers with frequent drought due to poor and delayed monsoon, incongruously temperature variation and water scarcity. In the present study the SPI has been computed for all the 32 district of Rajasthan. The SPI has been calculated for shorter period of 3-month as the 3-m SPI is suitable for representation of short and medium term moisture conditions and offers a seasonal estimation of precipitation scarcity or surplus that is particularly useful in agricultural activities. A number of drought events occurred in all 32 districts of Rajasthan have been analysed and the drought events faced at four worst affected districts of Rajasthan viz., Jaisalmer, Jodhpur, Barmer and Jalor.

Introduction

Drought can be defined in a number of ways. In general terms, drought is a “prolonged absence or marked deficiency of precipitation”, a “deficiency” that results in water shortage for some activity or for some group”, or a “period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance”. Agricultural drought relates to moisture deficiency in the uppermost one meter or more of soil (root zone) that affects the crops, meteorological drought is deficiency of precipitation for a long period of time and hydrologic drought is related to below-normal stream flow, lake, and groundwater levels. A mega drought is a long-drawn out and pervasive drought, lasting much longer than normal usually a decade or more. According to the Indian Meteorological Department (IMD), an area or region is considered to be under drought, if it receives total seasonal rainfall less than 75% of its normal value.

In the context of Rajasthan, nearly 61% of the geographical area falls under arid/ semi-arid zone. Rajasthan is the most sensitive place which affected by climate change. The variability in climate is likely to have a considerable impact on the physical and socio-economic fabric of the entire state. The entire state receives erratic rainfall. Thar Desert in western Rajasthan is characterized by low and erratic rainfall, high air and soil temperature, intense solar radiation and high wind velocity. These factors give rise to frequent droughts and famines.

According to a study recently undertaken by the state control board, Rajasthan is going to face more shortage of water due to overall reduction in rainfall and

increased evapotranspiration because of global warming. In addition, the State has the maximum vulnerability and lowest adaptive capacity to climate change challenges. Rajasthan has the maximum probability of occurrence of drought. One percent increase in temperature from base data could result in an increase in evapo-transpiration. All of the above, quality and quantity of ground water as well as surface water resources in Rajasthan has deteriorated rapidly in last two decades. The climatic data from 1869-1969 were analyzed to look into the aspect of occurrences of droughts in the region (Banerjee and Upadhyay, 1975). It was found that the variability of rainfall increased from east to west, resulting in an increase in the frequency of drought in a similar spatial pattern. Rathore *et al.*, (2005) analyzed the frequencies of droughts over the past hundred years and have interpreted that severe and very severe droughts are more likely to occur in the south and western parts of the state with a probability of 47%. Limited water resources, erratic rainfall, and repetitive droughts lead to poor agricultural and economic condition in the state.

Materials and Methods

Description of study area : Rajasthan is the largest state in the country and covers about 3, 42,000 square kilometers area. It is divided into 32 districts and is located between 69°30' to 78°17'E longitude and 23°30'to 30°12' N latitude. Rajasthan is the largest state in the country and covers about 3, 42,000 square kilometers area. Geologically, the state can be broadly divided into three natural regions, viz. (i) Aeolian sands (ii) Alluvium and (iii) Aravallis.

Standardized Precipitation Index (SPI) : Drought

occurrence depends on various interactions of many hydrological phenomenon such as precipitation, runoff, evaporation, infiltration, surface and ground water storage. Standardized Precipitation Index (SPI) is one of the well-known approaches to identify the long term behavior of precipitation in terms of drought or non-drought conditions. The SPI (McKee and others, 1993, 1995) is a powerful, flexible index that is simple to calculate. SPI is based on the probability of precipitation for any time scale. In this method firstly the probability of observed precipitation is transformed into an index. SPI is being used by more than 70 Countries for research or operational purposes. The SPI was designed to calculate the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of the different water resources. Soil moisture conditions respond to precipitation inconsistencies on a relatively short scale. Groundwater, stream flow and reservoir storage reflect the longer-term precipitation anomalies. For these reasons, McKee *et al.* (1993) originally calculated the SPI for 3-m, 6-m, 12-m, 24-m and 48-month timescales. The SPI calculation for any location is based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards and McKee, 1997). Positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation.

The SPI assigns a single numeric value to the precipitation varying between -3 and +3 which can be compared across different region with different climate. The SPI allows determining the occurrence of probability of dry or wet events at different time scale varying from 3 to 24 months and monthly rainfall data for a minimum of 30 years is required (Hayes *et al.*, 1999).

A drought event occurs during the period when the SPI is continuously negative with an intensity of -1 or less. As the threshold alteration from drought condition to wet condition is sudden and very fast in the classification (McKee *et al.* 1993) due to the gap between drought and wet being zero, a modified classification has been used in the drought analysis in which SPI value in the range of -0.50 to -0.99 represent mild drought, -1.0 to -1.49 represent moderate drought, -1.50 to -1.99 represent severe drought and SPI < -2.0 represent extreme drought.

The computation of standardized precipitation index consists of following steps :

(1) Calculation of the mean for the normalized precipitation values of the log-normal (L_n) rainfall series and computation of the shape and scale parameters and respectively by the equation given here under,

$$\text{Log mean} \quad \bar{X}_n = \frac{\ln X}{N} \quad \dots(i)$$

$$\text{Shape parameter} \quad \frac{1}{4U} = \frac{1}{\sqrt{\frac{4U}{3}}} \quad \dots(ii)$$

$$\text{Scale parameter} \quad \bar{X} \quad \dots(iii)$$

Here, U is the constant $U = \ln(\bar{X}) - \bar{X}_n$

(2) The resulting parameters are then used to find the cumulative probability of an observed precipitation event for the given month and time scale for the station in equation. The cumulative probability as given by gamma distribution is as follows :

$$G(x) = \frac{1}{\Gamma(x)} \int_0^x t^{x-1} e^{-t} dt \quad \dots(iv)$$

Letting $t = \frac{x}{\bar{X}}$, this equation becomes the incomplete gamma function;

$$G(x) = \frac{1}{\Gamma(x)} \int_0^{\frac{x}{\bar{X}}} t^{x-1} e^{-t} dt \quad \dots(v)$$

Since the gamma function is undefined for $x = 0$ and a precipitation distribution may contain zero, the cumulative probability becomes

$$H(x) = q + (1 - q)G(x)$$

Where, q is the probability of a zero.

Thom (1966) states that q can be estimated by m/N where m is the number of zero in a precipitation time series. He used the table of the incomplete gamma function to determine the cumulative probability $G(x)$. McKee *et al.* (1993) used an analytic method to determine the cumulative probability.

The cumulative probability $H(x)$ is then transformed to the standard normal random variable Z with mean zero and variance one, which is the value of the SPI.

The Z or SPI value can be easily obtained computationally using an approximation provided by Abramowitz and Stegun, (1965) that convert cumulative probability to the standard normal random variable Z .

$$Z = \text{SPI} = -t \frac{c_0 - c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \quad \text{for } 0 < H(x) < 0.5 \quad \dots(vi)$$

$$Z = \text{SPI} = +t \frac{c_0 - c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3} \quad \text{for } 0.5 < H(x) < 1.0 \quad \dots(vii)$$

Where,

$$t = \sqrt{\ln \frac{1}{(H(x))^2}} \quad \text{for } 0 < H(x) < 0.5 \quad \dots(viii)$$

$$t = \sqrt{\ln \frac{1}{(H(x))^2}} \text{ for } 0.5 < H(x) < 1.0 \quad \dots(\text{ix})$$

c_0 2.515517, c_1 0.802853 and c_2 0.010328

d_1 1.432788, d_2 0.189269 and d_3 0.001308

A drought event occur anytime during the period where SPI is continuously negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive. The positive sum of the SPI for all the months within a drought event is termed as drought magnitude and the division of magnitude by its duration is the intensity of drought for that particular duration. In order to evaluate the drought severity in different areas using SPI, one of the most commonly used classification presented by (Hayes *et al.* 1999) at the National Drought Mitigation Center (NDMC) is given in table-1.

Table-1 : Standard ranges of SPI values and their classification.

S. No.	SPI	Classification
1.	= 2.0	Extremely wet
2.	1.5 to 1.99	Very wet
3.	1.0 to 1.49	Moderately wet
4.	0.5 to 0.99	Mild wet
5.	0.5 to -0.50	Normal condition
6.	-0.5 to -0.99	Mild drought
7.	-1.0 to -1.49	Moderate drought
8.	-1.5 to -1.99	Severe drought
9.	-2.0	Extreme drought

Results and Discussion

Identification and Characterization of drought by Standardized Precipitation Index (SPI) :

Drought event in the Worst affected districts based on 3-m SPI : In the present study the SPI has been computed for the 3-m time scale for all the 32 district of Rajasthan. A number of drought events occurred in all 32 districts of Rajasthan have been analysed and the

about 100 years (1901-2002) followed by Barmer (9), Jodhpur (8) and Jaisalmer (7). Jaisalmer had highest number of mild droughts and lowest number of very severe drought, though it receives lowest rainfall in the whole Rajasthan state. The reason for this could be attributed to less variation in the low rainfall. Areas receiving very high rainfall have more chances of variation in the magnitude of rainfall compared to the regions receiving less rainfall. In terms of moderate droughts Jaisalmer (43), Barmer (42) and Jalor (40) were almost at par. Jodhpur observed maximum of 27 severe droughts. From the analysis of the drought events one can conclude that Jodhpur looks to be worst affected in terms of severity of the drought (severe+very severe drought) followed by Jalor (32) and Barmer (29) but hottest Jaisalmer district has least number of severe and very severe droughts (14).

Drought characteristics of worst affected drought districts :

The drought characteristics, including onset, termination, duration and severity based on the 3-month SPI have been evaluated for Jaisalmer, Jodhpur, Barmer and Jalor districts. The drought severity assessment based on the 3-month SPI time series, indicates that the maximum drought severity of -5.99 occurred continuously between May and August 1905 at Jodhpur which was almost at par with that at Jaisalmer (-5.93 during June-September 1987 and -5.85 during May-Aug 1905) indicating a complete failure of monsoon rainfall in the area. Whereas a maximum duration drought of five months is observed at the Jaisalmer district from May 1969 to September 1969. Based on 3-m SPI, Barmer observed total of 9 droughts during the hundred years period and all were shortest duration of three months. Similarly Jalor had 5 droughts during the study period and all except one were of shortest duration of three months. The drought characteristics including the onset, termination, duration and severity is given in Table-3.

Table-2 : Drought event at Jaisalmer, Jodhpur and Barmer, Jalor district for the period 1901-2002 based on 3-m SPI.

S. No.	Drought class	Jaisalmer	Jodhpur	Barmer	Jalor
1.	Extreme	7	8	9	14
2.	Severe	7	27	20	18
3.	Moderate	43	30	42	40
4.	Mild	135	89	59	43
5.	Total	192	154	130	115

drought events faced at four worst affected districts of Rajasthan viz., Jaisalmer, Jodhpur, Barmer and Jalor have been presented in Table-2. It has been observed (table-2) that Jaisalmer faced highest number of droughts (192) followed by Jodhpur (154), Barmer (130) and Jalor (115) but in terms of very severe droughts, Jalor was ahead of all these districts with 14 droughts in a span of

Conclusions

The drought severity assessment based on the 3-month SPI time series, indicates that the maximum drought severity of -5.99 occurred continuously between May and August 1905 at Jodhpur which was almost at par with that at Jaisalmer (-5.93 during June- September 1987 and -5.85 during May-Aug 1905) indicating a complete failure

Table-3 : Drought characteristics of Jaisalmer, Jodhpur, Barmer and Jalore districts for the period 1901-2002 based on 3-m SPI.

District	Onset	Termination	Duration (months)	Severity
Jaisalmer	May-05	Aug-05	4	-5.85
	May-15	Aug-15	4	-3.75
	May-18	Aug-18	4	-5.05
	Jul-25	25-Sep	3	-2.48
	Apr-47	Jul-47	4	-3.4
	Apr-48	Jun-48	3	-1.65
	Apr-58	Jun-58	3	-2.54
	Jul-60	Sep-60	3	-2.22
	May-69	Sep-69	5	-4.97
	May-84	Jul-84	3	-2.62
	Jun-87	Sep-87	4	-5.93
	Apr-00	Jun-00	3	-1.65
	Jun-02	Sep-02	4	-4.92
Jodhpur	May-05	Aug-05	4	-5.99
	May-15	Aug-15	4	-4.65
	May-18	Aug-18	4	-5.92
	Jul-25	25-Sep	3	-2.67
	Jul-38	1-Sep	3	-2.45
	May-47	Jul-47	3	-4.09
	May-63	Jul-63	3	-3.69
	May-69	Aug-69	4	-3.71
	May-84	Jul-84	3	-2.62
	Jul-87	Sep-87	3	-4.66
	Jun-02	Sep-02	4	-4.76
Barmer	Jun-15	Aug-15	3	-4.08
	Jul-20	Sep-20	3	-3.42
	Jul-25	Sep-25	3	-2.99
	Jul-38	Sep-38	3	-2.18
	Jul-60	Sep-60	3	-2.86
	Jun-69	Aug-69	3	-3.05
	Jul-74	Sep-74	3	-2.89
	Jul-87	Sep-87	3	-4.54
	Jul-02	Sep-02	3	-3.56
Jalor	Jun-01	Sep-15	4	-4.42
	Jul-20	Sep-20	3	-3.09
	Jul-25	Sep-25	3	-3.57
	Jul-74	Sep-74	3	-3.3
	Jul-87	Sep-87	3	-4.39

of monsoon rainfall in the area. Whereas a maximum duration drought of five months is observed at the Jaisalmer district from May 1969 to September 1969. Based on 3-m SPI, Barmer observed total of 9 droughts

during the hundred years period and all were shortest duration of three months. Similarly Jalor had 5 droughts during the study period and all except one were of shortest duration of three months.

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***In vitro* Evaluation of Fungicides, Bio-Control Agents and Plant Extracts against *Alternaria triticina* Causing Leaf Blight of Wheat of (*Triticum aestivum* L.)**

Sardar Singh Kakraliya^{1*}, Sunil Zacharia¹, Abhinav², Pushpendar Singh Shekhawat¹ Dechan Choskit³ and Sheikh Saima Khusbhoo³

¹Department of Plant Pathology, SHUATS, (Deemed-to-be-University), Allahabad-211007, U.P.

²Department of Plant Pathology, RCA, MPUAT, Udaipur-313001, Rajasthan

³CSIR-Indian Institute of Integrative Medicine-Jammu and Kashmir

*Corresponding Author Email : sardarchoudhary70@gmail.com

Abstract

The experiment was conducted under in vitro to observe the effect of fungicides bio-agents, and plant extracts against *Alternaria triticina*. Different systemic fungicides propiconazole, hexaconazole and vitavax at four concentrations i.e. 50, 100, 150 and 200 ppm were used for in vitro evaluation of fungi toxicity against *A. triticina*. Under in vitro conduction, the highest inhibition was recorded by propiconazole (100%) at 200 ppm concentration followed by Hexaconazole (92.17%) and Vitavax (67.33%) at 200 ppm concentration. Antagonistic activity of bioagents viz., *Trichoderma viride*, *T. harzianum* and *Pseudomonas fluorescens* against *A. triticina* was tested using dual culture technique. Maximum inhibition of mycelial growth was observed with *T. viride* (56.01%) followed by *P. fluorescens* (42.81%) and *T. harzianum* (35.05%). Three locally available plants which grow in abundance viz., *Azadirachta indica*, *Lantana camera* and *Eucalyptus chamadulonsis* were used and aqueous extracts of different concentrations (10 and 20%) were tested for their efficacy against the pathogen. An increased inhibitory effect of mycelia growth was observed with an increase in concentration from 10 to 20 per cent. *Azadirachta indica* at 20 per cent was found best (45.47%) followed by *Lantana camar* (40.33%) and *Eucalyptus chamadulonsis* (32.04%).

Introduction

The bread wheat (*Triticum aestivum* L.) is the most important spices accounting to a little over 87 per cent of the total wheat production of India followed by the *Triticum durum* wheat 12 per cent and *Triticum dicoccum* wheat 1 per cent. The *T. dicoccum* wheat is grown only on limited acreage in Tamil Naidu, Andhra Pradesh, Maharashtra and Gujarat. Some wheat varieties (e.g. *T. aestivum*) are suitable for bread making while others (e.g. *T. durum*) are suitable for biscuits and cooking making (Sapirstein *et al.*, 2007). Gluten, the protein component of flour which gives the dough elasticity and strength, can be defined as the rubbery mass that remains when wheat dough is washed to remove starch granules and water soluble constituents (Wieser, 2007; Kaushik, *et al.*, 2013). In India, foliar blight of wheat had been noticed as early as 1924 (Kulkarni, 1924), but it was not of much consequence till recently. In the recent past, with the change in cropping system, foliar blight has now become a major disease far and wide in our country causing 2.72 to 36.24 per cent yield losses under different agro climatic zones. In India, foliar blights of wheat are considered as one complex, which includes leaf blight caused by *Alternaria triticina* Prasada and Prabhu and spot blotch caused by *Bipolaris sorokiniana*. In the Indogangetic plains, covering the entire northwestern and north-eastern plains, rice-wheat rotation is the dominant

cropping sequence. It has been commonly observed that the intensity of foliar blights has considerably increased in the rice-wheat system (Nagarajan and Kumar, 1998). During last decade multilocal surveys for determining incidence of foliar blights of wheat have been conducted in eastern U.P, Bihar, Haryana, Punjab, Delhi, Gujrat and Rajasthan (Singh *et al.*, 2004) In view of the growing concern about foliar blight of wheat, it was considered desirable to study the incidence of the disease and the causal organisms in Allahabad region where wheat (*T. aestivum*) is main food crop. Leaf blight caused by *A. triticina* is the major disease in irrigated wheat in Vidarbha region of Maharashtra. *Alternaria* leaf blight was first reported from Maharashtra in 1924 (Kulkarni, 1924). The disease initially appears as small and irregularly scattered chlorotic lesions on the leaves in last week of December. As the disease progresses, several spots coalesce and cover the whole or part of the leaf giving it a blighted' appearance. Heavily infected fields show a burnt appearance. The normal sown as well as late sown irrigated wheat varieties were found heavily infected with *Alternaria* leaf blight during January and February in Vidarbha region, causing considerable losses in the grain yield of irrigated wheat. Therefore, this trial was formulated to estimate the losses caused due to leaf blight disease (Shivankar *et al.*, 2000). The application of two irrigations reduced the severity of foliar blight as compared

to no irrigation (Shrestha *et al.*, 1998) reported that low or imbalance soil nutrient levels predispose plants to more severe leaf blight attack found low incidence of disease when wheat crop was sowing on 30th November as compared 20th December.

Materials and Methods

In vitro evaluation of different fungicides against *Alternaria tritricina* : The bio-efficacy of different fungicides namely propiconazole, hexaconazole and vitavax were evaluated under *in vitro* conditions using poisoned food technique (Nene and Thapliyal, 2000) against *A. tritricina* to record the inhibition of radial growth on potato agar medium. The fungicides were evaluated at 50, 100, 150 and 200 ppm concentrations. The requisite quantities of fungicides were incorporated aseptically to PDA medium. Twenty ml of the poisoned PDA medium was poured into each sterile Petri plate. The Petri plates were then inoculated by cutting 5.0 mm of 7 days old mycelial discs of *A. tritricina* with a sterile cork borer and incubated at 25 ± 1°C. The inoculated Petri plates were wrapped with cellophane film to minimize the chances of contamination. Three replications were maintained for each treatment. The experiment was conducted in completely randomized design (CRD). The fungus growth on the PDA medium without any fungicide served as control. The radial growth (mm) of the colony was recorded when maximum growth in control plates was noticed. The efficacy of fungicides was expressed as per cent inhibition of mycelial growth over control which was calculated by formula given by Vincent, 1947.

Bio-control agents : Antagonistic activity of bioagents viz., *Trichoderma viride* and *T. harzianum* against *A. tritricina* was tested using dual-culture technique (Huang and Hoes, 1976). Two mm dia culture discs of each of the pathogen and bio control agent were picked from the margin of 7 day old cultures with a sterilized cork borer and transfer under aseptic conditions to PDA plates in such a way that the distance between the pathogen and bio-agent was about 5 cm. In case of bacterial antagonist *Pseudomonas fluorescens* disc of 2 mm dia of the pathogen was placed at the centre of PDA plate and the bacterium was streaked around the disc (Laha *et al.*, 1992). The disc of the pathogen grown alone on the PDA plates served as control. The cultures were incubated at 25 ± 1 °C. Each treatment was replicated thrice. Data on mycelial growth were recorded when control Petri plate was fully covered. Per cent inhibition of mycelial growth was calculated by Vincent (1947) formula :

$$I = \frac{(C - T)}{C} \times 100$$

Where, I = % inhibition C = growth in control, T = growth in treatment

In vitro evaluation botanicals : In this experiment, ethanol extract of three botanicals viz., *Azadirachta indica*, *Lantana camera* and *Eucalyptus chamadulonsis* were evaluated in the laboratory for their efficacy against *A. tritricina*. The plant extracts were evaluated *in-vitro* through poison food technique (Nene and Thapliyal, 2000).

Preparation of extracts : Ethanol extract of the botanicals was prepared by the method adopted by Deshpande *et al.* (2004). The plants/plant parts were washed with tap water and rinsed with sterile distilled water followed by shade drying. Leaves of neem, lantana and *Eucalyptus* cloves were also dried till brittle. The shade dried plant/plant parts were ground with the help of electric grinder to obtain fine powder of each botanical. The dried powder was then stored in plastic containers for further use. The dried powder of the plant parts (20 gm) was mixed with 200 ml solvent (70 % ethanol) in 250 ml conical flask. The flasks were tightly plugged with sterile cotton plugs wrapped with aluminum foil and kept on a rotator shaker for 36 hours and kept undisturbed for 6 hours to allow suspended plant material to settle down. The extract was decanted filtered and centrifuged at 500 rpm for 15 minutes. The supernatant was collected and the solvent was evaporated at 40-50 °C to make final volume 1/4th of the original volume. The extract now taken as 100 per cent standard extract was stored in air tight containers/bottles for further use. The ethanol extract of each botanical was bioassay for toxic activity at different concentration against *A. tritricina* by employing poisoned food technique.

Mycelial inhibition

$$\frac{\text{Radial growth in control} - \text{Radial growth in treatment}}{\text{Radial growth in control}} \times 100$$

Results and Discussion

In vitro evaluation of different fungicides : The *in-vitro* evaluation of propiconazole, hexaconazole and vitavax at 25, 50, 100 and 200 ppm showed that they all could significantly inhibit the growth of *A. tritricina* at all the concentrations (Table-1). At 200 ppm concentration, propiconazole showed maximum inhibition of mycelial growth (100%) while the minimum inhibition was showed by hexaconazole (92.17%) and vitavax (67.33%). This proves the inhibitory action of all the fungicide against *A. tritricina* as all the results are significantly superior. Further, propiconazole and hexaconazole are the most effective against the phytopathogen that can completely inhibit the pathogen at 200ppm. A similar inhibitory action of propiconazole and carbendazim was demonstrated by Naik and Jayalakshmi (2017); Saha *et al.* (2018) and Rajeswari and Balasupramani (2020) on *Alternaria* leaf blight of bhendi, tomato, cabbage, and pigeon-pea,

Table-1 : In-vitro evaluation of the fungicides against the fungal pathogen *Alternaria trititica*.

Treatments	Mycelial growth (mm)				Percent inhibition of mycelial growth			
	25 ppm	50 ppm	100 ppm	200 ppm	25 ppm	50 ppm	100 ppm	200 ppm
Propiconazole	35.07	21.33	13.15	0.0	61.03	76.30	85.38	100
Hexaconazole	49.79	32.25	22.26	7.04	44.67	64.16	75.26	92.17
Vitavax	51.59	40.06	36.26	29.40	42.67	55.48	59.71	67.33
Control	90.00	90.00	90.00	90.00	-	-	-	-
C.D. 5%	2.35	2.48	2.86	-	-	-	-	-

Table-2 : Effect of bio-control agents on mycelial growth of *Alternaria trititica*.

Treatment	Mycelial growth (mm)*	Inhibition (%)
<i>T. viride</i>	37.00	56.01
<i>T. harzianum</i>	54.63	35.05
<i>P. fluorescens</i>	48.10	42.81
Control	84.12	-
CD (P=0.05)	4.12	-

Table-3 : Effect of botanicals on mycelial growth of *Alternaria trititica*.

Treatment	Mycelial growth (mm)*		Mycelial growth inhibition (%)	
	5%	10%	5%	10%
<i>Azadirachta indica</i>	55.30	46.00	34.44	45.47
<i>Lantana camara</i>	58.25	50.33	30.95	40.33
<i>Eucalyptus chamadulonsis</i>	68.67	57.33	18.59	32.04
Control	84.36	84.36	-	-
CD (0.05%)	4.91	3.86	-	-

respectively. Thus, the results suggest that propiconazole and hexaconazole at 200 ppm have a promising potential in reducing the growth of *A. trititica*.

In vitro evaluation of bio-control : *In vitro* evaluation of bio-control agents results of evaluation of antagonistic effects of bio control agents viz., *Trichoderma viride*, *T. harzianum* and *Pseudomonas fluorescens* against *A. trititica*, recorded as inhibition of mycelial growth in dual culture are presented in Table-2. Maximum inhibition of mycelial growth was observed with *T. viride* (56.01%), followed by *P. fluorescens* (42.81%) and *T. harzianum* (35.05%).

In vitro evaluation of botanicals : The data with respect to effect of four plant extracts on mycelial growth of *A. trititica* are presented in (Table 3). *Azadirachta indica* at 10 per cent was found best (45.47%) followed by *Lantana camara* (40.33%) and *Eucalyptus chamadulonsis* (32.04%). At 5 per cent *Azadirachta indica* was found to be most effective (34.44%) followed by *Lantana camara* (30.95%) and *Eucalyptus chamadulonsis* (18.59%). This finding confirms the earlier reports of Sallam (2011) and Sudarshana *et al.* (2012). As regards, the concentration of the botanicals, the efficiency of the botanicals was significantly the highest at 15 per cent concentration for all the botanicals. As regards the interaction among the botanicals and their concentrations it was observed to be statistically non-significant, thereby indicating that no correlation could be found between botanicals and their concentrations. Pollution problems in the

environment and the toxic effect of synthetic chemicals on non target organisms have promoted investigations on exploiting biological control agents as one of the component of disease control. As many species of fungi and other microbes have been reported to be antagonists of *A. trititica* only a few of them have been studied extensively. To reduce the harmful effects of pesticides in the ecosystem the use of bio control agents in plant disease management has been experimented.

Conclusions

Therefore, in this experiment propiconazole, hexaconazole and vitavax were found to be the best fungicides even at lower concentrations, and pyraclostrobin also controls 50% of infection at higher concentrations. Therefore, in the present study it can be determined that systemic fungicides can effectively suppress both pre- and post-infectious activity and inhibit sporulation and or limit the spread of early putrefactive pathogens. It is also found to not only fight blight, but also increase the yield of wheat. The use of inhibitory botanicals is one of the most possible methods for controlling some plant diseases. It is reasonable to collect and screen for more plants with high activity to suppress the leaf blight infection. This study has found two most promising botanicals; *Azadirachta indica*, *Lantana camara* and *Eucalyptus chamadulonsis* were able to inhibit the infection of leaf blight disease of wheat under *in vitro* conditions.

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Studies on Physical Properties of Osmotically Dehydrated Carrot (*Daucus carota* L.) Slices in Sugar Solution

Ajeet Rundla* and Atul Anand Mishra

Vaugh Institute of Agricultural Engineering and Technology, SHUATS, Prayagraj-211007 U.P.

Corresponding Author Email : ajeet11094@gmail.com

Abstract

The osmotic dehydration of carrot slices using microwave drying was investigated in the Department of Food Process Engineering, Vaugh Institute of Agricultural Engineering and Technology, Allahabad. The influence of different sugar solution concentrations (55 °Brix, 60 °Brix, and 65 °Brix concentrations) on microwave drying and several physical properties of carrot slices was investigated in this study. Overall, the physical parameters of dehydrated carrot slices revealed that the optimum moisture content of osmotic dehydrated carrot slices in sugar solutions was 20.13 percent, 79.89 percent dry matter content, and 4.85 dehydration ratio for a sugar solution with a Brix of 60. In the 55 °Brix, 60 °Brix, and 65 °Brix solutions, the ash concentration was 4.58, 5.23, and 5.83, respectively.

Key words : Osmotic dehydration, sugar, carrot.

Introduction

Carrots (*Daucus carota* L.) are a popular winter vegetable and one of the most important root crops grown around the world for its fleshy, tasty, and attractive edible roots. It is grown in temperate areas during the spring, summer, and autumn seasons, and in tropical and subtropical locations during the winter.

Fresh carrots may only be stored for 3–4 days under normal conditions, but if stored in crates with perforated plastic film at 0°C and 93–96% relative humidity, the shelf life can be prolonged to 7–8 months (Chadda, 2002). Freeze-drying generates the finest quality food items of these processes, but it is also the most expensive. As a result, a simple and low-cost equivalent technique might be developed, with low capital investment costs, and made available to locations outside of manufacturing zones.

Fruits and vegetables can be processed using a variety of methods. Dehydration of perishables such as fruits and vegetables is the best option for Indian conditions (Sagar and Suresh Kumar, 2010). Osmotic dehydration has been widely employed for the preservation of fruits and vegetables due to its ability to maintain sensory and nutritional attributes similar to fresh fruits while also enriching products with substances, such as functional foods (Prothon *et al.*, 2001).

When cellular components are placed in a concentrated solution of soluble solute, osmotic dehydration occurs, which results in the partial loss of water. Osmotic dehydration is used as a pretreatment to

improve the nutritional, sensory, and functional qualities of food. It works at room temperature and saves the color, texture, and flavor of food from heat (Nanjundaswamy *et al.*, 1978).

Research Methodology

The osmotic dehydration of carrot slices using microwave drying was investigated in the Department of Food Process Engineering, Vaugh Institute of Agricultural Engineering and Technology, Allahabad. In this investigation, the following materials and methods were used:

Materials

Carrot : The carrot (*Daucus carota* L.) is an orange-colored root vegetable. The carrot root vegetable was purchased from a local carrot market and was of good quality and maturity. For osmotic dehydration, fully grown, reddish-colored, flawless carrots were employed.

Sugar : Common sugar (Sucrose) was acquired at a local store.

Equipment and instruments used : We used weighing balances, a hot air oven, and a muffle furnace from Vaugh Institute of Agricultural Engineering and Technology Allahabad's Food Process Engineering department. Weighing scales were used to weigh different proportions of carrot slices and salt. The moisture content of osmotically dried carrots of various sugar solution concentrations was determined using a hot air oven. The ash content of osmotically dehydrated carrot slices of various sugar solution concentrations was measured

using the muffle furnace. After osmotic treatment in sugar solution, the carrot slices were dried in the microwave. The investigation was conducted using a microwave made by Ken Star (Model=OM-20 EGO, Output Power = 800W, Frequency = 2450 MHz).

Experimental procedure

Carrot slices preparation : Carrots of uniform color, size, and shape were chosen, weighed, and washed. After removing the top and bottom portion of the carrots, they were carefully washed with tap water, weighed, and sliced into 3-4 mm thick slices. The yield recovery of fresh slices to be used for osmotic dehydration was recorded by weighing the prepared slices again. After that, slices were blanched for 5 minutes at 60°C using a low- temperature-long-time (LTLT) method. For osmotic dehydration, blanched carrots were air chilled.

Sugar syrup preparation : Sugar syrup was made in three distinct concentrations: 55°Brix, 60°Brix, and 65°Brix. 400 g of syrup is required for 200 g of prepared carrot slices. For 400 gm of 55°Brix concentration sugar syrup, 220 mg of sugar and 180 gm of water were used, 240 gr of sugar and 160 gm of water for 60°Brix sugar syrup, and 260 gam of sugar and 140 gm of water for 65°Brix sugar syrup. In this study, the slice-to-sugar-syrup ratio was kept at 1:2 (W/V).

Osmosis : 200 g prepared carrot slices were dipped in 55, 60, and 65°Brix sugar syrup in a 1:2 (W/V) solution ratio and allowed to continue osmosis for 4 hours at 44 °C. Water flows out of the carrot slices to the sugar during the osmosis process, and a fraction of the solute travels into the carrot slices. The carrot slices were removed out of the osmotic solution at the end of the treatment for a specific osmotic duration, and the osmosed carrot slices were weighed to determine the extent of water loss from the slices via osmosis.

Microwave drying : A 200 g carrot sample was placed in a microwave-safe tray. An aspiration mechanism was added to the oven to empty the inside air. During the drying stage, the microwave was set to maximum power for 60 seconds and then turned off for 15 seconds (Baysal *et al.*, 2003).

Observation Record

Moisture content : Using a hot air oven, the initial moisture content of the raw material was determined. 10 g of the sample was dried in a moisture box that had been preweighed. The hot air oven was kept at a constant temperature of 70°C. The sample was dried until it reached bone dry weight. The sample dish was weighed after cooling in desiccators. This was continued until the weight difference between two succeeding weights was

roughly similar. The amount of moisture was estimated using the following method from the weight loss during drying, and the moisture can be expressed as a percentage.

$$\text{Moisture Content (\%)} = \frac{\text{Initial wt. (gm)} - \text{Final wt. (gm)}}{\text{Initial wt. (gm)}}$$

Ash content : Ash content refers to the inorganic residue left over after organic matter has been destroyed. Because certain losses may occur owing to volatilization, it may not be exactly comparable to mineral matter. A 5g sample was precisely weighed into a clean, pre-weighed crucible. The crucible was heated to the point that the sample on a hot plate charred. The crucible containing the carbon residue produced by ignition was placed in a muffle furnace at 650°C until the carbon residue vanished. Allow to cool before weighing. The ash content was determined using the following calculation based on the weight difference :

$$\text{Total ash content (\%)} = \frac{\text{Final weight (gm)}}{\text{Initial weight (gm)}} \times 100$$

(Ranganna S, 2005)

Dehydration ratio : Dehydration is the process of removing water from a sample until it reaches bone dry matter. The following formula was used to compute the dehydration ratio :

$$\text{Dehydration ratio} = \frac{\text{Wt. of material}}{\text{Wt. of dehydrated material}}$$

Dry matter content : The dry matter content was calculated by :

$$\text{Dry matter content (\%)} = 100 - \text{moisture content}$$

Results and Discussion

Moisture content : The quantity of moisture present following osmotic dehydration of carrot slices in various salt concentrations was evaluated using moisture content. The obtained moisture content value in sugar solution is shown in Table-1. The graph of moisture content vs. sugar solution concentration is shown in Figure-1. The moisture content of osmotic dehydrated carrot slices in sugar solutions was investigated, and the best values were discovered. For an 60 °Brix sugar solution, it was 20.13 percent.

Dry matter content : The mass of solute penetrated from the osmotic solution during the procedure was determined by determining the dry matter content of osmotic dehydrated carrot slices. The dry matter content of osmotic dehydrated carrot slices in sugar solution was investigated, and the best values were discovered. The

Table-1 : Moisture content of osmotic dehydrated carrot slices in different concentration of sugar solutions.

S. No.	Concentration	M.C. (%)
1.	55°Brix	21.16
2.	60°Brix	20.13
3.	65°Brix	22.96

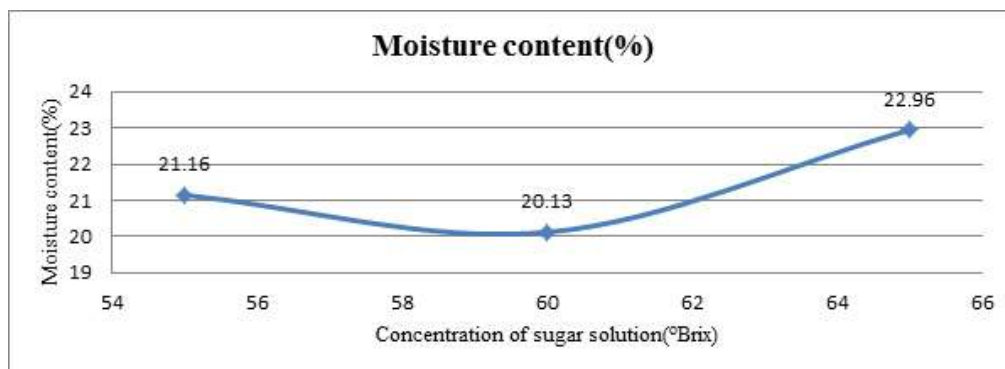


Table-2 : Dry matter content of osmotic dehydrated carrot slices in different concentration of sugar solutions.

S. No.	Concentration	Dry matter content (%)
1.	55°Brix	78.86
2.	60°Brix	79.89
3.	65°Brix	77.06

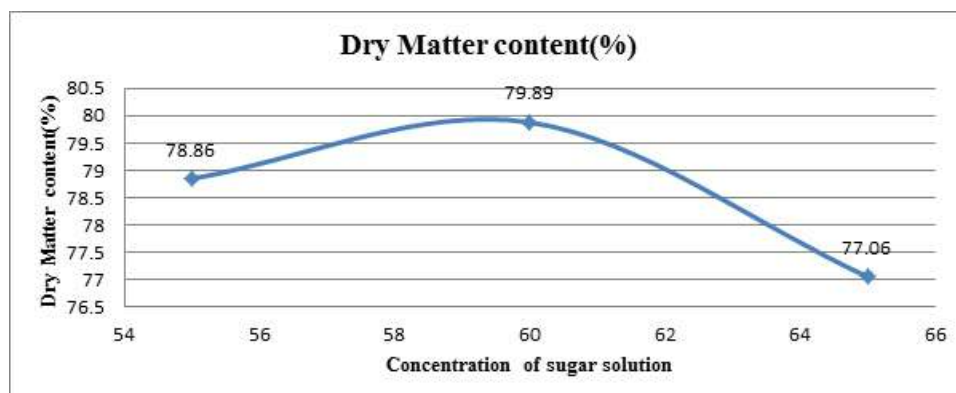


Table-3 : Dehydration Ratio of osmotic dehydrated carrot slices in different concentration of sugar solutions.

S. No.	Concentration	Dehydration Ratio
1.	55°Brix	4.57
2.	60°Brix	4.85
3.	65°Brix	4.42

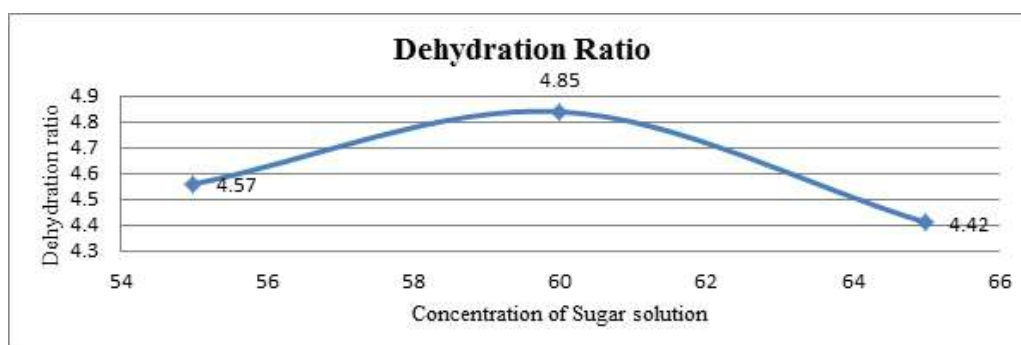
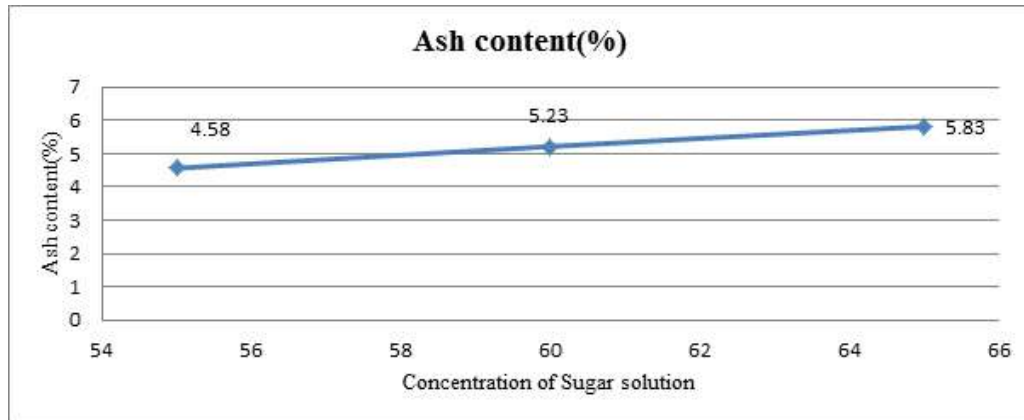


Table-4 : Ash content of osmotic dehydrated carrot slices in different concentration of sugar solutions.

S. No.	Concentration	Ash content
1.	55°Brix	4.58
2.	60°Brix	5.23
3.	65°Brix	5.83



obtained dry matter content value in sugar solution is shown in Table-2. For 60 °Brix of the sugar solution, it was 79.89 percent. Figure-2 depicts a graph of dry matter content vs. sugar solution concentration.

Dehydration Ratio : Dehydration ratios were discovered to determine the weight loss of carrot slices after drying. The obtained dehydration ratio value in sugar solution is shown in Table-3. As the concentration of the sugar solution increased, the dehydration ratio increased as well, and optimum values were discovered for 60 °Brix of the sugar solution. The graph of dehydration ratio vs. sugar solution concentration is shown in Figure-3.

Ash content : The obtained ash content value in sugar solution is shown in Table-4. The curve of ash content vs. sugar solution concentration is shown in Figure-4. The ash content of 55 °Brix 60 °Brix 65 °Brix sugar solution, respectively, was 4.58, 5.23, and 5.83.

Conclusions

The sugar solution of 60°Brix was found to be the optimum for dehydrating carrot slices. In the concentration of 60°Brix sugar solution, the overall physical parameter was found to be satisfactory.

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Housing, Lamb Management and Health Care Management Practices followed by Sheep Farmers in Tonk District of Rajasthan

Goatm Chopra^{1*}, Ramesh Pandey², Jhabar Mal Tatarwal², Arjun Lal Kakraliya², Om Prakash Chaudhary¹ and Priyanka Kayath¹

¹Department of Animal Production, Rajasthan College of agriculture, MPUAT, Udaipur, Rajasthan

²Department of Animal Husbandry and Dairying, SHUATS, Prayagraj, U.P.

*Corresponding Author (Goatm Chopra) Email : goutamchopra997@gmail.com

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. The management practices of housing, lamb management and health care were studied of all the respondents and revealed that 73.75 % of the farmers provided housing to their animals and 95.00 % of the farmers were cleaning the lambing area at the time of lambing. Most of the farmers were aware of the health status and diseases affecting sheep and the regularity of vaccination, deworming and found that all herders were regularly vaccinating and deworming their flocks.

Key words : sheep, housing, management practices, farmers, Tonk.

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.

Rajasthan state has livestock population of 56.80 million (11 per cent) of India contributing nearly 41.5 million Kg. of wool and 187 million tons of milk and 7.4 million tons of meat production to the country during year 2019. In Rajasthan, livestock population comprises large and small ruminants. Cattle and buffaloes are the main large animals while sheep and goats are the major small ruminants. According to estimates of the recent Livestock census, the share of cattle population was about 21 per cent and buffaloes constitutes about one-fifth of the total population.

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 adoptable to a wide range of environmental conditions. 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".

The Rajasthan state has 7.9 million sheep as per 20th livestock census and ranks 4th in India. During 2001-02 wool production stands at the modest level of 19.67 million kg and from that year to present year (2012-13) there was a continue decrease (14.07 million kg) in the wool production. Because there was continues decrease in the sheep population in the state and demand for the sheep meat is increasing day by day. Sheep forms a key component of Indian livestock biodiversity. They are lifeline for many marginal farmers and landless labourers

Table-1 : Existing housing management practices.

Practices	Households (Flock size)			Overall	² Value
	Small	Medium	Large		
Rearing					
Intensive	0	0	0	0	—
Semi-Intensive	0	0	0	0	
Extensive	20	36	24	80 (100%)	
Provision of housing					
Yes	15	25	19	59 (73.75%)	0.72 ^S
No	5	11	5	21 (26.25%)	
Placing of animals					
Near owners house	12	25	16	53 (66.25%)	0.51 ^S
Far away	8	11	8	27 (33.75%)	
Type of roof					
No roof	10	20	5	35 (43.75%)	—
Pucca	0	0	0	0	
Thatched	10	16	19	45 (56.25%)	
Type of floor					
Concrete	0	0	0	0	—
Slab	3	4	3	10 (12.50%)	
Mud	17	32	21	70 (87.50%)	
Enclosures					
Wall	4	8	4	16 (20.00%)	0.28 ^S
Fence	16	28	20	64 (80.00%)	
Provision of Water in shed					
Yes	0	0	0	0	—
No	20	36	24	80 (100%)	
Provision of Feed in shed					
Yes	0	0	0	0	—
No	20	36	24	80 (100%)	
Separate housing for young and adult					
Yes	0	0	0	0	—
No	20	36	24	80 (100%)	
Male and Female Separated					
Yes	0	0	0	0	—
No	20	36	24	80 (100%)	
Cleaning of remises					
Daily	18	31	20	69 (86.25%)	0.40 ^{NS}
for every 2-3days	2	5	4	11 (13.75%)	

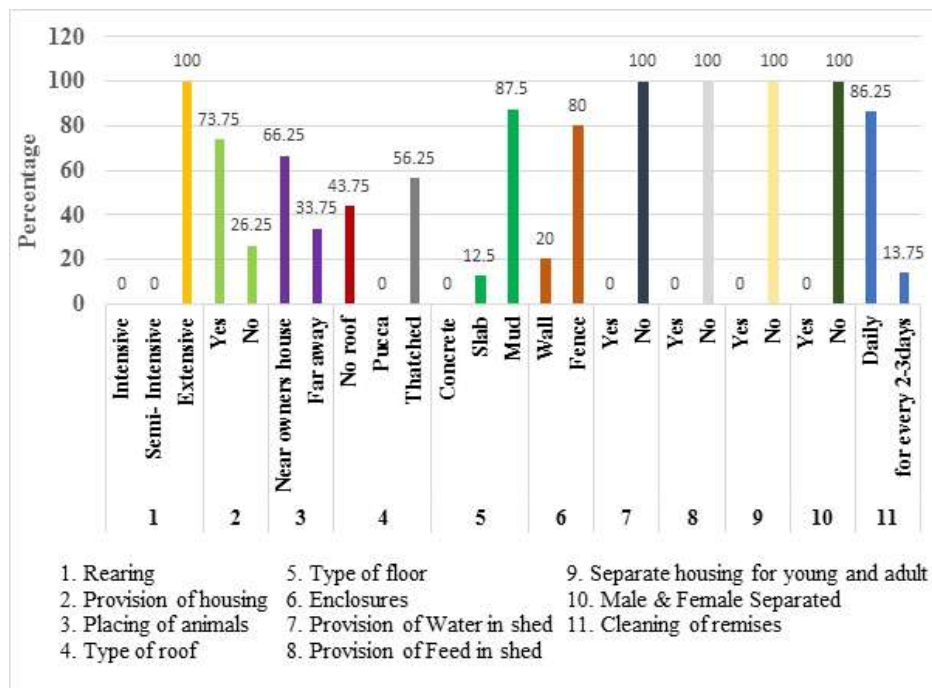


Fig.-1 : Existing housing management practices.

Table-2 : Existing lamb management practices.

Practices	Households (Flock size)			Overall	² Value
	Small	Medium	Large		
Cleaning at the time of lambing					
Yes	13	26	16	55 (68.75)	0.38 ^S
No	7	10	8	25 (31.25)	
Period of confinement of dam after lambing					
Retained	0	0	0	0	—
Sent for Grazing	20	36	24	80 (100)	
Care of the lamb by					
Women	2	7	1	10 (12.50)	3.89 ^{NS}
Children	2	3	4	9 (11.25)	
Both	16	26	19	61 (76.25)	
Lambs sent for grazing					
within 30 days	13	27	15	55 (68.75)	1.22 ^S
within 2 months	7	9	9	25 (31.25)	
Lamb Feeding					
Mothers milk alone	20	36	24	80 (100)	—
Supplementary feeding	0	0	0	0	
Weaning					
Practiced	0	0	0	0	—
Not Practiced	20	36	24	80 (100)	
Feeding of tender leaves (Subabul)					
Practiced	14	28	15	57 (71.25)	1.66 ^S
Not Practiced	6	8	9	23 (27.75)	

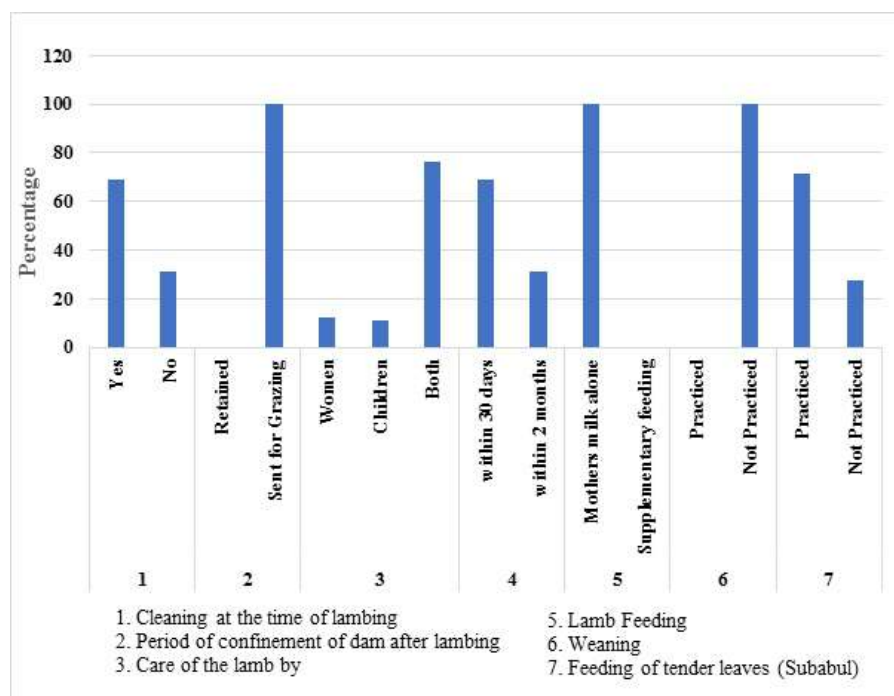


Fig.-2 : Existing lamb management practices.

surviving in adverse climatic conditions (Arora et al. 2011). The production of wool, meat and manure provides different sources of income generation to the shepherd.

Most of the farmers used to rear sheep for their subsistence and hence rarely adopt scientific

management practices due to lack of awareness and lack of access to veterinary services like supply of vaccine.

Research Methodology

The study was conducted in Tonk district of Rajasthan, which was selected randomly. Tonk district

Table-3 : Existing health care management practices.

Practices	Households (Flock size)			Overall	² Value
	Small	Medium	Large		
Knowledge on health & diseases					
Yes	19	25	22	66 (82.50)	7.81 ^S
No	1	11	2	14 (17.50)	
Deworming					
Regular	20	36	24	80 (100)	—
Not regular	0	0	0	0	
Vaccination					
Yes	20	36	24	80 (100)	—
No	0	0	0	0	
Vaccination done for					
FMD	0	0	0	0	—
Sheep pox	20	36	24	80 (100)	
PPR	20	36	24	80 (100)	
B.Q.	20	36	24	80 (100)	
ET	20	36	24	80 (100)	
Supply of Dewormer					
Government	0	0	0	0	—
Purchased	0	0	0	0	
Both	20	36	24	80 (100)	
Periodicity of Deworming					
Once in 3 months	14	28	17	59 (73.75)	1.47 ^S
Once in 6 months	4	7	5	16 (20.00)	
Annual	2	1	2	5(6.25)	
Supply of Vaccine					
Government	13	26	18	57(71.25)	0.56 ^S
Purchased	7	10	6	23(28.25)	
Practice of dipping					
Yes	2	5	3	10(12.50)	0.17 ^{NS}
No	18	31	21	70(87.50)	

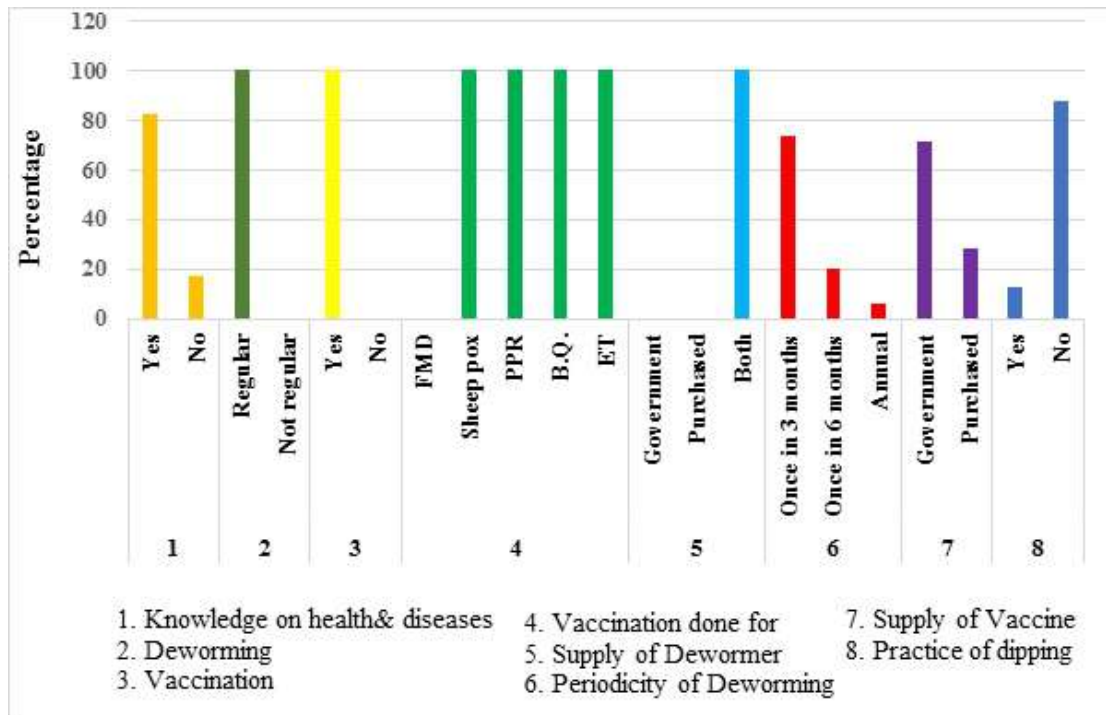


Fig.-3 : Existing health care management practices.

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 housing, lamb management and health care 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.

To analysis the collected information, several basic statistical tools and methods were used. The following statistical treatments were used for interpretation of data :

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

The management practices of housing, lamb management and health care were studied of all the 80 respondents and the different practices have been described in the following sub sections.

Existing housing management practices : In the present study an investigation has been made to study the housing management practices followed by the farmers in the Malpura tehsis of Tonk district. Housing management practices followed by the farmers were analyzed and are presented in the Table-1 and fig.-1.

In the present study, it was observed that all the farmers surveyed in the Tonk district were following extensive system of rearing of sheep. It was also observed that 73.75 % of the farmers provided housing to their animals. Out of the farmers providing housing majority (66.25 %) had their animal houses located near

their houses and the remaining (33.75 %) had their animal houses located away from their houses. The chi-square statistic is 0.51556. The p-value is .784556. The result is not significant at $p < .05$.

Out of all the farmers providing housing, 56.25% of the farmers provided thatched roofs while the rest of the farmers did not provide any roof and it was observed that none of the farmers provided pucca roof. 87.50% of sheep farmers had mud floors and 12.50% of them were of slab floors. Majority of the farmers (88.75 %) had enclosures made with bio fence material or by bamboo poles laden with thatches, whereas those of the remaining were made of wall (11.25). The chi-square statistic is 0.2663. The result is significant at $p < .05$. Majority (80.00 %) of the farmers were cleaning the animal houses daily and very few (20.00 %) were cleaning them once in 2-3 days. The chi-square statistic is 0.27778. The p-value is 0.875087. The result is not significant at $p < .05$. All the farmers in Malpura divisions had no provision either for watering or for feeding in the sheds. No provision was made to keep the males and females separately. These findings are in accordance with the findings obtained by Dinesh Kumar *et al.* (2006) Virojirao *et al.* (2008).

Existing lamb management practices : Lamb care and management practices followed by the sheep farmers were analyzed and are presented in the Table-2 and fig.-2.

In the present study, it was observed that 95.00 % of the farmers were cleaning the lambing area at the time of lambing. The chi-square statistic is 0.3814. The result is significant at $p < 0.05$ and care of the lamb was taken by both women and children. The chi-square statistic is 3.8884. The p-value is .424562. The result is not significant at $p < .05$ about 76.25 % households surveyed and the lambs were supported by only dam's milk in all the cases. After lambing all the farmers were sending the dams to grazing rather than confining them to the house. Among the shepherds surveyed, 68.75 % of the shepherds were sending the lambs for grazing within 30 days of lambing whereas remaining were sending them in 2 months' time. The chi-square statistic is 1.2218 The result is significant at $p < .05$. In the survey conducted, it was observed that none of the farmers were practicing weaning of lambs and only 71.25 % of them were practicing feeding lambs with tender leaves like Subabul, while the rest were not following it. The chi-square statistic is 1.6611. The result is significant at $p < .05$. These findings are in accordance with the findings obtained by Suresh *et al.* (2008).

Existing health care management practices : Health management practices followed by the shepherds were analyzed and are presented in the Table-3 and fig.-3.

A study was made to understand the regularity of vaccinations and deworming and found that all shepherds were regularly immunizing and deworming their flocks. It was also noted that the vaccines were supplied by the state Animal Husbandry Department alone whereas the deworming agents were either received from the Animal Husbandry Department or were purchased from the market. All the farmers surveyed had knowledge about the health status and diseases affecting the sheep. Majority of the selected farmers (87.50 %) were giving practice of dipping. These finding are supported by Arora et al. (2007), Rao et al. (2013) and Nisha et al. (2016).

Conclusion

It might be concluded from the results of the present study that; majority of the shepherds were landless and were following traditional methods of sheep rearing without any scientific inputs with regard to housing. The farmers were aware of health and disease and were practicing preventive vaccinations and deworming.

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Influence of Continuous Conservation Tillage Practices on Soil Resistance in *Inceptisols* of Eastern India under Maize Based Cropping System

Mamta^{1*}, Rajendra Bairwa², Premalata Meena³ and Ajit Kumar Meena⁴

¹Bihar Agricultural University, Sabour, Bihar

²Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar

³ICAR-Indian Agricultural Research Institute, New Delhi

⁴Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan

*Corresponding Author Email : rkchironjsoil@gmail.com

Abstract

Soil compaction is a serious threat to agricultural production because of an expanding agricultural mechanization. Conservation tillage and use of pioneer plants can be an environmentally solution to alleviate the adverse effects of soil compaction. For this, a long-term experiment was conducted to study the effect of conservation agriculture on soil compaction in maize based cropping system at Research Farm, Bihar Agricultural University, Sabour dominated by Inceptisols in eastern Indo-Gangetic plains. The maize based cropping system was studied having various tillage (ZT: Zero Tillage; PB: Permanent Raised Bed; CT: Conventional Tillage) and cropping sequences (MM: Maize-Maize, MW: Maize-Wheat; MC: Maize-Chickpea) with a special reference to changes in soil physical properties. Conservation tillage practices i.e. ZT and PB system under maize-chickpea cropping was found superior in terms of reducing bulk density and penetration resistance in soil. Significant negative correlation was found among bulk density and penetration resistance with root mass density.

Key words : Conservation tillage practices, cropping system, bulk density and penetration resistance.

Introduction

The European Commission has identified soil compaction as one of the primary dangers to sustainable agriculture (Alameda *et al.*, 2012), as it has a variety of negative effects on soil quality, crop development, and the environment (Huber *et al.*, 2008; Keller *et al.*, 2013; Unger and Kaspar, 1994). It is defined as “the process of rearranging soil grains in order to reduce vacant space and bring them closer together, hence improving bulk density” (Soil Science Society of America, 1996). The macroporosity accounts for a major amount of the pore space reduction, and the rearrangement of soil aggregates increases the tortuosity of pore conductivity. As a result, compaction inhibits plant root growth by raising mechanical resistance (Hettiaratchi, 1990; Unger and Kaspar, 1994) or reducing oxygen availability (Czyz, 2004), stifling plant development (Cook *et al.*, 1996) and lowering agricultural yields (Letey, 1985; Ishaq *et al.*, 2001; Saqib *et al.*, 2004; Vrindts *et al.*, 2005).

To address soil physical degradation problems by lowering sub-surface compaction, conservation agriculture (CA) promotes the use of little or zero tillage, as well as crop residue retention (Bautista *et al.*, 1996; Shaver *et al.*, 2002; Sayre and Hobbs, 2004). In Brazil, Madari *et al.* (2005) found that zero tillage (ZT) with residue cover resulted in increased aggregate stability,

larger aggregates, and more soil organic carbon (SOC). Roldan *et al.* (2003) discovered that soil wet aggregate stability increased after 5 years of ZT maize in Mexico compared to typical tillage. By decreasing crusting and erosion and allowing water and air to penetrate the soil, water stable aggregates in the upper soil layer may increase germination and seedling establishment. The introduction of ZT resulted in improved aggregation (Lal, 1992) and lower soil BD (Bhattacharyya *et al.*, 2006, 2009a,b). When compared to routinely tilled raised beds, permanent raised beds with residue retention improved aggregation (Bhattacharyya *et al.*, 2013a).

Crop roots can also be used to ease soil compaction through bio-drilling, which is a low-energy, environmentally friendly option. Cover crops with tap roots, such as forage radish (*Raphanus sativus* var. *longipinnatus*) and rapeseed (*Brassica napus*), are better capable of penetrating compacted soil than fibrous-rooted crops like rye (*Secale cereale*), according to Chen and Weil (2011). (Chen and Weil, 2010). Roots having a larger diameter and/or a sharper root tip opening angle may penetrate compacted soils more effectively and quickly than roots with a lower diameter and/or a bland opening angle (Colombi *et al.*, 2017b; Materechera *et al.*, 1991). Cover crops, on the other hand, have different advantages depending on the crop species and level of compaction (Arvidsson and Håkansson, 2014; Chen and Weil, 2011; Goutal *et al.*, 2012).

Table-1 : Initial physico-chemical properties of soil.

Particulars	Values	Method
A. Physical properties		
Sand (%)	47.4	Hydrometer method (Bouyocous, 1962)
Silt (%)	32.6	
Clay (%)	19.6	
Texture class	Sandy loam	Textural triangle (Black, 1965)
Bulk density (g cm ⁻³)	1.49	Blake and Hartage, (1986)
B. Chemical properties		
pH	7.5	1:2.5 soil water suspension by using glass electrode pH meter (Jackson, 1973)
Organic carbon (g kg ⁻¹)	5.3	Rapid titration method (Walkley and Black, 1934)
EC (dSm ⁻¹ at 25°C)	0.15	Electrical conductivity bridge (1:2.5) soil water suspension)
Available N (kg ha ⁻¹)	147.84	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P (kg ha ⁻¹)	27.19	Olsen's method (Olsen et al., 1954)
Available K (kg ha ⁻¹)	213.06	Flame photometer method (Jackson, 1973)

Parameter	Method	Reference
pH (1:2.5 soil : water)	Glass Electrode pH meter	Jackson (1973)
EC (1:2.5 soil : water)	EC meter	Jackson (1973)
Organic carbon	Rapid Titration Method	Walkley and Black (1934)
Available N	Alkaline Permanganate method	Subbiah and Asija 1956
Available P	0.5 M NaHCO ₃ (pH 8.5) Method	Olsen et al. 1954
Available K	1 N Ammonium Acetate Method	Jackson 1973

However, in the IGP region of South Asia, precise evidence on the long-term impacts of various tillage techniques and accelerated maize-based crop rotations on soil compaction is missing. The outcomes of this and other regions' studies provide an opportunity to look at the impact of long-term agricultural management techniques on soil compaction. When compared to conventional tillage, conservation agriculture based tillage practises (ZT and PB) and diverse maize-based crop rotations are thought to improve soil compaction. In this context, the goal of this research was to assess the long-term impacts of various tillage practises and intensive maize-based crop rotations on soil physical attributes in the eastern IGP's sandy loam (*Typic Haplustep*) soil.

Materials and Methods

The present investigation was carried out at Agricultural Research Farm, Bihar Agricultural University, Sabour in Bhagalpur region of Bihar for a duration of 7 years (2011 to 2018) as a long term experiment.

Description of experimental site : The geographical location of Bhagalpur comes under the Middle Gangetic plain region of Agro-climatic Zone IIIA. Sabour is situated between 25°07'10" and 25°18'15" N latitude and 86° 59'24" and 87°10'25"E longitude. The climate is subtropical with an average annual rainfall of 1300 mm and evaporation of 2100 mm (average over 30 years duration). The monthly mean temperature ranges from 20 to 45°C, while the annual mean temperature is 31°C. Soil has a dominance of *Inceptisols* having medium fertility

levels (Table-1). Its origin is mostly ferruginous lime quartzite, granites, and schistose rock minerals (Verma, Nepalia, and Kanthaliya 2005).

Soil samples were collected from the field and air dried followed by crushing and grinding to pass through a sieve of 0.5 mm sieve (0.2 mm sieve for °C). Processed samples were stored in air tight plastic bags at room temperature. Chemical and physical analyses of the selected studied soil are shown in Table-2.

Field experiment : Field layout was carried out as per split plot design for 3 treatments in main plots and 3 for sub-plots. Treatments included tillage in main plots having, ZT: Zero Tillage; PB: Permanent Raised Bed; CT: Conventional Tillage while cropping systems in sub-plots with MM: Maize-Maize; MW: Maize-Wheat; MC: Maize-Chickpea. Since this experiment was started in Kharif, 2011, the same cropping history was being adopted for last seven years.

The field was prepared by ploughing and followed by 2-3 harrowing or 3-4 inter crossing ploughing with the local plough in conventional plots. Planking was done after each ploughing. Then layout out of the field was done as per plan of the experiment for allocation of treatments. Channels and bunds were also made concurrently. Finally, a seedbed was prepared for sowing of maize seeds. In ZT and PB, sowing of maize was done without ploughing.

Soil analysis : The sieved soil samples were analyzed for pH (1:2.5 soil:water suspension) with a glass electrode Jackson (1973), electrical conductivity (EC, 1:2.5

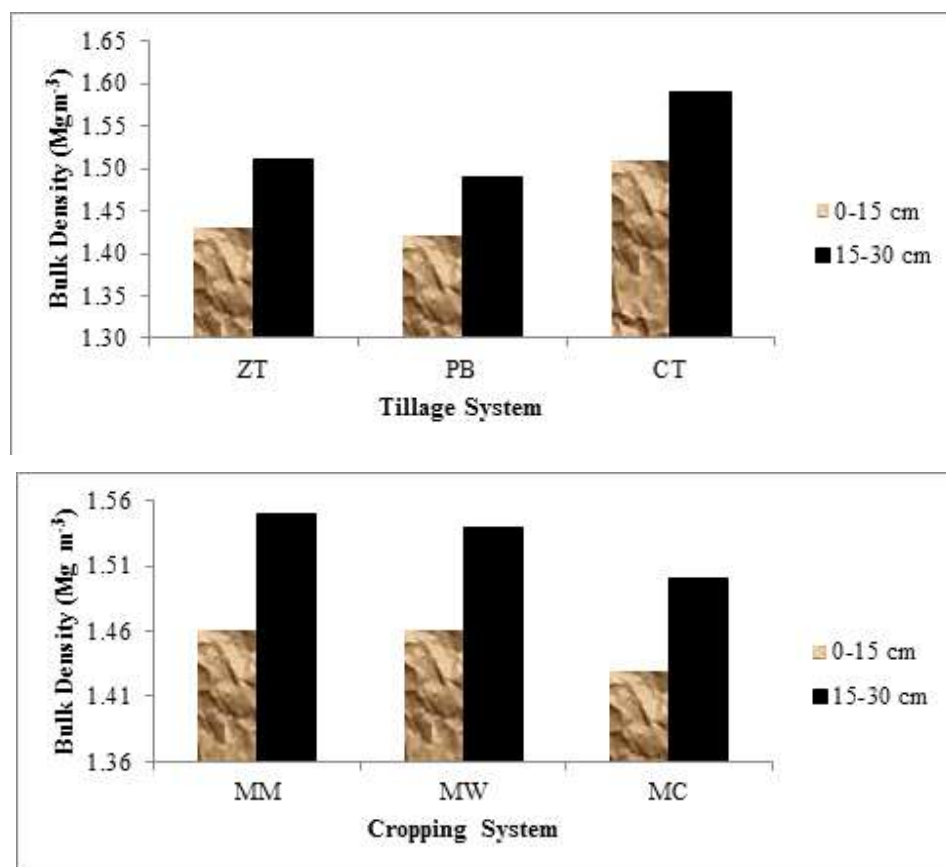


Fig-1 : Depth wise distribution of bulk density as affected by continuous (a) tillage and (b) cropping systems for last seven years.

soil:water supernatant) using a conductivity meter Jackson (1973), and SOC was analyzed by Rapid Titration Method as proposed by Walkley and Black (1934).

The *in-situ* determination of soil bulk density (b) was made by core method (Blake and Hartge, 1986). For this purpose, a core cutter of 6 cm diameter and 6 cm height was used. Core cutter held an assembly of a sectional cylinder (core) of 6 cm diameter and 6 cm height with 2 rings of same diameter but 2 cm height on either side of it and was screwed to the collar of sampler (2.5 cm high) from the upper side. Collar of the cutter was attached to a galvanized thick hollow iron rod of nearly 85 cm height. The other end of the rod was attached to a handle. The bottom part of the cutter had a sharp edge and nearly 2.5 cm of the bottom portion of core cutter was slightly bent inward, hence the inner assembly remained above 2.5 cm from bottom part of cutter. For taking samples, the assembled core cutter was positioned over the sampling site and pressed inside the soil by rotating the handles or by dropping a hammer over the center portion of the upper end of the thick rod until the edge of the collar came to rest over the soil surface. Core cutter was then moved back and forth to loosen the soil grip

around it. It was then slowly pulled out of the hole. After unscrewing the cutter from the collar, the unit of sectional cylinder with rings on each side was taken out carefully. Rings with undisturbed soil were used in pressure plate and determination of maximum water holding capacity. Cores with field soil were dried to 105°C in the oven and weighed. The ratio of dry soil mass (M_s) and internal volume (V_t) of the cylindrical ring is expressed as bulk density (b) of soil (Mg m^{-3}):

$$b = M_s / V_t$$

Penetration resistance was determined by Cone Penetrometer (Davidson *et al.*, 1965). The detail of the method is given below: In all the treatments soil penetration resistance (PR) was measured using Digital cone penetrometer (model no. DIK-5532). The maximum value of PR, which this instrument could measure, was 5000 kPa; maximum depth of penetration was 600 mm, as measured by an ultrasonic transducer. The diameter of the base of cone, and the slant height was 12 and 24 mm and angle of cone was 30°. The capacity of load cell was 60 kg. The instrument had a data logger system attached to it for automatic recording of data in the field. Retrieval of data on PC using CP20V2 software gave the recorded PR data at an interval 15 or 20 mm soil depth in graphical as

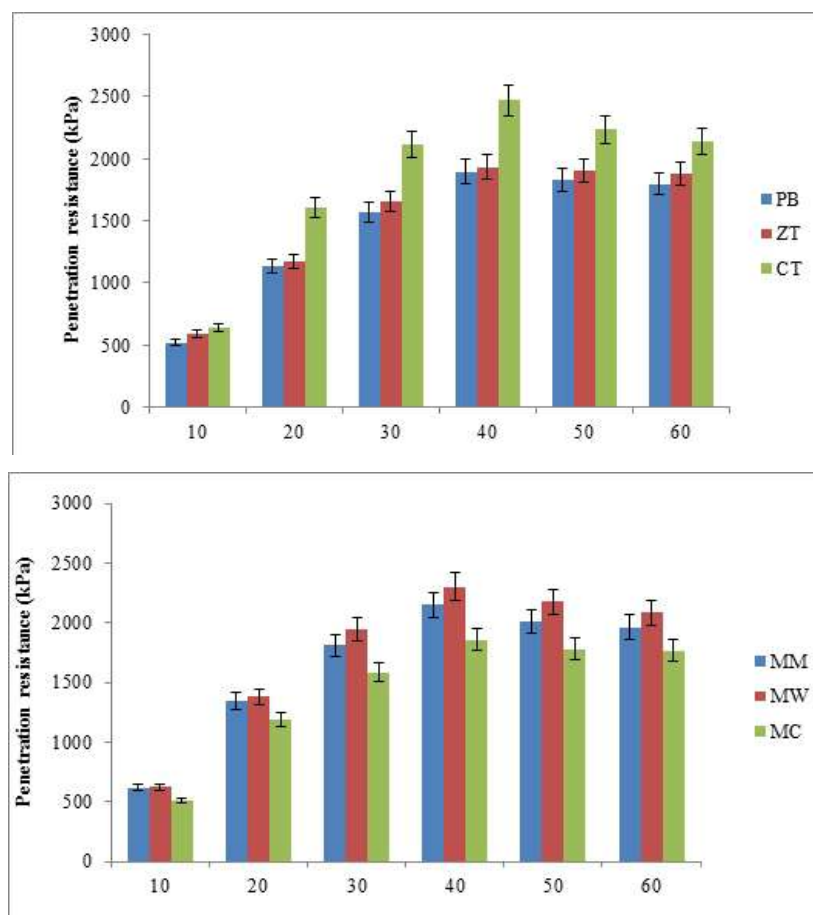


Fig-2 : Penetration resistance in various soil depth, as affected by continuous (a) tillage and (b) cropping systems for last seven years.

well as tabular form (details may be obtained from the hardware manual of 'Digital cone penetrometer (model no. DIK-5532)).

Results and Discussion

Soil Bulk Density : The PR and BD had similar trend to some extent at all depths which was expected because high BD produces high PR. At all depths, both parameters were significantly different among tillage practices (Figure-1(a), Figure-2(a)).

Tillage, depth and cropping system had significant impact on bulk density in the 0-15 cm and 15-30 cm soil layers (Figure-1(a),(b)). However, interaction effect found non-significant in both the layers. In comparison to upper depth, lower depth had higher soil bulk density irrespective of treatments (Figure-1). In the 0-15 cm depth, highest bulk density was found in CT (1.51 Mg m^{-3}) and lowest bulk density was recorded in PB (1.42 Mg m^{-3}) which was at par with ZT. The BD under CA practices (ZT and PB) was lowered by 5.4–6.8% in 0–30 cm soil profile than CT plots after the harvest of 7 year of continuous cropping. Similar trends were found in lower depth as well. In the 15-30 cm soil layer, bulk density varied from

1.49 Mg m^{-3} to 1.59 Mg m^{-3} . Higher SOC content, improved aggregation, enhanced root growth, and biomass could all contribute to the decrease in BD under CA (Unger and Jones, 1998). The BD of the surface soil layer in the PB and ZT plots, on the other hand, was lowered due to residue retention for seven crop seasons. Because soil organic matter is linked to increased aggregation and the establishment of permanent pores as a result of soil biological activity, it has a direct impact on bulk density. As a result, the lower bulk density in CA methods, such as PB and ZT, could be attributed to improved aggregation and a higher organic matter content (Yang et al., 2013). Yang and Wander (1999), Salem et al. (2015), and Parihar et al., 2016, 2018 all showed comparable findings of reduced BD values under CA procedures. Under ZT, however, several researchers found greater BD values in clay/silty loam soil (Kumar et al., 2002; Wilkens et al., 2002). All of these findings are consistent with those previously published (Hernanz et al., 2002; Bhattacharyya et al., 2012a, b, 2013a; Das et al., 2013).

When comparing different cropping systems, the maize-chickpea cropping system had a lower bulk density

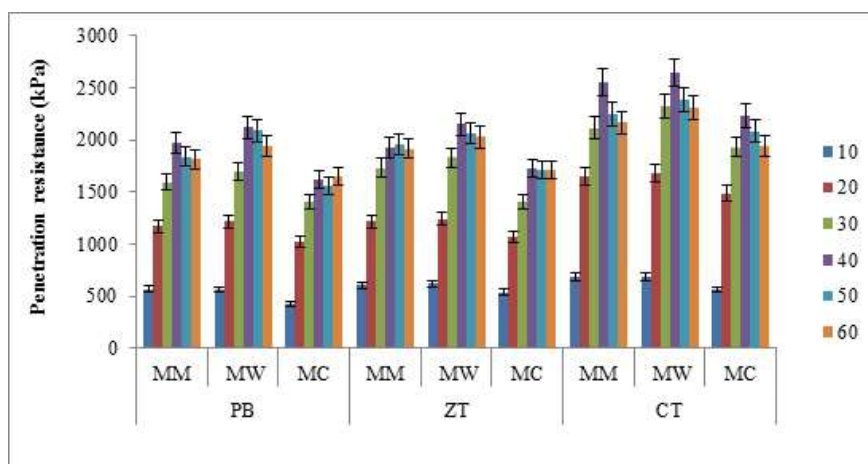


Fig.-3 : Effect of different tillage practices and cropping system on penetration resistance in various soil depth after seven years of crop rotation.

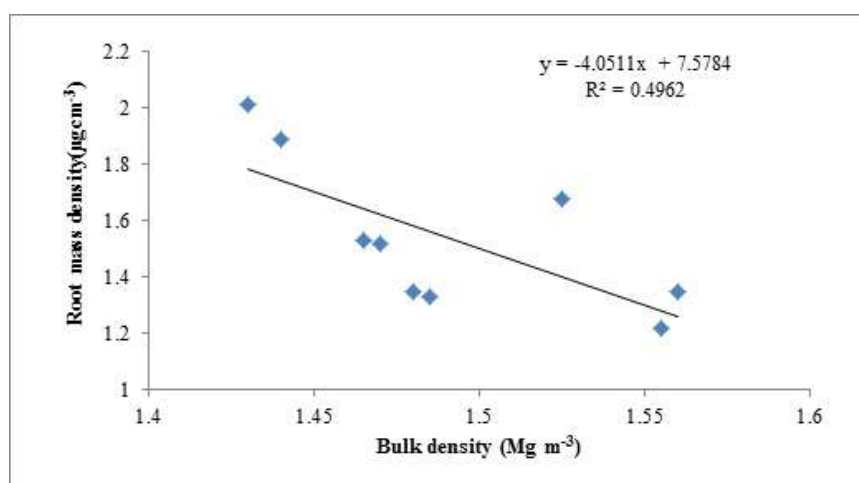


Fig-4 : Relationship between bulk density and root mass density ($\mu\text{g cm}^{-3}$) as affected by continuous tillage and cropping systems for last seven years.

than the others. The bulk density of the sub-surface soil was significantly higher than that of the surface soil, as shown in Fig.-. However, the trend recorded beneath this layer was nearly identical to that observed beneath the soil surface layer. As a result, greater BD values in MW rotation plots may be attributable to lower SOC content than in MC plots in our study (Table-2). The chemical makeup of crop leftovers and root biomass differs, resulting in varying SOC addition (Congreves *et al.*, 2015). Verhulst *et al.* (2011), Thierfelder *et al.* (2012), and Parihar *et al.* (2012) showed comparable findings of decreased BD due to pulses incorporation.

Soil penetration resistance : Likewise soil BD, the PR (kPa) was found to be significantly affected by conservation based management practices and different cropping system (Figure-2). The PR across tillage and crop rotations treatments increased with depth (upto 40 cm) because of higher intrinsic BD in deeper soil layers (Unger and Jones, 1998). In our long term study, the PR was maximum under conventional tillage (896.35 kPa)

followed by zero tillage (716.57), and least under permanent raised bed (655.28) at the surface soil layer (0-15 cm). Maximum PR (1857–2474 kPa) was measured at 30–40 cm soil depth in our long-term experiment. Furthermore, in different layers of the effective root zone (0–50 cm), PR fell by 22.71 % and PB by 28.27 % in ZT plots compared to CT. High PR in conventional tillage may be related to the formation of hard pans generated by the use of heavy machinery to execute five field operations prior to actual crop sowing. Other soil layers showed a similar pattern (Figure-2a). In other studies, Yang and Wander (1999) and Saha *et al.* (2010) found that CA methods reduced soil PR. Increased BD could be another explanation for increased PR in CT practises (Fig.-1a and b). Sharma and De Datta (1986) also reported positive and significant relationship between PR and BD.

Among different cropping system options minimum PR was observed under maize-chickpea throughout soil profile. In our study, after harvest of 7th year summer season crop, on surface soil layer (0-15 cm) the PR (kPa)

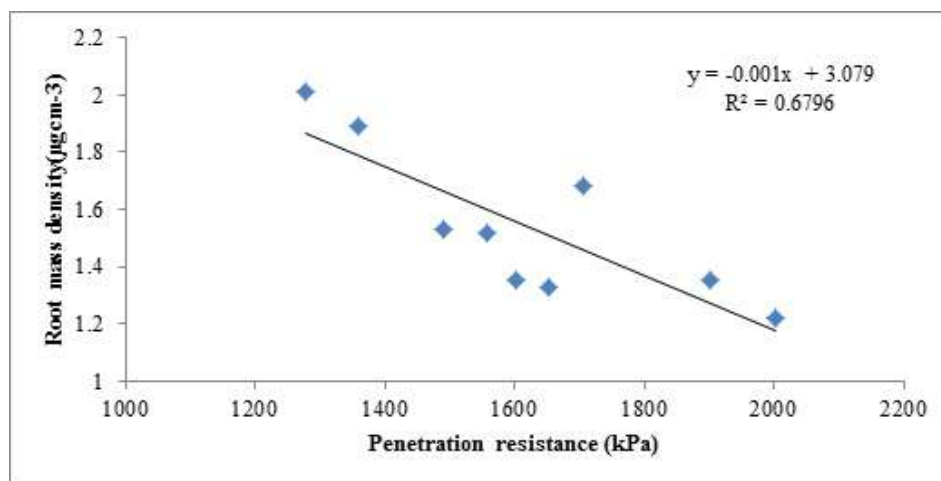


Fig.-5 : Relationship between penetration resistance (kPa) and root mass density ($\mu\text{g cm}^{-3}$) as affected by continuous tillage and cropping systems for last seven years.

was maximum under maize-wheat (760) followed by maize-maize (742), and least under maize-chickpea (638). Similar trend was observed for other soil layers. There was no significant difference were found at surface layer under different cropping system. At subsurface layer (15-40 cm) PR increased sharply which varied from 1905 kPa under maize-wheat to 1568 kPa under maize-chickpea. The result is in conformity with Parihar *et al.*, 2016. They also reported that legume based cropping system reduced mechanical resistance in sandy loam soils of north western Indo Gangetic Plain (IGP). Interaction effect of tillage, and cropping was found significant for lower depth (Figure-3). We observed that the maximum PR was found in maize-wheat cropping system under conventional tillage and lowest in maize-chickpea cropping system under permanent raised bed.

Correlations of root length density with BD and PR : Root length density significantly affected by soil compaction. Correlation analysis was carried out among BD and PR with root length density of maize to find out the correlation among them (Figure-4,5). The correlation analysis indicated that root length density was highly and negatively correlated with BD and PR. The R^2 values of root length density and BD was 0.49 (Figure-4) and for root mass density and PR was 0.67 (Figure-5) which depicts 49% and 67 % of variation in the root mass density of maize, respectively due to BD and PR, as explained by the fitted regression equation or line.

Conclusions

Our results from long term (seven years) study demonstrated that establishment of diverse crops under maize based rotations with CA based systems (ZT and PB) resulted in significant improvement in the physical properties of sandy loam (*Typic Haplustept*) soil. We

observed decrease in bulk density (5.4–6.8%) and penetration resistance (22.71–28.27%) compared to conventional tillage based maize production. Among the maize based crop rotations, maize-chickpea proved to be best rotation for improving these soil physical properties. Our study suggest that the CA (ZT and PB) with maize-chickpea rotations provides an alternate to improving soil health in sandy loam (*Typic Haplustept*) soil of eastern IGP.

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Effect of Foliar Application of Zinc Based Nanofertilizer and Different Fertility Levels on Growth Attributes and Yield of Maize in Southern Rajasthan

Piyush Choudhary^{1*}, D. Singh¹, M.K. Kaushik¹, S.S. Sharma², H.K. Jain³, V. Saharan⁴, D.P. Singh⁵, R.K. Sharma⁶ and D. Chouhan⁷

¹Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur

²Department of Plant Pathology, Rajasthan College of Agriculture, MPUAT, Udaipur

³Department of Statistics, Rajasthan College of Agriculture, MPUAT, Udaipur

⁴Department of MBBT, Rajasthan College of Agriculture, MPUAT, Udaipur

⁵Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture, MPUAT, Udaipur

⁶Department of Soil Science and Agricultural Chemistry, COA, Bhilwara, MPUAT, Udaipur

⁷Department of Genetics and Plant Breeding, Rajasthan College of Agriculture, MPUAT, Udaipur

*Correspondence Author's Email : piyushdudi@gmail.com

Abstract

A field experiment was conducted during two consecutive *Kharif*, seasons of 2020 and 2021 at Instructional Farm, Rajasthan College of Agriculture, Udaipur to evaluate the effect of foliar application of zinc based nanofertilizer and different fertility levels on growth attributes and yield of maize in Southern Rajasthan. The experiment was laid out in a factorial randomized design with three replications comprising four foliar application of nanofertilizer (Control, at knee high stage, at 50% tasseling stage and both at knee high stage and at 50% tasseling stage) and four fertility levels (100% RDF, 90% RDF, 80% RDF and control). Growth attributing characters viz., Plant height (cm), Plant dry matter (g plant⁻¹), Days to 50 per cent tasseling, Days to 50 per cent silking, LAI, CGR (g m⁻² day⁻¹) and RGR (g g⁻¹ day⁻¹) were significantly higher at all the stages of growth periods with the dual foliar application of nanofertilizer at knee high stage and at 50 per cent tasseling stage and application of 90 per cent RDF in maize. Similarly, the significantly highest Chlorophyll content (2.180 mg g⁻¹ and 2.181 mg g⁻¹) was found in with dual foliar application of nanofertilizer and 90 per cent RDF, respectively. Significantly highest grain, stover and biological yield (51.90, 82.32 and 134.21 q ha⁻¹) were recorded with the dual foliar application of nanofertilizer at knee high stage and at 50 per cent tasseling stage over single stage foliar application. Similarly, different levels of fertility, application of 90 per cent RDF significantly increased grain, stover and biological yield.

Key words : Nanofertilizer, zinc, yield, LAI, CGR, RGR, maize.

Introduction

Maize (*Zea mays* L.) is one of the most important cereals, next to wheat and rice in the world and India. It is one of the most versatile crops. It can be grown over diverse environmental conditions and diversified uses in human food, animal feed, and raw materials for many industrial products. It is a versatile crop that fits well in the existing cropping systems. In India, it is an important crop not only in terms of acreage but also in context to their versatility for adoption under wide range of agro-climatic conditions. Currently, maize is cultivated over 9.72 m ha area with 28.64 m t production and an average yield of 29.45 q ha⁻¹ (Govt. of India. 2020). In Rajasthan, the crop occupies 0.97 m ha area with an annual production of 2.70 m t and average yield of 27.69 q ha⁻¹ (Govt. of India. 2021). Amongst major nutrients, nitrogen is the most vital nutrient element and performs as a component of many organic compounds viz. proteins, amino acids, nucleic acids and nucleotides, enzymes, vitamins, hormones, alkaloids etc.

Phosphorus is the second most essential primary macronutrient, crucial for crop growth and yield.

Among micronutrients, zinc is most important micronutrient for crop as per its imperative role in plant's enzymes system as co-factor. Presently deficiency of zinc has become so widespread that it ranks next to N and P in Rajasthan as well as many other states under intensive cropping systems (Zhu *et al.*, 2012). Thus higher yield of single cross maize hybrid can be obtained through the judicious use of nitrogen, phosphorus and zinc. Nanotechnology can plays an important role in modern agriculture to address plant diseases and the limited availability of important plant nutrients (Parisi *et al.*, 2015). A variety of nanomaterials, mostly metal and carbon based nanomaterials has been studied in maize and wheat for plant growth (Yang *et al.*, 2015). It has been proved that various nanomaterials used in various crops can be exploited as nanonutrients. It is wise to evaluate the potential of nanomaterials for their ability to fulfil the need of nutrients for plants in much efficient manner as

compared to traditional fertilizers (Raliya *et al.*, 2018). Chitosan based nanomaterials like Cu, Zn and salicylic acid (SA) has great potential to be use in crop plants as fertilizers.

Materials and Methods

The experiment was conducted during both the years at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, which is situated at 24° 35' N latitude, 72° 42' E longitude and an altitude of 579.5 m above mean sea level. It falls under agro-climatic zone IVa (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan, India. The experimental soil was clay loam in texture, having alkaline reaction (7.6), medium in available nitrogen (292.0 kg ha⁻¹) and available phosphorus (21.8 kg ha⁻¹) but high in available potassium (303.1 kg ha⁻¹) and medium in available zinc (1.89 ppm).

The experiment was conducted during kharif 2020 and kharif 2021. The experiment was laid out in Factorial RBD with three replications. The experiment consisted of sixteen treatment combinations comprising of two factors viz. 4 level of foliar application of nanofertilizer includes control (Water Spray), at knee high stage (0.1%), at 50 per cent tasseling stage (0.1 %) and at knee high stage and 50 per cent tasseling stage (0.1%) and fertility levels includes control, 100 Per cent RDF, 90 Per cent RDF and 80 Per cent RDF. The recommended dose of fertilizer was 120 kg N, 60 kg P₂O₅ and 25 kg Zn ha⁻¹. As per treatment entire quantity of phosphorus was applied at the time of sowing where as nitrogen was applied in three split application viz., 1/3rd at sowing, 1/3rd at knee-high stage and remaining 1/3rd at 50 per cent tasseling stage. As per treatments Zn-chitosan NPs were prepared in Department of MBBT, Rajasthan College of Agriculture, Udaipur based on ionic gelation between chitosan and sodium tripolyphosphate (Saharan *et al.*, 2015 and Kumar *et al.*, 2020). The Zn-chitosan NPs 0.1 per cent solution was sprayed at knee high stage and at 50 per cent tasseling stage as per treatments. The maize crop variety Pratap Hybrid Maize-3 was sown using 20 kg seed ha⁻¹ with onset of rain on 4th July, during 2020 and 5th July 2021 in both year with a spacing of 60 x 25 cm.

Height of five randomly selected plants from border rows of each plot were measured from ground level to tip of flag leaf at 45 and 60 DAS while at harvest it was measured from ground level to top of tassel. Five plants were randomly selected and removed periodically at 45 and 60 DAS and at harvest of crop. After chopping, plants samples were placed separately in perforated paper bags and oven dried at 65 °C till a constant weight was obtained. Also, in each experimental unit, days were recorded to their 50 per cent silking *i.e.* silk appearance in 50 per cent plants.

The leaf area per plant was calculated by multiplying length and width of leaves and summing up area under each category of leaves and multiplied by standard factor 0.74 as suggested by Montgomery. Thereafter, LAI was calculated by using the formula given by Watson (1997).

The chlorophyll content was estimated as per standard procedure. The total chlorophyll content was computed by following formula :

$$\text{Total chlorophyll content (mg g}^{-1}\text{)} = \frac{20.2(A_{645})}{1} + \frac{8.02(A_{663})}{1000} \frac{V}{W}$$

Where,

a = Length of light path in cell (1 cm)

V = Volume of extract and

W = Weight of leaf sample

The growth efficiency parameters viz., crop growth rate and relative growth rate at successive duration viz. 45 to 60 DAS and 60 DAS to at harvest were computed by the use of following formulae suggested by Redford (1967).

$$\text{CGR (gm}^{-2} \text{ day}^{-1}\text{)} = \frac{W_2 - W_1}{(t_2 - t_1)}$$

Where,

W₁ and W₂ are plant dry weight (g) at time t₁ and t₂, respectively.

$$\text{RGR (g g}^{-1} \text{ day}^{-1}\text{)} = \frac{\log_e W_2 - \log_e W_1}{(t_2 - t_1)}$$

Where,

W₁, W₂ are dry matter at time t₁ and t₂, respectively.

Result and Discussion

Growth attributes : Results depicted in Table-1 and 2 revealed that application of nanofertilizer both at knee high stage as well as at 50 per cent tasseling stage increased plant height, plant dry matter, LAI at successive stages, chlorophyll content, CGR and RGR recorded at 45-60 DAR and 60 DAS to at harvest of crop on pooled basis. The foliar application of nanofertilizer failed to influence plant population, plant height at early stage and days taken to 50 per cent tasseling and silking of crop. Spherical and porous surfaced of Zn based chitosan nanofertilizer was composed of chitosan-tri poly phosphate nanomatrix, encapsulated with Zn ions having presence of carbon, oxygen, nitrogen, phosphorous and zinc in the Zn based chitosan nanofertilizer. Further these nanofertilizers showed 93.22 per cent zinc release in 7 days (Choudhary *et al.*, 2019 and Kumar, *et al.*, 2020).

Table-1 : Effect of foliar application of zinc based nanofertilizer and varying fertility levels on growth attributes of maize.

Treatment	Plant height (cm)			Plant dry matter (g plant ⁻¹)			Days to 50 per cent tasseling	Days to 50 per cent silking	Chlorophyll content (mg g ⁻¹)
	45 DAS	60 DAS	At harvest	45 DAS	60 DAS	At harvest			
Foliar application									
Control	82.13	142.90	181.49	15.37	59.20	190.74	44.56	50.20	2.113
At knee high stage	85.62	156.16	209.52	15.65	68.71	204.19	43.98	48.60	2.148
At 50 per cent tasseling stage	82.35	155.81	207.62	15.47	67.66	203.41	43.88	48.71	2.136
Both stages	87.03	164.32	223.76	15.82	74.58	219.78	43.71	47.78	2.180
SEm±	1.17	1.53	2.69	0.20	0.89	1.86	0.44	0.49	0.005
C.D. (P = 0.05%)	NS	4.33	7.60	NS	2.53	5.25	NS	NS	0.015
Fertility levels (N, P and Zn kg ha ⁻¹)									
Control	74.72	140.09	177.25	13.76	55.46	168.88	43.44	49.41	2.061
80 per cent RDF	83.18	153.10	205.76	15.38	65.98	199.75	44.21	48.88	2.140
90 per cent RDF	89.16	161.01	216.49	16.39	72.93	221.03	44.80	48.57	2.181
100 per cent RDF	90.07	165.01	222.90	16.78	75.77	228.47	43.67	48.44	2.195
SEm±	1.17	1.53	2.69	0.20	0.89	1.86	0.44	0.49	0.005
C.D. (P = 0.05%)	3.32	4.33	7.60	0.55	2.53	5.25	NS	NS	0.015

Table-2 : Effect of foliar application of zinc based nanofertilizer and varying fertility levels on growth attributes and yield of maize.

Treatment	LAI		CGR (g m ⁻² day ⁻¹)		RGR (g g ⁻¹ day ⁻¹)		Yields (q ha ⁻¹)		
	45 DAS	60 DAS	45-60 DAS	60 DAS to at harvest	45-60 DAS	60 DAS to at harvest	Grain	Stover	Biological
Foliar application									
Control	2.99	3.12	19.48	27.40	0.0901	0.0366	45.09	68.80	113.89
At knee high stage	3.03	3.47	23.58	28.68	0.0960	0.0351	47.79	75.43	123.21
At 50 per cent tasseling stage	2.99	3.36	23.20	28.70	0.0957	0.0356	46.62	71.95	118.57
Both stages	3.06	3.52	26.11	30.25	0.1029	0.0336	51.90	82.32	134.21
SEm±	0.02	0.02	0.43	0.44	0.0015	0.0006	0.62	0.93	1.04
C.D. (P = 0.05%)	NS	0.04	1.21	1.25	0.0041	0.0016	1.74	2.63	2.94
Fertility levels (N, P and Zn kg ha⁻¹)									
Control	2.32	3.10	18.53	23.83	0.0915	0.0354	34.07	53.25	87.33
80 per cent RDF	3.17	3.36	22.49	27.94	0.0961	0.0350	48.82	75.95	124.77
90 per cent RDF	3.25	3.48	25.13	31.07	0.0984	0.0352	53.70	84.11	137.82
100 per cent RDF	3.34	3.53	26.22	32.19	0.0988	0.0353	54.80	85.17	139.97
SEm±	0.02	0.02	0.43	0.44	0.0015	0.0006	0.62	0.93	1.04
C.D. (P = 0.05%)	0.07	0.04	1.21	1.25	0.0041	0.0016	1.74	2.63	2.94

Fully characterized Zn based chitosan nanofertilizer has exploited in the present study to find out its effect on source-activity and sink strength of single cross maize hybrid.

In earlier study seed priming with zinc based nanofertilizer improve vigour of seedling and enabled plant to withstand environmental stresses at early stages of development by up-regulation of carbohydrates metabolism (Dzung *et al.*, 2011 and Chandra *et al.*, 2015). Further Zn and Cu based chitosan nanomaterial reported to enhance seedling growth by many folds through slow releases of micro-nutrients like Zn and Cu (Saharan *et al.*, 2016 and Choudhary *et al.*, 2019). Similarly in present study, foliar application of zinc based

chitosan nanofertilizer prompted higher plant vigour index in maize which is in line with earlier reporting in maize by Saharan *et al.* (2015), Saharan *et al.* (2016), Kumaraswamy *et al.* (2018) and Choudhary *et al.* 2019). It has been reported that treatment of foliar application of zinc based chitosan nanofertilizer induced vigour of plant, improve growth due to many folds by increase of enzymes α -amylase and protease activity (Kumaraswamy *et al.*, 2018). In present study, Zn based nanofertilizer might have up-regulated the α -amylase and protease activity in maize plant which in turn increase N, P and Zn content in leaves, grain and stover and protein contents in grain correspondingly induces the higher plant growth in maize reflected through higher values of plant height, dry matter accumulation, LAI, chlorophyll content, CGR and RGR.

The results are in close accordance with findings of Yu *et al.* (2021) and Kumar *et al.* (2021).

Increasing fertility level from control to 100 per cent RDF significantly increased plant height, dry matter accumulation, LAI, chlorophyll content and crop growth rate at varying extents (Table-1 and 2). The fertility levels were statistically at par in terms of RGR estimated during both the years, however, on pooled basis increase RGR significantly with increasing fertility between 45-60 DAS and 60 DAS to at harvest. Maize is a highly nutrient exhaustive and highly fertilizer responsive crop needs special attention for its requirements for fertilizers especially for nitrogen, phosphorus potassium and zinc (Bharti *et al.*, 2019). It is well established fact that amongst plant mineral nutrients, nitrogen, phosphorus, potassium and zinc are considered to be most important for exploiting genetic behaviour of crop through growth and development (Halvin *et al.*, 2005). The single cross hybrid maize being highly responsive to applied nutrients particularly nitrogen and phosphorus (Bhatt, 2012) are considered to be essential for synthesis of chlorophyll (Dawadi and Sah, 2012) which is of great physiological significance in plant metabolism. Further phosphorus is involved in root proliferation and growth.

Yield : The grain, stover and biological yield (51.90, 82.32 and 134.21 kg ha⁻¹) of maize significantly increased to the tune of 15.09, 19.65 and 17.84 per cent with the foliar application of 0.1% zinc based nanofertilizer at knee high stage and 50 per cent tasseling stage over control, respectively (Table-2). Application of 90 percent RDF had significant influenced on grain, stover and biological yield of maize over 80 percent RDF and control, although highest yield was recorded with 100 per cent RDF. The grain yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The synthesis, assembly, and translocation of photosynthates depend upon the efficient photosynthetic structure and the extent of translocation into the sink (grains) and plant growth and development during the early crop growth stages. The production and translocation of synthesized photosynthates depend upon mineral nutrition through soil or foliar application. Zn, among micronutrients, is indispensable for plants as it acts as a structural, catalytic and co-catalytic component in many enzymes (Singh *et al.*, 2015). It has thoughtfully been assumed that its rational use, particularly dose and time, can significantly contribute to growth and yield of plants (Sharan *et al.*, 2015). Overall, it is assume that application of Zn based chitosan nanofertilizer enhanced cellular homeostasis and positively contribute source-activity and contributes to sink-strength viz., yield attributes and yield (Lemoine *et al.*, 2015). The study thus affirms that application of nanofertilizer both at knee high

stage followed by 50 per cent tasseling stage significantly increases the activity of major enzymes of starch biosynthetic pathways and is accountable for higher starch accumulation in grains. It is believed that higher import and assimilation of sucrose in developing grains create potent gradient in sink and source tissues, and more photo-assimilates translocate to sink to accelerate sink activity. Application of increasing fertility level from control to 90 per cent RDF significantly increased grain and stover yield (Table-2). The positive response of maize under N, P and Zinc fertilization is in close conformity with the findings of Rodinpuia *et al.* (2019), Van *et al.* (2020), Kumar *et al.* (2019) and Kumar *et al.* (2020).

Conclusions

The present study's finding indicates that foliar application of 0.1% zinc based nanofertilizer at knee high stage and 50 per cent tasseling stage significantly increased the growth attributes and yield of maize. Further, it is inferred that application of 90 per cent recommended dose of fertilizer produced statistically at par grain and stover yield as compared to 100 per recommended dose of fertilizer.

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Panchaytiraj Institution and their Role Towards the Awareness among the Rural People in Dubepur Block of Sultanpur District Uttar Pradesh

Shailendra Kumar Yadav*, U.A. Siddiqui, K.D. Singh and Akhilesh Tripathi¹

Chandra Bhanu Gupt Ag. PG College, Bakshi Ka Talab, Lucknow (U.P.)

¹Department of Entomology, Kulbhaskar Ashram P.G. College, Prayagraj (U.P.)

*Email : shivamkumaryadav786@gmail.com

Abstract

The present study was conducted in Sultanpur District of Uttar Pradesh to find out the role of Panchayati raj Institutions and their challenges in the rural development. This platform provides the decentralization of the governance at the ground level, which is the base of social, economic & political development of each class of societies. In this reference MGNREGA and other development schemes are also covered at a broad level, which creates an interactive environment for the intellectual awareness in the societies.

Key words : Awareness, panchayti raj institution, rural people.

Introduction

Panchayats have been the backbone of the Indian villages since the beginning of the recorded history. Panchayat Raj is a system of governance in which Gram Panchayats are the basic units of administration. Panchayat Raj Institutions (PRIs) have been involved in the programme implementation and they constitute the core of decentralized development of planning and its implementation. Panchayat Raj Institutions aim at translating the Gandhian dream of village self-governance (Gram Swaraj) and to become an effective tool of rural development and reconstruction. Since 1959, almost all rural development departments have been executing their programmes through PRIs. With the implementation of State Acts under the spirit of the 73rd Constitutional Amendment a clear cut role of Panchayat Raj Institutions in rural development has been envisaged.

Gram Panchayat Development Plan Campaign 2nd October 2018-31st December 2018) : Gram Panchayat have been mandated for the preparation of Gram Panchayat Development Plan (GPDP) for economic development and social justice utilizing the resources available to them. The GPDP planning process to be comprehensive and based on participatory process which involves the full convergence with scheme of all related Central Ministers / Line Departments related to 29 subjects enlisted in the Eleventh Schedule of the Constitution. Panchayats have a significant role to play in the effective and efficient implementation of flagship schemes on subjects of National Importance for transformation of rural India.

October 2018 to 31st December 2018 for preparing GPDP for 2019-20. The campaign initiated under “Sabki Yojana Sabka Vikas” will be an intensive and structured exercise for planning at Gram Sabha though convergence between Panchayati Raj Institutions (PRIs) and concerned Line Departments of the State.

Recent updates in budget 2020-21 by central government in panchayati raj and rural development : Rs.1.23 lakh crore has been allocated for rural development & Panchayati Raj. and A new scheme named as KRISHI UDAN Central Finance minister Smt. Nirmala Sitha raman as part of her budget speech said on February1, 2020 that to boost agriculture exports the civil aviation ministry will introduce a ‘Krishi Udan’ scheme to help farmers’ exports their produce internationally. F.M. Sitharaman also said that the Indian Railways will set up a ‘Kisan Rail’ for the transport of perishable goods to assist agriculture exports within India. The focus is to link up Indian farmers with more global and local markets through established and institutionalized supply chains, enabling them to get a higher price for their produce. This would be particularly effective in times of glut, when farmer struggle to deal with abundant supplies, as prices collapse in the local market forcing them to dump products in mandis. A large number of producers concentrated in one area tends to bring down per unit costs, giving them a competitive advantage in a global market. Union Finance Minister Nirmala Sitharaman Saturday proposed to allocate Rs. 6000 crore to Bharat net programme— a government- run programme which aims to provide on demand, affordable broadband connectivity for all household and institutions.

The people’s Plan Campaign will commence from 2

“Our vision is that all “public institutions” at gram

panchayat level such as Anganwadis, health and wellness centres, government schools, PDS outlets, post offices and police stations will be provided with digital connectivity. Fibre to the Home (FTTH) connections through Bharat net will link 1,00,000 Gram Panchayats this year," Sitha raman said while announcing the Budget 2020-21.

Recently Prime Minister Narendra Modi on April 24, 2020 launched two portals E-Gram Swaraj Portal & Swamitva Scheme for the upliftment of the rural areas of India. The portal was launched on the occasion of National Panchayati Raj Day 2020 through videoconferencing between PM Modi and Sarpanches of village panchayats. While launching the app, the Prime Minister stated that EGram Swaraj marks the complete digitization of villages and rural areas. The portal can be accessed at egramswaraj.gov.in and is also available as a mobile app. Along with the portal; PM Modi launched the Swamitva Scheme for the mapping of properties in villages.

New updates in union budget 2021-22 : The allocation to the Panchayati Raj Ministry for the year 2021-22 increased by more than 32 percent to Rs913.43crore in the Union Budget presented by Finance Minister Nirmala Sitharaman on Monday compared to the revised expenditure during the current financial year. The major jump in the allocation was seen in the Swamitva scheme, which more than doubled to Rs. 200 crore from Rs. 79.65crore in the current fiscal. Press Information Bureau New Delhi India

Objectives of the Study

To study the personal profile of respondent, awareness and participation of MGNREGA worker.

To assess the role of PRIs in implementation of MGNREGS of respondent, problem and constraints of respondent and these suggestion to overcome of these problem.

To study the role of Panchayati Raj Institutions in the development of rural areas, organization, structure and functioning of Panchayati Raj Institutions in Sultanpur district of Uttar Pradesh.

To point out the deficiencies, if any and to offer suggestions for the improvement of Panchayati Raj Institutions in Uttar Pradesh.

Research Methodology

In this the project the main result methodology is direct questionnaire to the village respondents, which is located in Dubepur block of Sultanpur U.P. The current data which has been used in this project has been taken from the village level head & other communities residing that

particular area. This data was taken in the survey during March 2020 for the different data set like Caste, Age, and Education etc.

Materials and Methods

The study was conducted in 5 villages of Dubepur block in Sultanpur district and 50 respondents were selected for sampling purpose and their name was collected from the village head usually known as Gram Pradhan. After that name of these workers were arranged systematically & present study was conducted during the month since July to December 2020.

Awareness of MGNREGA Workers : In the Panchayati Raj Institutions the various development schemes are running by Centre & State government at line to line in which MGNREGA is one of the foremost programme, in this reference the investigation has been started to know about the awareness of workers towards their schemes are discussed under following table.

N=50

S. No.	Agency	No.	Percentage (%)
1.	Village Panchayat	10	20%
2.	Block Panchayat	20	40%
3.	Zila Panchayat	20	40%
Total		50	100%

The above table shows the respondents awareness towards the different development scheme under the various level of PRIs such as the percentage of awareness at Village Level is 20% by 10 respondents, the percentage of awareness at Block Panchayat is 40% by 20 respondents, & the percentage of awareness at Zila Panchayat is 40% by 20 respondents.

Showing the Distribution of Caste Respondents

N=50

S. No.	Caste	No.	Percentage (%)
1.	Schedule Caste	3	6%
2.	Other Backward Caste	19	38%
3.	General	28	56%
Total		50	100%

This is clear from above that the 56% of respondents are belong to the General Caste of the society and 6% respondents belong to the Schedule Caste and rests of 38% caste were belonging to the Other Backward Caste of the Society.

Distribution of Age of Respondents

N=50

S. No.	Age group	No.	Percentage (%)
1.	40-50	17	34%
2.	51-60	14	28%
3.	61-70	11	22%
4.	71-Above	8	16%
Total		50	100%

The above table shows that 34% Respondents comes in 40-50 years as age group where as 28% Respondents where belongs to 51-60 years of age and 22% Respondents all under the age group of 61-70 years while 16% Respondents comes in 71 years and above age group.

Distribution of Education Attainment of Respondents

N=50

S. No.	Educational Level	No.	Percentage (%)
1.	Illiterate	7	14%
2.	Neo-literate	1	2%
3.	Primary	9	18%
4.	Upper Primary	16	32%
5.	High School	8	16%
6.	Intermediate	4	8%
7.	Graduate	5	10%
Total		50	100%

The above table shows that the 32% majority of respondents were educated up to the Upper Primary level while 18% respondents were educated up to Primary level and 16% respondents were educated up to the High School level but Graduate Intermediate & Neo literate percent is 10%, 8% and 2% respectively while 14% people are Illiterate respondents.

Showing the House Type of Respondents

N=50

S. No.	House	No.	Percentage (%)
1.	Hut	3	6%
2.	Thatched	4	8%
3.	Tiled House	1	2%
4.	RCC/PUCCA	42	84%
Total		50	100

The above table shows about the house type of respondents 84% of majority have Rcc/Pucca and 8% respondents have of Thatched house while 6% respondents have hut and 2% respondents have only Tiled house.

Showing the distribution of land holdings of respondents

N=50

S. No.	Land	No.	Percentage (%)
1.	Marginal	26	52%
2.	Small	16	32%
3.	Medium	7	14%
4.	Big Farmer	1	2%
Total		50	100%

The above table indicate the that landholdings of respondent in village from have table shows that 32% respondents have Small Landholdings and 52% respondents were belong to Marginal category of landholdings and 7% respondents have Medium

Landholdings, while 2% respondents have Big Farmer landholdings in block.

Showing the Annual Income of respondents

N=50

S. No.	Annual Income	No.	Percentage (%)
1.	< Rs.30,000	17	34%
2.	Rs. 30,001 to Rs. 50,000	17	34%
3.	Rs.50,001 to Rs.70,000	9	18%
4.	Rs. 70,001 to Rs. 91,000	3	6%
5.	Rs. 90,000 Above	4	8%
Total		50	100%

The above table shows the different respondent of different level of income in the different such as: Above 30,000 are 17 which is 34%, B/W 30,000-50,000 are 17 which is 34%, B/W 50,000-70,000 are 9 which is 18%, B/W 70,000-91,000 are 3 which is 6% & above 90,000 are 4 which is 8% respectively.

Results and Discussion

Social and Economic Perspective : After the survey at various level of Panchayatiraj Institutions in the Sultanpur District of Uttar Pradesh has soon that it is playing a vital role in the different perspective like socio, economic & political development in the societies at ground level. It has also created the advancement in general and educational level for the upcoming generation in our democratic country.

Women Empowerment Perspective : It has also provided a very important platform in our democratic country such as 33% seats are reserved for women empowerment.

Governance Perspective : It also provides the decentralization of power which promotes the transparency and accountability of government working procedure with the social participation.

Challenges and Future Enhancement : Although PRIs has provided many developments in various perspective, yet there are many challenges like lack of education, lack of own rights, political involvement in working procedure etc. are the key issue of this platform.

Now government must take towards the positive initiatives regarding these bottlenecks towards the overall development of the country with the social participations.

Conclusions

Although thus system has gained many advantages in the various sector of rural development but along with this there are many remote areas of the country, where people are unaware of their rights, lack of infrastructure, & govt. employees apathy towards the hurdles, lack of proper education system and social imbalances are the main key

issues regarding this problem. So, now the government must prepare a policy to review all these working system in a proper way in which various NGOs can also be employed to resolve these kinds of problems. Regarding this implementation of government targets & scheme in the rural development the local participation of village must also be included equally with the government infrastructure system, in which higher and equal education system is also the main key factor for overall rural & country development.

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Effect of Different Cropping Sequences on Soil Health under Irrigated Condition in Madhya Pradesh

Vijay Kumar, V.B. Upadhaya, S.B. Agrawal, R.P. Shahu and Arvind Ahirwal

Department of Agronomy, College of Agriculture, JNKVV, Jabalpur, M.P.

Email : vku9077@gmail.com

Abstract

The present investigation was conducted during two consecutive years of 2018-19 and 2019-20 entitled effect of different cropping sequences on soil health under irrigated condition in Madhya Pradesh. Higher soil organic carbon noted that green gram – chickpea – green gram (7.03 -7.06 and 7.02 to 7.04 g kg⁻¹) during 2018–19 and 2019–20, respectively. With respect to soil pH it was changes in soil pH (7.53 to 7.56), highest available NPK, highest number of total bacterial counts (45.57 and 46.49 10⁵ x cfu g⁻¹ soil), fungi (31.00 and 31.42 10⁻³ x cfu g⁻¹ soil) and actinomycetes (7.63 and 7.72 10⁻³ x cfu g⁻¹ soil) under green gram – chickpea – green gram cropping sequence as compared to rest of the cropping sequence.

Key words : Actinomycetes, available NPK, bacteria, fungi and soil health.

Introduction

The rice–wheat system is dominant cropping system of irrigated areas of Kymore Plateau and Satpura Hill Zone (Jain and Kushwaha, 2020). This system requires high input resources for higher productivity resulted higher cost per unit area and time. Continues cultivation of rice – wheat crops in this region create the more problems showed low in the system productivity with poor crop management practices consequently loss in soil fertility due to emergence of multiple nutrient deficiency (Fujisaka *et al.*, 1994; Dwivedi *et al.*, 2001; Kumar *et al.*, 2019), because of Incidence and expansion of multi-nutrient deficiencies in the soils under intensive cropping and in rice-based mono cropping systems, can be linked to inadequate and unbalanced nutrient input and considered as major reasons observed for declines in productivity associated with fertilizer use (Singh *et al.*, 2009), unattended intervening periods (Bhatt and Kukal 2014a,b; Bhatt and Kukal 2015a,b,c), soil degradation (Bhandari *et al.*, 2002) and atmospheric pollution, deterioration in soil physical properties (Tripathi, 1992), decline productivity, crop yield (Yadav, 1998), resurgences of weed, insect, pest and disease, over mining of nutrients, reduction in organic carbon, reduction in water table (Humphreys *et al.*, 2010; Hira *et al.*, 2001), imbalance use of fertilizer and water logging (Naresh *et al.*, 2017). Crop diversification shows lot of promises in alleviating these problems besides, fulfilling basic needs for cereals, pulses, oilseeds and vegetables as well as regulating farm income besides withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and

pesticide loads, ensuring environmental safety and creating employment opportunity (Gill and Ahlawat, 2006). In recent years double and triple cropping are more focusing points for increasing farmers income, so diversification and intensification of cropping systems with remunerative and efficient crops like pulses, oilseeds and vegetables has great scope to generate maximum net profit per unit investment per unit time to farmers. (Kalita *et al.*, 2019). Realizing this, significant thrust has been made on the inclusion of high value and high volume vegetable crops in rice–fallow systems to improve the economic condition of marginal and small farmers (Pooniya, 2015). Intensification of rice–fallow system is an effective approach for achieving food and nutrition security, poverty alleviation, employment generation, prudent use of land and water resources, sustainable agricultural development and overall environmental quality improvement (Hegde, 2003). In the era of resource attenuation, resource use efficiency is an important aspect for considering the suitability of a cropping system (Babu, 2014). Comprehensive information on effect of different cropping sequences on soil health under irrigated condition in Madhya Pradesh is meager and compilation of scientific information on this burning issue is a great challenge. Hence, with the above information the present study has been undertaken.

Materials and Methods

A field experiment was conducted during 2018-19 to 2019-20 at the Instructional Research Farm, Department of Agronomy, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. The soil of experimental field was sandy loam in

texture with pH 7.57, electrical conductivity 0.50 dSm^{-1} and organic carbon (6.9 g kg^{-1}), available nitrogen (227 kg kg^{-1}), available phosphorus (9.4 kg kg^{-1}) and available potassium (302 kg kg^{-1}) content. The varieties and hybrids which were popular among local farmers 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 a randomized block design with 10 treatments of rice based cropping systems and replicated thrice. (T₁) rice – wheat, (T₂) rice – chickpea, (T₃) green gram – chickpea – green gram, (T₄) green gram – lentil – black gram, (T₅) rice – potato – (cob) maize, (T₆) rice – *toria* (early rabi) wheat (late rabi), (T₇) sorghum (f) – egyptian clover (fodder + seed), (T₈) ricebean (f) – egyptian clover (f) – sorghum (f), (T₉) maize (cob) – vegetable pea – okra, (T₁₀) soybean – marigold – vegetable cowpea. The row to row spacing was 20 cm for rice, wheat, 30 cm for gram, pea cowpea, lentil, green gram, black gram, sorghum, soybean, ricebean and *Toria*, 60 cm for okra, marigold, maize (cob) and potato, 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, soil organic carbon, Electrical conductivity meter, glass electrode pH meter, N, P and K were estimated by the following methods; Walkley and Black (Jackson, 1973), Alkaline permanganate (Subbiah and Asija, 1956), modified kejldahl (Subbish and Asija, 1956), Olsen *et al.* (1954), and Flame Photometer (Jackson, 1954), respectively.

Results and Discussion

Soil organic carbon, pH and electrical conductivity Results of study reveal that the organic carbon significantly changed due to different cropping sequences during both the years as well as mean data. There it was interested to noted that green gram – chickpea – green gram (7.03 – 7.06 and 7.02 to 7.04 g kg^{-1}) followed by green gram – lentil – black gram recorded significantly higher content of organic carbon during 2018–19 and 2019–20, respectively. These treatments were proved at par to T₇ and T₈ where egyptian clover was included in cropping sequence. The increase of OC in legume component sequence over other sequences and initial values. Due to inclusion of legume crops having relatively higher above ground leaf biomass and below ground root biomass additions. Thus, higher root and shoot biomass additions might also be possible reasons for higher OC in green gram – chickpea – green gram cropping sequence (Dwivedi *et al.*, 2003; Sharma and Sharma, 2004). Further greater rhizo-deposition and shedding of leaves by the leguminous crops, both contributing to an increase in

organic carbon (Thakur and Sharma, 1988). Incorporation of green gram, black gram, egyptian clover stover and roots as well as roots and stubbles of cowpea and winter pulses (Yadav, 1988). Besides this, the cropping sequences having summer green gram, back gram, egyptian clover and veg. cowpea improved the plant growth and ultimately the yield of component crops in the respective sequences. It is quite obvious that this might have added greater biomass and stubble to the soil ultimately improving the soil organic carbon. Study of soil properties with respect to soil pH it was found that green gram – chickpea – green gram cropping sequence bring out the changes in soil pH (7.53 to 7.56) followed by green gram – lentil – black gram (7.54 to 7.52) as compared to other cropping sequence. Green gram – chickpea – green gram cropping soil pH. This decline in soil reaction might be due to organic compounds added to the soil in the form of green as well as dry biomass, which produced more humus and organic acid after decomposition. Similar results also reported by Pattanayak *et al.* (2001), Yaduvanshi *et al.* (2001), Smiciklas *et al.* (2002), Venkatesh (2009) and Upadhyay *et al.* (2011) who observed the decrease in soil pH after the use of organic materials. Due to inclusion of pulses as compared to cereal. Over initial value however the difference among the cropping sequences were found non-significant during both the years. The legume cropping sequence and legume as a component cropping system retain the pH to be neutral side. Under different cropping sequences soil electrical conductivity and pH was non-significant.

Available Nitrogen : Data presented in Table-2 with respect to available N in soil analyzed after harvest of crop during both the years of study showed significant variation due to different cropping sequence. It was noted that the nitrogen content in soil decreased over initial value and subsequent year under cereal – cereal cropping sequence. Further it was also noted that legume – legume cropping sequence serially increased the available nitrogen over initial value and preceding year. The inclusion of legume crop in all the yearly sequence viz. green gram – chickpea – green gram, green gram – lentil – black gram, sorghum – egyptian clover for fodder & seed as well as rice bean – Egyptian clover for fodder – sorghum for fodder only recorded marketable enhancement in available nitrogen over the year. The inclusion of legume crops in a yearly sequence has been reported to increase available soil nitrogen because of beneficial effect of legume crops residues to better nutrient reserves and buffering capacity besides enhancing bio-availability of nitrogen. (Devi and Thakur, 1994; Kumar *et al.* 2001; Gangwar and Ram 2005; Porpavai *et al.*, 2011) because of their nitrogen fixation ability.

Table-1 : Soil pH, EC (dSm⁻¹) and organic carbon (g kg⁻¹) as influenced by different cropping sequences.

Cropping sequences		pH			EC (dSm ⁻¹)			OC (g kg ⁻¹)		
		2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
Initial		7.57			0.50			6.9		
T ₁	Rice – Wheat	7.58	7.59	7.59	0.49	0.48	0.49	6.85	6.79	6.82
T ₂	Rice – Chickpea	7.57	7.57	7.57	0.49	0.48	0.49	6.88	6.85	6.87
T ₃	Greengram – Chickpea – Greengram	7.53	7.5	7.52	0.5	0.45	0.48	6.96	7.01	6.99
T ₄	Greengram – Lentil – Blackgram	7.54	7.52	7.53	0.5	0.47	0.49	6.95	6.99	6.97
T ₅	Rice – Potato – Maize (cob)	7.57	7.58	7.58	0.48	0.46	0.47	6.87	6.83	6.85
T ₆	Rice – <i>Toria</i> (early <i>rabi</i>) Wheat (late <i>rabi</i>)	7.57	7.58	7.58	0.48	0.47	0.48	6.86	6.81	6.84
T ₇	Sorghum (F) – Egyptian clover (F+S)	7.54	7.51	7.53	0.49	0.46	0.48	6.94	6.98	6.96
T ₈	Rice bean (F) – Egyptian clover (F) - Sorghum (F)	7.55	7.54	7.55	0.49	0.47	0.48	6.93	6.98	6.96
T ₉	Maize (cob) – Pea (V) - Okra	7.56	7.55	7.56	0.48	0.47	0.48	6.89	6.88	6.89
T ₁₀	Soybean – Marigold – Cowpea (V)	7.56	7.53	7.55	0.48	0.46	0.47	6.92	6.95	6.94
Sem±		0.01	0.15	0.08	0.024	0.025	0.02	0.03	0.03	0.03
CD (p =0.05)		NS	NS	NS	NS	NS	NS	0.09	0.08	0.09

Table-2 : Available soil nitrogen, phosphorus and potassium as influenced by different cropping sequences.

Cropping sequences		Available Nitrogen (kg ha ⁻¹)			Available Phosphorus (kg ha ⁻¹)			Available Potassium (kg ha ⁻¹)		
		2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
Initial		227			9.4			6.9		
T ₁	Rice – Wheat	225.33	224.33	224.83	9.35	9.29	9.32	302.67	303.00	302.84
T ₂	Rice – Chickpea	226.00	226.00	226.00	9.83	9.90	9.87	303.00	303.67	303.34
T ₃	Greengram – Chickpea – Greengram	230.33	233.00	231.67	10.05	10.12	10.09	304.33	304.67	304.50
T ₄	Greengram – Lentil – Blackgram	229.67	232.33	231.00	10.05	10.11	10.08	304.33	304.33	304.33
T ₅	Rice – Potato – Maize (cob)	226.00	225.00	225.50	9.36	9.30	9.33	302.00	302.67	302.34
T ₆	Rice – <i>Toria</i> (early <i>rabi</i>) Wheat (late <i>rabi</i>)	227.00	224.00	225.50	9.38	9.32	9.35	302.33	303.00	302.67
T ₇	Sorghum (F) – Egyptian clover (F+S)	229.00	229.67	229.34	10.00	10.05	10.03	303.67	304.33	304.00
T ₈	Rice bean (F) – Egyptian clover (F) - Sorghum (F)	229.00	230.67	229.84	10.00	10.06	10.03	304.00	304.33	304.17
T ₉	Maize (cob) – Pea (V) - Okra	227.33	227.67	227.50	9.33	9.43	9.38	303.00	303.67	303.34
T ₁₀	Soybean – Marigold – Cowpea (V)	228.00	229.00	228.50	9.93	9.98	9.96	303.00	304.33	303.67
Sem±		2.40	1.54	1.97	0.12	0.09	0.11	1.36	1.44	1.40
CD (p =0.05)		7.13	4.56	5.85	0.37	0.27	0.32	4.04	4.26	4.15

Furthermore, it was also pointed out that the biomass added by legume crops such as green gram, black gram, lentil, egyptian clover, chickpea, pea and cowpea, was rich in nitrogen, as they accumulate more nitrogen fixed by rhizobia. These observations are in agreement with those of Singh *et al.* (1996) and Chauhan *et al.* (2001).

Available Phosphorus

In general it was observed that all the cropping sequences increased the available phosphorus in soil over initial values except rice–wheat and rice–chickpea cropping sequence. Further it was noted that higher value of P in soil (10.12 kg P ha⁻¹) closely followed by (10.10, 10.06, 10.04 and 9.98 kg P ha⁻¹) was recorded under green gram – chickpea – green gram, green gram – lentil – black gram, rice bean for fodder – egyptian clover for fodder – sorghum for fodder, sorghum for fodder – egyptian clover for fodder + seed and soybean – marigold – vegetable cowpea, respectively. Including of legume crops in a

cropping systems not only economizes nitrogen requirement of cropping systems but also support in efficient utilization of native phosphorus due to secretion of certain acids that help in solubilization of various forms of phosphorus. This ability of legumes utilized the native phosphorus exists in different forms in soil. Increased available P is a result of P acquisition from insoluble phosphates by the action of root exudates. Chickpea crop has an ability to access P, normally not available to other crops, by mobilizing sparingly soluble Ca-P by acidification of rhizosphere through its citric acid root exudates. Ae *et al.* (1991), Saxena (1995), Kumar *et al.* (2001), Singh *et al.* (2004) and Gangwar and Ram (2005). Similar results were also reported by Upadhyay *et al.* (2007) and Kumar *et al.* (2008) who stated that P status marginally improved over initial value in all the legume based sequences. Available potassium Results of study (Table-2) reveal that the post harvest soil of cropping sequence green gram– chickpea – green gram, green gram – lentil –black gram possessed

Table-3 : Soil biological properties as influenced by different cropping sequences.

Cropping sequences		Total bacterial count (105 x cfu g ⁻¹ soil)			Fungi (103 x cfu g ⁻¹ soil)			Actinomycetes (103 x cfu g ⁻¹ soil)		
		2018-19	2019-20	Mean	2018-19	2019-20	Mean	2018-19	2019-20	Mean
Initial		39.36			27.67			6.37		
T ₁	Rice – Wheat	41.51	41.74	41.63	26.2	25.95	26.08	6.53	6.27	6.40
T ₂	Rice – Chickpea	41.67	42.17	41.92	27.3	27.38	27.34	6.77	6.44	6.61
T ₃	Greengram – Chickpea – Greengram	45.57	46.49	46.03	31	31.42	31.21	7.63	7.72	7.68
T ₄	Greengram – Lentil – Blackgram	45.47	46.46	45.97	30.51	30.63	30.57	7.45	7.53	7.49
T ₅	Rice – Potato – Maize (cob)	42.26	42.52	42.39	26.48	26.28	26.38	6.62	6.02	6.32
T ₆	Rice – <i>Toria</i> (early <i>rabi</i>) Wheat (late <i>rabi</i>)	41.66	41.92	41.79	26.67	26.5	26.59	6.91	6.38	6.65
T ₇	Sorghum (F) – Egyptian clover (F+S)	45.58	46.2	45.89	30.74	30.82	30.78	7.10	7.24	7.17
T ₈	Rice bean (F) – Egyptian clover (F) - Sorghum (F)	43.49	43.75	43.62	29.92	30.03	29.98	7.32	7.43	7.38
T ₉	Maize (cob) – Pea (V) - Okra	43.43	43.68	43.56	29.13	29.19	29.16	7.17	7.09	7.13
T ₁₀	Soybean – Marigold – Cowpea (V)	44.64	45.06	44.85	29.73	29.9	29.82	6.69	6.9	6.80
Sem ±		0.14	0.2	0.17	2.43	2.55	2.49	1.72	1.89	1.81
CD (p =0.05)		0.4	0.61	0.51	NS	NS	NS	NS	NS	NS

the higher available K (303.33 kg ha⁻¹) closely followed by sorghum (F) – egyptian clover for fodder & seed (304 kg ha⁻¹) during first year and (305.67, 305.33 and 305.33 kg ha⁻¹) under same treatment during subsequent year. The higher content of available K in green gram – chickpea – green gram cropping sequence over the initial values K. Might be due to legumes crops releases organic colloids having higher cation exchange capacity to attract K from applied K and changed non-labile pool into exchangeable pool which favours available K status in soil. (Lund and Doss, 1980). The findings are in accordance with the findings of Singh *et al.* (1995), Kumar *et al.* (2001), Gangwar and Ram (2005) and Upadhyay *et al.* (2011).

Soil Biological Properties : Study of soil biological properties with respect to total bacterial count, fungi and actinomycetes are presented in Table-3. It was found that the green gram – chickpea – green gram cropping sequence possessed higher number of total bacterial counts (45.57 and 46.49 105 x cfu g⁻¹ soil), fungi (31.00 and 31.42 10³ x cfu g⁻¹ soil) and actinomycetes (7.63 and 7.72 10³ x cfu g⁻¹ soil) followed by green gram – lentil – black gram (45.47 to 46.46 105 x cfu g⁻¹ soil), (30.51 and 30.63 10³ x cfu g⁻¹ soil) and (7.45 and 7.53 10³ x cfu g⁻¹ soil). The total bacterial population was increased in different legume cropping sequences and highest proliferation was observed under green gram – chickpea – green gram cropping sequence. Improvement in microbial counts of soil under legume based cropping sequence has been reported by Singh *et al.* (2001), Nath *et al.* (2011) and Davari *et al.* (2011). They reported indicate that inclusion of pulses in cropping sequences hence the soil microbial biomass and their activities that could be vital for long-term soil health and productivity. Tilak, (2004) also reported that higher counts of bacteria due to growing of green gram after rice.

Conclusions

On the basis of present study it can be concluded that among different cropping sequence maximum total carbon stock soil organic carbon, available NPK, total bacteria, fungi and action-mycetes under green gram–chickpea– green gram. This cropping sequence soil health improvement under present scenario of existing cropping sequence.

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Different Plantlets Production through Tissue Culture of Ishwarmul (*Aristolochia indica* Linn)

Anju Nehra¹, D.K. Shrivastava² and Girraj Kirar¹

¹Department of Plant Breeding and Genetics, College of Agriculture (RVSKVV), Indore, M.P.

²Department of Plant Breeding and Genetics, College of Agriculture (RVSKVV), Khandwa, M.P.

Abstract

The *Aristolochia indica* is a rare and endangered medicinal plant and also known as Snakeroot or Ishwarmul in Aurveda. It is famous in Indian System of Medicine as an antidote in bites of poisonous insects particularly the snake bite. It is also used in treatment of intestinal parasite, swelling, menstrual irregularities, white leprosy, dropsy, low appetite, ulcers and fever. For *In Vitro* regeneration of *Aristolochia indica*, seven media were tested out of which five based on Murashige and Skoog's medium (MS), one on Gamborg's B5 and one on White's media for their response on induction of callus from Stem segment, Leaf base and Cotyledons. Media based on MS responded well irrespective of explants used. Leaf base proved to be the best for callusing percent and fresh weight of callus in MS based media. The highest callusing efficiency was observed in MS medium with full strength of MS salts, 5mg/l 2, 4-D + 1.6mg/l BAP. Observation on shoot regeneration capacity suggested that MS medium contained MS salt +5mg/l 2,4-D+1.6 BAP has shown superior performance and was highly effective in inducing multiple shoots from callus. The MS medium with half strength of basic MS salts in combination with 1.2mg/l BAP/ 0.6 mg/l IBA was also found to be the best for root regeneration. The Darkness supports the fast root regeneration in *Aristolochia indica*. The rooted plantlets were successfully transplanted in pots in poly house, after 25 days these plants with pots were transferred in to green house for further acclimatization under natural environments. The survival rate was 63%.

Key words : callusing induction, explants, ishwarmul, *Aristolochia indica*.

Introduction

Aristolochia indica Linn. a divine herb which can fight against any poisonous bite. Indian Birthwort, Snakeroot, Ishwarmul, Iswarballi are the common names of *Aristolochia Indica*. It is a native of India and belong to family Aristolochiaceae. *Aristolochia indica* is distributed throughout the tropical, subtropical and Mediterranean countries. In India it is found in all most all types of forest throughout the country particularly in low hills and moist plains but due to indiscriminate harvesting from forest now it became arare endangered species. It is a twining herb, semiwoody, leaves are cordate or ovate, exstipulate; flowers are irregular, often offensively smelling, perianth is globose with a purple dilated and trumpet-shaped mouth with a strap-shaped brown purple appendage or lip behind; fruit is a subglobose capsule. It is used in India to induce vomiting and to treat poisons, intestinal parasite, swelling, menstrual irregularities, dropsy, low appetite, ulcers and fever (Dey (2011)) [3]. The roots of plant are used as antidote in scorpion sting, bites of poisonous insects and snake bite. This plant is used both internally and externally. For white leprosy, the roots are rubbed with honey. The plant possesses emmenagogue, abortifacient, anti-spermatogenic, anti-fertility, anti-arthritic, anti-inflammatory, antiperiodic, diuretic and anti-bilious properties. The leaves of plant are applied

externally in skin diseases. Though the plant is helpful in many ways, it has to be remembered that it is nephrotoxic and carcinogenic. Over dosage of the plant components may be lead to serious complications. The propagation of *Aristolochia indicais* done mainly through the seeds. Its seeds have poor germination and need specific care to grow, hence an effort has been made in this investigation to draw a protocol for In-Vitro plantlets of *Aristolochia indica*.

Materials and Methods

The research experiment was carried out at Tissue Culture Laboratory, College of Agriculture, Indore, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during the year 2015-2016. The experiment was conducted in Completely Randomized Design (CRD) with five replications for each explant under each medium. Explants viz. Stem segment, Leaf base and Cotyledons were collected from pretreated mother plants of *Aristolochia indica* available in Medicinal plant nursery of College of Agriculture Indore. Seven combination and concentration of hormones with full strength basic salts and vitamins of MS, B5 and White's media were used to test the response of different explants for organogenesis, shoot regeneration and root regeneration capacity. Aseptic environment were maintained during the investigation period. Observations were recorded on

Table-1 : Stock solution of culture media.

Components	Quantity used (mg/l)			Remarks
	MS-Medium	B5-Medium	White's-Medium	
Macronutrients				
NaH ₂ PO ₄ .H ₂ O	—	1500	—	Dissolved in one litre double distilled water and 100ml per litre culture medium was used.
KH ₂ PO ₄	1700	—	—	
NaH ₂ PO ₄ .4H ₂ O	—	—	190	
MgSO ₄ .7H ₂ O	3700	2500	7370	
KNO ₃	19000	25000	800	
NH ₄ NO ₃	16500	—	—	
CaCl ₂ .2H ₂ O	4400	1500	—	
(NH ₄) ₂ .SO ₄	—	1340	—	
Ca(NO ₃) ₂ .4H ₂ O	—	—	2880	
KCl	—	—	650	
Na ₂ SO ₄	—	—	2000	
Micronutrients				
H ₃ BO ₃	620	300	150	Dissolved in 100ml double distilled water and used1ml/l culture medium.
MnSO ₄ .4H ₂ O	2230	1000	670	
ZnSO ₄ .7H ₂ O	860	200	220	
Na ₂ MoO ₄ .2H ₂ O	25	25	—	
CuSO ₄ .5H ₂ O	2.5	2.5	2.5	
CoCl ₂ .6H ₂ O	2.5	2.5	2.5	
KI	83	75	75	
FeSO ₄ .7H ₂ O	1112	1112	—	Dissolved in 200ml double distilled water and used 5ml/litre culture medium
Na ₂ EDTA.2H ₂ O	1492	1492	—	
Sucrose	30	30	20	
Vitamins				
Glycine	200	—	300	Dissolved in 100ml double distilled water and used 1ml/litre culture medium
Thiamine HCl	10	1000	10	
Pyrodoxine HCl	50	100	10	
Nicotinic acid	50	100	50	
Inositol	100	100	100	
pH	5.8	5.5	5.5	

various explants viz., Cotyledons, Stem segment and leaf base for induction of callus, regeneration on different culture media, callusing percentage, weight of callus and regeneration capacity of callus into shoots and roots.

Results and Discussion

All the media under investigation responded for callusing percentage and fresh weight of callus irrespective of explants used, except B5 and White's media. All the three explants viz. Stem segment, Leaf base and Cotyledons showed their highest level of callusing percent and fresh weight of callus on M3 medium. On the basis of callusing efficiency M3 media was the best medium among all the media tested in the present investigation. The M3 media was supported with full strength of MS salts, 5mg/l 2,4-D + 1.6mg/l BAP. Several scientist were also reported the presence of 2,4-D alone or with other hormones in MS basal media will enhance the callusing efficiency viz.

Sahaya *et al.* (2011) observed that the highest percentage of callus induction (82.3 ± 0.57) from internodal segment on Murashige and Skoog's medium (MS) supplemented with 1.5mg/l of 2,4-D in *Aristolochia bracteata*. Wani *et al.* (2010) in his study on *Tridax procumbens* revealed that the Leaf and apical bud explants showed maximum callus induction by using MS media with the combination of 2, 4-D 0.5mg/lit and BAP 0.5mg/lit. The work of Soniya (2006) and Wani *et al.* (2010) is indirectly in support of the present study and suggested that the combination of 2, 4-D and BAP in different concentration may enhance the callusing efficiency of medium. In present investigation three explants viz. Cotyledons, stem segment and leaf base were evaluated for their effectiveness for induction of callus on different media. The leaf base was proved as the best explants on the basis of callusing percentage and averaged fresh weight of callus. Least effective explants was cotyledon. The evaluation of media for shoot

Table-2 : Different media used in experiment. Media Protocol.

Media	Combinations and concentrations of hormones (mg/l)
M ₁	MS salts +5mg/l 2,4-D
M ₂	MS salts + 5mg/l 2,4-D + 0.5 mg/l Kinetin
M ₃	MS salts + 5mg/l 2,4-D + 1.6mg/l BAP
M ₄	MS salts + 1.5mg/l BAP+1mg/l IBA
M ₅	MS salts + 1.5mg/l kinetin+1mg/l NAA
B ₅	B5 Salts +1mg/l IBA1.5mg/l kinetin
White's	White's salts + 2.5mg/l IBA + 1.5mg/l BAP

Table-3 : Callusing percentage of different explants on different media.

Media	Cotyledon	Stem segment	Leaf base	Mean
M ₁	11.80	18.00	21.80	17.2
M ₂	15.00	22.40	47.40	28.36
M ₃	31.60	43.20	71.60	48.8
M ₄	25.40	33.20	66.40	42.26
M ₅	17.80	28.80	55.40	34
B ₅	6.40	8.20	9.00	7.86
White's	8.80	12.40	16.40	12.53
Mean	16.68	23.74	41.14	

Table-4 : Average fresh callus weight (mg) of different explants on different media.

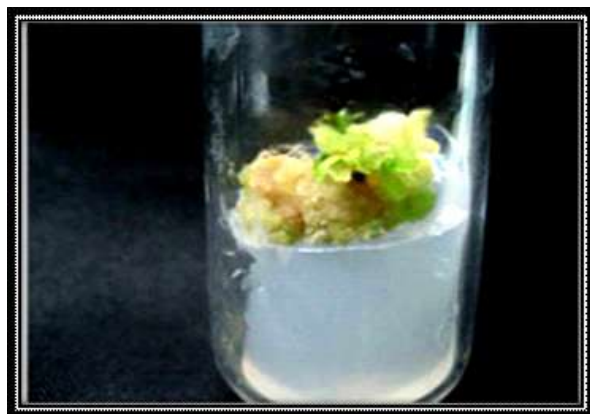
Media	Cotyledon	Stem segment	Leaf base	Mean
M ₁	155.20	117.00	299.40	190.53
M ₂	214.60	169.80	487.20	290.53
M ₃	406.00	340.60	910.60	552.4
M ₄	335.00	274.60	789.80	466.46
M ₅	269.40	226.60	645.20	330.4
B ₅	44.40	47.60	68.00	53.33
White's	85.40	72.80	126.00	94.73
Mean	215.7	178.42	475.17	

regeneration capacity suggested that medium M₃ contained MS salt +5mg/l 2,4-D+1.6 BAP has shown superior performance and was highly effective in inducing multiple shoots from callus. The efficiency of M₃ medium may be due to the presence of high concentration of 2, 4-D and BAP. The efficacy of 2,4-D and BAP in combination or alone in MS media for induction of shoot has already been reported by number of scientists. Siddiqui *et al.* (2006) in their two different studies on *Aristolochia indica* suggested that the highest percentage of shoot regeneration was obtained in MS medium fortified with 2.5mg/l Kn + 1.0mg/l BAP and 1.0 mg L-1 BAP + 2.5 mg L-1 NAA respectively. Biswas *et al.* (2007)^[1] and Sahaya *et al.* (2011) also suggested that combination of BAP and NAA in MS media enhance the shoot multiplication and proliferation in callus derived from nodal and inter-nodal segment. The MS medium with half strength of basic MS salts in combination with 1.2mg/l BAP/ 0.6 mg/l IBA was also found to be the best for root regeneration. The Darkness supports the fast root regeneration in *Aristolochia indica*. The rooted plantlets were successfully transplanted in pots in poly house, after 25 days these plants with pots were transferred in to green house for further acclimatization under natural

environments. The survival rate was 63%. Biswas *et al.* (2007)^[1] and Chandraprabha *et al.* (2010) reported in *Aristolochia tagala* Champ that excised shoot roots were cultured on half- strength MS medium containing 0.5 mg/l and 1.0 mg/l IBA respectively. While Remya *et al.* (2016)^[4] in the same plant observed that well developed shoots were rooted on MS medium supplemented with indole acetic acid (1.5 µM), Kinetin (1.5 µM) and 6-benzylaminopurine (0.5 µM). Sahaya *et al.* (2011) reported in *Aristolochia bracteata* Retz that highest percentage, maximum number of rootlets/shoot let and mean length of rootlets were observed in ½ Murashige and Skoog's medium supplemented with 1.0 mg/L of IBA. Sixty eight percentages of plantlets were established in the earthen pots.

Conclusions

Aristolochia indica is an important medicinal plant and it can be multiplied by in Vitro culture. Among Murashige and Skoog (MS), Gamborg's B5 and White's media only MS media were responded for callusing percentage and fresh weight of callus. Among the MS media, the callusing efficiency of media(M₃) which supported with full strength of MS salts, 5mg/l 2,4-D + 1.6mg/l BAP was the highest.



Callus Growth



Shoot Induction

The callusing percent and fresh weight of callus of all the three explants i.e. Stem segment, Leaf base and

Cotyledons were high on M3 medium. The shoot regeneration capacity of MS media M3 was proved to be the best irrespective of explants used but the highest number of shoots were induced through the leaf base.

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Irrigation Scheduling with Mulch under Drip Irrigation on Yield and Water Use Efficiency of Marigold

J.S. Shekhawat, R.K. Narolia and P.K. Yadav

College of Agriculture, Swami Keshwanand Rajasthan Agriculture University, Bikaner, Rajasthan

Email : singh.jeet04@gmail.com

Abstract

The field experiment was conducted for consecutive two seasons during *rabi* 2017-18 and 2018-19 at Instructional Farm, College of Agriculture, SK Rajasthan Agriculture University, Bikaner (Rajasthan) to study the effect levels and methods of irrigation on yield and water use efficiency of marigold (*Tagetes erecta* L.). The experimental layout was carried out in randomized block design with four replications and treatments included three irrigation levels and three irrigation methods. Irrigation was given based on pan evaporation values following alternate day irrigation schedule for drip irrigation while, surface irrigation was given according to the locally adopted frequency. Results showed that IW/CPE ratio 1.0 recorded significantly higher flower yield (145.4 and 140.2 q ha⁻¹) in 2017-18 and 2018-19, respectively. Maximum water use (721.73 and 606.43 mm) was observed with same irrigation treatment in 2017-18 and 2018-19, respectively. Although high water use efficiency (WUE) of 25.91 and 27.37 kg ha⁻¹mm⁻¹ was observed at IW/CPE ratio 0.6 in 2017-18 and 2018-19, respectively. Under different irrigation methods, maximum flower yield (150.6 and 144.6 q ha⁻¹) and high WUE (26.43 and 29.31 kg ha⁻¹mm⁻¹) was recorded under drip irrigation treatment in 2017-18 and 2018-19 respectively.

Key words : Marigold, Irrigation Level, WUE, Yield.

Introduction

The quantitative demand of marigold is the highest, particularly in South and in Northeast India. Marigold is a seasonal flower and can be grown round the year. Marigold probably ranks next only to jasmine in India. Marigold (*Tagetes erecta* L.) is an annual plant, erect and fast-growing with dark green, glossy and aromatic leaves which have deep recesses, grows up-to one meter and above, bears single or fully double large sized globular heads of yellow, orange and white shades. It belongs to the family of *Asteraceae*. It occupies an important place among loose flowers. It has nearly two third of total loose flower growing area in India. (Anonymous, 2018).

In India, flowers cover an area of 339 thousand ha with a total production of 1991 thousand tons (Loose flowers). Tamil Nadu is leading loose flower producing state followed by Karnataka, Andhra Pradesh etc. In Rajasthan, it covers an area of 4.0 thousand ha and the total production is 7.5 thousand tons (Loose flowers) only (Anonymous, 2018). Marigold is contributing its highest portion as loose flower in Rajasthan.

Irrigation improves the water regime of soil creating favorable conditions for growing plants. Frequent oscillations of weather conditions in the region, first of all the amount and distribution of precipitation, are the reason why irrigation is needed in crop production. Water is becoming an increasingly scarce resource in many

areas of the world, especially in arid and semi-arid regions (Bosma *et al.*, 2003). Proper irrigation scheduling results in increasing water use efficiency (WUE) and yield of crop. WUE relates to how much yield is obtained per unit of applied water. Scheduling of water application is very critical, as excessive irrigations reduce yield, while inadequate irrigation also causes water stress (Sujatha and Shanmuga, 2017). Drip irrigation is very important and efficient method of irrigation when compare to other conventional method of irrigation. Drip irrigation method plays very important role as it uses less water and gives more yield due to precise and direct application of water in root zone as per crop water requirement. A considerably saving in irrigation water, increased growth and development and yield under drip irrigation has been reported by Imtiyaz *et al.*, 2000 and Rajbir Singh *et al.*, 2009.

Materials and Methods

The field experiment to study the effect of irrigation levels and methods on marigold was conducted for two consecutive years of *rabi* 2017-18 and 2018-19 at College of agriculture farm, SK Rajasthan Agriculture University, Bikaner (Rajasthan) on light textured soil. The experimental layout was carried out in Split plot design and replicated four times. Thirty five days old seedlings of marigold var. *Pusa Narangi Genda* were transplanted on 12th December, 2017 and 23rd November, 2018 at row spacing of 50 cm using seed rate 1-1.5 kg ha⁻¹ (nursery).

Table-1 : Effect of different irrigation levels and mulch on yield and water use efficiency of marigold.

Treatment	Flower Yield (q/ha)		Water use (mm)		WUE (kg ha ⁻¹ mm ⁻¹)	
Irrigation levels	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
60% ETc	106.18	102.89	160.32	265.6	66.23	38.74
80% ETc	154.85	150.91	212.69	341.77	72.81	44.15
100% ETc	162.82	158.64	265.06	417.94	61.43	37.96
SEm +	1.61	1.48				
CD at 5%	5.57	5.13				
Mulch						
No mulch	129.77	126.28	212.69	341.77	61.01	36.95
Straw mulch	134.72	131.63	212.69	341.77	63.34	38.51
Polythene mulch	159.37	154.53	212.69	341.77	74.93	45.22
SEm +	3.52	3.40				
CD at 5%	10.47	10.11				

Table-2 : Interaction effect of different irrigation levels and mulching on flower yield (q/ha) of marigold.

Mulch	Irrigation levels					
	60% ETc		80% Etc		100% ETc	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
No mulch	82.52	79.57	147.97	144.3	158.80	154.97
Straw mulch	90.55	87.27	152.02	148.25	161.57	159.35
Polythene mulch	145.47	141.82	164.55	160.17	168.07	161.60
SEm +	6.10	5.89	6.10	5.89	6.10	5.89
CD at 5%	18.13	17.50	18.13	17.50	18.13	17.50

FYM @ 25 q/ha was applied to the experimental area during field preparation. The recommended fertilizers i.e., N (200 kg ha⁻¹), P₂O₅ (100 kg ha⁻¹) and K₂O (100 kg ha⁻¹) was applied to raise crop. Treatments included Irrigation level (Main plot) I₁ –60% Etc, I₂ –80% Etc, I₃ –100% ETc Mulch (Sub-plot) M₁ – No mulch, M₂ – Straw mulch, M₃ – Polythene mulch

Three irrigation levels (main treatments) viz.; IW/CPE ratio 0.6 (M₁), IW/CPE ratio 0.8 (M₂), IW/CPE 1.0 ratio (M₃) and three irrigation methods (sub treatments) viz; Check basin method (I₁), Furrow method (I₂), Drip irrigation method (I₃). The weather condition was dry and rainfall during period of experimentation during crop growing period was 6.6 mm and 37.1 mm in 2017-18 and 2018-19, respectively. Total pan evaporation during crop growing period was 731.09 mm and 656.1 mm of 2017-18 and 2018-19, respectively.

Results and Discussion

Increase in drip irrigation level from 60 to 100% ETc increased flower yield. Drip Irrigation levels of 100% ETc significantly recorded maximum flower yield (162.82 and 158.64 q ha⁻¹) over 60% ETc. Data presented in table 3.2 showed that highest (265.06 and 417.94 mm) and lowest

(160.32 mm) “water use” was recorded at drip irrigation level 100 % ETc and 60% ETc, respectively. Highest WUE (72.81 and 44.15 kg ha⁻¹mm⁻¹) was recorded with drip irrigated crop at 80% ETc and lowest with 100% ETc (61.43 kg ha⁻¹ mm⁻¹). Similar results were also obtained by Ayyanna *et al.* (2014). Results were similar to Sujatha and Shanmuga, (2017).

Mulch had a significant influence on flower yield and maximum was recorded under polythene mulch (159.37 and 154.53 qha⁻¹) followed by straw mulch (134.72 q ha⁻¹ and 129.77 q ha⁻¹). Mulch had a significant influence on WUE. Maximum WUE (74.93 and 45.22 kg ha⁻¹ mm⁻¹) was recorded with polythene mulch followed by straw mulch and no mulch treatment. Minimum WUE (61.01 kg ha⁻¹ mm⁻¹) was recorded under no mulch.

Interaction of irrigation levels and mulch was found significant. 100% ETc along with polythene mulch gave highest flower yield of 168.07 and 161.60 q ha⁻¹. However, at 80% ETc with straw and polythene mulch gave at per yield and at 100% ETc all mulches gave at par yield.

Conclusion

Marigold can be grown successfully at irrigation level of 80% ETc along with straw or polythene mulch.

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Yield and Quality Characteristics of Kinnow Fruits in Irrigated Area of Sri Ganagnagar District of Rajasthan

J.S. Shekhawat, I.M. Verma, R.K. Narolia and Atma Ram Meena

Department of Horticulture, College of Agriculture Bikaner, SKRAU, Bikaner, Rajasthan

Email : singh.jeet04@gmail.com

Abstract

An experiment entitled "Yield and quality characteristics of kinnow fruits in irrigated area of Rajasthan" was conducted at Sriganganagar district of Rajasthan during April, 2016 to April, 2017. There were ninety soil samples with three depths (0-30, 30-60 and 60-90 cm) were collected from thirty kinnow orchards. One composite leaf sample from four plants each at kinnow orchards were collected from 3rd pair of leaf apex during April, 2016 at the time of soil sampling. Fruit samples were collected during December, 2016 to January, 2017. The soil, leaf and fruit samples were analyzed for nutritional status of kinnow orchards being grown at farmers field. The fruit yield, quality and nutrient status of kinnow fruits were found superior in village Pussewala of Sriganganagar tehsil orchards (L₂₅, L₂₆, L₂₇, L₂₈, L₂₉ and L₃₀). The fruit quality parameters were significantly influenced by the status of nutrients in kinnow leaves. The studied area signifying the prominent role of leaf nutrition in determining the fruit quality at a given soil fertility level.

Key words : Fruit, kinnow, nutritional, orchard, quality.

Introduction

Fruit cultivation in India is spread over an area of 6.8 million hectares with 92.84 MT fruit production (NHB 2016-17). India has large arid zones covering an area of 317090 square kilometer mainly located in the North-West parts of the country. Rajasthan alone covers 62 per cent area under arid zone. The importance of fruits in providing nutrition, particularly vitamins and minerals in human diet is well know but the people of arid areas are known to suffer from a number of nutritional disorders owing to lower intake of protective foods like fruits and vegetables. It is worth to mention that fruit yield and quality are important for getting reasonable price of fruits in the market. Kinnow fruit trees, like other plants, need different nutrients in varying quantities to achieve optimum growth and fruiting. Ordinarily, the elements which need constant replenishment are mainly nitrogen (N), phosphorus (P) and potassium (K), as these are used up in considerable quantities by crops. Kinnow trees do much better in good nutrition and controlled nutrient supply during different seasons and can produce higher yield. However, nutrient imbalances or deficiencies have been identified in citrus orchards in recent years due to poor soil fertility and long-term imbalances caused by fertilization (Huang *et al.*, 2009; Wen *et al.*, 2012; Yu *et al.*, 2007). Leaf nutrient analysis is widely used as an effective method of fruit tree nutrient diagnosis and fertilizer calculation.

A number of nutritional survey have been conducted on various fruit crops in northern and western states of the

country (viz. Punjab, Haryana, Himachal Pradesh and Maharashtra) to study fertility status of soil and nutrient status of leaves in fruit crops (Chauhan and Patil, 1980 in ber, Yamadgani *et al.*, 1983 in kinnow, Singh *et al.* 1997 in ber). A number of nutritional survey have been conducted on ber, kinnow and aonla fruit crops in Rajasthan to study the fertility status of soil, nutrient status in leaves and physico-chemical characteristics of fruit crops (Bhatnagar, 2000; Kumar 2004 and Rohitash 2007) but studies on nutritional survey of kinnow in irrigated area of arid region of Rajasthan are meager inspite of their importance and relevance. However, citrus leaf nutrient diagnosis is insufficiently accurate for certain microelements, such as Fe (Abadía *et al.*, 2002). Further, the recommended sampling period for citrus leaf analysis is August and September (Manivannan and Chadha, 2011), which is the stage of rapid fruit expansion. With the changing market scenario it is essential to produce quality fruit for getting reasonable and fair prices of fruits in the market. Quality fruit production is also important for producing export oriented fruits which will help in earning valuable foreign exchange. Keeping in view of above mentioned facts, there is need to survey of orchards for determining nutrient status in soil and plants so that corrective measures can be undertaken accordingly.

Materials and Methods

An experiment entitled "Yield and quality characteristics of kinnow fruits in irrigated area of Rajasthan" was conducted at Sriganganagar district of Rajasthan during April, 2016 to April, 2017. Kinnow orchards under study

Table-1 : Yield and quality parameters of kinnow fruit juice in orchards of Sriganganagar district.

Samples	Fruit yield (kg plant ⁻¹)	Fruit volume (cc)	TSS (°B)	Ascorbic acid (mg 100 ⁻¹ ml)	Total acidity (%)	Total sugar (%)	Reducing sugar (%)
L ₁	53.46	139.95	14.85	26.26	1.15	8.58	5.17
L ₂	49.78	133.26	14.57	25.47	1.11	8.85	5.33
L ₃	44.25	122.58	15.68	25.86	1.13	8.72	5.25
L ₄	55.26	141.24	14.71	28.64	1.26	7.87	4.73
L ₅	60.14	153.49	15.45	27.98	1.23	8.05	4.85
L ₆	59.90	143.42	15.04	26.79	1.17	8.41	5.07
L ₇	51.97	129.41	14.00	30.95	2.26	10.12	5.71
L ₈	52.66	131.87	13.96	30.82	2.26	10.39	5.87
L ₉	51.33	144.12	13.68	30.03	2.22	10.26	5.79
L ₁₀	54.55	133.63	13.82	30.42	2.24	9.41	5.27
L ₁₁	58.96	124.25	14.79	33.2	2.37	9.59	5.39
L ₁₂	54.48	130.87	14.56	32.54	2.34	9.95	5.61
L ₁₃	49.37	141.58	11.52	31.83	2.37	10.57	5.86
L ₁₄	50.21	143.25	11.47	31.04	2.33	10.84	6.02
L ₁₅	51.19	144.23	11.19	31.44	2.35	10.71	5.94
L ₁₆	51.98	151.19	11.33	34.21	2.48	9.86	5.42
L ₁₇	55.42	154.37	12.30	33.55	2.45	10.04	5.54
L ₁₈	54.39	153.53	12.07	32.36	2.40	10.40	5.76
L ₁₉	51.25	129.35	12.75	29.06	1.83	9.75	5.48
L ₂₀	52.32	131.29	12.71	28.93	1.83	9.79	5.65
L ₂₁	54.65	135.41	12.43	28.14	1.79	10.06	5.57
L ₂₂	54.92	138.21	12.57	28.53	1.81	9.93	5.05
L ₂₃	53.11	154.11	13.54	31.31	1.94	9.08	5.16
L ₂₄	52.45	147.56	13.31	30.65	1.91	9.26	5.38
L ₂₅	66.35	172.28	8.68	28.89	2.15	9.99	5.61
L ₂₆	61.23	163.36	8.96	29.28	2.15	10.04	5.77
L ₂₇	59.54	165.18	8.82	32.06	2.11	10.31	5.69
L ₂₈	62.44	171.47	9.79	31.4	2.13	10.17	5.17
L ₂₉	58.90	132.58	9.56	30.21	2.26	9.32	5.29
L ₃₀	63.94	139.75	9.15	32.99	2.23	9.51	5.5
Minimum	44.25	122.58	8.68	25.47	1.11	7.87	4.73
Maximum	66.35	172.28	15.68	34.21	2.48	10.84	6.02
Average	55.01	143.23	12.58	30.16	1.98	9.66	5.46
C.V.	8.86	9.24	16.96	7.66	22.80	7.97	5.89

are located in different villages/chaks of Sriganganagar district comprising a part of Agro climate zone I b (Irrigated north-western plain) of Rajasthan. It is situated between 28°4¹ to 30°6¹ north latitude and 72°31¹ to 75° east longitude. It is surrounded by Firozpur district of Punjab in north. Hanumangarh district in east; Bikaner district in south and the international border of the Pakistan in north and north-west. The soils have developed from alluvial deposit of river Gaggar in the of flood plains of Sriganganagar district and are yellowish brown to light grey, well drained medium soil texture which varies from sandy loam to loam. In the upper layer in some pockets is

calcareous but the lower horizons are calcareous in nature with accumulation of concentrations. A composite fully matured fruit samples were taken from four trees in each orchard and packed in a plastic bag with sample label. Fruit samples for kinnow were collected during the month of December, 2016 to January, 2017 for studying the physical and chemical characteristics of kinnow fruits.

Results and Discussion

Physical characteristics of kinnow fruits : The fruit yield per plant of kinnow varied from 44.25 to 66.35 kg per plant with the mean value of 55.01 kg per plant. The

Table-2 : Nutrient content of kinnow fruit juice (ppm) in orchards of Sriganaganagar district.

Samples	N	P	K	Fe	Mn	Cu	Zn
L ₁	1312.51	195.61	1715.41	0.23	0.22	0.36	0.12
L ₂	1412.32	204.41	1889.62	0.15	0.21	0.35	0.12
L ₃	1716.60	214.72	1758.53	0.11	0.23	0.38	0.12
L ₄	1447.43	226.53	1914.55	0.18	0.32	0.30	0.12
L ₅	1401.41	250.80	1853.50	0.14	0.31	0.39	0.11
L ₆	1489.80	249.81	1794.51	0.16	0.31	0.41	0.11
L ₇	1312.51	191.40	1748.02	0.12	0.30	0.41	0.12
L ₈	1395.62	203.31	1776.51	0.08	0.32	0.45	0.12
L ₉	1412.41	209.82	1722.11	0.18	0.31	0.40	0.12
L ₁₀	1358.90	226.51	1704.40	0.13	0.30	0.39	0.12
L ₁₁	1542.65	237.53	1739.75	0.16	0.21	0.44	0.11
L ₁₂	1440.81	214.55	1786.31	0.14	0.32	0.50	0.11
L ₁₃	1332.93	212.52	1804.53	0.21	0.33	0.54	0.13
L ₁₄	1384.65	219.81	1824.42	0.26	0.40	0.59	0.15
L ₁₅	1407.51	220.80	1837.35	0.24	0.41	0.49	0.13
L ₁₆	1375.40	226.51	1889.40	0.25	0.42	0.45	0.15
L ₁₇	1411.81	224.42	1865.42	0.19	0.51	0.52	0.14
L ₁₈	1368.72	237.43	1814.61	0.30	0.60	0.53	0.13
L ₁₉	1523.61	234.50	1914.53	0.23	0.22	0.41	0.11
L ₂₀	1547.71	247.55	2000.80	0.19	0.22	0.32	0.12
L ₂₁	1603.62	250.31	1956.51	0.10	0.21	0.37	0.13
L ₂₂	1716.40	229.80	1963.50	0.12	0.22	0.45	0.13
L ₂₃	1584.82	226.91	1925.42	0.24	0.31	0.36	0.11
L ₂₄	1559.81	239.72	1888.91	0.25	0.31	0.31	0.12
L ₂₅	1292.30	184.60	1764.21	0.19	0.22	0.31	0.11
L ₂₆	1548.51	214.21	1802.71	0.35	0.32	0.36	0.12
L ₂₇	1386.52	193.53	1773.55	0.09	0.41	0.28	0.14
L ₂₈	1445.42	204.42	1823.91	0.23	0.31	0.24	0.14
L ₂₉	1492.01	227.41	1884.42	0.27	0.10	0.27	0.16
L ₃₀	1389.82	209.80	1872.91	0.18	0.40	0.29	0.13
Minimum	1292.30	184.60	1704.40	0.08	0.10	0.24	0.11
Maximum	1716.40	250.80	1963.50	0.35	0.60	0.59	0.16
Average	1453.82	220.98	1833.68	0.19	0.31	0.40	0.13
C.V.	7.58	8.20	4.28	34.75	32.57	22.23	10.66

minimum fruit yield per plant was obtained at orchard L₃, while maximum fruit yield per plant was recorded at the orchard L₂₅. The present result are also in agreement with those of Monga and Joshan (2000), Ashraf *et al.* (2013), Razzaq *et al.* (2013), Bhatnager and Singh (2014), Garhwal *et al.* (2014) and Khan (2015). The mean value of fruit volume of kinnow fruit samples computed was 143.23 cubiccentimeter. The minimum value of 122.58 cubic centimeter of fruit volume was observed at the orchard L₃, whereas maximum value of 172.28 cubic centimeter in fruit volume was observed at the orchard L₂₅. The TSS content of kinnow fruit juice varied from 8.68 to 15.68 brix with the mean value of 12.58 brix. The minimum TSS content (8.68 ?B) was obtained at orchard L₂₅, while maximum TSS content (15.68 ?B) was recorded at the

orchard L₃. The data showed that ascorbic acid content of kinnow fruit pulp varied from 25.47 to 34.21 mg 100⁻¹ ml pulp with mean value of 30.16 mg 100⁻¹ ml pulp. Razzaq *et al.* (2013), Bhatnager and Singh (2014) and Garhwal *et al.* (2014) also recorded similar type of results. A close study of data showed that titrable acidity of kinnow juice varied from 1.11 to 2.48 per cent. The present result are in confirmation with Din *et al.* (2012), Bhatnager and Singh (2014) and Garhwal *et al.* (2014). The total sugar of kinnow juice varied from 7.87 to 10.84 per cent. The present findings get partially support from the finding of Garhwal *et al.* (2014). The reducing sugar of kinnow juice varied from 4.73 to 6.02 percent. Similar type of result also obtained by Kazi *et al.* (2012), Garhwal *et al.* (2014) and Khan (2015).

Table-3 : Correlation between leaf nutrients concentration and fruit quality of kinnow.

Leaf nutrients	Fruit quality parameters						
	Fruit yield (kg plant ⁻¹)	Fruit volume (cc)	TSS (°B)	Ascorbic acid (mg 100 ⁻¹ ml)	Total acidity (%)	Total sugars (%)	Reducing sugar (%)
N (%)	0.197 ^{NS}	0.228 ^{NS}	-0.630**	0.811**	0.916**	0.778**	0.580**
P (%)	-0.023 ^{NS}	0.103 ^{NS}	-0.443*	0.853**	0.951**	0.858**	0.700**
K (%)	0.038 ^{NS}	0.170 ^{NS}	-0.534**	0.837**	0.969**	0.855**	0.747**
Fe (ppm)	-0.251 ^{NS}	0.129 ^{NS}	-0.258 ^{NS}	0.702**	0.739**	0.675**	0.603**
Zn (ppm)	0.011 ^{NS}	0.133 ^{NS}	-0.434*	0.865**	0.976**	0.830**	0.688**
Cu (ppm)	-0.343 ^{NS}	0.026 ^{NS}	-0.171 ^{NS}	0.699**	0.735**	0.683**	0.609**
Mn (ppm)	-0.073 ^{NS}	0.182 ^{NS}	-0.452*	0.802**	0.858**	0.776**	0.579**

*Significant at 5 per cent level of significance, **Significant at 1 per cent level of significance.

Fruit juice nutrient content : As indicated by the data that N content of kinnow fruit juice varied from 1292.30 to 1716.40 ppm, P content of kinnow fruit juice varied from 184.40 to 250.80 ppm, K content of kinnow fruit juice varied from 1704.40 to 1963.50 ppm, Jhones and Parker (1947) also recorded similar N, P and K mineral constituent in orange fruit juice, which is also confirms present finding. Fallahi and Moon (1970) reported higher N, P and K concentration in citrus varieties which is partially support present findings. Iron content of kinnow fruit juice varied from 0.08 to 0.35 ppm, Manganese content of kinnow fruit juice varied from 0.01 to 0.06 ppm, Copper content of kinnow fruit juice varied from 0.24 to 0.59 ppm and Zinc content of kinnow fruit juice varied from 0.11 to 0.16 ppm. The present result are in partial confirmation with Fallahi and Moon (1970), they also evaluated micronutrient (Fe, Zn, Cu and Mn) concentration in different citrus varieties.

Relationship between kinnow leaf nutrients and fruit parameters : The correlation coefficients between leaf N, P, K, Fe, Mn, Cu and Zn contents of kinnow with fruit quality parameters are presented in table 4.15 showed that the highly significant positive correlation was observed in kinnow leaf N, P, K, Fe, Mn and Zn with ascorbic acid, total acidity, total sugar and reducing sugar. Whereas, negative correlation was observed in kinnow leaf N, P, K, Mn and Zinc with TSS.

Since all the characteristics depend upon vegetative growth of the plant which are influenced by nitrogen. These results are in accordance with the findings of Kumar *et al.* (1998) and Mukherjee *et al.* (1981). A significant and negative correlation between leaf nitrogen with TSS and total sugars can be attributed to the competition for photosynthates between fruit and new shoot growth due to increase in nitrogen levels. The results are in accordance with the findings of Chadha and Singh (1972) and Desai and Phadnis (1987). Dar *et al.* (2014) reported that the N, P, K, Fe, Mn, Cu, and Zn level in pear fruit leaf showed significant and positive

relationship with total sugars. Casero *et al.* (2006) reported that Fruit quality attributes, such as fruit total acidity, are positively influenced by apple leaf K and P.

Conclusions

The kinnow leaf iron content found only 3.34, 83.33 and 13.33 per cent in low, optimum and sufficient range. The leaf Mn and Cu content were found in optimum to high range while leaf Zn content found in low category. The kinnow fruit juice N, P, K and Cu content were observed in optimum range. About 96.67 and 3.33 per cent fruit juice Fe content was rated in low and optimum category, whereas majority of Fruit juice Mn content in optimum to high range. All kinnow Juice samples was found in low zinc content. The fruit quality parameters were significantly affected by the status of nutrients in kinnow leaves.

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The Dynamic Changes of Accumulation of Starch, Amylose and Amylopectin During Grain Filling Stages on Kernel Weight in Wheat

Jadhav R.¹, Jaiswal J.P.², Verma A.K.¹, Pandey Dinesh³ and Agrawal S.¹

¹Department of Biochemistry, GBPUAT, Pantnagar-263145, India

²Department of Genetics and Plant Breeding, GBPUAT, Pantnagar-263145, India

³Department of Molecular Biology and Biotechnology, GBPUAT, Pantnagar-263145, India

Email : rcw7bio@yahoo.co.in

Abstract

Wheat is often considered primarily as a source of energy (carbohydrate). Starch is the main component of wheat having a number of food industry applications. The dynamics of starch accumulation determine the kernel weight, yield and quality of wheat. Nine wheat genotypes were analysed for total starch, amylose and amylopectin accumulation during grain filling stages (7, 14, 21, 28, 35 DAA). Total starch, amylose and amylopectin accumulation were highest in UP-2785 followed by UP-262 and UP-2584 in all stages of grain filling might be responsible for higher kernel weight. Fold increase in total starch and amylopectin accumulation was highest at early grain filling stages (14 DAA), whereas fold increase in amylose accumulation was highest at middle grain filling stage (21 DAA) in all genotypes. TKW in all stages was positively and significantly correlated to the total starch and amylopectin. TKW was not significantly correlated with amylose at early grain filling stages, but it was significantly correlated after middle stages at 28 DAA. Total starch accumulation was positive and significantly correlated to amylopectin accumulation, but it was not significantly correlated at early grain filling stages of amylose accumulation. At middle and late grain filling stage, amylose accumulation was positively and significantly correlated with starch accumulation. The genotype UP-2785, UP-262 and UP-2584 are performing well in relation to the total starch, amylose, amylopectin accumulation and TKW. Hence, these genotypes may be considered for industrial application on the basis of maximum total starch recovery.

Key words : Wheat, total starch, amylose amylopectin and TKW.

Introduction

Wheat (*Triticum aestivum* L.) is a major cereal crop that not only provides the world's population with calories and protein but also used as food, seeds, feed, and fuel. Wheat grain is composed of 13% water, ~70% carbohydrates, 7~15% proteins, and 1.5~2% lipids (Shewry, *et al.*, 2002). The yield of wheat depends on mainly three components: number of spikes per area, number of grains per spike, and thousand kernel weight (TKW). The grain endosperm contains starch as major component accounts for about 65–80% dry weight (Barron *et al.*, 2007). Starch is synthesized and accumulated during the grain-filling process and also used in major industrial material like textiles, paper, chemical and pharmaceutical industries as a thickener, stabilizer, gelling agent, and adhesive (Shevkani *et al.*, 2017). This diversification of wheat grain uses has given wheat breeders the idea of developing wheat varieties with grain characteristics suitable for new applications (Kim and Kim, 2021).

Amylose and amylopectin, the components of starch, are the major factor influencing kernel weight, grain yield and quality. Amylose is a linear α -1, 4 glucan, comprising 25~30% of wheat grain starch. Amylopectin is

a highly branched larger glucan comprising 70~75% of wheat grain starch. These components are synthesized during endosperm development in wheat with coordinating a series of enzyme-catalysed reactions result in starch synthesis (Zi *et al.*, 2018). Functional changes in starch metabolism genes dramatically influence starch, amylose, amylopectin content and other agronomic traits like kernel weight. With the increase in health-consciousness of consumers, there has been an increase in demand for high-quality wheat flour. The endosperm starch content and its composition are two critical parameters for evaluating the quality of wheat flour. Most starch is digested in the small intestine, but a proportion may escape digestion is termed “resistant starch” (RS). The amount of RS (type 2 and 3) is influenced by the amylose content of cereal starches. This has resulted in interest in identifying or developing lines with increased amylose content (Shewry and Hey, 2015). Hence considering these facts in mind, this study was undertaken to compare nine wheat genotypes to investigate starch, amylose and amylopectin accumulation at grain filling stages and elucidate factors affecting the kernel weight.

Table-1 : Total starch accumulation at different grain filling stages in wheat genotypes.

Sr. No.	Cultivars	Total starch accumulation (mg/grain) (Fold Increase)				
		7 DAA	14 DAA	21 DAA	28 DAA	35 DAA
1.	UP-2785	0.67	10.67 (15.93)	23.10 (2.16)	33.91 (1.47)	40.07 (1.18)
2.	UP-2784	0.39	6.69 (17.15)	15.09 (2.26)	21.29 (1.41)	26.56 (1.25)
3.	UP-2903	0.41	6.82 (16.63)	15.66 (2.30)	23.22 (1.48)	27.47 (1.18)
4.	UP-262	0.57	8.73 (15.32)	20.65 (2.37)	29.87 (1.45)	33.74 (1.13)
5.	UP-2748	0.38	6.37 (16.76)	13.56 (2.13)	22.39 (1.65)	26.26 (1.17)
6.	UP-2584	0.51	8.13 (15.94)	19.11 (2.35)	27.34 (1.43)	31.10 (1.14)
7.	C-306	0.33	6.99 (21.18)	16.58 (2.37)	24.7 (1.49)	27.78 (1.12)
8.	WH-1080	0.30	6.34 (21.13)	13.89 (2.19)	19.18 (1.38)	24.19 (1.26)
9.	PBW-660	0.31	5.39 (17.39)	11.59 (2.15)	18.22 (1.57)	21.33 (1.17)
	SE	0.042	0.542	0.651	1.172	1.033
	CD @ 5%	0.126	1.625	1.953	3.513	3.098
	CV%	16.88	12.78	6.77	8.36	6.26

Table-2 : Amylose accumulation at different grain filling stages in wheat genotypes.

Sr. No.	Cultivars	Amylose accumulation (mg/grain) (Fold Increase)				
		7 DAA	14 DAA	21 DAA	28 DAA	35 DAA
1.	UP-2785	0.18	0.78 (4.33)	5.26 (6.74)	8.88 (1.69)	11.10 (1.25)
2.	UP-2784	0.07	0.33 (4.71)	3.23 (9.79)	5.81 (1.80)	7.23 (1.24)
3.	UP-2903	0.15	0.70 (4.67)	3.41 (4.87)	5.64 (1.65)	7.90 (1.40)
4.	UP-262	0.09	0.47 (5.22)	3.54 (7.53)	6.64 (1.88)	8.70 (1.31)
5.	UP-2748	0.21	1.02 (4.86)	4.65 (4.56)	7.67 (1.65)	8.48 (1.11)
6.	UP-2584	0.21	0.87 (4.14)	3.59 (4.13)	6.40 (1.78)	9.11 (1.42)
7.	C-306	0.10	0.38 (3.80)	3.23 (8.50)	6.23 (1.93)	7.76 (1.25)
8.	WH-1080	0.07	0.31 (4.43)	2.39 (7.71)	4.45 (1.86)	6.50 (1.46)
9.	PBW-660	0.08	0.27 (3.38)	2.00 (7.41)	4.69 (2.35)	5.88 (1.25)
	SE	0.019	0.049	0.191	0.100	0.703
	CD @ 5%	0.057	0.146	0.572	0.299	2.109
	CV%	25.44	11.35	9.51	2.70	14.63

Materials and Methods

Nine genotypes of wheat viz, UP-2785, UP-2784, UP-2903, UP-262, UP-2748, UP-2584, C-306, WH-1080 and PBW-660 used for this study were procured from Principal scientist, AICRP on Wheat GBPUAT, Pantnagar. These genotypes were sown in experimental farm CRC, GBPUAT and developing grains of wheat were harvested from primary and secondary tillers after anthesis. Spikelet that headed on the same day was chosen and tagged for the each plot. Labelled spikes were sampled at 7 DAA in 7 days intervals until 35 days. Grains in spikelet were dried at 70 °C and weighed for thousand kernel weight (TKW). The grinded grain (flour) was used for measurement of amylose, amylopectin, and total starch accumulation. These experiments were carried out at Department of Biochemistry, CBSH, GBPUAT, Pantnagar.

Total starch was estimated by the method used by Sadashivam and Manickam, 1992. The dried grain

powder (100 mg) was weighed, homogenized into hot 80% ethanol to remove sugar and centrifuged. The residue was washed repeatedly with hot 80% ethanol till the washings does not show the presence of sugar using anthrone reagent. The residue was dried well over a water bath. To the residue 5.0 ml of water and 6 ml of 52% Perchloric acid was added. The extract was recovered after centrifugation. Extractions were repeated and pooled all supernatants to make up volume to 100 ml. Sugar was estimated using anthrone reagent at 630nm.

Amylose content was estimated by the method adopted from Juliano, (1971). 100 mg of wheat grain flour was weighed and transferred into 100 ml conical flask. 1 ml 95% ethanol and 9 ml NaOH (1N) was added. The samples were heated for 10 min in boiling water bath and made up to volume 100ml. From this, 2ml was taken for amylose estimation by using 1ml acetic acid (1N) and 2ml iodine reagent. Reaction mixture was kept in the dark for 20min and after that volume was made to 100ml.

Table-3 : Amylopectin accumulation at different grain filling stages in wheat genotypes.

Sr. No.	Cultivars	Amylopectin accumulation (mg/grain) (Fold Increase)				
		7 DAA	14 DAA	21 DAA	28 DAA	35 DAA
1.	UP-2785	0.49	9.71 (19.81)	17.85 (1.84)	25.03 (1.40)	28.95 (1.16)
2.	UP-2784	0.31	6.25 (20.16)	11.86 (1.90)	15.47 (1.30)	19.32 (1.25)
3.	UP-2903	0.25	5.9 (23.60)	12.25 (2.08)	17.59 (1.44)	19.58 (1.11)
4.	UP-262	0.48	8.14 (16.96)	17.11 (2.10)	23.24 (1.36)	25.05 (1.08)
5.	UP-2748	0.18	5.05 (28.06)	8.91 (1.76)	14.73 (1.65)	17.78 (1.21)
6.	UP-2584	0.30	7.02 (23.40)	15.51 (2.21)	20.94 (1.35)	22.00 (1.05)
7.	C-306	0.22	6.49 (29.50)	13.35 (2.06)	18.47 (1.38)	20.03 (1.08)
8.	WH-1080	0.23	5.88 (25.57)	11.49 (1.95)	14.73 (1.28)	17.7 (1.20)
9.	PBW-660	0.22	5.01 (22.77)	9.59 (1.91)	13.52 (1.41)	15.46 (1.14)
	SE	0.019	0.280	1.348	0.641	0.797
	CD @ 5%	0.058	0.839	4.040	1.923	2.391
	CV%	11.19	7.37	18.46	6.34	6.81

Table-4 : 1000 kernel weight (g) on dry basis at different stages of grain filling.

S. No.	Genotypes	TKW (g/1000 grain)				
		7 DAA	14 DAA	21 DAA	28 DAA	35 DAA
1.	UP-2785	9.17	22.87 (2.49)	38.01 (1.66)	51.12 (1.34)	56.58 (1.11)
2.	UP-2784	6.68	15.42 (2.30)	28.55 (1.85)	35.29 (1.24)	40.10 (1.14)
3.	UP-2903	7.12	16.31 (2.29)	27.34 (1.68)	35.43 (1.37)	41.35 (1.10)
4.	UP-262	7.95	20.56 (2.59)	34.47 (1.68)	45.85 (1.33)	48.40 (1.06)
5.	UP-2748	6.95	16.54 (2.38)	24.56 (1.48)	35.34 (1.44)	38.17 (1.08)
6.	UP-2584	7.87	18.03 (2.29)	33.66 (1.87)	44.96 (1.34)	45.86 (1.02)
7.	C-306	7.00	15.85 (2.27)	28.41 (1.79)	38.17 (1.34)	40.50 (1.06)
8.	WH-1080	6.83	15.01 (2.20)	25.16 (1.68)	31.88 (1.27)	37.10 (1.16)
9.	PBW-660	6.20	12.35 (1.99)	21.73 (1.76)	30.1 (1.39)	33.14 (1.10)
	SE	0.553	0.624	0.454	2.804	2.489
	CD @ 5%	1.657	1.872	1.361	8.406	7.462
	CV%	13.10	6.36	2.70	12.55	10.09

Absorbance was taken at 620nm. Amylopectin content was calculated by subtracting amylose content from total starch content. All measurements were replicated, and data were analysed for mean $\pm$ standard deviation and calculated using one way analysis of variance (ANOVA) with Duncan's multiple range tests. Analysis of Pearson correlation were performed using SPSS.

Results and Discussion

Accumulation of starch in single grain : Starch is the main component of wheat which has a number of applications in the food industry. Wheat cultivars/varieties differ in starch functionality (thermal, retrogradation, pasting and nutritional properties) are grown throughout the world. These properties are related to starch composition, morphology and structure, which vary with genetics, agronomic and environmental conditions (Shevkani *et al.*, 2017). In the present investigation, starch accumulation in grain was found to increase from 7 to 35 DAA. The increase of starch accumulation varied in different genotypes. The highest starch accumulation was

observed in UP-2785 (in all stages of grain filling) followed by UP-262 and UP-2584 (Table-1). The fold increase was markedly higher in all genotypes at 14 DAA. The fold increase was found in the range from 15.32 to 21.18 fold after that, the fold increase declined in 21, 28 and 35 DAA. At 35 DAA, the fold increase in starch accumulation was very low which ranged from 1.13 to 1.26 but starch accumulation was in its maximum level. This might be resulting in lower activity of starch metabolizing enzymes at late grain filling stage. Total starch accumulation was found to be lowest in PBW-660 with lowest in kernel weight, comparing to the all genotypes. The results indicate that the starch accumulation duration was the predominant factor responsible for the final starch accumulation and kernel weight. Dai *et al.*, (2009) reported that higher starch accumulation resulted mainly from higher enzyme activities in mid-late grain-filling stage contributed to the grain growth in wheat cultivars differing in kernel types.

Accumulation of amylose in single grain : Amylose accumulation was progressively increased from 7 to 35

Table-5 : Correlation analysis of 1000-kernel weight (TKW) with total starch (TS), amylose (AM) and amylopectin (AP) accumulation.

	TS 7 DAA	TS 14 DAA	TS 21 DAA	TS 28 DAA	TS 35 DAA
TKW7 DAA	0.946**	0.987**	0.951**	0.956**	0.978**
TKW14 DAA	0.893**	0.947**	0.917**	0.928**	0.934**
TKW21 DAA	0.931**	0.967**	0.986**	0.957**	0.961**
TKW28 DAA	0.955**	0.972**	0.979**	0.987**	0.980**
TKW35 DAA	0.961**	0.996**	0.975**	0.970**	0.995**
	AP 7	AP14	AP 21	AP 28	AP 35
TKW7 DAA	0.821**	0.985**	0.950**	0.949**	0.975**
TKW14 DAA	0.832**	0.939**	0.918**	0.931**	0.930**
TKW21 DAA	0.876**	0.968**	0.978**	0.948**	0.955**
TKW28 DAA	0.836**	0.973**	0.975**	0.978**	0.979**
TKW35 DAA	0.878**	0.995**	0.972**	0.964**	0.992**
	AM 7	AM 14	AM 21	AM 28	AM 35
TKW7 DAA	0.503 ^{NS}	0.445 ^{NS}	0.758*	0.775*	0.955**
TKW14 DAA	0.381 ^{NS}	0.382 ^{NS}	0.731*	0.719*	0.930**
TKW21 DAA	0.343 ^{NS}	0.278 ^{NS}	0.637 ^{NS}	0.665 ^{NS}	0.908**
TKW28 DAA	0.483 ^{NS}	0.415 ^{NS}	0.723*	0.764*	0.942**
TKW35 DAA	0.413 ^{NS}	0.358 ^{NS}	0.742*	0.768*	0.957**

* Significant at $p < 0.05$, **Significant at $p < 0.01$, NS Non-significant.

Table-6 : Correlation analysis of total starch (TS) accumulation with amylose (AM) and amylopectin (AP) accumulation.

	AM 7 DAA	AM 14 DAA	AM 21 DAA	AM 28 DAA	AM 35 DAA
TS 7 DAA	0.459 ^{NS}	0.416 ^{NS}	0.726*	0.738*	0.923**
TS 14 DAA	0.391 ^{NS}	0.328 ^{NS}	0.723*	0.754*	0.942**
TS 21 DAA	0.330 ^{NS}	0.264 ^{NS}	0.639 ^{NS}	0.690*	0.908**
TS 28 DAA	0.429 ^{NS}	0.385 ^{NS}	0.740*	0.783*	0.942**
TS 35 DAA	0.445 ^{NS}	0.393 ^{NS}	0.782*	0.814**	0.966**
	AP 7	AP14	AP 21	AP 28	AP 35
TS 7 DAA	0.901**	0.953**	0.906**	0.950**	0.964**
TS 14 DAA	0.882**	1.000**	0.974**	0.964**	0.987**
TS 21 DAA	0.864**	0.976**	0.999**	0.965**	0.963**
TS 28 DAA	0.868**	0.969**	0.971**	0.999**	0.983**
TS 35 DAA	0.868**	0.991**	0.965**	0.977**	1.000**

* Significant at $p < 0.05$, **Significant at $p < 0.01$, NS Non-significant.

DAA in all genotypes. Genotype UP-2785 was found to accumulate highest amylose content per grain followed by UP-262 and UP-2584 comparing to other genotypes. All these genotypes showed highest fold increase at 21 DAA range from 4.13 to 9.79 fold, whereas genotype UP-2903, UP-2748, and UP-2584 showed equally high fold amylose accumulation at 14 DAA (4.67, 4.86 and 4.14 respectively). Fold increase in amylose accumulation was declined at 28 and 35 DAA (Table-2). Fold increase in amylose accumulation at 35 DAA was very low ranged from 1.11 to 1.46. Results indicate that the amylase accumulation is predominant in early and middle grain filling stage. It may be due to the single enzyme that catalyses amylose synthesis. Granule bound starch synthase (GBSS) express higher in these stages. The activity of starch synthase (SSII) or starch branching enzymes (SBEIIa or SBEIIb) may be decreased (Shewry

and Hey, 2015). High amylose wheat differs in their processing properties of conventional wheat, particularly in starch swelling and viscosity which may be beneficial for bread and related industries (Schirmer *et al.*, 2013). The amylose content definitely affects the physicochemical properties of starch (Singh *et al.*, 2006). High-amylose starches of maize are widely utilized for RS materials, low calorie food manufacturing, and industrial applications such as a thickener, binder, and film (Li *et al.*, 2008). Hazard *et al.*, (2012) showed that double *SBEIIa* mutants in durum wheat had an increase of 22% in amylose content and 115% of resistant starch content. Similarly, Slade *et al.*, (2012) reported that combine mutations in *SBEIIa* genes elevated levels of amylase and resistant starch in durum and bread wheat lines compared to wild-type wheat.

Accumulation of amylopectin in single grain : High amylopectin (100%) waxy cereal starches have unusual properties (notably high viscosity and water-retention) (Kim *et al.*, 2003), that are exploited in the food industry, particularly for the production of refrigerated and frozen foods and as fat replacers (Jobling, 2004). Waxy starch is highly digestible and hence has a high glycemic index, whereas waxy (glutinous/sticky) rice with high amylopectin is widely consumed in Asia. In the present study amylopectin accumulation in grain was increased from 7 to 35 DAA (Table No. 3). Fold increase in amylopectin accumulation was observed to be higher at 14 DAA as compared to 21, 28 and 35 DAA. Results indicate that the amylopectin accumulation is predominant at early grain filling stage might be due to promising performance of enzymes involve in amylopectin synthesis. The fold increase in amylopectin accumulation was very low at 35 DAA stages, which ranged from 1.05-1.25 fold. Amylopectin accumulation per grain was highest in UP-2785 followed by UP-262 and UP-2584 comparing to other genotypes. The lowest amylopectin accumulation was observed in PBW-660.

Dai *et al.*, (2009) reported that amylose and amylopectin accumulation was higher in the large kernel types than in the small kernel types at the initial filling stage, indicating that more endosperm cells (sink capacity) might have played a major role at early grain-filling stage in grains of large kernel types. Zi *et al.*, (2018) reported that total starch, amylose, and amylopectin accumulation in waxy and non-waxy wheat showed overall increases during the grain-filling stage. The greatest rate of accumulation of grain total starch, amylose, and amylopectin occurred between 10th-25th days after anthesis, but decreased after the 25th day after anthesis for both types of wheat. At maturity, the rates of accumulation of total starch, amylose, and amylopectin declined and the accumulation of total starch, amylose, and amylopectin reached the maximum levels.

1000 kernel weight : TKW of grain progressively increased from 7 to 35 DAA (Table No.4). Fold increase in weight of the grain was observed to be higher at 14 DAA in all genotypes which ranged from 1.99 to 2.59. The fold increase in TKW was found to be lowest at 35 DAA which range from 1.02 to 1.16, whereas TKW was high at this stage. The genotype PBW-660 was found to be comparatively low TKW (33.14 g/1000 grain), whereas the highest observed in UP-2785 followed by UP-262 and UP-2584 (56.58, 48.40 and 45.86 g/1000 grain respectively). Zi *et al.*, (2018) reported that the activities of AGPase, SSS, GBSS and SUS play important roles in regulating starch synthesis which determines the individual grain weight in wheat endosperm.

A Pearson correlation among TKW with the total starch, amylose and amylopectin was presented in Table No. 5. The TKW in all stages was positively and significantly correlated to the total starch and amylopectin with r value is approximately 0.9 at $p < 0.05$. TKW was not significantly correlated with amylose at early grain filling stages. At the middle stages (28 DAA), it was significantly correlated at $p < 0.01$ with r value approximately 0.7, whereas at 35 DAA with r value is approximately 0.9 at $p < 0.05$. The result revealed that TKW of the wheat genotypes are mostly depending on the starch, amylopectin accumulation. The increase in total starch and amylopectin accumulation may increase the TKW. The total starch accumulation was positively and significantly correlated to amylopectin accumulation. Amylose accumulation was not significantly correlated at early grain filling stages. Amylose accumulation at middle and late grain filling stage showed the positive and significant correlation shown in table 6.

Conclusion

It may be concluded from the present study that early grain filling stages was found to be the most important stage for total starch and amylopectin accumulation, which may be responsible for the increase in kernel weight. On early grain filling stage, amylose accumulation was low which was not significantly correlated with TKW and total starch accumulation. Amylose accumulation was progressively highest at the middle stage of grain filling (21 DAA), which positively correlates with TKW and total starch accumulation. The highest total starch, amylose and amylopectin accumulation was observed in UP-2785 followed by UP-262 and UP-2584 in all stages of grain filling. These parameters may be responsible for higher kernel weight. The genotype UP-2785, UP-262 and UP-2584 was performing well in relation to the total starch, amylose, amylopectin accumulation and TKW. These genotypes may be considered for industrial application on the basis the maximum total starch, amylopectin and amylose accumulation.

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Influence of PGR and Thiourea on Yield and its Related Traits in Bottle Gourd cv. Pusa Summer Prolific Long

Reena Kumari^{1*}, S.P. Singh¹ and B.L. Meena²

¹Department of Horticulture, S.K.N. COA, Jobner-303329 Rajasthan

²ICAR-DRMR, Sewar, Bharatpur, Rajasthan

*Corresponding Author's Email : meenareena2007@gmail.com

Abstract

The investigation was carried out in the experimental farm of Department of Horticulture, S.K.N Agriculture University, Jobner, Jaipur (Rajasthan) to see the effect of various plant growth regulators and thiourea on yield and yield related traits of bottle gourd cv. Pusa Summer Prolific Long. The experimental was laid out with 13 treatments in RBD with 3 replication. The treatment comprised of plant growth regulators and thiourea, viz. T₀ (control), T₁ (100 ppm NAA), T₂ (200 ppm NAA), T₃ (300 ppm NAA), T₄ (150 ppm Ethrel), T₅ (300 ppm ethrel), T₆ (450 ppm ethrel), T₇ (100 ppm CCC), T₈ (200 ppm CCC), T₉ (300 ppm CCC), T₁₀ (250 ppm thiourea), T₁₁ (500 ppm thiourea), T₁₂ (750 ppm thiourea). The results revealed that the application of NAA 300 ppm (T₃) recorded maximum vine length (6.80 m), nodes per vine (22.01) and leaf area (274.00 cm²). The CCC 300 ppm (T₉) treatment produced maximum primary branches (22.97) and secondary branches (9.30) per vine and leaf area (203.26 m²) were observed in this treatment. The results showed that NAA 300 ppm registered maximum vegetative growth, ethrel 750 ppm significantly decreased male flower (65.60). Most of the quality parameters are maximum at ethrel 450 ppm as crude protein contents (0.226), ascorbic acid (12.90), TSS (5.31%). It may be concluded that ethrel 400 ppm (T₆) was found most effective as it remained statistically at par in all the growth, flowering attributes and yield.

Key words : Bottle guard, PGRs, thiourea, vegetative growth, flowering, yield, quality.

Introduction

Bottle gourd is a commonly grown and used vegetable in India. It belongs to family cucurbitaceae. Besides an important vegetable crop it has also got good medicinal as well as nutritional value. Due to these qualities and people now a days becoming more health conscious. The intake of its demand have been increasing day by day. The fruits are also used as vegetable or for making sweets/halwa, kheer, petha, barfi and pickles. It is economically found growing in Ethiopia, Africa and Central America. In India, bottle gourd is grown in the area of 532.7 thousand hectares with annual production of 6346.4 thousand metric tonnes and having 11.9 metric tonnes/hectares production (NHB Database, 2014). It occupies 5,120 hectares area in Rajasthan producing 17857 metric tonnes with a productivity of 3.4876 tonnes ha⁻¹ (Anonymous, 2011). In Jaipur district it occupies 1164 hectares area producing 1419 metric tonnes with a productivity of cucurbits, the growth regulators are more important due to their direct effect on males and female flowers ratio, fruit set, fruit drop and ultimately on yield. The use of plant growth regulators at proper stage play an important role in sex expression and yield of bottle gourd (Sircael, 1971). In bottle gourd, the production of staminate flowers is much more than pistillate flower. These situations lead to the use of plant growth regulators like NAA, Ethrel and CCC in

bottle gourd which play an important role in sex expression and sex ratio and thiourea plays a vital role in the physiology of plants both as a sulphhydryl compound and to some extent as an amino compound like urea. The stimulating action of thiourea in various physiological activities of plants is well known. Keeping these facts in view, the present investigation was undertaken with objectives to know the effect of plants growth regulators and thiourea on growth yield and quality of bottle gourd.

Materials and Methods

Field experiment was conducted on Bottle gourd cv. Pusa summer prolific long the experimental farm of the department of horticulture, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan). The soil of experimental farm was sandy loam texture, having organic carbon 0.13%, pH 8.2 and EC 0.85 (dSm⁻¹). The treatment comprised of plant growth regulators and thiourea viz. T₀ (control), T₁ (100 ppm NAA), T₂ (200 ppm NAA), T₃ (300 ppm NAA), T₄ (150 ppm Ethrel), T₅ (300 ppm ethrel), T₆ (450 ppm ethrel), T₇ (100 ppm CCC), T₈ (200 ppm CCC), T₉ (300 ppm CCC), T₁₀ (250 ppm thiourea), T₁₁ (500 ppm thiourea), T₁₂ (750 ppm thiourea) were designed in randomized block design with replicated thrice. The gross plot size was 6m x 3m with spacing of 2.5 m x 0.75 m (row x plant). The bottle gourd three to flower seeds per pit were sown on 12th July 2012 by dibbling method. Bottle gourd crop was fertilized

Table-1 : Impact of plant growth regulators and thiourea on vegetative growth and flowering parameters of bottle gourd [*Lagenaria siceraria* (Mol.) cv. Pusa Summer Prolific Long.

Treatment	Vegetative growth parameters				Flowering attributes		
	Vine length (m)	No. of nodes/vine	Leaf area (cm ²)	No. of primary branches/vine	No. of secondary branches/vine	No. of male flowers/ vine	Days taken to first male flower appearance
T ₀ : Control	4.50	20.12	210.40	8.01	4.05	95.17	58.12
T ₁ : NAA 100 ppm	6.80	24.42	260.10	13.40	6.15	80.49	40.70
T ₂ : NAA 200 ppm	6.17	25.50	261.00	11.60	5.60	85.50	40.40
T ₃ : NAA 300 ppm	6.80	26.40	274.00	10.70	5.40	71.40	40.00
T ₄ : Ethrel 150 ppm	5.50	24.40	240.00	14.70	6.30	76.55	49.00
T ₅ : Ethrel 300 ppm	5.00	23.13	226.60	16.18	7.16	68.51	47.50
T ₆ : Ethrel 450 ppm	4.53	22.01	215.00	17.25	7.60	65.60	46.55
T ₇ : CCC 100 ppm	4.50	19.92	225.56	18.50	8.20	78.23	56.05
T ₈ : CCC 200 ppm	4.40	18.98	214.80	18.78	8.32	73.81	54.00
T ₉ : CCC 300 ppm	4.36	18.05	203.26	20.97	9.30	70.18	52.00
T ₁₀ : Thiourea 250 ppm	5.79	25.82	243.05	13.39	6.14	75.80	45.79
T ₁₁ : Thiourea 500 ppm	5.47	23.35	258.10	11.58	5.25	70.77	41.20
T ₁₂ : Thiourea 750 ppm	5.00	22.15	258.90	11.70	5.41	70.68	41.17
SEm+	0.35	1.23	10.95	0.75	0.34	4.33	1.98
CD at 0.05%	1.01	3.58	31.95	2.19	0.98	12.63	5.79

Table-2 : Impact of plant growth regulators and thiourea on physio-chemical quality and yield parameters of bottle gourd [*Lagenaria siceraria* (Mol.) cv. Pusa Summer Prolific Long.

Treatment	Physio-chemical quality parameters			Yield parameters	
	TSS (°B)	Crude protein contents	Ascorbic acid contents	Yield/vine (kg)	Yield/hectare (q)
T ₀ : Control	5.03	0.200	11.66	5.70	349.25
T ₁ : NAA 100 ppm	5.07	0.210	12.10	6.15	378.19
T ₂ : NAA 200 ppm	5.17	0.217	12.40	6.40	396.76
T ₃ : NAA 300 ppm	5.21	0.220	12.50	6.95	472.55
T ₄ : Ethrel 150 ppm	5.16	0.216	12.46	7.02	499.15
T ₅ : Ethrel 300 ppm	5.26	0.222	12.75	7.45	533.86
T ₆ : Ethrel 450 ppm	5.31	0.226	12.90	7.55	549.84
T ₇ : CCC 100 ppm	5.14	0.215	12.35	6.14	426.35
T ₈ : CCC 200 ppm	5.23	0.221	12.65	6.40	447.96
T ₉ : CCC 300 ppm	5.28	0.224	12.82	6.70	473.42
T ₁₀ : Thiourea 250 ppm	5.15	0.211	12.25	6.08	377.26
T ₁₁ : Thiourea 500 ppm	5.18	0.212	12.21	6.30	393.71
T ₁₂ : Thiourea 750 ppm	5.20	0.219	12.49	6.65	416.32
SEm+	0.24	0.011	0.42	0.32	18.97
CD at 0.05%	NS	0.033	NS	0.94	55.36

with recommended dose i.e. 250 FYM, 60, 40, 60 NPK kg ha⁻¹. Nitrogen, phosphorus and potash fertilizer were applied in the form of urea, single super phosphate and muriate of potash respectively. Half dose of nitrogen and whole quantity of phosphorus and potash were applied. The remaining half dose of nitrogen (60 kg/ha) was top dressed after one month of sowing. The observation on growth and yield parameters were recorded during investigation.

Results and Discussion

The data pertaining to the effect of plant growth regulators and thiourea on vine length are presented in Table-1. The

data revealed that plant growth regulators and thiourea significantly increased as well as decreased the vine length and number of nodes per vine. The maximum vine length and number of nodes per vine was recorded under foliar spray of NAA 300 ppm (T₃) and minimum with CCC 300 ppm (T₉) but treatment NAA 200 ppm (T₂) was found at par with NAA 300 ppm (T₃). Chhonkar and Singh (1959) assigned that the increase in vine length under application of NAA was on account of its stimulatory effect on absorption of available nutrient present in the soil or by the modification in plant root system through the associated microflora of the soil similar results were also reported by Das and Das (1996) in pumpkin due to application of NAA (150 ppm).

The increased nodes on vine axis under exogenous application of NAA 250 ppm might be due to stimulatory effect of NAA on vine growth, cell division, cell elongation, cell enlargement (Chhonkar and Singh, 1959). These findings are also in conformity with Randhawa and Singh (1976) in bottle gourd and Chovatia *et al.* (2010) in bitter gourd cv. Priya.

The maximum leaf area was found under exogenous application of NAA 300 ppm (T_3) and minimum in CCC 300 ppm (T_9) are presented in Table 1. The effect of NAA on leaf area might be due to physiological process of plant that leads to accumulation of carbohydrates and minerals, which showed that gibberellins and auxins have some role in leaves other than cell elongation. These finding are in close conformity with the results reported by Sharma *et al.* (1988) in bottle gourd, Kabir *et al.* (1989) in bitter gourd, Das and Maurya (1992) and Das and Das (1996) in pumpkin, respectively.

The results of the present investigation revealed that the maximum number of primary branches and secondary branches were found under CCC 300 ppm (T_9) and minimum in control respectively (Table-1). These results are also in accordance with Randhawa and Singh (1976) in bottle gourd.

Among different treatment NAA 300 ppm (T_3) showed minimum days for first male flower appearance as compared to control (T_0) are presented in Table 1. The results obtained are in agreement with those Baruas and Das (1997) in Bottle gourd, respectively.

The data regarding to the effect of plant growth regulators and thiourea on all the fruit quality attributes are depicted in Table-2. Ethrel 450 ppm contributed maximum crude protein content, ascorbic acid and TSS in fruits as compared to control. These results are consonance with the finding of Shafeek *et al.* (2016) in summer squash guard.

The maximum fruit yield per vine and per hectare under ethrel 450 ppm (T_6) might be due to higher number of female flower, higher number of fruits and higher fruit weight under ethrel 450 ppm (T_6) are presented to table-2. These finding are in close conformity with those of Kumar *et al.* (2006) in bottle gourd, Das and Das (1996) in pumnpkin and Jadav *et al.* (2010) in cucumber.

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Impact of Boron, Zinc and Iron on Growth, Yield and Quality of Lemon (*Citrus limon* L.) in Rainy Season

Balkesh Kumari¹, Lokesh Kumar^{2*} and A.K. Soni¹

¹Department of Horticulture, Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan

²Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

*Corresponding Author Email : lokeshken9497@gmail.com

Abstract

An experiment was carried out on 3 years old lemon plants at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Jaipur) during rainy season 2020-21. The experiment entitled with "Impact of Boron, Zinc and Iron on Growth, Yield and Quality of Lemon (*Citrus limon* L.) in Rainy Season". There were ten treatments, denoted by control (T₁), Borax 0.1 per cent (T₂), Borax 0.2 per cent (T₃), Borax 0.3 per cent (T₄), ZnSO₄ 0.1 per cent (T₅), ZnSO₄ 0.2 per cent (T₆), ZnSO₄ 0.3 per cent (T₇), FeSO₄ 0.1 per cent (T₈), FeSO₄ 0.2 per cent (T₉), FeSO₄ 0.3 per cent (T₁₀). All 10 treatments were tested under Randomized Block Design. The application of 0.2 per cent borax to lemon plant is significantly increase in the plant height (21.34 cm), plant spread in E-W (19 cm) and in N-S (19.02 cm), total number of branches per plant (12), flowers cluster per branch (6), fruit set percentage (11.29%), number of fruits per plant (68), yield per plant (8.4 kg/plant), fruit weight (108.4 g), volume of fruit (130 cc) and yield per hectare (23.29 q/ha) of fruit were obtained as compared to control but statistically at par with zinc sulphate 0.2 per cent in almost all parameters.

Key words : Lemon, foliar application, growth, yield, quality, iron, zinc, boron.

Introduction

Under tropical and subtropical climates citrus is one of the major fruit crops. Lemon is cultivated in India 286.20 thousand ha area and 3148 thousand MT production (Anonymas, 2018). Among the citrus species, lemon is one of the important species and citrus cultivated in warm southern slopes of the Himalayas in North-Eastern India and adjacent to Burma, Southern China and Indo-China. It flourishes under humid and semi-arid condition and can tolerate heat and cold better than lime. Lemon contains 35-45 mg/100 g ascorbic acid, 7-8 °Brix TSS, 30-35 per cent juice and 6-7 per cent acidity and p^H of fruit ranges 2-3.

The fruit of Pant- C1 lemon is larger as compared to other variety and hence, the juice content of Pant- C1 fruit tends to be more. This variety is from India. It is hardy, medium, vigorous, spreading drooping, dense foliage, thorny, fruit color is yellow, smooth, nipped apex, base round, thin rind, hollow axis, segments 10-12 and matures during November- February. Citrus fruit use widely in variety of culinary, dietary, industrial and medicinal purpose. It is also widely used in the preparation of pickles, jams, squashes, marmalades, cordial and jellies. The oil obtained from the lemon is also used as a flavoring agent in soft drinks, confectioneries *etc.* and this oil also used as a major raw material in cosmetic industries like soaps, deodorants, creams *etc.*

Boron is absorbed in H₃BO₄ form. Next to zinc, boron is widely deficient nutrient. It is a micronutrient mobile in soil and immobile in plant. Availability of boron in soil is reduced on account of calcareousness, salinity/sodicity and overliming. Zinc is the most important micronutrient of global concern, and highly deficient nutrient of equal magnitude on both acid as well as alkaline soils. It is an immobile nutrient in plant. The availability of Zn in soil is adversely affected by soil calcareousness, high P content, salinity/sodicity, over liming *etc.* Zinc is absorbed in Zn²⁺ form by plant. Among the micronutrients, zinc (Zn) is the important nutrient required in the enzymatic activities for the nitrogen and carbohydrate metabolism and it results the increasing the uptake of nitrogen by citrus plants for its growth and developments (Gurjar *et al.*, 2015). Its deficiency problem is next to nitrogen deficiency in occurrence and it has been reported from all the citrus growing countries in the world. Lemon shows the decrease in the yield if the deficiency of Zn is occurs in the plants at the earlier stage of growth when there are no signs of pathological symptoms (Embleton and Jones 1956). Iron is one of the micronutrients becomes exceedingly mobile under waterlogged conditions; otherwise it is highly immobile in plant. In acid soils, soluble Fe could fix phosphates which are aggravated further by high water table and water logging. While on alkaline calcareous soils, lime induced iron chlorosis is perhaps the most researched nutritional disorder in citrus.

Table-1 : Effect of different concentration of boron, zinc and iron on increase of Plant height (cm), Plant spread (cm), Total number of branches per plant, Flower cluster per branches and Fruit set per cent in lemon.

Treatments	Increase in plant height (cm)	Increase in plant spread (cm)		Total number of branches per plant	Flower cluster per branches	Fruit set per cent
		E-W	N-S			
Control (T ₁)	14.76	13.50	13.33	6.00	3.00	9.13
Borax 0.1 % (T ₂)	17.00	16.01	17.79	8.00	4.00	10.20
Borax 0.2% (T ₃)	21.34	19.00	19.02	12.00	6.00	11.29
Borax 0.3% (T ₄)	19.03	16.55	18.31	8.00	5.00	10.91
ZnSO ₄ 0.1% (T ₅)	20.00	17.01	17.04	10.00	4.00	10.33
ZnSO ₄ 0.2% (T ₆)	20.57	18.77	18.77	11.00	5.00	11.17
ZnSO ₄ 0.3% (T ₇)	18.33	17.40	17.21	8.00	3.00	9.30
FeSO ₄ 0.1% (T ₈)	17.05	17.51	16.64	9.00	3.00	10.80
FeSO ₄ 0.2% (T ₉)	17.27	17.88	16.60	8.00	4.00	10.51
FeSO ₄ 0.3% (T ₁₀)	17.17	18.19	16.89	7.00	5.00	10.11
SEm±	0.160	0.252	0.232	0.090	0.053	0.109
CD @5%	0.47	0.74	0.68	0.27	0.16	0.32

Table-2 : Effect of different concentration of boron, zinc and iron on Total number of fruits per plant, Yield per plant (kg/plant), Yield per hectare (q/ha), Fruit weight (g) and Fruit volume (cc) in lemon.

Treatments	Total number of fruits per plant	Yield per plant (kg/plant)	Yield per hectare (q/ha)	Fruit weight (g)	Fruit volume (cc)
Control (T ₁)	52.00	5.00	13.85	81.21	70.00
Borax 0.1 % (T ₂)	55.00	6.40	17.73	95.60	95.00
Borax 0.2% (T ₃)	68.00	8.40	23.27	108.40	130.00
Borax 0.3% (T ₄)	63.00	5.30	14.68	93.10	100.00
ZnSO ₄ 0.1% (T ₅)	59.00	5.40	14.96	84.80	90.00
ZnSO ₄ 0.2% (T ₆)	66.00	7.80	21.61	106.10	124.00
ZnSO ₄ 0.3% (T ₇)	60.00	7.20	19.94	100.90	100.00
FeSO ₄ 0.1% (T ₈)	58.00	6.70	18.56	99.4	105.00
FeSO ₄ 0.2% (T ₉)	53.00	5.50	15.23	90.24	115.00
FeSO ₄ 0.3% (T ₁₀)	57.00	5.80	16.66	86.71	120.00
SEm±	0.855	0.076	0.122	1.104	1.065
CD @5%	2.52	0.22	0.36	3.26	3.14

Availability of Fe becomes less available in soils having pH beyond 7.8. High available Fe could induce Mn-deficiency. Iron by plant is absorbed in Fe²⁺ form. Iron (Fe) is also an important micronutrient necessary for the citrus plants. It involve in nucleic acid metabolism in the chloroplast. It has been reported that the application of iron sulphates as the foliar spray reduces the leaf chlorosis and consequently increase the yield (Devi *et al.*, 1997). It also helps in a significant increase of fruit yield, fruit volume, ascorbic acid content and leaf iron content in citrus (Aboutalebi and Hassanzadeh, 2013). Iron play roles in plant metabolism such as, it is constituent of cytochromes, nonhaeme iron proteins, which are involved in photosynthesis, N₂ fixation and respiratory linked dehydrogenase. It involved in reduction in nitrate and sulfates and activity of peroxidases are considered biochemical index of Fe-deficiency. As this cultivar of lemon being a heavy and regular bearing crop which bears throughout the year has to be supplied with

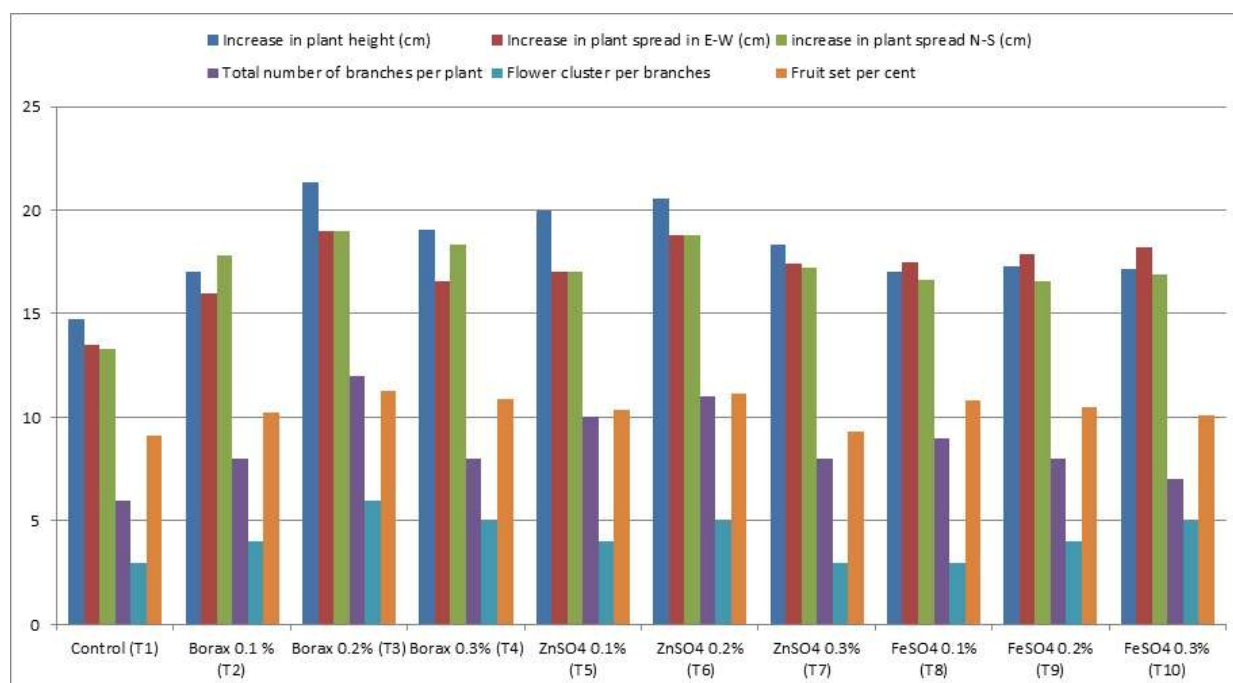
adequate nutrients to ensure the yield and quality of the harvest. Most of the time citrus growers are not giving proper emphasis to application of micronutrients, as they are required in minute quantities. This leads to a drastic decrease in growth and development of plants and it also affects the quality of fruits. So many approaches have been made by many researches for standardization of macro and micronutrients in many citrus species. However, very little work has been done for standardising the micronutrients requirement of lemon, which is an important and popular cultivar of lemon in North-Western region of India. It is thus necessary to standardize the concentration and time of application of micronutrients for improving the growth, yield and quality of lemon.

Materials and Methods

The field experiment entitled “Impact of Boron, Zinc and Iron on Growth, Yield and Quality of Lemon (*Citrus limon* L.) in Rainy Season” was conducted at Horticulture Farm,

Table-3 : Effect of different concentration of boron, zinc and iron on TSS (°Brix), Ascorbic acid (mg/100 g), Acidity (%), Ph Value and Juice content (%) in lemon.

Treatments	TSS (°Brix)	Ascorbic acid (mg/100 g)	Acidity (%)	pH value	Juice content (%)
Control (T ₁)	7.10	35.36	6.98	3.10	30.54
Borax 0.1% (T ₂)	7.32	41.42	6.82	2.60	30.97
Borax 0.2% (T ₃)	7.66	48.26	6.01	2.10	36.51
Borax 0.3% (T ₄)	7.44	44.54	6.54	2.20	34.10
ZnSO ₄ 0.1% (T ₅)	7.27	38.08	6.90	3.00	32.27
ZnSO ₄ 0.2% (T ₆)	7.52	47.32	6.09	2.20	36.05
ZnSO ₄ 0.3% (T ₇)	7.47	40.83	6.68	2.23	32.39
FeSO ₄ 0.1% (T ₈)	7.44	41.07	6.94	2.40	33.15
FeSO ₄ 0.2% (T ₉)	7.16	39.17	6.31	2.30	34.12
FeSO ₄ 0.3% (T ₁₀)	7.51	41.07	6.40	2.90	35.67
SEm±	0.104	0.473	0.077	0.022	0.406
CD @ 5%	0.31	1.40	0.23	0.07	1.20

**Fig-1 : Effect of different concentration of boron, zinc and iron on increase of Plant height (cm), Plant spread (cm), Total number of branches per plant, Flower cluster per branches and Fruit set per cent in lemon.**

S.K.N. College of Agriculture, Jobner (Jaipur), Rajasthan during rainy season, 2020. The details of the experimental techniques, materials used and criteria adopted for the evaluation of treatments during the entire course of investigation are described in this chapter.

The experiment was carried out at Horticulture Farm, S.K.N. College of Agriculture, Jobner during Rainy season 2020. Geographically, Jobner is situated in Jaipur district of Rajasthan at 26° 05' North latitude, 75° 58' East longitude and an altitude of 427 metres above mean sea level. This region falls under agro-climatic zone-IIIa (Semi-Arid Eastern Plains).

The climate of Jobner is typically semi-arid and characterized by aridity of the atmosphere, scarcity of water with extremes of temperature both in summer and winter season. Maximum temperature in summer season ranges between 20.04 to 37.3° C whereas, in winter, it falls down to as low as -1° C. The average annual rainfall varies between 118.5 mm to 250 mm, most of which is received in rainy season from July to September. Wells and tube wells are the only sources of irrigation. Water table is quite deep (about 80-100 m depth). The mean weekly weather parameters for the crop growing season recorded at the meteorologically observatory of the Agronomy Farm, S.K.N. College of Agriculture, Jobner

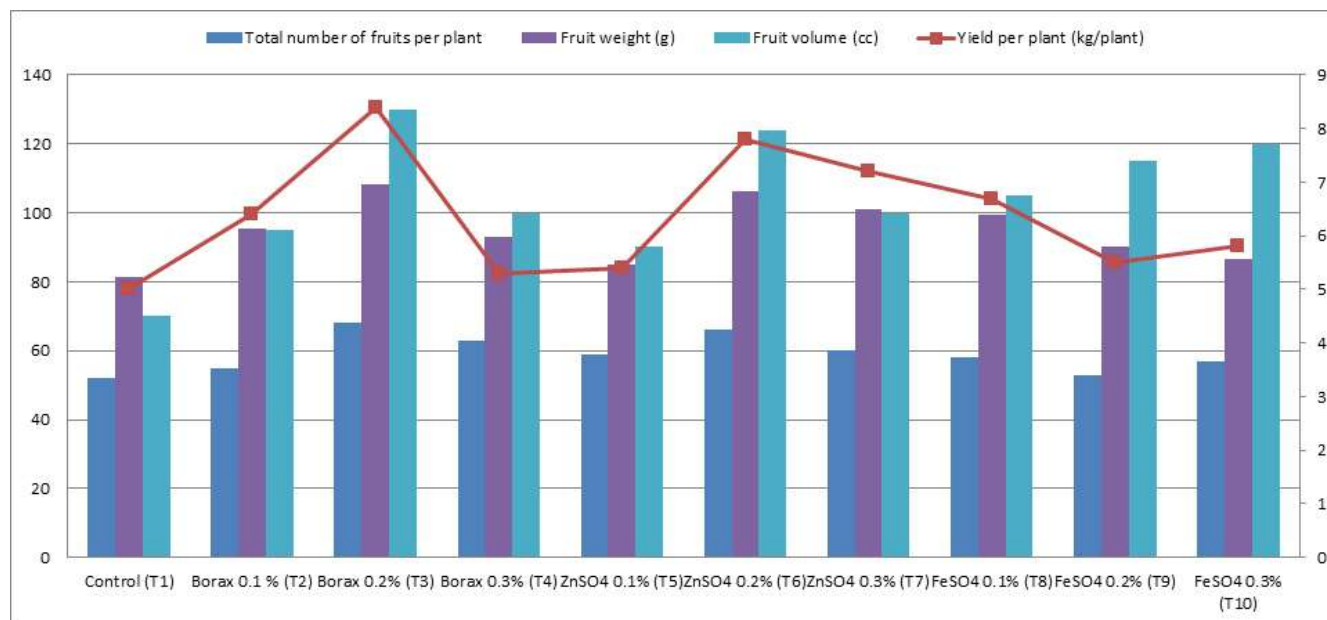


Fig-2 : Effect of different concentration of boron, zinc and iron on Total number of fruits per plant, Yield per plant (kg/plant), Fruit weight (g) and Fruit volume (cc) in lemon.

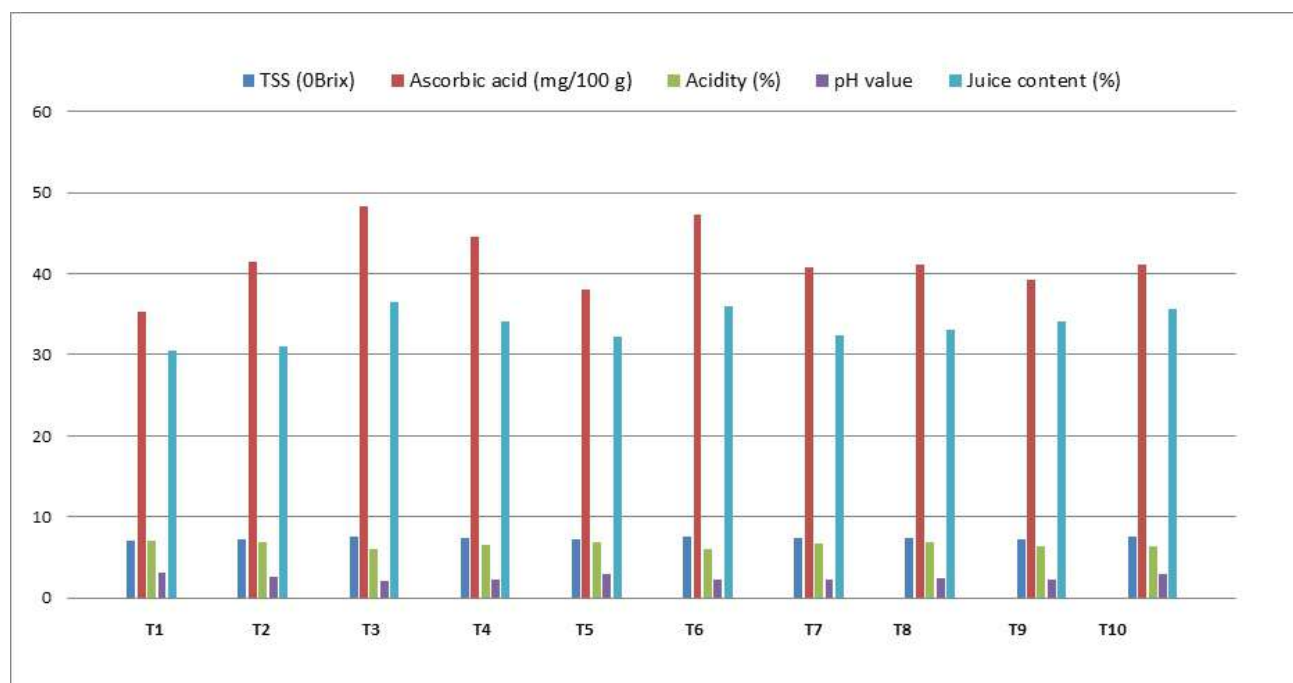


Fig-3 : Effect of different concentration of boron, zinc and iron on TSS (°Brix), Ascorbic acid (mg/100 g), Acidity (%), Ph Value and Juice content (%) in lemon.

are presented in Table-1 and graphically depicted in Fig-1.

To a certain physico-chemical characteristics of the soil during experimentation, soil samples from 0-15 cm depth were collected from different locations of the experimental field before application of manures and fertilizers. A representative composite sample was prepared by processing and mixing them together and

analysed to determine physical and chemical properties. The standard procedure used for analysis are presented in Table 3.2 showed that the soil was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon (0.16%) with low available nitrogen (146.60 kg/ha), phosphorus (18.50 kg/ha) and sulphur (8.40 kg/ha) and medium in potassium (155.50 kg/ha) status. Water of this area is partially saline in nature. The pH and Ec of water are 8.1 and 2.9 ds/m, respectively.

The present experiment was conducted on thirty healthy and uniform plants Pant-C1 cultivar (it bears fruits in cluster, fruit size large as kinnow and bears fruit throughout the years) of lemon trees of 3 year age which were used as study material. The fruit plants were planted according to square system at 6m × 6m distance. The experimental trees were located at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Jaipur), Rajasthan and subjected to the uniform cultural practices such as irrigation, weeding, insect pest and disease control and a single tree was used as a single treatment unit, replications are three.

For foliar application of B, Zn and Fe as single nutrients were dissolved in required quantity of water. The boron was applied through Folibor containing 20 per cent boron, Zn was applied through ZnSO₄ containing 36 per cent zinc and iron was given through FeSO₄ containing 19 per cent iron. The spraying was done in the morning hours 1st at flowering and 2nd at 30 days after first spray (peach size of fruit). Few drops of teepol were mixed with the spray solution as a surfactant. Spraying was done by Knapsack sprayer @ 2 liter / plant. The control, plants were sprayed with distilled water.

Results and Discussion

The data recorded for various parameters are statistically analyzed, their mean value are presented in Table 1-3.

Vegetative parameters : In table-1 and Fig.-1 it is clear that the application of borax spray 0.2 per cent (T₃) resulted into maximum increase in plant height (21.34 cm) and minimum (14.76 cm) was under control. Maximum increase in plant spread in East-West direction (19.00 cm) and in North-South direction (19.02 cm) recorded under T₃ treatment i.e. borax 0.2 per cent and minimum in East-West direction (13.30 cm) & North-South direction (13.33 cm) increase in plant spread was recorded under control. Similarly the maximum (12) number of branches were observed under T₃ treatment i.e. borax 0.2 per cent and minimum (6) was under control. This change may be due to fact that boron, zinc and iron are chiefly involved in various biological functions (photosynthesis, nitrogen assimilation and respiration), physiological (sugar translocation, formation of auxin) and metabolic process of tree. They help in cell division, elongation and growth of meristematic tissue and also due to enhanced photosyntheses which forced plant to produce higher vegetative growth. Role of boron on vegetative growth was also reported by Ullah *et al.* (2012), Rathore and Chandra (2002) in Acid lime and Meena *et al.* (2014) in aonla. The increase in vegetative growth due to spray of zinc was also reported by Supriya *et al.* (1993) in Assam lemon, Ram and Bose (2000) 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. Our findings related to iron spray was supported by Tagad *et al.* (2018) in acid lime, Bhanukar *et al.* (2018) in sweet orange and Pawar *et al.* (2019) in mandarin.

Yield parameters : In Table-2 and Fig.-2 shown that maximum number of flower cluster (6) and fruit set per cent (11.29%) was recorded under T₃ treatment i.e. borax 0.2 per cent and minimum flowers cluster per branch (3) and fruit set per cent (9.13%) was recorded under control. The maximum numbers of fruits per plant (68), fruit yield per plant (8.4 kg/plant) and per hectare yield (23.26 q/ha) were observed with borax 0.2 per cent (T₃) and minimum number of fruits per plant (52), fruit yield per plant (5.2 kg/plant) and per hectare yield (14.40 q/ha) were recorded under control. The maximum fruit weight (108.4 g), fruit volume (130 cc) were recorded under T₃ treatment i.e. borax 0.2 per cent, and minimum fruit weight (81.21 g), fruit volume (70 cc) was recorded under control. This influence might be due to fact that boron, zinc and iron helped in increase in chlorophyll content and leaf area which together have accelerate the photosynthesis rate that increase the supply of carbohydrates to the plant and finally increase the yield of plant. Similar findings in support of yield contributing character by Boaretto *et al.* (2002), Al-Obeed *et al.* (2018), Throat *et al.* (2018) and Meena *et al.* (2014) in Nagpur mandarin, Nirmaljit *et al.* (2015) in Kinnow and Kumar *et al.* (2018) in lemon.

Quality parameter : In Table-3 and Fig.-3 shown that the maximum (7.66 0B) TSS value was found under T₃ treatment i.e. borax 0.2 per cent which was statistically at par with T₆ but higher over T₁, T₂, T₄, T₅, T₇, T₈, T₉ and T₁₀. The per cent increase in TSS under the treatment T₂ is found to be 7.89 per cent, while minimum (7.10 0B) TSS was found under control. Maximum (48.26 mg/100 g) vitamin - C content was found under treatment T₃ i.e. borax 0.2 per cent which was statistically higher over T₁, T₂, T₄, T₅, T₇, T₈, T₉ and T₁₀. The per cent increase in vitamin-C content in T₃ treatment when compared with control was 36.40 per cent, while minimum (35.36 mg/100 g) TSS was recorded under control. The maximum (36.51%) juice percentage was observed under treatment T₃ i.e. borax 0.2 per cent which was higher over the T₁, T₂, T₄, T₅, T₇, T₈ and T₁₀ but statistically at par with T₆ and T₉. The per cent increase in juice content under T₃ and T₆ was 19.55 and 18.04 respectively when compared with control, while minimum (30.54%) juice content was recorded under control. Table clearly showed that the minimum (6.01%) acidity was recorded under treatment T₃ i.e. borax 0.2 per cent, which was statistically at par to T₆ treatment but lower than T₁, T₂, T₄, T₅, T₇, T₈, T₉ and T₁₀. The per

cent decrease in acidity under T_3 and T_6 is 13.89 and 12.75 when comparison made over control, while maximum (6.98%) acidity was recorded under control. The Table revealed that minimum (2.1) P^H was under T_3 treatment i.e. borax 0.2 per cent which was lower than the T_1 , T_2 , T_4 , T_5 , T_7 , T_8 , T_9 and T_{10} treatment but significantly at par with T_6 and T_4 treatment while maximum (3.1) PH was recorded under control. A decreased in acidity may be due to fact that the acids present in fruit are converted to sugars and its derivatives with maturity of fruits. The increase in juice percentage due to boron zinc and iron spray may also be responsible for decreased in acidity. Researchs results in agreement with Kumari *et al.* (2009), Aboutalebiamd Hassanzadeh (2013), Kaur *et al.* (2015) and Mohammed *et al.* (2018).

Conclusions

The best vegetative growth in terms of increase in plant height, increase in plant spread in N-S and E-W and total number of branches and best yield parameter in terms of number of flower clusters per branches, fruit set per cent, number of fruits per plant, yield per plant and expected yield per hectare and best quality parameter such as weight of fruit, volume of fruit, TSS ^{0} Brix, vitamin-C content, juice per cent, acidity of fruit and P^H value of fruits were recorded under 3rd treatment i.e. borax 0.2 per cent.

Based on the above findings, it could be recommended the lemon plant should be foliar sprayed with 0.2 per cent borax 1st at flowering and 2nd at peach size stage of fruit for better growth, yield and quality of lemon plant under Rajasthan conditions.

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Response of Bioagents as Soil Application in Eco-Friendly Management of Reniform Nematode (*Rotylenchulus reniformis*) in Cluster Bean (*Cyamopsis tetragonoloba* L.)

Deepak Kumar Rajvaniya¹, Lokesh Kumar^{2*}, Babita Jangir² and Balkesh Kumari³

¹Department of Nematology, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

²Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

³Department of Horticulture, Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan

*Corresponding Author Email : lokeshken9497@gmail.com

Abstract

The study was conducted to test the efficacy of botanicals to control the reniform nematode infecting cluster bean. Soil application of VAM @ 10 g/kg soil was the best treatment followed by *Pochonia chlamydosporia* @ 10 g/kg soil and *Metarhizium anisopliae* @ 10 g/kg soil in improving plant growth of cluster bean and reducing reproduction of reniform nematode. Seed treatment with botanicals, Aak @ 15% w/w was the best treatment followed by Water hyacinth @ 15% w/w and Lantana @ 15% w/w in terms of improving plant growth of cluster bean and reducing reproduction of reniform nematode.

Key words : Reniform nematode; *Rotylenchulus reniformis*; cluster bean; botanicals; soil application.

Introduction

Pulses occupy a unique position in every known system of farming all over the world, India is a premier pulse growing country of the world. The pulses form an integral part of the cropping system all over the country because these crops are fit well in the crop rotation. Pulses, also called legumes in many parts of the world, are the edible grains of pod bearing plants belonging to the family Leguminosae. Pulses occupy an important position in human dietary, being a good source vegetable protein (17-43%) and supplement to cereal based diet (Swaminathan, 1974). Indian population depends greatly on pulses to meet its demand for protein. Legumes are considered as a "Poor man's meat". Cluster Bean (*Cyamopsis tetragonoloba* L.) popularly known as Guar, Guarphalli, Chavali etc, is being cultivated in India since ancient time for various purposes viz., vegetable, green fodder, green manuring and seeds. Being a leguminous crops, it is comparatively more drought hardy which is grown during rainy season in semiarid and arid regions of India. In recent years, besides its conventional uses, it has emerged as an industrial crop due to presence of natural hydrocolloids (galactomannan). The guar seed consists of three parts seed coat (14 -17%), endosperm (35-42%) and germ (43-47%). The spherical shaped endosperm contains 28-33% gum (Goldstein and Alter, 1959). Guar gum is a natural nano-particle and its derivatives are used as crucial ingredients in about 98 products over diversified applications. Guar gum is used as an important ingredient in producing food emulsifier, food additive, food thickener, gelling filming agent and non - calorific fibrous food.

Industrially it is used in cosmetics, mining, petroleum drilling, printing, mining, textile, explosive, firefighting, pharmaceutical (Wong and Parmar, 1997). Guar meal or by-products after gum extraction is a rich source of proteins, minerals and fibres with high digestibility are being a feed for livestock including fishery, as it contains more than 42% protein against 31% in guar seed. Cluster bean also adds to the fertility of soil by fixing considerable amount of nitrogen (Nagar and Meena, 2004). India accounts about 80% of the world guar production. Guar mainly grown in India (Rajasthan, Haryana, Gujarat, Punjab), Pakistan, Sudan and USA. In Rajasthan, cluster bean mainly grown in Bikaner, Sri Ganganagar, Udaipur, Jalore, Sikar, Churu and Jodhpur districts. Cultivation of Cluster bean is being popular in southern Rajasthan due to suitability of its cultivation under rainfed condition and good market price. Total area under the crop in India was 4.26 million hectare with annual production of 2.42 million tonnes and productivity of 567 kg ha⁻¹. (Anonymous, 2019). In Rajasthan, total area under cluster bean is 45.10 lac ha and production is 20.23 lac tonnes. However, the productivity of cluster bean in Rajasthan is only 447 kg ha⁻¹ which is far below than its potential yield 1400 kg ha⁻¹. More than 95% of area of cluster bean is under rainfed conditions (Anonymous, 2019). The crop of such an immense economic value is prone to attack by several pests and disease (aphid, white fly, jassids, blight, powdery mildew etc.) including plant parasitic nematode (Sitaramaiah *et al.*, 1971 and Rao *et al.*, 2007). Several plant parasitic nematodes viz., *Meloidogyne incognita*, *M. javanica*, *Rotylenchulus reniformis*, *Helicotylenchus incises*, *Pratylenchus delatrei*, *Tylenchorhynchus*

capitatus, *Xiphinema* sp., *Tylenchus* sp., *Criconea* sp. and *Aphelenchus* sp. have been found associated with cluster bean in India and abroad (Bishnoi and Yadav, 1989). Linford and Oliveira (1940) reported and described reniform nematode, *Rotylenchulus reniformis*, for the first time from the root of cowpea grown in pineapple field in the Island of Ohio, Hawaii (U.S.A.). In India it was first reported by Siddiqui and Basir (1959) on the roots of coffee from South India. Swarup *et al.* (1967) were the first to discover reniform nematode from the Rajasthan state. Since then, several important crops have been recorded as its host in India. Reniform nematode, *Rotylenchulus reniformis* received greater attention due to its polyphagous nature, cosmopolitan distribution and adaptability to adverse condition. The reniform nematode attacks over 140 species of more than 115 plant genera in 46 families (Jatala, 1991). The losses to Indian Agriculture due to nematodes are estimated about Rs. 120 crore annually (Jain *et al.*, 2007).

To manage the nematode through chemicals proved effectively but due to their hazardous effects and non-judicious use have enhanced the development of biological control strategies for integrated management of plant parasitic nematodes with various types of antagonistic organisms (Jatala, 1986). The bio-agents *Paecilomyces lilacinus*, *Pochonia chlamydosporia* and *Trichoderma harzianum* have been reported to be effective fungal parasites of nematodes (Khan, 1986). The plant extract of neem (*Azadirachta indica*), garlic (*Allium sativum*), sadabahar (*Vinca rosea*), aloe vera (*Aloe barbadense*), leaves and seeds of jatropha (*Jatropha curcas*), onion (*Allium cepa*) and aak (*Calotropis gigantea*) have the nematicidal properties and they not only reduce the nematode population but also enhance the plant growth (Hussain *et al.*, 2011). So far substantial work has been done on various aspects of reniform nematode, *Rotylenchulus reniformis* on cluster bean but there is not much information available on ecofriendly management of reniform nematode through biological agents and botanicals. Keeping in view, the present study “Ecofriendly management of reniform nematode (*Rotylenchulus reniformis*) infecting cluster bean (*Cyamopsis tetragonoloba* L.)” was conducted at Department of Nematology, RCA, Udaipur with above mentioned objectives.

Materials and Methods

The present investigation entitled “Eco-friendly management of reniform nematode (*Rotylenchulus reniformis*) infecting cluster bean (*Cyamopsis tetragonoloba* L.)” was conducted at Department of Nematology, RCA, Udaipur. The present study was conducted during March to June, 2021 at Department of

Nematology, RCA, MPUAT, Udaipur. Udaipur lies under sub-humid southern plain and Aravalli hills of Rajasthan (IVA). During the year 2021 it received annual average rainfall 636.4 mm while temperature maximum 43°C minimum 16°C were recorded. The agro-climatic condition of Rajasthan supporting for the growing of vegetables, pulses and oil seed crops. The Reniform nematode, *Rotylenchulus reniformis* has been found more frequently associated with cluster bean (*Cyamopsis tetragonoloba* L.) and which results for severe economic losses. Therefore, it is necessary to develop technology or some practice for the management of reniform nematode (*Rotylenchulus reniformis*) in cluster bean. To fulfill this objective, present investigation were carried out to checkout the efficacy of bioagent as soil application viz., Vesicular Arbuscular Mycorrhiza, *Metarhizium anisopliae*, *Pochonia chlamydosporia* and *Trichoderma viride* (as standard check) against reniform nematode infecting cluster bean. The experiments were carried out to check the efficacy of different management practices. Reniform nematode (*Rotylenchulus reniformis*) has been discovered more commonly linked with cluster bean (*Cyamopsis tetragonoloba* L.) causing substantial economic losses. As a result, some eco-friendly method for the management of reniform nematode is required. To determine the efficiency of bioagents as a soil application against Reniform nematode, *Rotylenchulus reniformis* on cluster bean, the experiment was set up in pots filled with *Rotylenchulus reniformis* infested soil with an initial inoculum of four larvae per gram soil collected from the pure culture field. Bioagents such as Vesicular Arbuscular Mycorrhizal, *Metarhizium anisopliae* and *Pochonia chlamydosporia* were applied to the soil at 2.5, 5.0 and 10 g/kg soil. For comparison of experiment results, a standard check (*Trichoderma viride*) and an untreated check were kept. The bioagents were well mixed with FYM before being added to the soil. The experiment was carried out in a completely randomised design with 3 replications of each treatment. From sowing to harvest, every precaution was taken to ensure that the plants grew and developed properly. Ten days after planting, one healthy plant in each pot was maintained and watered on a regular basis, and when needed, cluster bean plants were harvested 45 days later. At harvest, observations were taken out of shoot length, shoot weight, root length, root weight and the number of nodules per plant. The roots were then thoroughly cleaned in tap water prior to getting stained with 0.1 percent acid fuchsin in lacto phenol and kept for 24 hours in lactophenol. Following that, the root was extensively examined under a stereoscopic binocular microscope to count the number of females per plant, the number of egg masses per plant, and the number of eggs and larvae per egg mass, as well as the final nematode

Table-1 : Efficacy of bioagents as soil application against reniform nematode infecting.

Treatments	Shoot length (cm)	Rootlength (cm)	Shoot weight (g)	Root weight (g)	No. of nodules	No. of female / plant	No. of egg masses/ plant	No. of eggs and larvae/egg mass	Final nematode population/200 cc soil
(T ₁) VAM at 2.5 g/kg soil	26.00 (26.83)	11.50 (36.90)	8.50 (21.42)	5.10 (58.52)	30.00 (9.76)	22.67 (16.07)	20.00 (24.98)	61.00 (21.79)	601.00 (25.89)
(T ₂) VAM at 5.0 g/kg soil	40.50 (97.56)	15.75 (87.50)	14.75 (110.71)	8.40 (147.05)	34.33 (25.61)	18.00 (33.33)	17.00 (36.32)	41.00 (47.43)	471.67 (41.84)
(T ₃) VAM at 10 g/kg soil	55.00 (168.29)	24.00 (185.71)	24.00 (242.85)	10.60 (211.76)	38.00 (39.04)	12.33 (54.33)	11.00 (58.75)	35.67 (54.28)	324.33 (60.00)
(T ₄) Metarhizium anisopliae at 2.5 g/kg soil	22.75 (10.98)	9.50 (13.09)	7.20 (2.85)	3.80 (11.76)	27.67 (1.24)	24.67 (8.66)	22.33 (16.24)	72.33 (7.26)	731.00 (9.86)
(T ₅) Metarhizium anisopliae at 5.0 g/kg soil	31.25 (52.44)	12.20 (45.23)	10.75 (53.57)	6.75 (98.52)	31.67 (15.87)	20.33 (24.70)	19.00 (28.75)	53.33 (31.62)	560.00 (30.64)
(T ₆) Metarhizium anisopliae at 10 g/kg soil	45.75 (123.17)	20.50 (144.04)	18.50 (164.28)	9.00 (164.70)	36.00 (31.72)	16.00 (40.74)	15.00 (43.75)	38.33 (50.85)	406.00 (49.89)
(T ₇) Pochonia chlamydosporium at 2.5 g/kg soil	24.20 (18.05)	10.50 (25.00)	7.94 (13.42)	4.32 (27)	29.33 (7.31)	23.33 (13.59)	21.00 (26.95)	66.33 (14.96)	681.00 (16.02)
(T ₈) Pochonia chlamydosporium at 5.0 g/kg soil	35.50 (73.17)	13.50 (60.71)	12.00 (71.42)	7.50 (120.58)	33.00 (20.74)	19.33 (28.40)	17.00 (36.23)	47.33 (39.32)	500.00 (38.34)
(T ₉) Pochonia chlamydosporium at 10g/kg soil	50.25 (145.12)	22.30 (165.47)	23.50 (235.71)	9.95 (192.64)	36.67 (34.17)	14.67 (45.70)	13.00 (51.23)	38.00 (51.28)	352.33 (56.55)
(T ₁₀) Trichoderma viride at 10 g/kg soil (standard check)	57.50 (180.48)	25.24 (200.00)	24.40 (248.57)	11.00 (223.52)	39.33 (43.90)	10.67 (60.51)	9.33 (65.00)	33.33 (57.26)	318.00 (60.78)
(T ₁₁) Untreated check	20.50	8.43	7.00	3.40	27.33	27.00	26.67	78.00	811.00
SEm±	1.71	0.76	0.71	0.30	1.46	0.77	0.78	2.48	21.42
CD at 5%	5.03	2.23	2.08	0.89	4.28	2.26	2.28	7.28	62.82
CV (%)	7.98	8.35	8.51	7.26	7.66	7.04	7.75	8.38	7.09

Initial Nematode population: 615 pre adults/200cc soil. Crop variety: Milan-51

Data are the avg. value of 3 replications. Values in parentheses are % increase (Plant Growth Characters) / decrease (Nematode Reproduction) over control.

population per 200 cc soil. Remove all traces of the plant from each pot, the soil was well mixed and 200 cc from each pot was analysed using Cobb's sieve and decanting technique, followed by Baremann's funnel technique for nematode population estimation in soil.

Results and Discussion

The results of experiment showed that the different using bioagents viz., Vesicular Arbuscular Mycorrhiza, *Metarhizium anisopliae*, *Pochonia chlamydosporia* and *Trichoderma viride* (standard check) had significantly reduced the number of egg masses/plant, number of eggs and larvae/egg mass, number of females/plant and final nematode population/200cc soil and considerably increase the shoot and root length, shoot and root weight and number of nodules/plant of cluster bean. Among all bioagents, Vesicular Arbuscular Mycorrhiza was found best as compare to *Metarhizium anisopliae* and *Pochonia chlamydosporia* for the management of *Rotylenchulus reniformis* on cluster bean. However, all the treatments were found much superior over untreated check.

Shoot length (cm) : Data revealed that all the bioagents applied increased the shoot length significantly as compared to untreated check (control). Result also showed that higher dose of bio-agents i.e. 10g/ kg soil were found more effective than lower doses i.e. 2.5 g/kg of soil. The significant higher increase in shoot length was observed with VAM @ 10 g/kg soil (55.00 cm) followed by *Pochonia chlamydosporia* @ 10 g/kg soil (50.25 cm) and *Metarhizium anisopliae* @ 10 g/kg soil (45.75 cm). However, the maximum shoot length was recorded with standard check i.e. *Trichoderma viride* @ 10 g/kg soil (57.50 cm) while minimum shoot length (20.50 cm) was recorded with untreated check. Results illustrated the maximum increase shoot length (168.29%) was with the application VAM @ 10 g/kg soil followed *Pochonia chlamydosporia* @ 10 g/kg soil (145.12%) and *Metarhizium anisopliae* @ 10 g/kg soil (123.17%) over untreated check. It was observed to be minimum (10.98%) with *Metarhizium anisopliae* when applied at 2.5 g/kg soil. Among all the treatments, highest increase shoot length (180.48%) was recorded with *Trichoderma viride* (standard check) at 10 g/kg soil.

Root length (cm) : Data revealed that all the bioagents applied increased the root length significantly as compared to untreated check. Result also showed that higher doses of bioagents i.e. 10 g/kg soil were found more effective than lower doses i.e. 2.5 g/ kg soil. The significant higher increase in root length was observed with VAM @ 10 g/kg soil (24.00 cm) followed by *Pochonia chlamydosporia* @ 10 g/kg soil (22.30 cm) and *Metarhizium anisopliae* @ 10 g/kg soil (20.50 cm). However, the maximum root length was recorded with

standard check i.e. *Trichoderma viride* (25.24 cm) while minimum root length (8.40 cm) was recorded with untreated check. Results showed that maximum increase root length with the application of VAM @ 10 g/kg soil (185.71%) followed *Pochonia chlamydosporia* @ 10 g/kg soil (165.47%) and *Metarhizium anisopliae* @ 10 g/kg soil (144.04%) over untreated check. It was observed to be minimum (13.09%) with *Metarhizium anisopliae* when applied at 2.5 g/kg soil. However, highest increase in root length (200%) was estimated to be when soil were treated with *Trichoderma viride* at 10 g/kg soil.

Shoot weight (g) : Data revealed that all the bioagents applied increased the shoot weight significantly as compared to untreated check. Result also showed that higher doses of bioagents i.e. 10 g/ kg soil were found more effective than lower doses i.e. 2.5 g/ kg soil. The significant increase in shoot weight was observed with VAM @ 10 g/kg soil (24.00 g) followed by *Pochonia chlamydosporia* @ 10 g/kg soil (23.50 g) and *Metarhizium anisopliae* @ 10 g/kg soil (18.50 g). However, the maximum shoot weight was recorded with standard check i.e. *Trichoderma viride* (24.40 g) while minimum shoot weight (7.00 g) was recorded with untreated check. Results revealed that seed treatment with VAM @ 10 g/kg soil (242.85%) followed *Pochonia chlamydosporia* @ 10 g/kg soil (235.71%) and *Metarhizium anisopliae* @ 10 g/kg soil (164.28%) over untreated check. It was observed that minimum (2.85%) shoot weight increased was found with *Metarhizium anisopliae* @ 2.5 g/kg soil. However, highest increase in shoot weight (248.57%) was observed when chickpea seed were treated with *Trichoderma viride* at 10 g/kg soil (standard check).

Root weight (g) : Data revealed that among bioagents applied increased the root weight significantly as compared to untreated check. Result also showed that higher doses of bioagents i.e. 10 g/ kg soil were found more effective than lower doses i.e. 2.5 g/ kg soil. The significant increase in root weight was observed with VAM @ 10 g/kg soil (10.60 g) followed by *Pochonia chlamydosporia* @ 10 g/kg soil (9.95 g) and *Metarhizium anisopliae* @ 10 g/kg soil (9.00 g). However, the maximum root weight was recorded with *Trichoderma viride* (11.00 g) while minimum root weight (3.40 g) was recorded with untreated check. Amongst various bioagents tested, maximum increase in root weight was observed VAM @ 10 g/kg soil (211.76%) followed *Pochonia chlamydosporia* @ 10 g/kg soil (192.64%) and *Metarhizium anisopliae* @ 10 g/kg soil (164.70%) over untreated check. Minimum increase in root weight (11.76%) was observed with *Metarhizium anisopliae* when applied @ 2.5 g/kg soil. Highest increase in root weight (223.52%) was obtained when soil were treated with *Trichoderma viride* @ 10 g/kg soil.

Number of nodules/plant : Data revealed that all the bioagents applied increased the number of nodules per plant significantly as compared to untreated check. Result also showed that higher doses of bioagents

i.e. 10 g/ kg soil were found more effective than lower doses *i.e.* 2.5 g/ kg soil. The significant higher increase in number of nodules per plant was observed with VAM @ 10 g/kg soil (38.00) followed by *Pochonia chlamydosporia* @ 10 g/kg soil (36.67) and *Metarhizium anisopliae* @ 10 g/kg soil (36.00). However, the maximum number of nodules per plant was recorded with standard check *i.e.* *Trichoderma viride* (39.33) while minimum number of nodules per plant (27.33) was recorded with untreated check. Results showed that maximum increase in number of nodules per plant (39.04%) was with the application of VAM @ 10 g/kg soil followed by *Pochonia chlamydosporia* @ 10 g/kg soil (34.17%) and *Metarhizium anisopliae* @ 10 g/kg soil (31.72%) over untreated check. It was observed to be minimum (1.24%) with *Metarhizium anisopliae* when applied at 2.5 g/kg soil. Among all the treatments highest increase in number of nodules per plant (43.90%) was recorded with *Trichoderma viride* @ 10 g/kg soil.

Number of egg masses per plant : The presence of egg masses per plant was determined by using standard methodology at time of crop harvest to determine the effect of different bioagents. Results showed that VAM @ 10 g/kg soil with (11.00) number of egg masses per plant was the better treatment followed by *Pochonia chlamydosporia* @ 10 g/kg soil (9.50) and *Metarhizium anisopliae* @ 10 g/kg soil (15.00). The highest reduction in number of egg mass was observed by standard check *Trichoderma viride* @ 10 g/kg soil (9.33) and lowest reduction was observed in untreated control (26.67). Results showed that maximum reduction (58.75%) in egg masses per plant were recorded with soil treatment of VAM @ 10 g/kg soil followed by *Pochonia chlamydosporia* @ 10 g/kg soil (51.23%) and *Metarhizium anisopliae* @ 10 g/kg (43.75%) soil over untreated check. Minimum reduction (15.29%) was observed with *Metarhizium anisopliae* @ 2.5 g/kg soil. However, on the whole highest reduction (65.00%) was recorded with *Trichoderma viride* (Standard check) when applied @ 10 g/kg soil.

Number of egg and larvae per egg mass : The presence of egg masses and larvae per egg mass was determined by using standard methodology at time of crop harvest to determine the effect of different bioagents. Results showed that VAM @ 10 g/kg soil with (35.67) number of eggs and larvae/egg mass was the better treatment followed by *Pochonia chlamydosporia* @ 10 g/kg soil (38.00) and *Metarhizium anisopliae* @ 10 g/kg soil

(38.33). The highest reduction in number of eggs and larvae per egg mass was observed by standard check *Trichoderma viride* @ 10 g/kg soil (33.33) and lowest reduction was observed in untreated control (78.00). Data pertaining that the maximum reduction (54.28%) in eggs and larvae per egg mass was recorded with soil treatment of VAM @ 10 g/kg soil followed by *Pochonia chlamydosporia* @ 10 g/kg soil (51.28%) and *Metarhizium anisopliae* @ 10 g/kg soil (50.85%). Minimum reduction (7.26%) was observed with *Metarhizium anisopliae* @ 2.5 g/kg soil. However, on the whole highest reduction (57.26%) was recorded with *Trichoderma viride* (Standard check) when applied @ 10 g/kg soil over untreated check.

Number of female per plant : The presence of females per plant was determined by using standard methodology at time of crop to determine the effect of different bioagents. Results showed that VAM @ 10 g/kg soil was the better treatment with (12.33) mean number of females /plant followed by *Pochonia chlamydosporia* @ 10 g/kg soil (14.67) and *Metarhizium anisopliae* @ 10g/kg soil (16.00). The highest reduction in the number of females was observed by standard check *Trichoderma viride* @ 10 g/kg soil (10.67) and lowest reduction was observed in untreated control (27.00). Maximum reduction in number of females per plant (54.33%) was obtained with VAM @ 10 g/kg soil followed by *Pochonia chlamydosporia* @ 10 g/kg soil (45.70%) and *Metarhizium anisopliae* @ 10 g/kg soil (40.74 %) over untreated check. Minimum reduction (8.66%) was obtained in *Metarhizium anisopliae* 2.5 g/kg soil. However, highest reduction females per plant (60.51%) were estimated in *Trichoderma viride* applied @ 10g/kg soil (standard check).

Final nematode population per 200cc soil : The final nematode population per 200cc soil was determined by using standard methodology at time of crop harvest to determine the effect of different bio- agents. Results showed that VAM @ 10 g/kg soil with (324) mean final nematode population/200cc soil was the better treatment followed by *Pochonia chlamydosporia* @ 10 g/kg soil (352) and *Metarhizium anisopliae* @ 10 g/kg soil (406). However highest reduction in the final nematode population was observed by standard check *Trichoderma viride* @ 10 g/kg soil (318) and lowest reduction was observed in untreated control (811). Data showed that highest reduction (60%) in nematode population was observed VAM @ 10 g/kg soil followed by *Pochonia chlamydosporia* @ 10 g/kg soil (56.55%) and *Metarhizium anisopliae* (49.89%) when applied 10 g/kg soil. Minimum reduction was noticed in *Metarhizium anisopliae* @ 2.5 g/kg soil (9.86%) over untreated check. Highest reduction (61%) @ 10 g/kg soil *Trichoderma viride* (standard check). The bioagents Vesicular

Arbuscular Mycorrhiza, *Metarhizium anisopliae* and *Pochonia chlamydosporia* used as soil application at 2.5, 5.0 and 10 g/kg soil and *Trichoderma viride* used as standard check at 10 g/kg soil to estimate superior bioagent with their dose for management of *Rotylenchulus reniformis* infecting cluster bean. In comparison to the untreated control, all bioagents were proven to be highly effective in improving plants growth and reducing *Rotylenchulus reniformis* reproduction. In comparison to *Pochonia chlamydosporia* and *Metarhizium anisopliae* 10 g/kg soil of bioagent Vesicular Arbuscular Mycorrhiza was shown to be the most efficient in improving plant growth. Further research on bioagents and their dosages revealed that bioagent Vesicular Arbuscular Mycorrhiza at 10 g/kg soil was the most efficient in improving plant growth and lowering *Rotylenchulus reniformis* nematode reproduction followed by *Pochonia chlamydosporia* and *Metarhizium anisopliae* at 10 g/kg soil over other treatments.

These findings are in agreement with the results of Youssef *et al.* (2020) who reported that *Metarhizium anisopliae* reduced nematode infection with subsequently improved plant growth and yield of cowpea. Similarly Baheti *et al.* (2015) reported that bioagents *P. Chlamydosporia* and *T. viride* at 4% w/w increase shoot weight, root weight and reduced the no. of cyst per 100 cc soil,

cyst per plant and final larvae population per 100 cc soil on sweet corn (*Zea mays* L. *Saccharata*). While Ramezani and Ebrahimi (2014) found that VAM fungus (*Glomus mosseae*) as soil application improved the plant growth and yield of sunflower and caused maximum reduction of nematode population in roots (65.1%) and soil (73.1%) and Khan *et al.* (2012) reported that *P. chlamydosporia* reduced *M. incognita* population in eggplant cv. Pusa Purple Round. Sivakumar (2009) reported that *Trichoderma viride* and *Pochonia chlamydosporia* effective fungal bioagent in increasing the yield and reducing *Rotylenchulus reniformis* nematode population on cotton cv. CU-5 and Gurjar *et al.* (2012) reported that application of bioagent *Pochonia chlamydosporia* at 2 g/kg soil improve plant growth characters and reducing the reniform nematode reproduction in soyabean. Mishra *et al.* (2003) found that *Trichoderma viride* has the potential to suppress nematode populations to about the same degree as other bioagents (*Aspergillus niger* and *Paecilomyces lilacinus*). While Rao *et al.* (2003) reported that *Pochonia chlamydosporia* formulation for the control of *M. incognita* on egg plants and combination of *V. chlamydosporium* and *Glomus fasciculatum* increased plant growth and reducing root galling as well as nematode population. Soil application of VAM was effective in reducing reniform nematode population by 80% and improved the growth of

seedlings in papaya var. 'CO.3' (Visalakshi *et al.*, 2003). Goswami and Mittal (2004) revealed that *Trichoderma viride* improve tomato plant growth and decreased the nematode population in Tomato. In the present investigation among dose, 10 g/kg soil for each bioagents was found most effective in reducing nematode reproduction over 2.5 g/kg soil. These finding are in agreement with Ramezani and Ebrahimi (2014) who reported significant increased the plant growth and reduction in final nematode population when treated with VAM fungus at higher level.

Conclusions

Soil application of VAM @ 10 g/kg soil was the best treatment followed by *Pochonia chlamydosporia* @ 10 g/kg soil and *Metarhizium anisopliae* @ 10 g/kg soil in improving plant growth of cluster bean and reducing reproduction of reniform nematode. Seed treatment with botanicals, Aak @ 15% w/w was the best treatment followed by Water hycianth @ 15% w/w and Lantana @ 15% w/w in terms of improving plant growth of cluster bean and reducing reproduction of reniform nematode.

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Eco-Friendly Management of Reniform Nematode (*Rotylenchulus reniformis*) Infecting Cluster Bean (*Cyamopsis tetragonoloba* L.)

Deepak Kumar Rajvaniya¹, Balkesh Kumari², Lokesh Kumar^{3*} and Babita Jagir³

¹Department of Nematology, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

²Department of Horticulture, Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan

³Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

*Corresponding Author Email : lokeshken9497@gmail.com

Abstract

The study was conducted to test the efficacy of botanicals to control the reniform nematode infecting cluster bean. Botanicals i.e. Aak (*Calotropis procera*), Lantana (*Lantana camara*), Water hyacinth (*Eichhornia crassipes*) were used as seed treatment (ST) @ 5%, 10% and 15% as leaves powder. A standard check (Neem at 10%) and untreated check was also maintained to interpretate experimental findings. The results revealed that Aak (*Calotropis procera*) significantly improve the plant growth parameters of cluster bean and reduced the infestation of reniform nematode (*Rotylenchulus reniformis*) infecting cluster bean compared to treatments.

Key words : Reniform nematode; *Rotylenchulus reniformis*; cluster bean; botanicals.

Introduction

Pulses occupy a unique position in every known system of farming all over the world, India is a premier pulse growing country of the world. Cluster Bean (*Cyamopsis tetragonoloba* L.) popularly known as Guar, Guarphalli, Chavali etc, is being cultivated in India since ancient time for various purposes viz., vegetable, green fodder, green manuring and seeds. Being a leguminous crops, it is comparatively more drought hardy which is grown during rainy season in semiarid and arid regions of India. India accounts about 80% of the world guar production. Guar mainly grown in India (Rajasthan, Haryana, Gujarat, Punjab), Pakistan, Sudan and USA. In Rajasthan, cluster bean mainly grown in Bikaner, Sri Ganganagar, Udaipur, Jalore, Sikar, Churu and Jodhpur districts. Total area under the crop in India was 4.26 million hectare with annual production of 2.42 million tonnes and productivity of 567 kg ha⁻¹. (Anonymous, 2019). Reniform nematode, *Rotylenchulus reniformis* received greater attention due to its polyphagous nature, cosmopolitan distribution and adaptability to adverse condition. The reniform nematode attacks over 140 species of more than 115 plant genera in 46 families (Jatala, 1991). The losses to Indian Agriculture due to nematodes are estimated about Rs. 120 crore annually (Jain *et al.*, 2007). To manage the nematode through chemicals proved effectively but due to their hazardous effects and non-judicious use have enhanced the development of biological control strategies for integrated management of plant parasitic nematodes with various types of antagonistic organisms (Jatala, 1986). So

far substantial work has been done on various aspects of reniform nematode, *Rotylenchulus reniformis* on cluster bean but there is not much information available on ecofriendly management of reniform nematode through biological agents and botanicals.

Materials and Methods

The management mechanism for *Rotylenchulus reniformis* on cluster bean was evolved through an experiment in pots. Pots filled with *Rotylenchulus reniformis* infested soil from the pure culture field. Botanicals i.e. Aak (*Calotropis procera*), Lantana (*Lantana camara*) and Water hyacinth (*Eichhornia crassipes*) were applied as leaves powder at 5%, 10%, and 15%. For comparison with the experimental findings, a standard check Neem (*Azadirachta indica*) and an untreated check were kept. A weighed quantity of seeds (100 g) was placed in a beaker with a few drops of gum and continuously swirled with a glass rod, afterwards the appropriate quantity of botanicals was added and well mixed to disseminate the botanicals evenly over the seeds. Before planting, the initial nematode population was determined. The experiment was set up in a completely randomised manner, with each treatment replicated three times. From the time of seeding through the time of harvest, great care was taken to ensure that the plants grew and developed properly. After ten days of planting, one healthy plant was maintained in each pot, which was watered as needed. After 45 days after planting, the plants were harvested.

At harvest, parameters were measured of shoot

length, root length and number of nodules per plant. Final nematode population/200cc soil were counted using a stereoscopic binocular microscope. After the plant was removed from the pots, the soil was properly mixed and 200cc of each pot was collected and analysed using Cobb's sifting and decanting procedure. For nematode population estimate in soil, Baremann's funnel technique was being used.

Results and Discussion

The trial was conducted to study the effect of different botanicals as seed treatment on plant growth characters and reproduction of reniform nematode on cluster bean. For this study, on the basis of the preliminary studies conducted botanicals viz., Aak (*Calotropis procera*), Lantana (*Lantana camara*), Water hyacinth (*Eichhornia crassipes*) and botanicals will be applied 5%, 10%, 15% w/w as leaves powder as seed treatment and one untreated check and one standard check i.e., neem leaf powder @ 10% w/w as seed treatment were also maintained. Data revealed that all the botanicals applied increased the shoot length significantly as compared to untreated check. The significant increase in shoot length was observed with aak @ 15% w/w (54.50 cm) followed with water hyacinth @ 15% w/w (49.50 cm) and Lantana @ 15% w/w (44.75 cm). However, the maximum shoot length was recorded in standard check with neem @ 10% w/w (56.50 cm) while minimum shoot length (19.50 cm) was recorded with untreated check. Data showed that all the botanicals maximum increase in shoot length (179.48%) was with the seed treatment aak @ 15% w/w (179.48) followed by water hyacinth (153.84%) @ 15% w/w and lantana (129.48%) @ 15% w/w over untreated check. It was observed to be minimum (12.82%) with lantana when applied at 5 % w/w. Highest increase in shoot length (189.74 %) was recorded with neem (standard check) @ 10 % w/w. Data revealed that among the botanicals applied increased the root length significantly as compared to untreated check. The significant higher increase in root length was observed with aak @ 15% w/w (23.00 cm) followed by water hyacinth @ 15% w/w (21.30 cm) and lantana @ 15% w/w (19.75 cm) over untreated check. It was observed to be minimum (12.82%) with lantana when applied at 5.0% w/w. However, the maximum root length was recorded in standard check with neem @ 10% w/w (24.20 cm) while minimum root length (7.40 cm) was recorded with untreated check. Results illustrated through the seed treatment with aak @ 15% w/w (210.81%) followed by water hyacinth (187.83%) @ 15 %w/w and lantana (166.89%) @ 15% w/w over untreated check. The highest increase in root length (227.02%) with neem @ 10% w/w (standard check), However, minimum increase in root

length (21.62%) with lantana when applied at 5% w/w. Data revealed that all the botanicals applied increased the shoot weight significantly as compared to untreated check. The significant higher increase in shoot weight was observed with aak @ 15% w/w (23.10 g) followed with water hyacinth (22.50 g) w/w and lantana @ 15% w/w (17.25 g). However, the maximum shoot weight was recorded in standard check with neem @ 10% w/w (23.40 g) while minimum shoot weight (6.00 g) was recorded with untreated check. Results showed through revealed that with seed treatment aak @ 15% w/w (285%) increase shoot weight to the tune of followed by water hyacinth @ 15% w/w (275%) and lantana @ 15% w/w (187.50%) over untreated control. It was observed that minimum increase in shoot weight (12.5%) with lantana when applied at 5% w/w. However, highest increase in shoot weight (290%) was observed when cluster bean seed were treated with neem at 10% w/w as standard check. Data revealed that all the botanicals applied increased the root weight significantly as compared to untreated check. The significant higher increase in root weight was observed aak @ 15% w/w (9.75 g) followed with water hyacinth @ 15% w/w (9.00 g) and lantana @ 15% w/w (8.00 g). However, the maximum root weight was recorded in standard check with neem @ 10% w/w (10.00 g) while minimum root weight (2.50 g) was recorded with untreated check. Amongst various botanicals maximum increase in root weight was observed with seed treatment aak @ 15% w/w (290%) increase shoot weight to the tune of followed by water hyacinth @ 15% w/w (260%) and lantana @ 15% w/w (220%) over untreated control. Minimum increase in root weight (20%) with lantana when applied at 5% w/w. Highest increase in root weight (300%) was obtained when cluster bean seeds were treated with neem @ 10% w/w (standard check). Data observed that among the botanicals applied increased the number of nodules per plant significantly as compared to untreated check. The significant higher increase in number of nodules/plant was observed with aak @ 15% w/w (37.33) followed with water hyacinth 15% w/w (36.00) and lantana @ 15% w/w (34.66). However, the maximum number of nodules/plant was recorded in standard check with neem @ 10% w/w (38.99), while minimum number of nodules/plant (26.00) was recorded with untreated check. Data pertaining the maximum number of nodules/plant were recorded in seed treatment with aak @ 15% w/w (43.57%) increase shoot weight to the tune of followed by water hyacinth @ 15% w/w (38.46%) and lantana @ 15% w/w (33.30%) over untreated control. While it was minimum (5.11%) in seed treated with lantana @ 5% w/w and highest was recorded (49.96%) seed treated with neem @ 10% w/w as standard check. Data revealed that all the botanicals applied as seed treatment decrease the egg masses significantly as

Table-1 : Efficacy of botanicals as seed treatment against Reniform Nematode.

Treatments	Shoot length (cm)	Root length (cm)	Shoot weight (g)	Root weight (g)	No. of nodules	No. of female/plant	No. of egg masses/plant	No. of eggs and larvae/egg mass	Final nematode population/200 cc soil
(T ₁) Aak at 5%	25.00 (28.20)	11.00 (48.64)	7.50 (25.00)	4.20 (68.00)	30.00 (15.34)	23.67 (15.50)	21.00 (21.25)	62.00 (21.50)	610.00 (25.06)
(T ₂) Aak at 10%	40.00 (105.12)	14.75 (99.32)	14.50 (141.66)	7.50 (200.00)	33.00 (26.92)	19.00 (32.17)	17.33 (35.02)	42.00 (46.84)	471.33 (42.09)
(T ₃) Aak at 15%	54.50 (179.48)	23.00 (210.81)	23.50 (285.00)	9.75 (290.00)	37.33 (43.57)	13.33 (52.39)	12.00 (55.00)	36.67 (53.58)	325.00 (60.07)
(T ₄) Lantana camera at 5%	22.00 (12.82)	9.00 (21.62)	6.75 (12.50)	3.00 (20.00)	27.33 (5.11)	25.33 (9.53)	23.33 (12.52)	75.00 (5.05)	733.00 (9.95)
(T ₅) Lantana camera at 10%	30.42 (56.41)	11.75 (58.78)	10.00 (66.66)	6.00 (140.00)	31.67 (21.76)	21.00 (25.03)	19.67 (26.24)	55.33 (29.95)	561.00 (31.08)
(T ₆) Lantana camera at 15%	44.75 (129.48)	19.75 (166.89)	17.25 (187.50)	8.00 (220.00)	34.67 (33.30)	17.00 (39.28)	15.33 (42.51)	40.00 (49.36)	406.00 (50.12)
(T ₇) Water hyacinth at 5%	23.20 (18.97)	9.50 (28.37)	6.94 (15.66)	3.50 (40.00)	28.33 (8.96)	24.33 (13.10)	22.00 (17.51)	68.00 (13.91)	686.00 (15.72)
(T ₈) Water hyacinth at 10%	34.50 (76.92)	12.75 (72.29)	11.25 (87.50)	6.75 (170.00)	32.00 (23.07)	20.00 (28.57)	18.00 (32.50)	48.33 (38.81)	502.00 (38.32)
(T ₉) Water hyacinth at 15%	49.50 (153.84)	21.33 (187.83)	22.50 (275.00)	9.00 (260.00)	36.00 (38.46)	15.33 (45.25)	14.33 (46.26)	39.00 (50.62)	356.00 (56.26)
(T ₁₀) Neem at 10% (standard check)	56.50 (189.74)	24.20 (227.02)	23.44 (290.00)	10.00 (300.00)	39.00 (49.96)	11.33 (59.53)	10.67 (59.99)	34.00 (56.95)	320.00 (60.68)
(T ₁₁) Untreated check	19.50	7.40	6.00	2.50	26.00	28.00	26.67	79.00	814.00
SEm±	1.66	0.71	0.65	0.28	1.45	0.93	0.80	2.57	24.00
CD at 5%	4.88	2.09	1.91	0.81	4.26	2.74	2.36	7.54	70.38
CV (%)	7.93	8.27	8.29	7.48	7.79	8.15	7.65	8.45	7.90

compared to untreated check. The significant higher decrease in egg masses was observed with aak @ 15% w/w (11.99) followed with water hyacinth @ 15% w/w (14.33) and lantana @ 15 % w/w (15.33). However, the minimum egg masses was recorded in standard check with neem @ 10% w/w (10.66) while maximum egg masses (26.67) was recorded with untreated check. Data pertaining number of egg mass per plant that the maximum reduction was recorded with seed treatment aak @ 15% w/w (56.65%) increase egg masses to the tune of followed by water hyacinth (48.19%) @ 15% w/w and lantana (44.57%) @ 15% w/w over untreated control. Minimum reduction was observed with lantana (15.65%) @ 5% w/w. However, on the whole highest reduction (61.40%) was recorded with neem (standard check) when apply @ 10% w/w over untreated. The presence of egg masses/plant was determined by using standard methodology at time of crop harvest to determine the effect of different botanicals. Results showed that aak @ 15% w/w with (36.66) number egg and larvae/egg masses was the better treatment followed by water hyacinth @ 15% w/w (39.00) and lantana @ 15% w/w (40.00). However the highest reduction in number of egg and larvae/egg mass was observed by the seed treatment of neem @ 10% w/w (34.00) and lowest reduction was observed in untreated check (78.99). Results showed that maximum reduction (53.58%) in eggs and larvae per mass were recorded with seed treatment of aak @ 15% w/w followed by water hyacinth (50.62%) @ 15% w/w and lantana (49.36%) @ 15% w/w over untreated control. Minimum reduction (5.05%) was observed with lantana @ 5% w/w. However, on whole highest reduction (56.95%) was recorded with neem (standard check) when applied @ 10% w/w over untreated check. The presence of females per plant was determined by using standard methodology at time of crop harvest to determine the effect of different botanicals. Results show that aak @ 15% w/w with (13.33) mean number of females/plant was the better treatment followed by water hyacinth (15.33) and lantana @ 15% w/w (17.00). However highest reduction in number of females was observed by the standard check neem @ 10% w/w (11.33) and lowest reduction observed in untreated control (28.00). Maximum reduction in number of females/plant (52.39%) was obtained with aak @ 15 % w/w followed by water hyacinth @ w/w (45.25%) and lantana @ 15% w/w (39.28%) over untreated check. Minimum reduction (9.53%) was obtained with lantana @ 5% w/w. While maximum number of females/plant (59.53%) was estimated with neem @ 10% w/w (standard check). Data revealed that among the botanicals applied as seed treatment decrease the nematode population significantly as compared to untreated check. The significant higher decrease in

nematode population was observed with aak @ 15% with (325) nematode population was the better treatment followed by water hyacinth @ 15% w/w (356) and lantana @ 15% w/w (406). However, the minimum nematode population were recorded in standard check with neem @ 10% w/w (320) while maximum nematode population (814) were recorded with untreated check. Observation on nematode population/200cc soil in seed treatment of botanicals showed that highest reduction (60.68%) in nematode population/200cc soil was observed with neem @ 10% w/w (standard check). It was observed that aak @ 15% w/w followed by water hyacinth @ 15% w/w (60%) and lantana @ 15% w/w (50.12%) over untreated check. Minimum reduction was noticed in lantana @ 5% w/w (9.95%) over untreated check.

Botanicals, Aak (*Calotropis procera*), Lantana (*Lantana camara*), and Water hyacinth (*Eichhornia crassipes*) were used as seed treatments at 5%, 10% and 15% of each to determine the best dose for the control of *Rotylenchulus reniformis* infected cluster bean.

Data indicated that various botanicals were considerably more effective than the untreated control in improving plant growth parameters and decreasing *Rotylenchulus reniformis* nematode reproduction. The amount of botanicals applied has a direct relationship with the improvement in plant's growth characteristics and the reduction in *Rotylenchulus reniformis* nematode reproduction. *Calotropis procera* at 15%, was found to be the most efficient in enhancing plant's growth characteristics and reducing *Rotylenchulus reniformis* nematode reproduction when compared to *Eichhornia crassipes* at 15% and *Lantana camara* at 15%. *Calotropis procera* at 15% was seen to be superior to *Calotropis procera* at 5% in terms of dosage. *Calotropis procera* at 15% and *Eichhornia crassipes* at 15% were determined to be the best treatments among botanicals and dosage interactions, compared to other bioagents treatments. This investigation is in adjustable conformity with finding of Singh and Prasad (2016) who reported that combination of *Calotropis procera* + *Trichoderma viride* + Triazophos were efficient in managing reniform nematode, *Rotylenchulus reniformis* and maximum yield in case of cowpea. Mehta et al. (2015) reported that neem (*Azadirachta indica*), aak (*Calotropis procera*) and water hyacinth (*Eichhornia crassipes*) leaf powder at 4 g/plant as soil amendment maximum increase in plant growth character and significantly reduce nematode population in maize variety PEHM-2. While Patil et al. (2013) found that combined effect of *T. harzianum* at 2g/kg soil application and 30 per cent concentration of Lantana (*Lantana camara*), as seed soaking proved better over other treatments in enhancing growth parameters of cowpea and minimizing infection of *Rotylenchulus reniformis*. Jain

and Trivedi (1997) stated that soil amended with *Calotropis procera*, followed by *Azadirachta indica* showed significantly greatest decreased the number of root galls, eggs per eggmass and ultimate nematode population after such amendments, indicating a decline in disease incidence in chickpea. Rangaswamy *et al.* (2000) reported that *Trichoderma viride* was most efficient in parasitizing the nematode's egg masses when used alone or in conjunction with either neem or castor cake in Tomato and Umamaheswari and Babu (2001) reported that *Calotropis procera* leaf powder as seed treatment at 10% w/w showed the minimum nematode populations recording 87.6% and 95.2% decrease in root-knot and reniform nematode population, respectively, in cowpea roots. Dibakar and Mishra (2002) reported that neem seed powder at a higher dosage reduce nematode populations in the soil and improvements in plant growth parameters of pigeonpea. While Mishra *et al.* (2003) found that plant growth parameters were better under neem seed powder (50 kg/ha) treatment, but soil treatment with carbofuran at 2 kg a.i./ha was found to be equally successful in improve plant growth parameters and reducing nematode population. Bhargava *et al.* (2005) reported that fresh water hyacinth (*Eichhornia crassipes*) reduce nematode populations in tomato. Prasad and Suverna (2005) found that *Calotropis procera* leaf extracts greatly reduced *Rotylenchulus reniformis* penetration and eventual growth in sunflower seedlings resulted in higher mortality of pre adults of *Rotylenchulus reniformis* race A infesting sunflower cv. Morden. Prasad, D (2006) reported that *Lantana camara* 2.0 quintal/ha resulted in the largest nematode population loss (60.9%) 30 days after treatment in chickpea cv. Pusa-267. Gurjar *et al.* (2012b) reported that plant extracts (20 to 30% concentration) of aak (*Calotropis gigantea*) inhibited hatching and higher mortality percentage on eggs and larvae of the reniform nematode, *Rotylenchulus reniformis*, in vitro. Umamaheswari *et al.* (2005b) stated that *Calotropis procera* leaf powder as just a seed treatment at 10% w/w resulted in 87.6% and 95.2% reduction in root-knot and reniform nematode populations, respectively and at this concentration, plant growth characteristics such as shoot weight, root weight, shoot length, and root length were also at their peak in cowpea cv.CO-4. Hence in the present study, application of Aak (*Calotropis procera*), Lantana (*Lantana camara*) and Water hyacinth (*Eichhornia crassipes*) at 15% were found most effective over others in reducing *R. reniformis* population and in enhancing the plant growth character.

Conclusions

The trial was conducted to study the effect of different botanicals as seed treatment on plant growth characters

and reproduction of reniform nematode on cluster bean. For this study, on the basis of the preliminary studies conducted botanicals viz., Aak (*Calotropis procera*), Lantana (*Lantana camara*), Water hyacinth (*Eichhornia crassipes*) and botanicals will be applied 5%, 10%, 15% w/w as leaves powder as seed treatment and one untreated check and one standard check i.e., neem leaf powder @ 10% w/w as seed treatment were also maintained. The significant increase in all the parameter was found with aak @ 15% w/w followed with water hyacinth @ 15% w/w and Lantana @ 15% w/w.

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Analysis of Growth, Yield and Quality of Strawberry (*Fragaria × ananassa* Duch.) cv. Winter Dawn by Foliar Application of Iron, Zinc and Boron

Lokesh Kumar^{1*}, Balkesh Kumari², H.L. Bairwa¹, L.N. Mahawer¹ and Beerendra Singh³

¹Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

²Department of Horticulture, Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan

³Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan

*Corresponding Author Email : lokeshken9497@gmail.com

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 petiole length (8.57 cm), number of leaves (25.07), plant spread i.e. E-W (28.37 cm) and N-S (27.37 cm), runner per plant (5.87), days to final harvest (115.07 days), 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) and quality parameters like TSS (11.99), TSS : Acid (13.89), juice content (64.56%), ascorbic acid (60.80 mg 100g⁻¹) while recorded lowest in term of days to first flower initiation (56.47 days), days to initiation of fruit set (59.40 days), days to first harvest (73.07 days) and titratable acidity (0.87) were recorded significantly decrease. 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, Mahabaleshwar (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 H_3BO_4 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 P₂O₅ kg ha⁻¹ (17.1) and Available K₂O 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 + ZnSO₄ (0.2%), S₄ i.e. RDF + FeSO₄ (0.2%), S₅ i.e. RDF + Borax (0.2%), S₆ i.e. RDF + ZnSO₄ (0.4%), S₇ i.e. RDF + FeSO₄ (0.4%), S₈ i.e. RDF + Borax (0.1%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%), S₉ i.e. RDF + Borax (0.1%) + ZnSO₄ (0.4%) + FeSO₄ (0.4%), S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%), S₁₁ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.4%) + FeSO₄ (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. Petiole length (cm) of the leaves was recorded with meter scale from five tagged plant in each replication. After harvesting period, total number of leaves were counted, Meter scale was used to determine the plant spread, 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, Digital hand refractometer was used to calculate total soluble solid, Standard N/10 NaOH solution and phenolphthalein as an indicator were used to determine the titratable acidity of strawberry fruit juice until faint pink color appeared, The ripe strawberry fruits were crushed and pass through muslin cloth. The weight of strawberry juice was measured with electronic balance and the percentage of juice was worked out on the basis of total weight of fruit taken for juice extraction, calculation of ascorbic acid/100 ml juice by using below formula (Sadasivam and Theymoli, 1987).

Results and Discussion

The data recorded for various parameters are statistically analyzed, their mean value are presented in Table1-4. It is clear that maximum petiole length (8.57 cm) was noted in treatment S₁₀ i.e. RDF (100: 80: 80 NPK) + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas S₁ i.e. RDF + Control (Water spray) recorded minimum petiole length (7.10 cm). This change might be due to that iron, zinc and boron help in cell division, elongation and growth of

Table-1 : Response of micronutrient on petiole length, leaves per plant and plant spread, runner per plant.

Notations	Treatments	Petiole length (cm)	Leaves plant ⁻¹	Plant spread (cm)		Runner plant ⁻¹
				E-W	N-S	
S ₁	RDF + Control (Water spray)	7.10	20.07	24.60	20.63	3.27
S ₂	RDF + Borax (0.1%)	7.17	21.60	25.03	21.10	3.27
S ₃	RDF + ZnSO ₄ (0.2%)	8.27	22.73	26.03	22.07	3.33
S ₄	RDF + FeSO ₄ (0.2%)	7.23	21.87	25.83	21.80	3.47
S ₅	RDF + Borax (0.2%)	8.27	22.13	26.00	22.03	3.40
S ₆	RDF + ZnSO ₄ (0.4%)	8.17	23.07	26.83	22.73	3.33
S ₇	RDF + FeSO ₄ (0.4%)	8.27	22.87	25.30	21.70	3.40
S ₈	RDF + Borax (0.1%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	8.30	23.80	26.87	22.87	3.40
S ₉	RDF + Borax (0.1%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	8.37	24.47	27.10	23.13	3.53
S ₁₀	RDF + Borax (0.2%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	8.57	25.07	28.37	24.70	3.67
S ₁₁	RDF + Borax (0.2%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	8.50	24.93	27.87	23.87	3.60
	SEm±	0.32	0.61	0.71	0.73	0.05
	CD at 5%	0.95	1.80	2.07	2.14	0.14

Table-2 : Response of micronutrient on, days to initiation of fruit set, days to first harvest, days to final harvest, number of picking, fruit length.

Notations	Treatments	Days to initiation of fruit set	Days to first harvest	Days to final harvest	Number of picking	Fruit length (mm)
S ₁	RDF + Control (Water spray)	68.80	77.07	107.07	15.07	34.07
S ₂	RDF + Borax (0.1%)	65.27	76.93	108.67	15.33	34.17
S ₃	RDF + ZnSO ₄ (0.2%)	65.20	76.80	109.00	15.53	34.20
S ₄	RDF + FeSO ₄ (0.2%)	67.27	76.47	109.73	15.73	34.50
S ₅	RDF + Borax (0.2%)	64.13	76.33	110.53	15.80	34.83
S ₆	RDF + ZnSO ₄ (0.4%)	64.47	75.93	111.93	15.93	35.13
S ₇	RDF + FeSO ₄ (0.4%)	65.60	75.60	112.40	16.13	35.27
S ₈	RDF + Borax (0.1%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	64.07	75.00	113.60	16.33	35.43
S ₉	RDF + Borax (0.1%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	61.80	74.60	114.60	16.60	35.53
S ₁₀	RDF + Borax (0.2%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	59.40	73.07	115.07	17.07	36.03
S ₁₁	RDF + Borax (0.2%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	60.73	74.20	114.47	16.93	35.87
	SEm±	1.77	0.88	1.76	0.49	0.36
	CD @ 5%	5.24	2.60	5.20	1.44	1.06

meristamatic tissue and also due to enhanced photosynthes 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. Similarly highest leaves per plant (25.07), plant spread i.e. E-W (28.37 cm) and N-S (24.37 cm) and runner per plant (5.87) was recorded in the treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas treatment S₁ i.e. RDF + Control (Water spray) recorded minimum leaves per plant (20.0), plant spread i.e. E-W (24.60 cm) and N-S (20.63 cm) and runner per plant (3.27). 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. The foliar application of iron, zinc and boron exhibited significant effect on yield parameter of strawberry. Treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) recorded minimum days to first flower initiation (56.47 days) which was found to be better over the S₁ control as RDF + water spray (64.27

Table-3 : Response of micronutrient on fruit width, length : diameter, fresh weight of fruit, number of fruit/plant and fruit yield/plant.

Notations	Treatments	Fruit width (mm)	Length : Diameter	Fresh weight of fruit (g)	Number of fruit/plant	Fruit yield/plant (g)
S ₁	RDF + Control (Water spray)	25.53	1.15	10.88	14.93	162.00
S ₂	RDF + Borax (0.1%)	26.00	1.16	10.95	15.00	164.00
S ₃	RDF + ZnSO ₄ (0.2%)	26.10	1.18	11.12	15.13	168.33
S ₄	RDF + FeSO ₄ (0.2%)	26.20	1.17	11.26	15.33	172.67
S ₅	RDF + Borax (0.2%)	26.27	1.16	11.39	15.47	176.00
S ₆	RDF + ZnSO ₄ (0.4%)	26.30	1.19	11.56	15.60	180.00
S ₇	RDF + FeSO ₄ (0.4%)	26.40	1.17	11.73	15.60	183.33
S ₈	RDF + Borax (0.1%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	26.50	1.16	11.87	15.67	186.00
S ₉	RDF + Borax (0.1%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	26.67	1.20	12.02	15.80	190.00
S ₁₀	RDF + Borax (0.2%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	27.17	1.24	12.32	16.20	198.00
S ₁₁	RDF + Borax (0.2%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	26.83	1.23	12.20	16.00	194.67
	SEm±	0.34	0.02	0.12	0.26	7.82
	CD @5%	NS	0.06	0.34	0.76	23.07

Table-4 : Response of micronutrient on TSS, titratable acidity, TSS acid ratio, Juice content, Ascorbic acid, Gross return/ha, Net return/ha and B:C.

Notations	Treatments	TSS (OB)	Titratable acidity (%)	TSS : Acid	Juice content (%)	Ascorbic acid (mg/100g)	Gross return/ha (Rs.)	Net return/ha (Rs.)	B:C
S ₁	RDF + Control (Water spray)	11.10	1.00	11.10	57.76	57.75	649633	307633	0.90
S ₂	RDF + Borax (0.1%)	11.14	0.93	11.98	61.15	57.89	653219	311173	0.91
S ₃	RDF + ZnSO ₄ (0.2%)	11.25	0.93	12.07	61.60	58.16	660617	318428	0.93
S ₄	RDF + FeSO ₄ (0.2%)	11.82	0.90	13.13	62.47	58.82	673183	330868	0.97
S ₅	RDF + Borax (0.2%)	11.32	0.93	12.17	60.35	59.11	677903	335273	0.98
S ₆	RDF + ZnSO ₄ (0.4%)	11.10	0.93	11.93	60.38	59.31	677540	335285	0.98
S ₇	RDF + FeSO ₄ (0.4%)	11.47	0.90	12.74	61.90	59.86	679316	336806	0.98
S ₈	RDF + Borax (0.1%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	11.58	0.90	12.87	62.18	59.99	683764	341100	1.00
S ₉	RDF + Borax (0.1%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	11.25	0.90	12.50	62.88	60.19	696437	353202	1.03
S ₁₀	RDF + Borax (0.2%) + ZnSO ₄ (0.2%) + FeSO ₄ (0.2%)	11.99	0.87	13.89	64.56	60.80	715439	372680	1.09
S ₁₁	RDF + Borax (0.2%) + ZnSO ₄ (0.4%) + FeSO ₄ (0.4%)	11.90	0.87	13.79	63.95	60.62	704111	360782	1.05
	SEm ±	0.21	0.02	0.43	1.21	0.70	12514.38	12514.38	0.04
	CD at 5%	0.63	0.07	1.27	3.56	2.04	36700.13	36700.13	0.11

days). 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 Yadlo 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. Similarly minimum days to initiation of fruit set (59.40 days) and days to first harvest (73.07 days) was recorded under the treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas treatment S₁ i.e. RDF + Control (Water spray) recorded maximum days to initiation of fruit set (68.80 days) and days to first harvest (77.07 days). 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%) + ZnSO₄ (0.2%) + FeSO₄ (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. The maximum fresh weight of fruit, fruit per plant and fruit yield per plant (12.32 g, 16.20 and 198 g respectively) was 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 and 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 Cakici, Bakshi *et al.* (2013) and Mehraj *et al.* (2015) in strawberry, Tagad *et al.* (2018) in acid lime.

The maximum TSS (11.99) was 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 TSS (11.10). The increase in TSS might be due to hydrolysis of the polysaccharides, conversion the organic acids to the soluble sugars and

improved solubilization of insoluble starch and pectin are present in cell wall as well as middle lamella. In conformity of its similar observations were reported by Chaturvedi *et al.* (2005) in strawberry, Kumar *et al.* (2010), Bakshi *et al.* (2013), Thorat *et al.* (2018) in sweet orange, Chandrakar *et al.* (2018) and Chandrakar *et al.* (2019) in strawberry, Pawar *et al.* (2019) in mandarin.

It is clear from the mean data showed that treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) were recorded minimum titratable acidity of the fruit (0.87%) whereas, S₁ i.e. RDF + Control (Water spray) recorded maximum titratable acidity (1.0%). The decrease in acidity might be due to the metabolic changes with fast conversion of organic acids to the sugars and its derivatives and utilization as the respiratory substrate during growth and development of the fruits, which was stimulated by zinc and iron foliar spray. These finding are collaborates with the findings of Chaturvedi *et al.* (2005) in strawberry, Kumar *et al.* (2010), Pathak *et al.* (2011) in banana, Bakshi *et al.* (2013), Thorat *et al.* (2018) in sweet lemon.

The highest TSS Acid ratio (13.89) was recorded treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas S₁ i.e. RDF + Control (Water spray) recorded lowest TSS Acid ratio (11.10). The increase in TSS Acid ratio might be due to the increase in TSS content and decrease in acidity of the fruit and this change have stimulated by ZnSO₄ and FeSO₄ foliar spray. These finding are collaborates with the findings of Kumar *et al.* (2010), Chandrakar *et al.* (2018), Bakshi *et al.* (2013), Chaturvedi *et al.* (2005) in strawberry, Pathak *et al.* (2011) in banana, Pawar *et al.* (2019) in mandarin.

The highest juice content (64.56 %) were recorded under the combined treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas S₁ i.e. RDF + Control (Water spray) recorded lowest juice content (57.76%). The increase in juice per cent might be due to the metabolic changes with fast conversion of organic acids in to sugars and its derivatives and utilization as the respiratory substrate during growth and development of the fruits, which was stimulated by zinc and iron foliar spray. These finding are collaborates with the findings of Chaturvedi *et al.* (2005) in strawberry, Kumar *et al.* (2010), Singh *et al.* (2012), Chandrakar *et al.* (2018) and Chandrakar *et al.* (2019) in strawberry.

Highest ascorbic acid content (60.80 mg 100g⁻¹ pulp) was recorded in combined treatment S₁₀ i.e. RDF + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) whereas S₁ i.e. RDF + Control (Water spray) recorded lowest ascorbic acid content (57.75 mg 100g⁻¹ pulp). In conformity of its similar observations were well reported by Chaturvedi *et al.* (2005) in strawberry, Kumar *et al.* (2010), Pathak *et al.*

(2011) in banana, Bakshi *et al.* (2013), Chandrakar *et al.* (2018) and Chandrakar *et al.* (2019) 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 petiole length, leaves per plant, plant spread (E-W and N-S), runner per plant, days to first flower initiation, days to initiation of fruit set, days to first harvest, days to final harvest, 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 (100: 80: 80 NPK) + Borax (0.2%) + ZnSO₄ (0.2%) + FeSO₄ (0.2%) were found increase in term of TSS, TSS Acid ratio, juice content and ascorbic acid content while, decrease in titratable acidity.

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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A Water Relations Analysis of Seed Germination Rates of Different Soybean Cultivars

Mahesh Jajoria¹, H.K. Kausadikar², V.D. Patil², Indubala Sethi¹ and Digvijay Dhama²

¹Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan-303328, India

²Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra-431402, India

Abstract

A lab experiment was conducted during 2014-15 at department of Soil science and Agricultural Chemistry, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani using different six soybean cultivars to study the seed germination rate of different soybean varieties under sandy soil with six treatment combination (soybean cultivars). The treatment consist of six soybean cultivars viz. JS-335, MAUS-71, MAUS-158, MAUS-162, MAUS-504 and MAUS-609 and two water potential at 50 per cent and 100 per cent field capacity. The results emerged out clearly indicated that seed germination rate was different for different cultivars under study. The objective of our laboratory study was to quantify seed germination of six soybean cultivars at two water potential (50% and 100% field capacity). Germination was measured as a function of time for period of 96 hours.

Introduction

Seed germination is the process of initiating growth of a previously quiescent or dormant embryo. For most seeds, it begins with imbibition of water. Generally Imbibition is a three phase process, phase I is with rapid initial water uptake, phase II followed by a plateau phase with little change in water content and phase III is a subsequent increase in water content coincident with radicle growth. In terms of the regulation of germination, phase II is of primary interest, since germination in the physiological sense can be considered to be completed when embryo growth is initiated. It is the length of phase II that is generally extended by dormancy, water deficit, low or high temperatures, or abscisic acid, while factors which promote germination do so by shortening this lag phase. Once the radicle has penetrated any enclosing tissues and is growing, germination is complete and seedling growth has begun (Bradford, 1990).

It is well known that different soils vary in how much water they can hold and how tightly they hold on water as the soil dries. Seed germination and plant growth is influenced by how tightly the water is being held, not by how much total water a soil contains. This means measuring how much moisture a soil contains does not tell us enough to predict whether a seed will germinate or not. From the seed perspective, it is how tightly the water is being held by the soil that matters. This property called water potential. Lyles and Fanning (1964) reported that as the water potential is lowered below a certain threshold, germination rate and seedling growth are reduced and delayed. The water uptake at a given time and the total water absorption by seeds of all the varieties declined with a decrease in water potential. The seeds of all the

varieties did not require the same amount of water for germination and the total amount of water absorbed at the time of germination by seeds of the same variety at different moisture potential varied considerably (Mali *et al.*, 1979).

Materials and Methods

The present investigation was conducted using sandy soils having pH 7.9, field capacity 15.40 per cent and two moisture levels 50 and 100 per cent field capacity. The details about soil properties of experimental soils are given in (Table. 1). Six soybean cultivars viz., JS-335, MAUS-71, MAUS-158, MAUS-162, MAUS-504 and MAUS-609 were evaluated for their germination rate at different soil moisture levels. Twenty healthy seeds of each of the six cultivars of soybean were placed in petri dishes containing 200 gm of the soil at a depth of 10 mm at $28 \pm 1^\circ \text{C}$. The germination was defined when 2 mm long radical sprouted from the seed coat. The time of germination was considered by recording germination rate upto 96 hours.

Results and Discussion

The percentage of seeds germinated for six soybean cultivars as a function of time with two water potential (50% and 100% field capacity) shown in Table-2 and 3. There is no germination after 64 hours. The different seed germination rate of different soybean cultivars in sandy soil at 50% and 100% field capacity were noted. The MAUS-504 and MAUS-609 showed better performance compared to other varieties at both soil moisture levels but germination rate was low. The seeds of JS-335 recorded lower germination in sandy soil at both moisture levels. Our data suggest that MAUS-71 gave excellent

Table-1 : Mechanical and chemical composition of experimental soil.

Sr. No.	Particulars	Unit	Sandy soil	Method
1.	Coarse sand	Per cent	19.50	International pipette method, (Piper, 1966)
2.	Fine sand	Per cent	49.60	
3.	Silt	Per cent	22.50	
4.	Clay	Per cent	7.40	
5.	pH		7.9	Suspension ratio of 1:2.5 of soil water (Jackson, 1973)
6.	EC	dSm ⁻¹	0.25	
7.	Organic carbon	g kg ⁻¹	1.65	Walkley and Black's rapid titration method (Piper, 1966)
8.	Calcium carbonate	g kg ⁻¹	32.0	Rapid titration method (Piper, 1966).
9.	CEC	Cmol (p+) kg ⁻¹	5.72	Ammonium acetate method (Jackson, 1973)
10.	Field capacity	Per cent	15.40	Method No. 30, USDA Hand Book No. 60 (Richards, 1968)

Table-2 : Total seed germination (%) of six soybean varieties at 50 per cent field capacity under sandy soil as a function of time.

Sr. No.	Varieties	Time (hours) required for germination													
		8	16	20	24	28	32	36	40	44	48	52	56	60	64
1.	JS-335	-	-	-	-	5	5	15	20	5	nfg				
2.	MAUS-71	-	-	5	15	25	15	20	5	nfg					
3.	MAUS-158	-	-	-	-	10	20	20	25	20	nfg				
4.	MAUS-162	-	-	10	5	10	30	20	15	-	10	nfg			
5.	MAUS-504	-	-	-	-	-	-	10	60	15	5	-	-	10	nfg
6.	MAUS-609	-	-	5	10	25	15	20	15	-	5	-	-	5	nfg

Nfg = No further germination.

Table-3 : Total seed germination (%) of six soybean varieties at 100 per cent field capacity under sandy soil as a function of time.

Sr. No.	Varieties	Time (hours) required for germination													
		8	16	20	24	28	32	36	40	44	48	52	56	60	64
1.	JS-335	-	-	-	-	-	5	40	15	-	-	-	5	nfg	
2.	MAUS-71	-	-	-	-	-	40	5	20	25	nfg				
3.	MAUS-158	-	-	-	-	-	10	20	30	15	10	nfg			
4.	MAUS-162	-	-	-	-	-	10	15	45	15	5	5	nfg		
5.	MAUS-504	-	-	-	-	-	-	10	45	15	10	15	-	5	nfg
6.	MAUS-609	-	-	-	-	10	10	25	25	20	-	10	nfg		

Nfg = No further germination.

emergence ability at both water potential (50 % and 100 % field capacity) than other cultivars. This may be due to coarse soil fraction which hold water for short period. Donnen and MacCillivry (1943) observed that most seed yielded better germination over the entire range of available water. This can be ascribed to a function of each species to attain a specific moisture content for germination (Hunter and Erickson, 1952).

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Evaluation of the Suitable Concentration and Economic of Plant Growth Regulators and Thiourea on Bottle Gourd [*Lagenaria siceraria* (Mol.)]

Reena Kumari*, S.P. Singh and B.L. Meena¹

Department of Horticulture, S.K.N. COA, Jobner-303329 Rajasthan

¹ICAR-DRMR, Bharatpur, Rajasthan

*Corresponding Author's Email : meenareena2007@gmail.com

Abstract

The present investigation was under taken in the experimental farm of Department of Horticulture, S.K.N Agriculture University, Jobner, Jaipur (Rajasthan) to find out the suitable concentration of plant growth regulators and thiourea for quality and yield attributes of bottle gourd cv. cv. Pusa Summer Prolific Long. The experimental was laid out with 13 treatments in randomized block design and replicated thrice. The treatment comprised of plant growth regulators and thiourea, viz. T₀ (control), T₁ (100 ppm NAA), T₂ (200 ppm NAA), T₃ (300 ppm NAA), T₄ (150 ppm Ethrel), T₅ (300 ppm ethrel), T₆ (450 ppm ethrel), T₇ (100 ppm CCC), T₈ (200 ppm CCC), T₉ (300 ppm CCC), T₁₀ (250 ppm thiourea), T₁₁ (500 ppm thiourea), T₁₂ (750 ppm thiourea). The results showed that most of the quality parameters are maximum at ethrel 450 ppm as crude protein contents (0.226), ascorbic acid (12.90), TSS (5.31%). It may be concluded that ethrel 400 ppm (T₆) was found most effective as it remained statistically at par in all the growth, flowering attributes and yield. The most effective treatment for increasing the growth and yield of bottle guard under present investigation was ethrel 450 ppm with cost benefit ratio 3.38.

Key words : Bottle guard, PGRs, thiourea, vegetative growth, flowering, yield, quality.

Introduction

Bottle gourd [*Lagenaria siceraria* (Mol.) standl.] cv. Pusa summer prolific long is a commonly grown and used vegetable in India. It belong to family cucurbitaceae. Besides an important vegetable crop it has also got good medicinal as well as nutritional value. Due to these qualities and people now a days becoming more health conscious. The intake of its demand have been increasing day by day. The fruits are also used as vegetable or for making sweets/halwa, kheer, petha, barfi and pickles. It is economically found growing in Ethiopia, Africa and Central America. The growth regulators are more important due to their direct effect on males and female flowers ratio, fruit set, fruit drop and ultimately on yield. The use of plant growth regulators at proper stage play an important role in sex expression and yield of bottle gourd (Sircael, 1971). In bottle gourd, the production of staminate flowers is much more than pistillate flower. These situations lead to the use of plant growth regulators like NAA, Ethrel and CCC in bottle gourd which play an important role in sex expression and sex ratio and thiourea plays a vital role in the physiology of plants both as a sulphhydryl compound and to some extent as an amino compound like urea. The stimulating action of thiourea in various physiological activities of plants is well known. Keeping these facts in view, the present investigation was under taken with objectives to know the effect of plants growth regulators and thiourea on growth yield and quality of bottle gourd.

Materials and Methods

Field experiment was conducted on Bottle gourd cv. Pusa summer prolific long the experimental farm of the department of horticulture, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan). The soil of experimental farm was sandy loam texture, having organic carbon 0.13%, pH 8.2 and EC0.85 (dSm⁻¹). The treatment comprised of plant growth regulators and thiourea viz. T₀ (control), T₁ (100 ppm NAA), T₂ (200 ppm NAA), T₃ (300 ppm NAA), T₄ (150 ppm Ethrel), T₅ (300 ppm ethrel), T₆ (450 ppm ethrel), T₇ (100 ppm CCC), T₈ (200 ppm CCC), T₉ (300 ppm CCC), T₁₀ (250 ppm thiourea), T₁₁ (500 ppm thiourea), T₁₂ (750 ppm thiourea) were designed in randomized block design with replicated thrice. The gross plot size was 6m x 3m with spacing of 2.5 m x 0.75 m (row x plant). The bottle gourd three to flower seeds per pit were sown on 12th July 2012 by dibbling method. Bottle gourd crop was fertilized with recommended dose i.e. 250 FYM, 60, 40, 60 NPK kg ha⁻¹. Nitrogen, phosphorus and potash fertilizer were applied in the form of urea, single super phosphate and muriate of potash respectively. Half dose of nitrogen and whole quantity of phosphorus and potash were applied. The remaining half dose of nitrogen (60 kg/ha) was top dressed after one month of sowing. The observation on growth and yield parameters were recorded during the investigation.

Results and Discussion

Weight of fruit was significantly affected by the application of plant growth regulators and thiourea. Plant growth regulators and thiourea significantly increased the weight of fruit as compared to control. Maximum weight of fruit was recorded under treatment ethrel 450 ppm and minimum under control. However, the treatments ethrel 300 ppm, ethrel 150 ppm, NAA 300 ppm, CCC 100 ppm, CCC 200 ppm and CCC 300 ppm were found statistically at par with ethrel 450 ppm. Application of ethrel 450 ppm as a foliar spray enhanced the fruit weight by 18.85 per cent over control. Results showed that spray of plant growth regulators and thiourea significantly increased the fruit weight. The maximum fruit weight (1.311 kg) was recorded under ethrel 450 ppm (T_6) and minimum (1.103 kg) in control (T_0). These findings are in close consonance with those of Kshirsagar *et al.* (1996) in cucumber. Sharma *et al.* (1988) and Patel (1992) in bottle gourd. An increase in fruit weight may be further attributed to the reason that plant remained physiologically more active to build up sufficient food stock for the developing flowers and fruits, ultimately leading to higher fruit weight.

The significant increase in fruit yield (kg) per vine was shown with the foliar application of plant growth regulators and thiourea as compared to control. The treatment ethrel 450 ppm recorded maximum fruit yield per vine as compared to the control. Application of ethrel 450 ppm as a foliar spray enhanced the fruit yield per vine by 32.45 per cent over control. However, the treatments ethrel 300 ppm, ethrel 150 ppm, NAA 300 ppm, CCC 300 ppm and thiourea 750 ppm were found statistically at par with treatment ethrel 450 ppm.

The significant increase in fruit yield (q) per hectare was shown with the foliar application of plant growth regulators and thiourea as compared to control. The treatment ethrel 450 ppm recorded maximum fruit yield per hectare as compared to the control. Application of ethrel 450 ppm as a foliar spray enhanced the fruit yield per hectare by 57.43 per cent over control. However, the treatment ethrel 150 ppm and ethrel 300 ppm were found statistically at par with treatment ethrel 450 ppm. The maximum fruit yield per vine and hectare under ethrel 450 ppm might be due to higher number of female flower, higher number of fruits and higher fruit weight under ethrel 450 ppm. These findings are in close conformity with those of Kumar *et al.* (2006) in bottle gourd, Das and Das (1996) in pumpkin and Jadav *et al.* (2010) in cucumber.

Analysis of variance for fruit weight (kg), fruit yield per vine (kg) and fruit yield (q) per hectare.

Source of variance	d.f.	Mean sum of square		
		Fruit weight (g)	Fruit yield per vine (kg)	Fruit yield per hectare (q)
Replication	2	0.0025	0.2826	981.4008
Treatment	12	0.0204**	0.8984**	11840.7854**
Error	24	0.0074	0.3131	1079.1595

**significant at 5% level of significance

Analysis of variance for crude protein content (%), ascorbic acid content (mg) and total soluble solids (%) fruits.

Source of variance	d.f.	Mean sum of square		
		Crude Protein Content (%)	Ascorbic acid content (mg/100 g)	Total soluble solids (%)
Replication	2	0.00002	0.6911	0.0026
Treatment	12	0.00015**	0.2521**	0.0186
Error	24	0.00005	0.5391	0.1684

**significant at 5% level of significance.

The treatments showed non significant increase in crude protein content of fruits with the foliar application of plant growth regulators and thiourea as compared to control. The treatment ethrel 450 ppm contributed maximum crude protein content in fruits as compared to control. The treatments showed non significant effect on ascorbic acid content of fruits. Fruit weight (kg). The total soluble solids of fruits was found non significant with the

Table-1 : Effect of plant growth regulators and thiourea on net returns (Rs/ha) and B:C ratio.

Treatments	Net returns	B:C ratio
Control	112546	1.81
NAA 100 PPM	126147	2.00
NAA 200 PPM	134530	2.11
NAA 300 ppm	171594	2.65
ETHREL 150 PPM	187257	3.00
ETHREL 300 PPM	204373	3.27
ETHREL 450 PPM	212120	3.38
CCC 100 ppm	150415	2.40
CCC 200 ppm	160539	2.53
CCC 300 ppm	172591	2.69
Thiourea 250 ppm	126374	2.03
Thiourea 500 ppm	134422	2.15
Thiourea 750 ppm	145550	2.32
SEm+	9042	0.14
CD (P=0.05)	26393	0.42

Table-2 : Impact of PGR and thiourea on quality and yield parameters of bottle gourd.

Treatment	Quality parameters			Yield parameters		
	Crude protein contents	Ascorbic acid contents	TSS (°B)	Yield/hectare (q)	Fruit weight (kg)	Yield/vine (kg)
T ₀ : Control	0.200	11.66	5.03	349.25	1.103	5.70
T ₁ : NAA 100 ppm	0.210	12.10	5.07	378.19	1.107	6.15
T ₂ : NAA 200 ppm	0.217	12.40	5.17	396.76	1.116	6.40
T ₃ : NAA 300 ppm	0.220	12.50	5.21	472.55	1.224	6.95
T ₄ : Ethrel 150 ppm	0.216	12.46	5.16	499.15	1.280	7.02
T ₅ : Ethrel 300 ppm	0.222	12.75	5.26	533.86	1.290	7.45
T ₆ : Ethrel 450 ppm	0.226	12.90	5.31	549.84	1.311	7.55
T ₇ : CCC 100 ppm	0.215	12.35	5.14	426.35	1.250	6.14
T ₈ : CCC 200 ppm	0.221	12.65	5.23	447.96	1.260	6.40
T ₉ : CCC 300 ppm	0.224	12.82	5.28	473.42	1.272	6.70
T ₁₀ : Thiourea 250 ppm	0.211	12.25	5.15	377.26	1.117	6.08
T ₁₁ : Thiourea 500 ppm	0.212	12.21	5.18	393.71	1.125	6.30
T ₁₂ : Thiourea 750 ppm	0.219	12.49	5.20	416.32	1.127	6.65
SEm+	0.011	0.42	0.24	18.97	0.050	0.32
CD at 0.05%	0.033	NS	NS	55.36	0.14	0.94

foliar application of plant growth regulators and thiourea as compared to control (Table-2).

The effect of plant growth regulators (NAA, ethrel, CCC) and thiourea on net returns and B:C ratio of fruits are presented in the Table-1. The economics of the treatments was calculated. The treatment ethrel 450 ppm was found superior with maximum net income per hectare from sale of fruits, as compared to control. The sale price of one kg of fruits was Rs 5.0. Amongst all the treatments, the B:C (Benefit : Cost) ratio was the maximum for treatment ethrel 450 ppm, whereas, the minimum in control. Among the different treatments of plant growth regulators and thiourea significantly higher net returns (212120 Rs/ha) and B:C ratio (3.38) were obtained under the application of ethrel 450 ppm (T₆). This was due to higher yield in the treatments ethrel 450 ppm (T₆) resulting in higher net returns. On the basis of results obtained from the field experiment following conclusions may be drawn. The results showed that most effective treatment for increasing the growth and yield of bottle guard under present investigation was ethrel 450 ppm with cost benefit ratio 3.38.

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Evaluation of Different Fungicides, Bio-Agents and Botanicals against Leaf Blight of Wheat (*Alternaria triticina*)

Sardar Singh Kakraliya^{1*}, Sunil Zacharia¹, Dechan Choskit³, Abhinav², Pushpendar Singh Shekhawat¹, and Sheikh Saima Khusbhoo³

¹Department of Plant Pathology, SHIATS (Deemed-to-be-University), Allahabad-211007, U.P.

²Department of Plant Pathology, RCA, MPUAT, Udaipur 313001, Rajasthan

³CSIR-Indian Institute of Integrative Medicine-IIIM-Jammu and Kashmir

*Corresponding Author Email : sardarchoudhary70@gmail.com

Abstract

The experiment was conducted under *in vivo* conditions to observe the effect of bio-agents, botanical and fungicides against *Alternaria triticina*. Eight treatments were taken up in RBD design with three replications. The effect of recommended dose of fungicides (Propiconazole, Hexaconazole and Vitavax), bio-agents and botanicals on severity of leaf blight of wheat were studied. Two sprays of Propiconazole at 0.1% at tillering and boot leaf stage resulted in the maximum reduction in leaf blight intensity followed by two applications of Propiconazole at tillering and boot leaf stage. Propiconazole was also found to be quite effective in reducing the level of disease and enhancing crop yield followed by hexaconazole and vitavax. However, Propiconazole, Hexaconazole and Vitavax were almost equally effective against blight of wheat and may be used as an alternative to each other for management of disease. Two applications of Propiconazole at tillering and boot leaf stages also resulted in highest grain yield. Out of the two bio-agents tested against blight of wheat under field conditions, *Pseudomonas fluorescence* followed by *Trichoderma harzianum* resulted in the highest reduction in disease intensity. However, both of these bio-agents were comparatively less effective in minimizing the disease as compared to chemical fungicides. Out of four plant extracts two applications of aqueous neem leaf extract at tillering and boot leaf stage resulted in the highest wheat yield as compared to other botanical extracts.

Key words : *Alternaria blight*, *Trichoderma spp.*, *fungicides*, *neem leaf extract*.

Introduction

The bread wheat (*Triticum aestivum* L.) is the most important species accounting to a little over 87 per cent of the total wheat production of India followed by the *Triticum durum* wheat 12 per cent and *Triticum dicoccum* wheat 1 per cent. The *T. dicoccum* wheat is grown only on limited acreage in Tamil Nadu, Andhra Pradesh, Maharashtra and Gujarat. Some wheat varieties (e.g. *T. aestivum*) are suitable for bread making while others (e.g. *T. durum*) are suitable for biscuits and cooking making (Sapirstein *et al.*, 2007). Gluten, the protein component of flour which gives the dough elasticity and strength, can be defined as the rubbery mass that remains when wheat dough is washed to remove starch granules and water soluble constituents (Wieser, 2007; Kaushik, *et al.*, 2013). In India, foliar blight of wheat had been noticed as early as 1924 (Kulkarni, 1924), but it was not of much consequence till recently. In the recent past, with the change in cropping system, foliar blight has now become a major disease far and wide in our country causing 2.72 to 36.24 per cent yield losses under different agro climatic zones. In India, foliar blights of wheat are considered as one complex, which includes leaf blight caused by *Alternaria triticina* Prasad and Prabhu

and spot blotch caused by *Bipolaris sorokiniana*. In the Indo-gangetic plains, covering the entire north-western and north-eastern plains, rice-wheat rotation is the dominant cropping sequence. It has been commonly observed that the intensity of foliar blights has considerably increased in the rice-wheat system (Nagarajan and Kumar, 1998). During last decade multilocal surveys for determining incidence of foliar blights of wheat have been conducted in eastern U.P., Bihar, Haryana, Punjab, Delhi, Gujarat and Rajasthan (Singh *et al.*, 2004). In view of the growing concern about foliar blight of wheat, it was considered desirable to study the incidence of the disease and the causal organisms in Allahabad region where wheat (*T. aestivum*) is main food crop. Leaf blight caused by *A. triticina* is the major disease in irrigated wheat in Vidarbha region of Maharashtra. *Alternaria* leaf blight was first reported from Maharashtra in 1924 (Kulkarni, 1924). The disease initially appears as small and irregularly scattered chlorotic lesions on the leaves in last week of December. As the disease progresses, several spots coalesce and cover the whole or part of the leaf giving it a 'blighted' appearance. Heavily infected fields show a burnt appearance. The normal sown as well as late sown irrigated wheat varieties were found heavily infected with

Alternaria leaf blight during January and February in Vidarbha region, causing considerable losses in the grain yield of irrigated wheat. Therefore, this trial was formulated to estimate the losses caused due to leaf blight disease (Shivankar *et al.*, 2000). The application of two irrigations reduced the severity of foliar blight as compared to no irrigation (Shrestha *et al.*, 1998) reported that low or imbalance soil nutrient levels predispose plants to more severe leaf blight attack found low incidence of disease when wheat crop was sowing on 30th November as compared 20th December.

Materials and Methods

Experimental design : The experiments were carried out of Sam Higginbottom Institute of Agriculture Technology and Sciences (Deemed to-be University) Allahabad, during the crop season 2014–2015. Bread wheat (*Triticum aestivum* L.) was sown in November of 2014 at a seed rate of 100 kg ha⁻¹ with a commercial seeder. Ten treatments were used, which included untreated control as water spray (check), foliar application with fungicides viz., Propiconazole, Carbendazim, Hexaconazole at 0.1%, bio-agents *Trichoderma viride*, *Trichoderma harzianum* and *Pseudomonas fluorescence* at 10 g/L water and botanicals Neem leaf extract at 0.5% of aqueous solution were used.

Preparation of aqueous neem leaf extract : Two hundred gram freshly collected neem leaves were crushed with the help of mortar and pestle to prepare fine paste. The paste was soaked overnight in 200 ml distilled water. This was then filtered using fine muslin cloth. The filtrate obtained served as aqueous solution for further use at desired concentration. Experiments were conducted in randomized block design with 3 replications per treatment, with plots size 5 × 4 m². The foliar application was done with a knapsack sprayer, and spraying pressure was maintained at 300 kPa and the rate was 1000 l water ha⁻¹. The foliar applications were applied at tillering and boot leaf stages during evening time.

Disease assessment : Disease severity of *Alternaria* blight on leaves was assessed at 15 days intervals after incidence of 5 marked plants per plot on leaves. The assessments were started when foliage or all the open leaves had infected. Disease Severity of leaves was determined by the diagrammatic keys according to the scale described by (Singh *et al.*, 2004). The infection on leaves were graded in 0-9 scale on the basis of severity of infection on leaves and pod.

Disease Intensity : Per cent disease intensity was recorded at 90 days after incidence of leaf blight. The initial infections or incidence were recorded in the experimental field at 45 days after sowing. Per cent

Disease Index (PDI) was calculated by using formula given by (Singh *et al.*, 2004).

Per cent Disease Index (PDI)

$$= \frac{\text{Sum of all numerical rating}}{\text{Maximum disease grade} \times \text{Total number of leaves observed}} \times 100$$

Results and Discussion

Effect on disease intensity : The results exhibited in Table-3 revealed that in check plot, disease intensity was 38.09% which was significantly higher than remaining other treatments. Two applications of Propiconazole@ 0.1% at tillering and boot leaf stage resulted in least intensity 17.21% with 54.81% reduction in the intensity followed by Hexaconazole@ 0.5% in 18.93% and 50.30% reduction in the intensity. Among the bio-agents and botanical used the maximum disease intensity 27.11% with 28.32% reduction in the intensity of *Pseudomonas fluorescens* followed by *Trichoderma viride* 30.10% with 20.97%, *Trichoderma harzianum* (33.84% with 11.15%) and Neem leaf extract (29.14% with 23.49%) was superior over the other botanicals and bio-agents applied, but significantly there effect were non-significant to each other.

Effect of grain yield : During 2014-2015, the results exhibited that in check plot, grain yield was 23.11q/ha⁻¹ which was significantly higher than in remaining other treatments. Maximum grain yield (37.00 q/ha⁻¹) with yield increase 60.10% was obtained where Propiconazole@0.1 was applied at tillering and boot leaf stages. It was significantly higher than the yield obtained in the remaining other treatments. Second highest grain yield (34.63 q/ha⁻¹) with 49.84% increase in yield was obtained where Hexaconazole was applied and it was significantly higher than the yield obtained due to application of *Pseudomonas fluorescens* (28.00 q/ha⁻¹ with 21.15%) followed due to application of neem leaf extract, there was (26.37 q/ha with 14.10%) yield and increase yield respectively.

The present study showed that foliar application of fungicides, bio-agent and botanicals can be effective in reducing the disease intensity of leaf blight of wheat. The causal pathogen of spot blotch is a necrotroph and possibly the reduced severity that was observed can be attributed to the nutrients increasing plant cell resistance to infection. Result indicated that two applications of Propiconazole at tillering and boot leaf stages which is already in practice for management of leaf blight disease, gave the maximum reduction in intensity. Propiconazole was found superior at 0.1% concentration in suppressing the blight disease of wheat than any other chemical, bio-agent and botanicals tested. Kalappanavar and Patil (1998) reported that propiconazole, tridimefon and

Table-1 : The scales for disease assessment were as follows.

Grade	Per cent leaf area covered	Reaction
0	No infection or '0' infection	Immune
1	less than 1% leaf area damage	Highly resistant
3	1 to 5% leaf area damage	Resistant
5	6 to 25 % leaf area damage.	Moderately resistant/Susceptible
7	26 to 50 % leaf area damage	Moderately susceptible
9	More than 50 % leaf area damage	Highly susceptible

Table-2 : Evaluation of different fungicides, bio-agents and botanicals against leaf blight of wheat.

Treatment	Per cent disease intensity	Per cent reduction in disease intensity	Per cent average yield (Q/ha ⁻¹)	Per cent yield increase
Propiconazole@ 0.1%	17.21	54.81	37.00	60.10
Hexaconazole@ 0.5%	18.93	50.30	34.6	49.84
Vitavax@ 0.25%	23.34	38.72	32.20	39.33
<i>Trichoderma viride</i> @2%	30.10	20.97	27.04	17.05
<i>Trichoderma harzianum</i> @2%	33.84	11.15	25.11	8.65
<i>Pseudomonas fluorescens</i> @2.5%	27.11	28.82	28.00	21.15
Neem leaf extract @ 10%	29.14	23.49	26.37	14.10
Control	38.09	—	23.11	—
SE (m)	1.25		2.45	
CD (0.5%)	3.45		5.42	

Hexaconazole were the most effective fungicides for management of leaf rust of wheat. Rao (2006) reported Bayleton as effective fungicide against leaf blight of sunflower which increased yield up to 63%. Mesta *et al.* (2003) reported Propiconazole (0.1%) was effective fungicide against *Alternaria* blight of sunflower. Higher efficacy of Carbendazim and Propiconazole may be due to same dose of Carbendazim and Propiconazole present in crop system for longer time as it was applied for two times. When two applications of Carbendazim and Propiconazole at tillering and boot leaf stages were compared, the Carbendazim seem to be more effective and economic as well. Comparatively higher reduction in incidence and severity of spot blotch was observed due to *T. harzianum* which was significantly higher than *P. fluorescence*. Hamdy *et al.* (2001) reported that under field conditions guard (*T. harzianum*) reduce 64.29% disease in case of spot blotch of wheat. The *P. fluorescence* was evaluated under field conditions. Two sprays were applied at tillering and boot leaf stages of wheat and experimental results showed that *P. fluorescence* minimized the incidence and severity of spot blotch of wheat.

Singh *et al.* (2009) reported that either twice application of Carbendazim, or four application of *T. harzianum* and *P. fluorescence* (1:1 ratio) at seed, seedling, tillering and symptoms initiation stage or two application of antagonists at seedling and symptoms initiation stage were almost equally effective in reducing the disease severity of sheath blight in rice.

Vidhyasekaran *et al.* (1997) developed the powder formulation of *P. fluorescence* and applied in the form of seed treatment and foliar spray. Through the findings of Alkhail, 2005. During present investigation, aqueous extract of Neem leaf at 5% was applied as foliar spray at tillering and boot leaf stages, which showed reduction of disease severity. Twice application of Neem cake aqueous extract at 5% to the wheat plants, at tillering and boot leaf stages resulted in reduction of disease severity and incidence. Mohammad and Niazi (2001) reported that *A. indica* controlled 56.96% leaf rust of wheat.

Conclusions

Leaf blight of wheat caused by *Alternaria tritici* is an important disease, causing significant yield losses throughout the world. From the experiments carried out in the cropping season of 2014-15, it may be concluded that out of different fungicides studied, Propiconazole at 0.1% was also found to be quite effective in reducing the level of disease intensity and enhancing crop yield followed by Hexaconazole and Vitavax. Out of the two bio-agents tested against wheat blight, *Pseudomonas fluorescence* resulted in the highest reduction in disease intensity whereas out of four plant extracts, application of aqueous neem leaf extract at tillering and boot leaf stage resulted in the highest wheat yield as compared to other botanical extracts. The present research findings are limited to one crop season under Allahabad agro-climatic conditions and thus as such more trials are required in future to validate the findings.

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Association and Path Analysis in Lentil (*Lens culinaris* M.) Genotypes for Seed and Seedling Characteristics

Sonu Get*, D.K. Gothwal, Rekha Choudhary, Vaibhav Sharma and Swarnlata Kumawat

Department of Plant Breeding and Genetics, Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan

*Corresponding Author Email : sonugate79@gmail.com

Abstract

Thirty genotypes of lentil were evaluated for their seed and seedling characteristics in randomized block design with three replications to study the association and path analysis for different characters. 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 association analysis revealed that the 100-seed weight was positively and significantly correlated with seed volume, water absorption capacity and seedling dry weight, whereas water absorption index, seedling length and seedling vigour index had negative and significant correlation with 100-seed weight. Path analysis was carried out by taking 100-seed weight as dependent variable and other traits as independent variables. The direct and positive effect on 100-seed weight was recorded for water absorption capacity, seed volume, seedling vigour index, porosity, bulk density, seedling fresh weight and seedling dry weight, while negative direct effect were exhibited by true density, germination per cent, seedling length and water absorption index.

Key words : association analysis, lentil, physical properties, water absorption capacity, seedling vigour index, bulk density.

Introduction

Lentil belongs to family Fabaceae (Leguminosae) and subfamily Papilionaceae. Genus *Lens* consists of the cultivated *Lens culinaris* and six related wild taxa. Among these different taxa of wild lentils, *L. orientalis* is considered to be the progenitor of the cultivated lentil. According to Ladizinsky, 1979 (8) lentil has been originated in Southern Turkey. Lentil thrives well in sub-marginal lands with low inputs under water-limited conditions and has great importance in cereal-based cropping systems. The seed of this plant are commonly used as edible pulse and largely consumed as *dal* and also used in soups, stews, salads, casseroles, snacks and vegetarian dishes. Lentil contains high lysine and tryptophan content and is consumed with wheat or rice which provides a balance in essential amino acids for human nutrition. 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. Lentil seeds contain about 25-27% crude protein, 59% carbohydrates, 0.5% fat, 2.1% minerals and significant amount of vitamins (3). Lentil is mainly grown in India, Canada, Turkey, USA, Syria and Australia. India has a distinction of being the world's largest producer of pulses and occupies second position in the world with respect to lentil production. Major lentil growing states are Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal. The broad knowledge of physical

properties of agricultural products is being used in farming, planting, harvesting, processing, storage and transportation. Scientists from different corners of the world, have made high efforts in evaluating physical properties of agricultural products and found out their practical utility in designing and handling equipments and machineries. Recent scientific research and developments have made improvement in the handling and processing of biological materials through mechanical, thermal, electrical, optical and other techniques, but there is little knowledge about the basic physical characteristics of agricultural products. Such basic information is important to food scientists, processors, plant breeders and other scientists who may find new uses (12). The purpose of this research work was to investigate the association among different seed and seedling characteristics and their direct and indirect effects on component characters of the lentil genotypes to assist the breeding strategies for increasing the production of pulses including development and utilization of improved varieties, production technologies and plant protection measures which are expected to reduce the existing knowledge gap in the production and requirement of pulses.

Materials and Methods

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. The experiment was conducted under laboratory conditions at room temperature where the temperature was maintained at $24 \pm 2^\circ\text{C}$. Glass petridishes were used in the experiment after sterilization in hot air oven at 165°C for 4 hours (16). The germination papers were autoclaved at 15 psi and 121°C for 20 minutes and used as a matrix for seed germination. Thirty genotypes of lentil (Table 1.) were obtained from AICRP on MULLaRP at Rajasthan Agricultural Research Institute, Durgapura, Jaipur. 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. After that the seeds were ready for placing in the petridishes. The disinfected seeds were planted in petridishes and were maintained in controlled laboratory conditions. The germination was completed within 6 days of planting and monitored on 7th day from the day of seed planting. Observations on different seedling characters viz., seedling length, seedling fresh weight, seedling dry weight, and seedling vigour index were recorded on randomly selected seedlings on 11th day of seed planting. The data on seedling dry weight was recorded after drying in hot air oven for 48 hours at 65°C .

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

Observations recorded for seed characteristics : To determine 100-seed weight (g), a sample of one hundred seeds was drawn from each replication and weighed on an electronic balance. Seed volume was measured by liquid displacement technique (17). For each lentil genotype from each replication 100 seeds were weighed and put into a 100 ml measuring cylinder containing 15 ml (initial reading) of water that could completely cover all the seeds. Seed volume was recorded as (final reading – initial reading)/100 (12) and expressed as ($\mu\text{l}/\text{seed}$).

The true density (g/cm^3) was determined by dividing individual seed weight (g) by its volume which was

measured already in cm^3 . To measure bulk density, a rectangular container was weighed in gram (W_1) and the seeds of each replication was filled in this container and weighed with container (W_2) by using electronic balance. The bulk density of seed was measured by dividing the mass of seed (g) by volume of the container (cm^3) by using following formulae (6) :

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

Where, M = Mass of seed ($W_2 - W_1$) in grams

V = Volume of container in cm^3

The porosity () of bulk seed was computed from the values of the true density (ρ_t) and bulk density (ρ_b) using the following formula (18) :

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

The water absorption capacity was determined by weighing 100 seeds from each replication, 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 by using filter paper and seeds were weighed. Water absorption capacity in terms of mg per seed was recorded as per Mohsenin (12) formula :

$$\text{WAC (mg/seed)} = \frac{\text{Weight after soaking} - \text{Weight before soaking}}{100}$$

Where, WAC = Water absorption capacity

Water absorption index was obtained by dividing the water absorption capacity of a single seed by its size or weight 20.

Water absorption index

$$= \frac{\text{Water absorption capacity (mg / seed)}}{\text{Original seed size (g)}}$$

Observations recorded for seedling characteristics :

A seed was considered to have germinated at the emergence of both radicle and plumule up to 2 mm length (2). The number of germinated seeds was recorded 7th day after plating of seeds in petridishes and the germination percentage was determined by using the following formula (11) :

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 plating in petridishes. Five seedlings from each petridish were randomly selected from each replication. The seedling length (the distance

Table-2 : Phenotypic correlation coefficients for various characters in lentil.

Characters	SW	SV	TD	BD	Por	WAC	WAI	Germ	SL	SFW	SDW
SV	0.828**										
TD	0.036	-0.523**									
BD	-0.152	-0.213*	0.163								
Por	0.073	-0.471**	0.942**	-0.154							
WAC	0.942**	0.804**	0.009	-0.210*	0.047						
WAI	-0.257*	-0.147	-0.078	-0.153	-0.075	0.079					
Germ	0.021	0.148	-0.233*	0.040	-0.249*	0.034	0.057				
SL	-0.343**	-0.265*	-0.070	-0.018	-0.031	-0.374**	-0.042	-0.017			
SFW	0.196	0.168	-0.017	0.095	-0.021	0.124	-0.182	-0.076	0.541**		
SDW	0.685**	0.739**	-0.265*	-0.084	-0.261*	0.696**	-0.031	0.138	-0.392**	-0.032	
SVI	-0.330**	-0.227*	-0.117	-0.007	-0.083	-0.358**	-0.031	0.202	0.975**	0.516**	-0.353**

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

Note : SW = 100-seed weight, SV = seed volume, TD = true density, BD = bulk density, Por = porosity, WAC = water absorption capacity, WAI = water absorption index, Germ = germination, SL = seedling length, SFW = seedling fresh weight, SDW = seedling dry weight and SVI = seedling vigour index

from root tip to leaf tip) was measured by using a measuring scale in centimeter and averaged. The fresh weight of five seedlings from each replication was taken by using a sensitive electronic balance and average was expressed in milligram (mg).

To obtain seedling dry weight, freshly weighed same five seedlings 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 averaged. The seedling vigour index was determined by multiplying the seedling length with concerned germination percentage by the following formula (6) :

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

Where, SL= Mean seedling length (cm)

GP= Germination percentage

Results and Discussion

In general, correlation and path coefficients were stronger at phenotypic level in comparison to genotypic level; this indicated the strong effect of environment on the expression of the characters. Significance was tested at phenotypic level only. The association and path coefficient at phenotypic level are generally considered as there is no tangible test for knowing the statistical significance of correlation and path coefficient at genotypic level (15 and 19). Considering this reference, association and path analysis at phenotypic level is described here.

Character association analysis : Association analysis provides information about degree and direction of association between two characters. It may result due to genetic causes such as pleiotropic effect or linkage or both. It may also be due to environmental cause. Improvement in one character may cause simultaneous

change in other characters and may be judged by the magnitude and direction of correlation.

Phenotypic and genotypic correlation coefficients among twelve characters are presented in table-2. and table-3. In this study, the 100-seed weight had positive and significant association with seed volume (0.828), water absorption capacity (0.942), and seedling dry weight (0.685). The seed volume had positive and significant association with water absorption capacity (0.804), seed weight (0.828) and seedling dry weight (0.739). The water absorption capacity had positive and significant association with seed weight (0.942), seed volume (0.804) and seedling dry weight (0.696). Williamsa *et al.*, 1983 (20), Khattak *et al.*, 2006 (7), Paksoy and Aydin, 2006 (14), Makkawi *et al.*, 2008 (8), Malik *et al.*, 2011 (11), Nichal *et al.*, 2015 (13) and Hadi *et al.*, 2016 (4) also reported similar results for these characters. The true density had positive and significant association with porosity (0.942). The bulk density had negative and significant association with seed volume (-0.213) and water absorption capacity (-0.210). The porosity had positive and significant association with true density (0.942). Similar findings were reported earlier by Williams *et al.*, 1983 (20) and Hadi *et al.*, 2016 (4) for true density and water absorption capacity. The water absorption index showed negative and significant association with seed weight (-0.257) and the germination percentage showed negative and significant association with true density (-0.233) and porosity (-0.249). The seedling fresh weight had positive and significant association with seedling length (0.541) and seedling vigour index (0.516). The seedling dry weight had positive and significant association with seed weight (0.685), seed volume (0.739), and water absorption capacity (0.696). The seedling length had positive and significant association with seedling fresh weight (0.541) and seedling vigour

Table-3 : Phenotypic path coefficients for various characters in lentil.

Ch.	SV	TD	BD	Poro	WAC	WAI	Ger	SL	SFW	SDW	SVI	100 SW
SV	0.28821	0.01414	-0.01165	-0.09046	0.58206	0.03653	-0.00608	0.05966	0.00268	0.00287	-0.05044	0.828**
TD	-0.15076	-0.02702	0.00896	0.18101	0.00676	0.0194	0.00956	0.01567	-0.00028	-0.00103	-0.02596	0.036NS
BD	-0.06129	-0.00442	0.05479	-0.02957	-0.15189	0.03801	-0.00163	0.00407	0.00151	-0.00033	-0.00162	-0.152NS
Poro	-0.13567	-0.02546	-0.00843	0.19216	0.03436	0.01868	0.0102	0.00695	-0.00033	-0.00101	-0.01837	0.073NS
WAC	0.23162	-0.00025	-0.01149	0.00912	0.72428	-0.01965	-0.00139	0.08426	0.00198	0.00270	-0.07951	0.942**
WAI	-0.04243	0.00211	-0.0084	-0.01447	0.05736	-0.24809	-0.00235	0.00954	-0.00291	-0.00012	-0.00687	-0.257*
Ger	0.042710	0.0063	0.00217	-0.04778	0.0245	-0.01423	-0.04102	0.00389	-0.00121	0.00054	0.04485	0.021NS
SL	-0.07630	0.00188	-0.00099	-0.00593	-0.27083	0.01051	0.00071	-0.22534	0.00864	-0.00152	0.2163	-0.343**
SFW	0.04835	0.00047	0.00519	-0.00396	0.0896	0.04514	0.0031	-0.12187	0.01597	-0.00013	0.11452	0.196NS
SDW	0.21308	0.00716	-0.00461	-0.05014	0.50441	0.00778	-0.00566	0.08831	-0.00052	0.00388	-0.07826	0.685**
SVI	-0.06552	0.00316	-0.0004	-0.01591	-0.25958	0.00768	-0.00829	-0.21969	0.00824	-0.00137	0.22186	-0.330**

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

Note : SW = 100-seed weight, SV = seed volume, BD = bulk density, Por = porosity, WAC = water absorption capacity, WAI = water absorption index, Ger = germination, SL = seedling length, SFW = seedling fresh weight, SDW = seedling dry weight and SVI = seedling vigour index

index (-0.975) which was also reported by Latha, 2014 (9). In this study, the seedling vigour index showed negative and significant correlation with seedling dry weight which was contradictory to the findings of Nichal *et al.*, 2015 (13) who reported the positive and significant correlation between seedling vigour index and seedling dry weight.

Path coefficient analysis : Path coefficient analysis helps in separating the direct effects of a component character on a dependent character from indirect effects via other characters. In the present study 100-seed weight was considered as dependent variable. The genotypic and phenotypic correlation coefficients of 100-seed weight with its contributing characters were partitioned into direct and indirect effects through path coefficient analysis and are presented in table 4 and table 5 both at genotypic and phenotypic levels. The trend in direct and indirect effects of different traits on 100-seed weight was similar at genotypic and phenotypic levels.

Seven out of eleven characters had positive and direct effect on 100-seed weight at phenotypic level. The highest direct and positive effect on 100-seed weight was recorded for water absorption capacity (0.72428) and succeeded by seed volume (0.28821), seedling vigour index (0.22186), porosity (0.19216), bulk density (0.05479), seedling fresh weight (0.01597) and seedling dry weight (0.00388), while true density (-0.02702), germination per cent (-0.04102), seedling length (-0.22534) and water absorption index (-0.24809) had negative direct effect on 100-seed weight. The detail is given in table-4.

The seed volume showed positive indirect effect on 100-seed weight through water absorption capacity (0.58206), seedling length (0.05966), water absorption index (0.03653), true density (0.01414), seedling dry weight (0.00287) and seedling fresh weight (0.00268), whereas negative indirect effect through germination (-0.00608), bulk density (-0.01165), seedling vigour index (-0.05044) and porosity (-0.09046).

The true density showed positive indirect effect on 100-seed weight through porosity (0.18101), water absorption index (0.01940), seedling length (0.01567), germination (0.00956), bulk density (0.00896) and water absorption capacity (0.00676), whereas negative indirect effect through seedling fresh weight (-0.00028) and seedling dry weight (-0.00103), seedling vigour index (-0.02596) and seed volume (-0.15076).

The bulk density showed positive indirect effect on 100-seed weight through water absorption index (0.03801), seedling length (0.00407) and seedling fresh weight (0.00151), whereas negative indirect effect

through and seedling dry weight (-0.00033), seedling vigour index (-0.00162), germination (-0.00163), true density (-0.00442), porosity (-0.02957), seed volume (-0.06129) and water absorption capacity (-0.15189).

The porosity showed positive indirect effect on 100-seed weight through water absorption capacity (0.03436), water absorption index (0.01868), germination (0.01020) and seedling length (0.00695), whereas negative indirect effect through seedling fresh weight (-0.00033), seedling dry weight (-0.00101), bulk density (-0.00843), seedling vigour index (-0.01837), true density (-0.02546) and seed volume (-0.13567).

The water absorption capacity showed positive indirect effect on 100-seed weight through seed volume (0.23162), seedling length (0.08462), seedling dry weight (0.00270), seedling fresh weight (0.00198) and porosity (0.00912), whereas negative indirect effect through true density (-0.02546), germination (-0.01020), bulk density (-0.00843), water absorption index (-0.01868), and seedling vigour index (-0.01837).

The water absorption index showed positive indirect effect on 100-seed weight through water absorption capacity (0.05736), seedling length (0.00954) and true density (0.00211), whereas negative indirect effect through seedling dry weight (-0.00012), germination (-0.00235), seedling fresh weight (-0.00291), seedling vigour index (-0.00687), bulk density (-0.00840), porosity (-0.01447) and seed volume (-0.04243).

The germination showed positive indirect effect on 100-seed weight through seedling vigour index (0.04485), seed volume (0.04271) water absorption capacity (0.0245), true density (0.00630), seedling length (0.00389), bulk density (0.00217) and seedling dry weight (0.00054), whereas negative indirect effect through seedling fresh weight (-0.00121), water absorption index (-0.01423) and porosity (-0.04478).

The seedling length showed positive indirect effect on 100-seed weight through seedling vigour index (0.2163), water absorption index (0.01051), seedling fresh weight (0.08640), true density (0.00188) and germination (0.00071), whereas negative indirect effect through bulk density (-0.00093), seedling dry weight (-0.00152), porosity (-0.00593), seed volume (-0.07630) and water absorption capacity (-0.27083).

The seedling fresh weight showed positive indirect effect on 100-seed weight through seedling vigour index (0.11452), water absorption capacity (0.0896), seed volume (0.04835), water absorption index (0.04514), bulk density (0.00519), germination (0.00310) and true density (0.00047), whereas negative indirect effect through

seedling dry weight (-0.00013), porosity (-0.00396) and seedling length (-0.12187).

The seedling dry weight showed positive indirect effect on 100-seed weight through water absorption capacity (0.50441), seed volume (0.21308), seedling length (0.08831), water absorption index (0.00778) and true density (0.00716), whereas negative indirect effect through seedling fresh weight (-0.00052), bulk density (-0.00461), germination (-0.00566), porosity (-0.05014) and seedling vigour index (-0.07826).

The seedling vigour index showed positive indirect effect on 100-seed weight through seedling fresh weight (0.00824), water absorption index (0.00768) and true density (0.00316), whereas negative indirect effect through bulk density (-0.0004), seedling dry weight (-0.00137), germination (-0.00829), porosity (-0.01591), seed volume (-0.06552), seedling length (-0.21969) and water absorption capacity (-0.25958). There is a little research work for this objective of study but some related findings were reported by Honnappa *et al.*, 2018 (5).

Conclusions

Information on physical properties of seeds of various genotypes may be helpful in designing desirable machines and equipments to be used during seed processing and safe storing of the seed. 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 on these aspects in lentil.

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Foliar Application of Plant Bio Regulator (PBR) and Micro-Nutrient on Flowering and Yield of African Marigold under Jhalawar Conditions

Ashok Choudhary^{1*}, Ashutosh Mishra¹, S. K. Mood², Rajesh Choudhary⁴, R. Bajia⁴, R.N. Choudhary⁵ and S.K. Jat⁶

¹Department of Floriculture and Landscaping, College of Horticulture and Forestry, Jhalapatan, Jhalawar, Rajasthan

²Department of Horticulture, COA, Agriculture University, Jodhpur, Rajasthan

³Department of Horticulture, S.K.N. Agriculture University, Jobner-Jaipur, Rajasthan

⁴Department of Agriculture, V.G.U., Jaipur, Rajasthan

⁵Agriculture, Government P.G. College Sawaimadhopur, Rajasthan

⁶Department of Entomology, Agriculture University, Kota, Rajasthan

*Corresponding Author Email : ashokchoudhary116@gmail.com

Abstract

Marigold is one of the popular exploited flower crops that belong to the family Asteraceae. The production of economical yield and better quality of marigold flowers requires proper crop management techniques. This can be done by adopting application of plant bio regulator (PBR) and micro-nutrient. The present study was designed to investigate the foliar application of plant bio regulator (PBR) and micro-nutrient on flowering and yield of African marigold under Jhalawar conditions. Plants were sprayed with zinc at five concentrations (0.0, 0.25, 0.50, 0.75, and 1.0 %) and salicylic acid at four concentrations (0.0, 0.25, 0.50 and 1.0 mM/L). The plants sprayed with Zn₃SA₂ (Zinc 0.75 % + Salicylic acid 0.50 mM/L) exhibited maximum increase in diameter of flower (24.10%), fresh weight of flower (47.18%) and dry weight of flower (61.22%). The exogenous application of treatment Zn₄SA₃ significantly improved maximum flower yield/ha in African marigold plants. Conclusively, the results suggest that foliar application of PBR and micro-nutrient improved flowering and yield of African marigold.

Key words : African marigold, zinc, salicylic acid, Pusa Narangi gairda

Introduction

African marigold (*Tagetes erecta* L.) belongs to family Asteraceae, is a very popular commercial flower and widely grown for loose flower production (Bussmann *et al.*, 2020). It is an ornamental plant species with known medicinal use due to the high content of carotenoids and phenolic in flower petals (Paradikovic *et al.*, 2019). It is popular throughout the world because of its wide spectrum of attractive colours, shape and good keeping quality. Marigold has gained popularity on account of its easy cultivation, wide adaptability and production throughout the year (Choudhary *et al.*, 2014). Marigold, having ornamental, medicinal and industrial uses, has additional use in controlling the soil nematodes. All varieties of marigold are resistant to *Meloidogyne incognita* and could be used to control *Meloidogyne incognita* in highly infested areas (Visser and Vythilingam, 1959). It is established fact that nutrition plays an important role in the improvement of flowering and yield in marigold. Zinc is a well-known component for many enzymes and affects many biological processes such as photo-synthetic reactions, nucleic acids metabolism, protein and carbohydrate synthesis (Choudhary *et al.*, 2016). The role of zinc in plant is due to its requirement in the synthesis of tryptophan which is a

constituent of indole acetic acid (Shukla *et al.*, 2009) as well as its ability to trigger plant defence mechanisms (Anupriya *et al.*, 2005). Salicylic acid is phyto-hormone that play an important role in response to biotic stresses pathogenesis and also participate in the signaling of abiotic stress response. Salicylic acid is also used for induction of flowering in marigold. It regulates a number of processes in plants including disease resistance, seed germination, sex polarization and ethylene production (Raskin *et al.*, 1992). Exogenous administration of salicylic acid before the reproductive stage of marigold plants may result in increased biomass production and total flavonoids content.

Foliar applications constitute the most effective means of micro-nutrient application when problems of nutrient fixation in the soil exist. Therefore keeping this in view, the present experiment was initiated with an objective to study response of foliar application of plant growth regulator (PGR) and micro-nutrient on flowering and yield of African marigold to work out optimum concentrations of Zinc and Salicylic acid.

Materials and Methods

The field experiment is performed at the Instructional

Farm, Krishi Vigyan Kendra, Jhalawar, Agriculture University Kota, which is located in southern Rajasthan among 23°4' and 24°52' N latitude and 75°29' to 76°56' E longitude. The zone's climate is sub-humid and sub-tropical, with mild winters and warm summers, as well as generally high humidity from July to September. The region receives 954.7 mm of annual rainfall during the South-West monsoon between the last week of June to September, and only occasional showers during the winter season.

The soil of experimental field had organic carbon 0.48 % (Walkley and Black, 1934), available nitrogen 240.68 kg/ha (Subbiah and Asija, 1956) available phosphorus 16.83 kg/ha ((Olsen *et al.*, 1954) and available potash 299.0 kg/ha ((Hanway and Heidel, 1952.). Four -week old seedlings of African marigold were planting at the spacing of 30 X 30 cm by drip irrigation in RBD factorial design with three replications and 20 treatments combinations. The healthy and disease free seed of African marigold cv. PNG was obtained from Indian Agricultural Research Institute, New Delhi.

The observations on diameter of flower was measured by vernior caliper, fresh weight of flower, dry weight of flower, flower yield per ha were observed by digital weighing balance and average data was analyzed statistically.

Results and Discussion

In this experiment, statistically data was recorded that flower diameter, showed significant variances amongst zinc and salicylic acid treatments (Table-1). During the main effect of foliar spraying of zinc, the maximum flower diameter (8.23 cm) was observed at Zn₃ treatment, which was 16.57 per cent higher as compared to control. The treatment SA₂ observed largest flower diameter (7.76 cm), which was 1.03 fold more response as compared to control. In interaction, the treatments Zn₃SA₂ had a highest flower diameter (8.34 cm) which was 24.10, 12.90 and 12.55 per cent higher as compared to Zn₀SA₀, Zn₀SA₁ and Zn₁SA₂ treatments, respectively. The treatment Zn₃SA₃ showed a 1.07 and 1.10-fold greater response as over to Zn₂SA₃ and Zn₁SA₃ treatments in African marigold crops, respectively.

Statistical analysis of the data for fresh weight of flower s revealed significant differences among the zinc and salicylic acid (Table-2). The application of zinc, the highest fresh weight (6.03 g) was observed at Zn₃ treatment, which was a 1.17-fold better response as compared to control. The foliar spraying at SA₂ treatment measured maximum fresh weight (6.06 g) which was statistically at par with SA₃ treatment and minimum was observed in control. During interaction, In African

marigold, the fresh weight of flower at Zn₃SA₂ treatment which was 0.99, 3.29, 1.45 and 47.18 percent greater than the treatments Zn₂SA₂, Zn₄SA₃, Zn₁SA₂ and Zn₀SA₀, respectively. The treatment Zn₁SA₂ found a 1.18-fold greater response as compared to Zn₁SA₀ and Zn₂SA showed a 1.11-fold better response as over to Zn₁SA₀ treatment. The treatment Zn₀SA₃ showed a 1.27-fold better response as compared to control.

Zinc and salicylic acid had a significant effect on the dry weight of flower of African marigold. The amount of dry weight of flower increased as a result of zinc application of 25.86% as compared to non-treated plants. The foliar application of salicylic acid, the maximum dry weight was observed at SA₂ treatment which was statistically at par with SA₃ treatment. During interaction, the highest dry weight of flower was observed in the Zn₃SA₂, Zn₃SA₁ and Zn₂SA₂ with the values of 1.58, 1.44 and 1.42, respectively, which was 61.22, 46.93, and 44.89 % more than the control treatment respectively. The treatment Zn₁SA₂ found a 1.10-fold more response as compared to Zn₁SA₀ and Zn₂SA showed a 1.04-fold better response as over to Zn₂SA₁ treatment. The lowest dry weight of flower was obtained with 0.98, 1.24, 1.30, 132 and 1.48 in the treatments Zn₀SA₀, Zn₁SA₀, Zn₂SA₀, Zn₃SA₀ and Zn₄SA₀, respectively (Table-3).

The maximum flower yield per hectare (242.69 qtl.) was observed in Zn₄ treatments which was 1.33-fold greater than those of untreated plants. The treatment SA₃ found a 1.26-fold more response as compared to SA₀ treatment. The highest flower yield per hectare (259.87 qtl.) was observed in the Zn₄SA₃ which was followed by Zn₃SA₃, Zn₃SA₂ and Zn₄SA₂ treatments, respectively. Lowest flower yield per hectare was obtained with 131.35, 177.82, 191.68, 214.30 and 231.99 in the treatments Zn₀SA₀, Zn₁SA₀, Zn₂SA₀, Zn₃SA₀ and Zn₄SA₀, respectively (Table-4).

The increase in the flower diameter with zinc and salicylic acid application might be attributed to more tryptophan production which acts as a precursor of auxin which increases the vegetative growth of plant and stimulates the production of more food material, which in turn might have been utilized for better development of flowers (Muthumanickam, 1999). Salicylic acid may have affected the biophysical properties of the cell wall, and there is a synergistic interaction between salicylic acid and auxins (Padmapriya and Chezhiyan, 2002), favouring photosynthesis and assimilate transport into flower organs (Khurana and Cleland, 1962). The current findings agree with those of Pacheco *et al.* (2013) for marigold and Anwar *et al.* (2014) for tuberose. The application of salicylic acid significantly accelerated the fresh and dry weight of flower due to improved photosynthesis rate,

Table-1 : Effect of plant Bio regulator (PBR) and micro-nutrient on flower diameter of African marigold cv. PNG.

Treatments	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Zn ₄	Mean
SA ₀	6.72	7.27	7.44	8.03	7.90	7.44
SA ₁	7.14	7.40	7.45	8.32	7.98	7.66
SA ₂	7.39	7.41	7.54	8.34	8.12	7.76
SA ₃	7.41	7.43	7.69	8.24	8.18	7.67
Mean	7.12	7.37	7.53	8.23	7.94	
	CD (P=0.05)					
Zn	0.19					
SA	0.17					
Zn X SA	0.39					

Table-2 : Effect of plant Bio regulator (PBR) and micro-nutrient on fresh weight of flower of African marigold cv. PNG.

Treatments	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Zn ₄	Mean
SA ₀	4.26	5.23	5.55	5.97	5.96	5.40
SA ₁	5.03	5.31	5.82	5.79	5.92	5.58
SA ₂	5.76	6.18	6.21	6.27	5.89	6.06
SA ₃	5.44	5.97	6.00	6.11	6.07	5.92
Mean	5.12	5.67	5.89	6.03	5.96	
	CD (P=0.05)					
Zn	0.22					
SA	0.20					
Zn X SA	0.45					

Table-3 : Effect of plant Bio regulator (PBR) and micro-nutrient on dry weight of flower of African marigold cv. PNG.

Treatments	Zn ₀	Zn ₁	Zn ₂	Zn ₃	Zn ₄	Mean
SA ₀	0.98	1.24	1.30	1.32	1.48	1.26
SA ₁	1.18	1.30	1.36	1.44	1.39	1.33
SA ₂	1.28	1.37	1.42	1.58	1.47	1.42
SA ₃	1.18	1.35	1.41	1.51	1.44	1.38
Mean	1.16	1.32	1.37	1.46	1.44	
	CD (P=0.05)					
Zn	0.06					
SA	0.05					
Zn X SA	0.12					

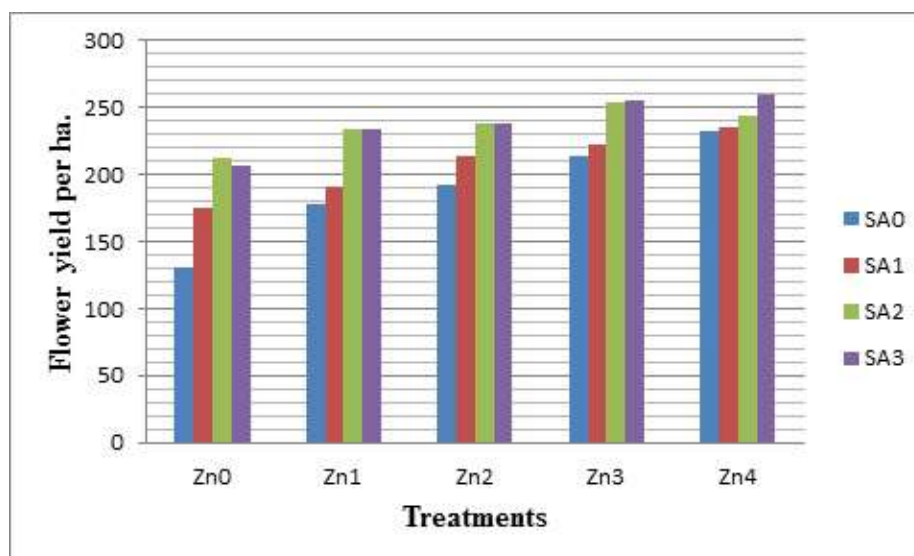


Fig-1 : Effect of plant Bio regulator (PBR) and micro-nutrient on yield per hectare (qtl.) of African marigold cv. PNG.

chlorophyll fixation and translocation of assimilates from source to sink (Fariddudin *et al.*, 2003). The increase in fresh and dry flower weight with zinc could be associated with greater nutrient availability for photosynthesis and dry matter accumulation, and also increased zinc accessibility and absorption by the plants, leading to increased flower weight (Abdi *et al.*, 2009). Samia and Mahmoud (2009) in *Tritonia* and Yadegari and Shakerian (2014) in marigold reported similar results. The maximum flower production per hectare may be attributable to the ability to accommodate the highest number of flowers per hectare, as well as larger vegetative growth, photosynthetic pigments, minerals, and certain bio components that affect plant growth and, as a result, enhanced output (Gharib, 2007). The current findings agree with those of Reddy and Rao (2012) for gerbera and Yadegari and Shakerian (2014) for marigold.

Conclusions

It is found that the foliar application of zinc 1.0% + salicylic acid 1.0 mM⁻¹ and zinc 0.75 % + salicylic acid 0.50 mM⁻¹ may positively regulated the marigold flowering and thus improved the production.

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Field Evaluation of Two *Bacillus* spp. for Plant Growth Promotion and *Fusarium* Wilt Management in Chickpea

Puneshwar Kumar^{1*}, Sushil K. Sharma² and Anup Kumar Singh¹

¹Department of Agricultural microbiology, IGKV, Raipur, Chhattisgarh-492012

²ICAR-National Institute of Biotic Stress Management, Baronda, Raipur-493225

*Email : kpuneshwar21@gmail.com

Abstract

The proposed investigation was carried out in Collage of Agriculture, IGKV, Raipur, Chhattisgarh during rabi season 2020-21. The experiment was laid out in randomized block design with eighteen treatments and three replications. *Fusarium oxysporum* f. sp. *ciceri*. wilt of chickpea is a widely distributed and the most destructive disease caused by *Fusarium oxysporum* f. sp. *ciceri*. Objective of this study was evaluation of *Bacillus* species of their effect on plant growth promotion, yield and disease control of chickpea. All the isolates showed different colony morphology, cells were rod in shape and showed gram positive reaction of two *Bacillus* isolates (CRS-6 and CRS-9). Maximum germination percent 87.7% was observed in T₁₄ (Vishal X *Bacillus bingmayongensis*). At 30 DAS maximum plant height 22.8 cm, in T₃ (Vaibhav X *B. glycinifermentans*) and after 60 DAS, maximum plant height 40.13 cm, in T₁₇ (JG-16 X *B. bingmayongensis*). Maximum dry weight of plant was found 13.7 g, in T₃ (Vaibhav X *B. Glycinifermentans*) showed significantly higher. Maximum disease severity 4.9% was recorded in T₁ (Vaibhav X Control) at 30DAS in 60 DAS maximum disease severity 37.6% was recorded in T₁₀ (RG-2009-16 X Control) and 90 DAS maximum disease severity 80.0% was recorded in T₇ (Jaki X Control). Maximum grain yield (1085.83 kg ha⁻¹) was recorded in T₆ (JG-226 X *B. glycinifermentans*) significantly higher as compared to rest of the treatments. Inoculation of *Bacillus* sp. improved crop growth and yield.

Key words : Antagonistic strains, *Fusarium oxysporum*, *B. glycinifermentans*, *B. Bingmayongensis*, disease severity, chickpea.

Introduction

Pulses historically have been one of the most important constituent of the Indian cropping systems, consumption patterns and long considered “the poor man’s meat” as it is one of the less expensive sources of protein (Mohanty and Satyasai 2015). Chickpea is an important pulse crop and stands third amongst the food grain after rice and wheat. Chickpea (*Cicer arietinum* L.), also called garbanzo bean or Bengal gram or King pulse (Lev-Yadun *et al.* 2000). Chickpea is containing 21.1 per cent protein, 61.5 per cent carbohydrates and 2.2 per cent oil (Gupta 1988). Chickpea crop has got special importance in Indian diet because it can be consumed in a various ways. Chickpea split seeds are used in the form of dal, parched, fried, roasted and boiled as snack food, sweet and condiments The seeds are ground to flour known as besan and used in preparing various dishes like pakora, laddu etc. The tender leaves of chickpea are used as fresh green vegetables, while the aboveground dry plant parts are used as the cattle feed. Leaves exudation containing medicinally valuable oxalic and malic acids are being used for treatment of stomach aches, blood purification etc. Consumption of the germinated seeds prevents scurvy disease.

During 2017-18, chickpea was grown on 149.66 lakh hectares area, with the total production of 162.25 lakh tonnes (FAOSTAT, 2019) and average productivity of 1252 kg/ha at global level. Out of which, 71 per cent of global area with 70 per cent of global production of chickpea is contributed by India as it ranks 1st in area and production but lags behind several countries in terms of productivity because of poor adoption of improved varieties and production technologies by farmers’. Apart from India, Australia (12.35%), Myanmar (3.25%) and Ethiopia (2.92%) are the major chickpea producing countries of the world. In India (during 2017-18), chickpea production recorded an all-time high of 11.23 million tonnes in an area of 10.56 million hectare, with a productivity of 1063 kg/ha. Madhya Pradesh (4.60 million tonnes), Maharashtra (1.78 million tonnes), Rajasthan (1.67 million tonnes), Karnataka (0.72 Million tonnes), Andhra Pradesh (0.59 million tonnes), Uttar Pradesh (0.58 million tonnes), and Gujarat (0.37 million tonnes) are the top seven states in terms of chickpea production. Madhya Pradesh is a leading state in terms of area and production of chickpea. Five major pulse growing districts of Chhattisgarh are Mungeli, Bemetra, Kabirdham, Rajnandgaon and Bilaspur & have identified in term of area and production first Bemetra and Mungeli

respectively (Commissioner of Land Revenue, 2016-17). Chickpea productivity, on the other hand, has remained virtually unchanged over the last few decades due to its susceptibility to diseases like wilt (*Fusarium oxysporum* f. sp. *ciceris*), black root rot (*Fusarium solani*), and charcoal rot (*Macrophomina phaseolina*). The interaction of these pathogens can result in yield losses up to 80% and more (Pandey et al. 2007). Among three diseases, the wilt incited by *Fusarium oxysporum* f. sp. *ciceris*, is the most devastating for chickpea crop (Gupta et al., 1986). *Fusarium oxysporum* f. sp. *ciceris*, is found in its many pathogenic forms that damaging species of plants, a matter of great concern. Recently, many pathogenic microorganisms have developed resistance against chemical fungicides and this has seriously hinders the management of diseases of crops and agricultural plants. Looking above facts in view, the following objectives were targeted for further study to manage disease using microbes, an eco-friendly approach: Screening of *Bacillus* species isolated from different sources against *Fusarium oxysporum* f. sp. *ciceris* and other soil-borne pathogens and evaluation of *Bacillus* species to observe their effect on plant growth promotion, yield and disease control of chickpea crop.

Materials and Methods

This investigation was carried out in instructional cum research farm, Collage of Agriculture, IGKV, Raipur, Chhattisgarh during 2020-21 Rabi season. The experiment was laid out in randomized block design with eighteen treatments and three replications. Two *Bacillus* isolates (CRS-6 and CRS-9) were collected from, ICAR-NIBSM, Baronda, Raipur. Seed treatment (bacterization) with bacterial culture strains *B. bingmayongensis* CRS-6 and *B. glycinifermentans* CRS-9 were revived on NA growth medium and 6 fungal cultures were revived on PDA medium at respective temperature. The agar plates and slants showing well desired growth was picked and stored at 6-8°C until further use. Each bacterium culture was grown in nutrient broth in 150 ml Erlenmeyer flask followed by incubation at 28°C for 2-3 days on an orbital shaker with a speed of 120 rpm. After incubation, OD of culture was measured aseptically at 600nm using spectrophotometer to maintain OD of 0.5 which is equivalent to approximately 10^8 cfu ml⁻¹ cell suspension. The seeds of chickpea varieties were bacterized at the rate of 5 ml of 0.5 OD culture (10^8 -cfu ml⁻¹) per Kg of seeds. The bacterized seeds were kept for 30 min in shade before sowing. The absolute control of each variety was done by applying equivalent amount of nutrient broth. In field experiment recorded germination in each treatment was recorded at 30 days after sowing. Number of seedlings were counted and expressed as

germination percentage. Plant height (cm) of 5 randomly selected plants were taken from each treatment and tagged accordingly. Height of each tagged plant was measured at 15 days interval. After harvest, plant height was measured from base of the plant to tip of the main shoot by meter scale (100 cm) and average height of five plants was recorded as mean plant height in centimeter. The wilted chickpea plants were collected from different treatments on the basis of characteristic wilt symptoms; drooping of petioles and rachis, yellowing and drying of leaves from base to upward, browning of vascular bundles, withering of plants and finally death of plants (Westerlund et al. 1974; Prasad and Padwick 1939). Further, the collected samples were brought to the laboratory for isolation of *Fusarium oxysporum* f.sp. *ciceris*. Post emergence mortality will be recorded up to 90 days.

Observations of fresh weight and dry weight were recorded at the time of maturity. Mature plants were carefully uprooted for measuring the height, fresh weight and dry weight. After measuring length and fresh weight, the seedling were placed between blotting paper and kept at 70 °C for 3-4 days in an oven for drying and dry weight was recorded. Grain yield of chickpea the net plot area were harvested, bundled and weighed after sun drying. Thereafter, the material was transferred to threshing floor, threshed, cleaned and grain yield was recorded treatment wise. Yield obtained in kg plot⁻¹ were converted to yield in kg ha⁻¹ by multiplying with appropriate conversion factor. The treatment-wise straw yield was obtained by deducting the seed yield from the total produce (dry biomass) of the bundle weight and recorded in kg plot⁻¹ and then computed on hectare basis.

Results and Discussion

Data indicated in Table-1 germination percentage among treatment ranged from 63.67 to 87.7 %. Maximum germination percentage was observed 87.7 % in T₁₅ (Vishal X *Bacillus glycinifermentans*) All the treatment had higher germination percentage as compared to untreated control. Among the treatments, minimum germination (63.67 %) was observed in T₁₆ (JG-16 X Control) followed by 65.12% in T₁₈ (JG-16 X *B. glycinifermentans*).

Mashooda Begum et al. (2003) reported the same result in colonization of the bacterial strains *B. pumilus* (SE-34), *B. pasteurii* (T4), *B. subtilis* (IN 937-6), and *B. subtilis* (GB-03) decreased seed mycoflora frequency. This by implication improves seed germination rate and the seedling strength index.

Plant height of chickpea data presented in table-1 at 30 DAS show that significantly increased in all the treatments except untreated control. Maximum plant

Table-1 : Effect of *Bacillus* isolates against *Fusarium oxysporum* f.sp. *ciceris* on germination percentage, disease severity % plant height, fresh weight, dry weight Grain and straw yield of field chickpea.

Notation	Treatments details	Germination %	Disease severity % (30DAS)	Disease severity % (60DAS)	Disease severity % (90DAS)	Plant height 30 DAS (Cm)	Plant height 60DAS (Cm)	Fresh weight g/plant	Dry weight g/plant	Grain yield kg/h	Straw yield kg/h
T ₁	Vaibhav X Control	70.33	4.9	8.4	53.7	17.7	35.6	30.9	9.9	641.67	1150
T ₂	Vaibhav X <i>Bacillus bingmayongensis</i>	71.67	2.8	6.9	50.7	21.7	36.1	35.2	11.5	708.33	1308.33
T ₃	Vaibhav X <i>Bacillus glycinifermentans</i>	74.50	1.9	5.9	49.4	22.8	37.06	32.4	13.7	812.5	1458.33
T ₄	JG-226 X Control	67.81	3.9	10.3	51.1	17.5	32.63	35.0	8.2	870.83	1453.33
T ₅	JG-226 X <i>Bacillus bingmayongensis</i>	71.50	3.6	6.7	46.3	18.8	34.4	33.9	9.9	950.83	1530.67
T ₆	JG-226 X <i>Bacillus glycinifermentans</i>	78.83	3.0	7.6	36.3	19.7	37.3	34.5	10.6	1085.83	1683
T ₇	Jaki X Control	65.50	3.1	25.3	80.3	19.6	34.76	31.4	9.5	325	512.5
T ₈	Jaki X <i>Bacillus bingmayongensis</i>	66.83	1.3	26.3	75.3	19.7	35.96	35.2	11.9	437.5	787.5
T ₉	Jaki X <i>Bacillus glycinifermentans</i>	71.00	1.1	19.7	60.3	22.5	37.83	35.1	10.1	487.5	779.17
T ₁₀	RG-2009-16 X Control	73.83	4.4	37.6	70.0	19.0	35.1	29.1	8.9	375	516.66
T ₁₁	RG-2009-16 X <i>Bacillus bingmayongensis</i>	76.17	2.4	27.4	68.3	22.5	35.23	33.5	10.2	391.67	641.5
T ₁₂	RG-2009-16 X <i>Bacillus glycinifermentans</i>	76.87	3.2	19.3	65.9	21.8	36.13	34.1	9.2	900	662.5
T ₁₃	Vishal X Control	80.50	3.1	11.3	56.8	15.8	36.66	29.6	8.7	800	1225.83
T ₁₄	Vishal X <i>Bacillus bingmayongensis</i>	83.7	3.1	9.0	54.7	13.7	37.7	28.6	8.0	885.5	1425.83
T ₁₅	Vishal X <i>Bacillus glycinifermentans</i>	87.7	1.1	7.4	52.8	15.9	38.39	33.1	10.6	1073.33	1786.66
T ₁₆	JG-16 X Control	63.67	3.4	13.2	66.4	13.8	37.4	28.9	8.7	628.33	979.16
T ₁₇	JG-16 X <i>Bacillus bingmayongensis</i>	67.90	2.7	9.8	58.0	14.5	40.13	30.2	9.4	679.16	1114.17
T ₁₈	JG-16 X <i>Bacillus glycinifermentans</i>	65.12	1.3	8.1	51.3	14.6	39.03	34.9	10.0	794.17	1209.17
	C.D. at 5%	8.46	0.46	2.69	6.27	2.80	6.40	4.57	2.22	146.66	227.59
	C.V.	7.09	10.00	11.39	6.58	9.28	10.70	8.57	13.65	12.55	12.37

cm, 22.5 cm, 22.5 cm, 21.8cm, 21.7 cm and 19.7 cm was recorded in T₃ (Vaibhav X *B. glycinifermentans*) followed by T₉ (Jaki X *B. glycinifermentans*), T₁₁ (Vishal X *B. bingmayongensis*), T₁₂ (RG-2009-16 X *B. glycinifermentans*), T₂ (Vaibhav X *B. bingmayongensis*) and T₆ (JG-226 X *B. glycinifermentans*), respectively and minimum plant height recorded 13.7 cm in T₁₄ (Vishal X *B. bingmayongensis*). After 60 DAS, maximum plant height 40.13 cm, 39.03 cm, 38.39 cm, 37.83 cm, 37.7 cm and 37.3 cm were recorded in T₁₇ (JG-16 X *B. bingmayongensis*), T₁₈ (JG-16 X *B. glycinifermentans*), T₁₅ (Vishal X *B. glycinifermentans*), T₉ (Jaki X *B. glycinifermentans*), T₁₄ (Vishal X *B. bingmayongensis*) and T₆ (JG-226 X *B. glycinifermentans*), respectively and minimum plant height was recorded 32.63 cm in T₄ (JG-226 X Control).

Suthar *et al.* (2017) was also found that the BS-K18 seed treatment under *Fusarium oxysporum ciceris* stress expanded root length in resistant and susceptible variety. *B. lentus* has followed up on the quantity of branches, the length of the stems and the length of the roots. The effect of *B. firmus*, was seen on the weight of the vegetative growth and the length of the roots lastly *A. aneurinlyticus* affects the length of the stems and the weight of the root system. Incidence of *F. oxysporum* infection was fundamentally diminished by up to half while plant height, root and shoot fresh weight expanded essentially contrasted with the control. *Bacillus* spp from the rhizosphere have been accounted for to be effective against a variety of soil borne pathogen using different mechanisms (Choudhary and Johri, 2009).

Fresh weight of chickpea plant presented in table 1 show that at the time of maturity was significantly higher in all the treatments as compared to (untreated control).

Higher fresh weight 35.2 g, 35.2 g, 35.1 g, 34.9 g, 34.5 g and 34.1 g were recorded in T₈ (Jaki X *B. bingmayongensis*), T₂ (Vaibhav

X *B. bingmayongensis*), T₉ (Jaki X *B. glycinifermentans*), T₁₈ (JG-16 X *B. glycinifermentans*), T₆ (JG-226 X *B. glycinifermentans*) and T₁₂ (RG-2009-16 X *B. glycinifermentans*) respectively and minimum fresh weight recorded 28.6 gm in T₁₄ (Vishal X *B. bingmayongensis*).

Dry weight of chickpea plant data presented in table 1 show that significantly higher in all the treatments as compared to (untreated control) at the time of maturity.

Higher dry weight 13.7 g, 11.9 g, 11.5 g, 10.6 g, and 10.6 g were recorded in T₃ (Vaibhav X *B. glycinifermentans*), T₈ (Jaki X *B. s bingmayongensis*), T₂ (Vaibhav X *B. bingmayongensis*) T₆ (JG-226 X *B. glycinifermentans*) and T₁₅ (Vishal X *B. glycinifermentans*), respectively and minimum dry weight recorded 8.0 gm in T₁₄ Vishal X *B. bingmayongensis* followed by 8.2 gm in T₄ (JG-226 X Control).

The ability of *Bacillus* sp. to upgrade nodulation, plant dry matter and grain yield on co-inoculation with *Rhizobia* has likewise been accounted for different legumes like white clover (Holl *et.al.*, 1988), pigeon pea (Podile *et. al.*, 1995) and peanut (Turner *et.al.*, 1991). The Rhizobacteria utilized in this study enhanced some growth parameters of the two varieties of chickpea. Along these lines, *B. licheniformis* and *B. amyloliquefaciens* further developed aerial growth parameters, to which *Bacillus lentus* was added to further develop root system weight. This is occurring on the grounds that *Bacillus* spp or potentially their by-products are successful in restraining the mycelial development of *F. oxysporum*. f. sp. *ciceris*. (Karthick *et al.*, 2017)

Disease severity per cent of chickpea plant presented in table 1 shows that at the time of 30 DAS ranged from 1.1 to 4.9% as compared to T₁ (untreated control). Maximum disease severity 4.9% was recorded in T₁ (Vaibhav X Control) followed by 3.9 % in T₄ (JG-226 X Control) and minimum was observed 1.1% in T₉ (Jaki X *B. glycinifermentans*) and T₁₅ (Vishal X *B. glycinifermentans*).

At 60 DAS ranged from 5.9 to 37.6%. Maximum disease severity 37.6% was recorded in T₁₀ (RG- 2009-16 X Control) followed by 27.4% in T₁₁ (RG-2009-16 X *B. bingmayongensis*) and minimum 5.9% was observed in T₃ (Vaibhav X *B. glycinifermentans*) followed by 6.7% in T₅ (JG-226 X *B. bingmayongensis*).

At 90 DAS disease severity percent ranged from 36.3 to 80.3%. Maximum disease severity 80.3% was recorded in T₇ (Jaki X Control) followed by 75.3% in T₈ (Jaki X *B. bingmayongensis*) and minimum 36.3 % was

observed in T₆ (JG-226 X *B. glycinifermentans*) followed by 46.3% in T₅ (JG-226 X *B. bingmayongensis*).

Choudhary and Johri (2009) exhibited that the quantity of *Bacillus* strain activities suppresses pathogens or in any case advance plant development. Enhancements in plant health and productivity are interceded through three different biological components: (I) pathogen antagonism, (II) host nutrition and growth promotion, and (III) plant host defence stimulation. Rhizobacteria are great for use as biocontrol agents. Rhizobacteria occupy the rhizosphere that gives the forefront defence to roots against assault by pathogens. Pathogens track antagonism from rhizobacteria previously and during essential root contamination. Rhizobacteria are accounted for to give protection against several plant pathogens. For the most part, rhizobacteria qualities related with plant pathogens biocontrol include antibiotic synthesis and are therefore observed to be promising in diminishing the root wilt of chickpea in glasshouse and field conditions (Smitha *et al.*, 2017).

The data (Table-1) in respect to grain yield of chickpea were influenced significantly due to different treatments. The T₆ (JG-226 X *B. glycinifermentans*) recorded maximum grain yield (1085.83 kg ha⁻¹) followed by T₁₅ Vishal X *B. glycinifermentans* (1073.33kg ha⁻¹) as compared to rest of the treatments. T₇ (Jaki X Control) produced minimum grain yield (325.00 kg ha⁻¹) due to highest infestation of wilt in field of chick pea.

The grain yield of chickpea is the function of luxurious growth, dry matter accumulation, yield attributes and physiological characters. The T₆ (JG-226 X *B. glycinifermentans*). *Bacillus* spp. from spores, are resistant to unfavorable conditions and can in this manner be adjusted to the field. According to Gardener (2004), different populations of aerobic endospore-forming bacteria show up in farming fields, this may straightforwardly and in a roundabout way add to crop productivity. Numerous *Bacillus* spp. what's more *Paenibacillus* spp. can advance yield wellbeing in shifted ways. The T₆ (JG-226 X *Bacillus glycinifermentans*) achieved luxurious crop growth due to efficient control of wilt diseases and efficient utilization of essential macro- and micro- nutrients.

Straw yield of chickpea as influenced by different treatments during rabi season, 2020-21 are summarized in Table-1. The data in respect to straw yield of chickpea were influenced significantly due to different treatments. The T₁₅ (Vishal X *Bacillus glycinifermentans*) recorded significantly maximum straw yield (1786.66 kg ha⁻¹) followed by T₆ JG-226 X *B. glycinifermentans* (1683.00kg/ha) and T₅ JG-226 X *B. bingmayongensis* (1530.67kg/ha) as compared to rest of the treatments

during investigation. Minimum straw yield of chickpea was observed in T₇ (Jaki X Control) (512.50 kg/ha.) due to highest infestation of wilt in field of chickpea. Minimum straw yield of chickpea was observed in T₇ (Jaki X Control) (512.50 kg/ha.) due to highest infestation of wilt in field of chickpea.

Conclusions

Losses of chickpea due to diseases caused by *F.oxysporum* f.sp. *ciceris* is tremendous in Chhattisgarh state. To control such diseases, two *Bacillus bingmayongensis* and *Bacillus glycinifermentans* were tested on chickpea challenged naturally with the above two pathogens. Seed inoculation with *Bacillus* improved crop growth and yield as revealed by increase plant height, root length, shoot weight grain and straw yield in the chickpea.

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To Identify the Constraints and Provide Suitable Suggestions Faced by the Paddy Growers Living in the Khambhat Taluka of Anand District in Gujarat

Raju Singh Jakhar^{1,2*}, A.S. Saiyad¹ and Divya Choudhary³

¹Department of Extension Education, B.A. College of Agriculture, Anand Agricultural University, Anand-388110, Gujarat

²Department of Agriculture, Vivekananda Global University, Jaipur-303012, Rajasthan

³Department of Agriculture Extension and Communication, SKRAU, Bikaner-334006, Rajasthan

*Corresponding Author Email : raju.jakhar2@gmail.com

Abstract

The pesticide using behavior of paddy crop may differ from individual to individual because of their differences in age, education, size of land holding, type of family, social participation and socio-economic status. It is a mental process to use pesticides. It entails the selection of goals to be achieved as well as the evaluation of different methods for their efficacy in achieving the chosen goals. As a result, "A Study on Pesticide Use Behavior of Paddy Growers in Khambhat Taluka of Anand District" was carried out with the following precise goals: To analyze the constraints faced by the respondents and to seek suggestions to overcome the constraints. Ten villages were chosen at random from the Khambhat taluka, which had the most area under paddy cultivation. The relevant Gram Panchayat provided a list of rice growers who were farming paddy crops in each of the chosen villages. Each community has twelve paddy producers chosen at random. As a result, the study's sample included 120 people. Various studies used appropriate scales and methodologies to measure the independent and dependent variables. The interview schedule was created with the study's objectives in mind. In order to make the findings relevant, the data was classified, tabulated, and evaluated. Percentage, mean score, standard deviation, and correlation coefficients were applied as statistical measures.

Key words : Pesticide, producers, paddy crop, village.

Introduction

India is primarily an agricultural country. Its entire economy is based on farming, with resistance in plants playing a key role. One of the most critical aspects of crop husbandry is effective plant protection. To sustain the population, food production must continue to rise, notably in Asia, Africa, and Latin America's emerging countries [1]. Additional yields of key crops farmed on current arable areas must account for the majority of the increased food output. One feasible method of crop production is to reduce pest-related losses, which are now estimated to account for 14 per cent of overall agricultural output [2].

Nevertheless, when the average per acre pesticide usage of other nations is compared to ours, it is determined to be among the lowest in the world. The agricultural production per acre is also lowest in the world. Different crops pests and diseases are suspected to affect roughly 30.00 percent of overall agricultural production damage. As a result, the pesticides business plays a critical role in crop protection and, as a result, in enhancing the country's agricultural productivity [3]. Agricultural production damages in India are projected to be over 30,000 crores, with illnesses accounting for roughly 28.00 percent of the total. According to current figures, India loses Rs. 1,40,000 crores per year.

Insecticide usage accounts for 19.80 per cent of total consumption, fungicide for 10 per cent, weedicide for 6.4 per cent, and others for 3.4 per cent. Cotton and paddy are the most pesticide-intensive crops, accounting for around 54.00 per cent and 17.00 per cent of total pesticide use in the country, respectively. Pesticide use in India is minimal, at 438 gm/ha, relative to 14 kg/ha in the United States and 10-12 kg/ha in Japan. As a result, India's pesticide use is far lower than that of numerous other nations. Gujarat is the fourth-largest contributor to overall pesticide usage in India, accounting for 15.20 per cent of overall demand [4].

Plant protection techniques have been the most efficient agricultural techniques when this is taken into account. Low yields in paddy are largely due to poor plant protection. After employing all of the inputs, such as hybrid seeds, irrigation, fertilisers, insecticides, pesticides, fungicides, and so on, it is critical that we protect our crops from pests. As a result, it's critical to apply pesticides wisely to combat bug, pest, and disease management [5].

Although some extension scientists have lately been interested in the issue, relatively little study has been done in this area. Different types of farmers' awareness of pesticides, as well as their lack of knowledge of

Table-1 : Distribution of respondents according to constraints faced by them in adoption of recommended plant protection measures.

S. No.	Constraints	Mean weighted scores	Rank
A. Input-supply constraints			
1.	Non- availability of chemicals at affordable rates	30.00	I
2.	Poor quality of chemicals	25.25	II
3.	Non-availability of pest resistance varieties of paddy crop	22.10	III
B. Economical constraints			
1.	High cost of chemicals	65.00	II
2.	Spraying of chemicals required more labors	77.10	I
3.	Fluctuations in market prices of chemicals	33.15	III
4.	High rates of loan interests	20.50	IV
C. Technological constraints			
1.	Lack of knowledge regarding identification of pest and diseases	39.35	I
2.	Lack of skill for proper use of chemicals	36.25	II
D. Administrative constraints			
1.	Non-availability of spraying equipment	76.50	II
2.	Lack of timely technical advice	82.00	I
3.	Lack of market facility in nearby places	74.30	III

Table-2 : Suggestions given by the paddy growers to overcome the constraints faced by them.

S. No.	Suggestions	Frequency	Percentage	Rank
1.	Pest and disease resistance varieties of paddy crop should be developed	102	82.70	III
2.	Plant protection chemicals should be provided at reasonable rates	120	97.94	I
3.	Training programmes on insect-pest management should be organized by extension personnel	65	56.33	V
4.	Method demonstrations should be conducted on farmers' fields to develop skill for proper use of chemicals	48	40.17	VIII
5.	Adequate supply of plant protection inputs should be timely made available	84	69.50	IV
6.	Technical guidance should be provided	62	50.90	VII
7.	Credits should be provided at reasonable rates	108	90.66	II
8.	Market facility should be developed	75	54.84	VI

pesticides, in combination with their personal and socio-psychological features, are predicted to contribute to differences in their perceptions of the problem [6]. The goal of this study is to find out the constraints faced by the farmers and identify the suitable suggestions for their betterment.

Research Methodology

The present investigation was purposively carried out in Khambhat taluka of Anand district, where paddy crop is cultivated in larger area as compared to other talukas. Ten villages were randomly selected from Khambhat taluka having the larger area under paddy cultivation. Totally, twelve paddy growers were randomly selected from each village. Thus, the sample consisted of 120 respondents for the study. 14 independent variables and 3 dependent variables were chosen for the study and these were measured by using suitable scales and procedures adopted by various researchers. The interview schedule was prepared keeping in view the objectives of the study. Before its actual use, it was pre-tested and translated into Gujarati. The data of this study were collected by arranging personal interview with 120 respondents of the

10 selected villages. The data so collected were classified, tabulated and analyzed in order to make the findings meaningful. The statistical measures such as percentage, mean score, standard deviation and coefficient of correlation were used.

Results and Discussion

The information related to this study was collected from the paddy growers by means of personal interview schedule. The collected information was classified, tabulated and analyzed in light of the objectives of the study. The facts and findings derived after analyzing the constraints and suggestions have been presented.

Constraints in adoption of recommended plant protection measures of paddy are never ended. However, they can be minimized if known to policy makers and planners. During the course of present investigation, the respondents expressed many constraints which were grouped into four categories viz., (i) input-supply, (ii) economical, (iii) technological and (iv) administrative constraints. The constraints were ranked on the basis of mean weighted scores. The responses of the

respondents with regard to the constraints are presented in Table-1.

With regard to input-supply constraints, the respondents had assigned first rank to non-availability of chemicals at affordable rates, followed by poor quality of chemicals (Rank II) and non-availability of pest resistance varieties of paddy crop (Rank III).

Among economical constraints, the paddy growers endorsed major constraints were: spraying of chemicals required more labors (Rank I), high cost of chemicals (Rank II), fluctuations in market prices of chemicals (Rank III) and high rates of loan interests (Rank IV).

As regarding technological constraints, lack of knowledge regarding identification of pest and diseases (Rank I) and lack of skill for proper use of chemicals (Rank II) were the most important constraints mentioned by paddy growers.

With respect to administrative constraints, lack of timely technical advice was the first major constraint endorsed by paddy growers, followed by non-availability of spraying equipment (Rank II) and lack of market facility in nearby places (Rank III).

Thus, it can be concluded that non-availability of chemicals at cheaper rates, lower quality of chemicals, spraying of chemicals required more labors, high cost of chemicals, lack of knowledge regarding identification of pest and diseases, lack of skill for proper use of chemicals, lack of timely technical advice and non-availability of spraying equipment were the most important constraints as perceived by the paddy growers in adoption of recommended plant protection measures of paddy crop.

Suggestions offered by the respondents to overcome the constraints faced by them : An attempt was made to ascertain suggestions from paddy growers to overcome various constraints faced by them in use of recommended plant protection measures in paddy. The respondents were requested to offer their valuable suggestions against difficulties faced by them in use of recommended plant protection measures in paddy. The suggestions offered by the paddy growers are presented in Table-2.

The data given in Table-2 reveal that the major suggestions made by the paddy growers to overcome the constraints associated with the use of recommended plant protection measures in sequential order were: plant protection chemicals should be provided at reasonable rates (Rank I), followed by credits should be provided at reasonable rates (Rank II), pest and disease resistance varieties of paddy crop should be developed (Rank III), adequate supply of plant protection inputs should be timely made available (Rank IV), training programmes on

insect-pest management should be organized by extension personnel (Rank V), market facility should be developed (Rank VI), technical guidance should be provided (Rank VII) and method demonstrations should be conducted on farmers' fields to develop skill for proper use of chemicals (Rank XIII).

Conclusions

In agriculture, the most effective approaches are plant protection measures. Low yields in paddy are largely due to poor plant protection. The vast majority of respondents (82.50 per cent) had a moderately to extremely favorable view regarding pesticide use. Pesticides were applied by nearly two-thirds (62.50 per cent) of paddy producers according to recommendations. Crop rotations are an effective technique that limits the accumulation of pests, pathogens and weeds in crops. This method is effective in relation to those pests that are tied to certain cultures in their development. The most significant challenges encountered by rice producers were the lack of economical pesticides, poor chemical quality, and the lack of pest-resistant paddy crop types. Plant protection chemicals should be provided at reasonable rates, credits should be provided at reasonable rates, pest and disease resistant paddy crop varieties should be developed, and method demonstrations should be performed on farmers' fields to create and establish skill for proper chemical use, according to the majority of paddy growers. Plant Protection The major thrust areas of plant protection are promotion of Integrated Pest management, ensuring availability of safe and quality pesticides for sustaining crop production from the ravages of pests and diseases, streamlining the quarantine measures for accelerating the introduction of new high yielding.

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Mean Performance of Cluster Bean [*Cyamopsis tetragonoloba* (L.) Taub.] Genotypes for Pod and Seed Yield Parameters

Praveen Choyal^{1*}, Sankar Lal Yadav², Kamal Mahala³, Radhelal Dewangan¹, Ramesh N.D.¹ and Kalyan Singh Seervi¹

¹Department of Horticulture, SHUATS, Allahabad, U.P.

²Department of Soil Science, SHUATS, Allahabad, U.P

³Department of Horticulture SKNAU, Jobner

*Email : praveenchoyal52@gmail.com

Abstract

The experiment will be carried out at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, SHUATS, Allahabad. The experiment will be conducted in Randomized block design having 15 genotypes in three replications. The genotype Rajnandgaon Local-1 was maximum for plant height 90 days followed by genotypes Sarit Saimaya and S-77. The genotype Rajnandgaon Local-2 was minimum for plant height at 90 days. The genotype IC-40021 was maximum for number of branches 90 days followed by genotypes Rajandgaon local-2 and RGC-986. The genotype IC-10345 was minimum number of branches at 90 days. the genotype Sukomal was recorded highest for pod length, pod/cluster and pod yield/ha (q). IC-40021 was recorded highest for branches at 90 days, seed/pod, 100 seed weight (g). Sarit saimaya was recorded highest for 10 fresh pod weight, pod width and pod yield/plant (g).

Key word : Cluster bean, mean performance, pod and seed yield.

Introduction

Cluster bean (*Cyamoposis tetragonoloba* L. Tabu), an annual kharif arid legume, commonly known as Guar, Chavlikayi, Khutti was traditionally grown for cattle feed, fodder, medicine and soil improvement. Apart from its present uses as green fodder, vegetable, green manure and grain purposes, its utility in explosive, textile, paper, food, gum and cosmetic industries also fetches foreign currencies. Seeds of cluster bean have a large endosperm when compared to other legumes, and contains galactomannan type of gum, which forms a viscous gel and has diversified industrial applications viz., paper, food, cosmetics, mining, petroleum, well drilling, pharmaceuticals etc. (Pathak *et al.*, 2009). This crop plays great role in nitrogen (N) economy of the succeeding crops though N-fixation from atmosphere and also by addition of organic matter. In India, cluster bean occupies an area of 2.33 million hectares with pod production of 1.2 million tones with average productivity of 428 kg/ha. in North Indian states like Rajasthan, Haryana, Gujrat and Punjab. Whereas Rajasthan occupies the largest area (82.1%) under guar cultivation in the country. In Rajasthan districts like Jodhpur, Bikaner, Pali, Nagaur, Sri-Ganganagar and Hanumangarh are the major Guar trading markets. Hanumangarh and Ganganagar is the main production area for best quality guar beans, so called "Fast-Hydrating Guar". In south India, it is being cultivated for vegetable purpose. In Karnataka, it is cultivated round

the year in limited area in districts like Dharwad, Belgium, Bijapur, Haveri etc. for tender vegetable pods. It is being cultivated on very little area in Maharashtra for vegetable purpose. From India, cluster bean is mainly exported to USA, Germany, Netherlands, Italy, UK, Japan and France value at Rs. 200 million rupees annually (Singh *et al.*, 2002). Keeping it in mind, the present investigation was taken up to study the mean performance of the genotypes for identification of high yielding varieties possessing high gum content.

Materials and Methods

In the present investigation, 15 genotypes will be grown in the *kharif* seasons at field experimentation Centre of the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P.). Experimental materials for this study consist of 15 genotypes of cluster bean (including check), collected from different sources University of Agriculture Sciences (GKVK) Bangalore, Chhattisgarh, Allahabad and RARI Durgapura Jaipur (Raj.). Five plants in each experimental plot were randomly selected plants. The selected plants were tagged for taking observations on various growth and yield contributing parameters.

The picking of tender green pods was done at weekly intervals for vegetable purpose. Allahabad is situated at an elevation of 78 meters above sea level at 25.87-degree North latitude and 81.15-degree E

Table-1 : Analysis of variance for various characters in cluster bean genotypes.

S. No.	Source of Variance/ Characters	Mean Sum of Squares		
		Replications	Genotypes	Error
1.	Days to 1st flowering	0.15	30.71*	2.53
2.	Days to 50% flowering	7.22	30.41*	2.22
3.	Plant height cm 45 days	3.05	237.69*	4.45
4.	Plant height cm 90 days	2.68	728.95*	6.54
5.	Branches/plant 45 days	0.49	16.78*	0.51
6.	Branches/plant 90 days	5.9	53.93*	1.89
7.	days to 1st pod picking	7.62	22.99*	5.55
8.	10 fresh pod weight (g)	0.29	199.48*	4.90
9.	Pod length (cm)	0.83	35.70*	0.60
10.	Pod width (cm)	0.0032	0.021*	0.002
11.	Fruit clusters/plant	1.09	257.31*	13.90
12.	Number of pods/cluster	3.45	3.76*	1.56
13.	Number of pods/plant	2.85	16249.54*	39.31
14.	Pod yield/plant (g)	2.33	3947.11**	6.20
15.	Pod yield/hactare (q)	5.06	647.34**	7.58
16.	10 dry pod weight (g)	0.70	8.6**	0.33
17.	Number of seeds/pod	0.0037	1.89*	0.017
18.	100 seed weight (g)	1.16	1.85*	0.60
19.	Seed yield/plant (g)	5.72	135.13**	7.95
20.	Seed yield/ha. (q)	3.54	50.20**	4.92

longitude. This region has a sub-tropical climate prevailing in the south-east part of U.P. with both the extremes in temperature, i.e. the winter and the summer. In cold winters, the temperature sometimes is as low as 32°F in December – January and very hot summer with temperature reaching up to 115°F in the months of May and June. During winter, frosts and during summer, hot scorching winds are also not uncommon. The average rainfall is around 1013.4 mm, with maximum concentration during July to September months with occasional showers in winter.

Results and Discussion

The results of the analysis of variance for different quantitative characters for 15 genotypes of cluster bean are presented in Table-1. The results indicated that there is highly significant variation among the genotypes for almost all the characters under study. Vir *et al.*, (2015), Kumar *et al.*, (2015), Malaghan *et al.*, (2014), Preeti *et al.*, (2018) Rai *et al.*, (2012) also recorded highly significant difference among the cluster bean genotypes with respect to all the characters under studied.

The results of mean performance for different cluster bean genotypes are presented in (Table-2a and b). Plant height in 90 days range from (79.86 cm) to (134.93 cm). The genotype Rajnandgaon Local-1 (134.93 cm) was maximum for plant height 90 days followed by genotypes Sarit Saimaya (124.27 cm) and S-77 (114.26 cm). The

genotype Rajnandgaon Local-2 (79.86 cm) was minimum for plant height at 90 days. Out of 15 genotypes studied 7 (46.66 %) genotypes were high for plant height 90 days than population mean (100.48 cm). These results are in concurrence with the findings of those reported by Rai *et al.*, (2012) and Girish *et al.*, (2013).

Number of branches in 90 days range from (0.00) to (15.00). The genotype IC-40021 (14.80) was maximum for number of branches 90 days followed by genotypes Rajandgaon local-2 (14.73) and RGC-986 (14.13). The genotype IC-10345 (0.00) was minimum number of branches at 90 days. Out of 15 genotypes studied 9 (60.00 %) genotypes were early for number of branches 90 days than population mean (9.70).

Days to first flowering range from (30.00 days) to (39.66 days). The genotype RGC-986 (30.00 days) was earliest for days to first flowering followed by genotypes IC-13496 (30.33 days) and RGC-1025 (32.00 days). The genotype Ankur Rani (39.66 days) was late in flowering followed by genotype Rajnandgaon Local- 2 (39.33 days) and Rajnandgaon Local- 2 (38.66 days). Out of 15 genotypes studied 9 (60.00 %) genotypes were early for days to first flowering than population mean (35.51 days).

Days 50% flowering range from (32.00 days) to (42.33 days). The genotype RGC-986 (32.00 days) was earliest for number of days to 50% flowering followed by genotypes IC-13496 (33.33 days) and RGC-1025 (34.66

Table-2a : Mean Performance of Cluster bean genotype for different characters.

S. No.	Character	Days to 1 st flowering	Days to 50% flowering	Plant height (cm) 45 days	Plant height (cm) 90 days	Branches/ plant 45 days	Branches/ plant 90 days	Days to 1 st pod picking	10 fresh pod weight (g)	Pod length (cm)	Pod width (cm)
1.	RGC-1047	32.33	35.00	35.86	92.33	6.00	12.80	50.00	10.53	6.53	0.74
2.	Sarit Saimaya	37.33	39.66	56.60	124.26	4.20	8.80	51.66	28.72	13.82	1.00
3.	IC-10345	36.33	39.00	31.86	81.73	0.00	0.00	53.33	12.90	8.52	0.94
4.	Sona	37.66	40.33	43.10	84.80	8.13	12.26	54.00	8.20	6.81	0.71
5.	Rajnandgaon Local-1	38.66	40.00	50.40	134.93	2.53	5.73	51.33	19.50	14.80	0.89
6.	Sukomal	36.00	38.66	47.80	96.60	2.26	4.66	50.33	30.50	15.23	0.84
7.	SARDA (Check)	37.00	38.00	40.53	89.66	5.00	10.13	51.00	16.70	11.14	0.78
8.	IC-40021	34.00	36.00	28.00	100.20	7.66	14.80	51.66	21.81	14.36	0.94
9.	RGC-986	30.00	32.00	38.66	107.60	7.93	14.13	48.00	5.75	6.98	0.78
10.	Rajnandgaon Local-2	39.33	41.00	45.80	79.86	7.20	14.73	55.66	12.80	6.92	0.73
11.	IC-11388	34.00	36.33	39.20	102.60	4.93	10.20	48.66	25.09	12.01	0.83
12.	S-77	38.00	42.33	58.40	114.26	3.53	7.40	52.00	20.54	13.35	0.84
13.	Ankur Rani	39.66	42.00	53.26	106.00	2.86	6.16	54.66	26.78	15.19	0.80
14.	IC-13496	30.33	33.33	35.86	103.86	5.93	12.53	44.666	24.99	9.92	0.91
15.	RGC-1025	32.00	34.66	40.53	88.60	5.53	11.20	50.66	7.80	7.33	0.80
	Mean	35.51	37.88	43.06	100.48	4.91	9.70	51.17	18.17	10.86	0.83
	C.V.	4.48	3.93	4.90	2.54	14.55	14.13	4.60	12.17	7.18	5.74
	S.E.	0.91	0.86	1.21	1.47	0.41	0.79	1.36	1.27	0.45	0.02
	C.D. 5%	2.66	2.49	3.52	4.27	1.19	2.29	3.94	3.70	1.30	0.080

days). The genotype S-77 (42.33 days) was late for days to 50% flowering followed by genotype Ankur Rani (42 days) Rajnandgaon Local-2 (41 days). Out of 15 genotypes studied 9 (60.00 %) genotypes were early for days to 50% flowering than population mean (37.88 days).

Days required to first pod picking range from (44.66 days) to (55.66 days). The genotype IC-13496 (44.66 days) was earliest for days required to first pod picking followed by genotypes RGC-986 (48.00 days) and IC-11388 (48.66 days). The genotype Rajnandgaon Local-2 (55.66 days) was late for days required to first pod picking followed by genotype Ankur Rani (54.66 days) and Sona (54.00 days). Out of 15 genotypes studied 8 (53.33 %) genotypes were early for number of days required to first pod picking than population mean (51.17 days).

Pod length range from (6.53 cm) to (15.23 cm). The genotype Sukomal (15.23 cm) was maximum pod length followed by genotype Ankur Rani (15.19 cm) and Rajnandgaon Local-1 (14.80). The genotype RGC-1047 (6.53 cm) was minimum pod length. Out of 15 genotypes studied 8 (53.33 %) genotypes had pod length more than population mean (10.86 cm).

Pod width (cm) range from (0.71 cm) to (1.00 cm). The genotype Sona (0.71 cm) was slimmest for pods width followed by genotypes Rajnandgaon Local-2 (0.73 cm) and RGC-1047 (0.74cm). The genotype IC-40021 and IC-10345 (0.94 cm) was thickest for pods width. Out

of 15 genotypes studied 7 (46.66 %) genotypes were thicker than population mean (0.83 cm).

Ten fresh pod weight range from (5.75 g) to (30.50 g). The genotype Sukomal (30.50 g) was heaviest for 10 fresh pods (g) followed by genotype Sarit Saimaya (28.72 g) and Ankur Rani (26.78 g). The genotype RGC-986 (5.75 g) was lightest for 10 fresh pods (g). Out of 15 genotypes studied 8 (53.33 %) genotypes pods were heaviest than population mean (18.17 cm).

Number of pods per plant range from (87.40) to (325.00). The genotype Rajnandgaon Local-1 (325.00) was maximum number of pods per plant followed by genotypes Ankur Rani (320.6) and RGC-1025 (315.06). The genotype IC-40021 (87.40) was minimum number of pods per plant. Out of 15 genotypes studied 7 (46.66 %) genotypes were more number of pods per plant than population means (234.32 days).

Pod yield per plant is the prime criteria for any crop improvement programme. Pod yield per plant (g) range from (98.93 g) to (231.47 g). The genotype Sarit Saimaya (231.47 g) was highest pod yield per plant (g) followed by genotypes Sukomal (224.73 g) and Ankur Rani (218.06 g). The genotype IC-40021 (98.93 g) was lowest pod yield per plant (g). Out of 15 genotypes studied 6 (40.00 %) genotypes were more pod yield per plant than population mean (177.29 g). The similar pattern of result was reported by Henry and Krishna (1990), Gipson and Balakrishnan (1990) and Anandhi and Oommen (2007).

Table-2b : Mean Performance of Cluster bean genotype for different characters.

S. No.	Character	Fruit clusters/plant	Pods/cluster	Pods/plant	Pod yield/plant (g)	Pod yield/ha. (q)	10 dry pod weight (g)	Seed/pod	100 seed weight (g)	Seed yield/plant (g)	Seed yield/ha. (q)
1.	RGC-1047	51.00	8.73	224.66	158.20	77.75	5.90	6.46	3.90	44.20	26.00
2.	Sarit Saimaya	60.33	8.66	308.06	231.46	100.25	8.20	7.36	4.00	25.60	15.07
3.	IC-10345	48.93	8.86	160.06	155.26	75.75	5.93	6.72	4.72	30.35	18.25
4.	SONA	48.06	7.86	196.20	153.60	74.75	4.00	6.16	4.75	33.40	19.77
5.	Rajnandgaon Local-1	64.60	9.33	325.00	212.93	87.49	8.70	7.58	3.80	24.60	14.62
6.	Sukomal	60.60	10.20	290.79	224.73	112.50	7.21	7.71	3.20	31.80	20.27
7.	Sarda (Check)	50.33	7.80	214.93	164.60	76.24	6.28	7.02	3.62	30.00	17.69
8.	IC-40021	36.00	7.00	87.40	98.93	64.25	6.00	8.87	4.80	20.40	11.82
9.	RGC-986	55.46	10.00	221.60	163.73	95.00	5.16	7.45	3.70	40.10	24.04
10.	Rajnandgaon Local-2	66.13	9.80	265.93	188.33	88.74	6.82	5.88	2.50	32.75	19.22
11.	IC-11388	51.86	7.40	140.40	139.00	77.49	7.33	6.84	5.33	38.60	23.65
12.	S-77	57.40	9.26	275.46	205.13	97.49	10.00	7.82	2.80	26.69	15.90
13.	Ankur Rani	57.06	9.86	320.60	218.06	80.00	9.00	7.13	4.60	29.20	18.00
14.	IC-13496	43.200	6.80	168.60	172.20	61.74	7.98	7.96	3.60	28.70	17.22
15.	RGC-1025	71.80	9.46	315.06	173.26	62.49	4.62	6.32	3.80	41.30	24.82
	Mean	54.85	8.73	234.32	177.29	82.12	6.87	7.15	3.94	31.84	19.08
	C.V.	6.77	14.30	2.67	1.40	3.35	8.41	1.81	19.80	8.85	11.62
	S.E.	2.14	0.72	3.619	1.43	1.58	0.33	0.07	0.450	1.62	1.28
	C.D. 5%	6.21	2.09	10.48	4.16	4.60	0.96	0.21	1.305	4.71	3.71

Pod yield per hectare (q/ha) range from (61.74 q/ha) to (112.50 q/ha). The genotype Sukomal (112.50 q/ha) was maximum pod yield per hectare (q/ha) followed by genotypes Sarit Saimaya (100.25 q/ha) and S-77 (97.49 q/ha). The genotype IC-13496 (61.74 q/ha) was minimum pod yield per hectare (q/ha). Out of 15 genotypes studied 6 (40.00 %) genotypes were more pod yield per hectare (q/ha) than population mean (82.12 q/ha).

Number of cluster per plant range from (36.00) to (71.80). The genotype RGC-1025 (71.80) was maximum number of cluster per plant followed by genotypes Rajnandgaon Local-2 (66.13) and Rajnandgaon Local-1 (64.60). The genotype IC-40021 (36.00) was minimum number of cluster per plant. Out of 15 genotypes studied 8 (53.33 %) genotypes were more number of clusters per plant than population means (54.85). These results are in concurrence with the findings of those reported by Vir and Singh (2015) and Vikas and Ram (2015).

Number of pods per cluster range from (6.80) to (10.20). The genotype Sukomal (10.20) was maximum number of pods per cluster followed by genotypes RGC-986 (10.00) and Ankur Rani (9.86). The genotype IC-13496 (6.80) was minimum number of pods per cluster. Out of 15 genotypes studied 8 (53.33 %) genotypes were more number of pods per cluster than population means (8.73). The results of this study collaborate with the results of Rai *et al.*, (2012) and Vikas and Ram (2015).

Ten dry pod weight range from (4.00 g) to (10.00 g).

The genotype RGC-1025 (4.62 g) was lightest for 10 dry pod weight followed by genotypes Sona (4.00 g). The genotype S-77 (10.00 g) was heaviest 10 dry pods weight followed by genotype Ankur Rani (9.00 g) and Sarit Saimaya (8.20). Out of 15 genotypes studied 7 (46.66 %) genotypes were more 10 dry pod weight than population mean (6.87 g).

Number of seeds per pod range from (5.88) to (8.87). The genotype IC-40021 (8.87) was maximum number of seeds per pod followed by genotypes IC-13496 (7.96) and S-77 (7.82). The genotype Rajnandgaon Local-2 (5.88) was minimum number of seeds per pod. Out of 15 genotypes studied 7 (46.66 %) genotypes were more number of seeds per pod than population means (7.15).

Hundred seeds weight range from (2.50 g) to (5.33 g). The genotype IC-11388 (5.33 g) was heaviest for hundred seeds weight followed by genotypes IC-40021 (4.8 g) and Ankur Rani (4.60). The genotype S-77 (2.80 g) was lightest hundred seeds weight followed by genotype Rajnandgaon Local-2 (2.5 g). Out of 15 genotype studied 6 (40.00 %) genotypes were more hundred seeds weight than populations mean (3.94 g).

Seed yield per plant (g) range from (20.40 g) to (44.20 g). The genotype RGC-1047 (44.20 g) was maximum seed yield per plant (g) followed by genotypes RGC-1025 (41.30 g) and RGC-986 (40.10 g). The genotype IC-40021 (20.40 g) was minimum seed yield per plant (g). Out of 15 genotype studied 6 (40.00 %) genotypes were more seed yield per plant (g) than population mean (31.84 g).

genotypes were more pod yield per plant than population mean (31.84 g).

Seed yield per hectare (q/ha) range from (11.82 q/ha) to (26.00 q/ha). The genotype RGC-1047 (26.00 q/ha) was maximum seed yield per hectare (q/ha) followed by genotype RGC-1025 (24.82 q/ha) and RGC-986 (24.04 q/ha). The genotype IC-40021 (11.82 q/ha) was minimum seed yield per hectare (q/ha). Out of 15 genotype studied 6 (40.00 %) genotypes were more seed yield per hectare (q/ha) than population mean (19.09 q/ha).

Conclusions

In the present investigation, based on per se performance of the accessions, Sukomal [pod length, pod/cluster and pod yield/ha (q)], Sarit saimaya [10 fresh pod weight, pod width and pod yield/plant (g)] and IC-40021 [branches per plant at 90 days, seed/pod and 100 seed weight]. was adjudged as the best one since, it recorded superior performance for these characters. Hence these accessions could be better utilized for further breeding programme for the improvement of pod yield, quality and gum content.

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Effect of Nutrient Management on Economics of Indian Mustard

Mamata^{1*}, R.P. Singh¹, Suman Dhayal² and Priyanka²

¹Department of Agronomy, Bhagwant University, Ajmer, Rajasthan

²Department of Agronomy, MPUAT Udaipur, Rajasthan

*Email : mamta442255@gmail.com

Abstract

A field experiment was conducted during *rabi* season of 2017-18 at Agriculture Farm, Bhagwant University, Ajmer to study the effect of nutrient management on growth yield and quality of mustard. The study used a randomised block design with three replications, with a total of ten treatments. Results revealed that application of 100% RDF + 2% urea + 2% multiplex spray resulted in the highest seed yield, gross return (Rs. 36109/ha) and net return (Rs. 17584/ha) followed by 100% RDF + 2% urea spray and 100% RDF + 2% Multiplex spray. Whereas, highest B:C ratio was obtained with the application of 100% RDF + 2% urea spray followed by 100% RDF + 2% urea + 2% multiplex spray and 100% RDF + 2% Multiplex spray. Under water spray and control, the minimum gross return, net return and B:C ratio were obtained.

Key words : Mustard, nutrient, urea, multiplex gross and net return.

Introduction

Indian mustard (*Brassica juncea* (L.) Czern. & Coss) is the second most important oilseed crop after soybean in the country and has also been cultivated on significant area in north India since last one decade. Rapeseed-mustard production accounts for 26.0 per cent of India's total oilseed production. Only half of the overall demand for edible oils is met by domestic production, with the remainder coming from abroad. The enormous gap between domestic use and production of edible oils can be bridged by either expanding the area under oilseed crops like rapeseed and mustard, sunflower and soybean, or boosting production per unit area. Oleic, linoleic, linolenic, erucic acid are the primary fatty acids found in rapeseed and mustard oil, respectively (Chauhan *et al.* 2007). Each gram of fats and oils provides 9 kcal of energy, whereas each gram of carbohydrate/protein provides approximately 4 kcal of energy (Alam *et al.* 2014). Essential fatty acids can also be found in fats and oils. Phospholipids, which are crucial components of active tissues such as the brain, nerves, and liver of humans and other animals, are synthesised from fats and oils.

The only way to increase productivity in a resource-constrained environment is to produce more oilseeds. The unbalanced and insufficient supply of fertilizers, combined with the limited application of organic manures, not only limits yield potential, but also depletes soil nutrients, causing soil health to degrade and crop responsiveness to drop. Due to variable soil moisture and nutritional quality, various trends in seed yield of Indian

mustard have been seen under different agro-climatic conditions. It responds to a variety of plant nutrients, including nitrogen, phosphorus, and sulphur. In mustard, nutrients have a critical function in enhancing seed yield. It was discovered that foliar treatment of important nutrients like nitrogen and potassium was as effective as soil application. The leaves of most crop plants can absorb urea quickly and effectively. Application of sulphur was reported to increase yield attributes and yield of Indian mustard and also increased S uptake as well as oil content. The objectives of this study were to examine the effect of nutrient management on profitability of Indian mustard.

Materials and Methods

The field experiments were conducted at Agriculture Farm, Bhagwant University, Ajmer, Rajasthan, India (24° 40'N latitude and 82° 12'E longitude at an altitude of 113 meters above mean sea level) during *rabi* season of 2017-18. At the start of the experiment, the soil in the experimental field was sandy clay loam, slightly alkaline in reaction (pH 7.1), with 190.50 kg/ha available nitrogen (Alkaline permanganate method, Subbiah and Asija, 1956), medium available phosphorus of 19.30 kg/ha, (Olsen's method, Olsen *et al.*, 1954), and medium available potassium of 210.13 kg/ha, (Flame photometric method (Metson, 1956) in 0-15 cm soil depth. The experiment comprising total 10 treatment combinations such as control, water spray, 2% urea spray, 100% RDF, 50% RDF + 2% urea spray, 50% RDF + 2% multiplex spray, 50% RDF + 2% urea + 2% multiplex spray, 100% RDF + 2% urea spray, 100% RDF + 2% multiplex spray and 100% RDF + 2% urea + 2% multiplex spray in

Table-1 : Effect of nutrient management on water use efficiency and economics of Indian mustard.

Treatments	Gross return (Rs./ha)	Net return (Rs./ha)	B:C Ratio	Seed yield (kg/ha)	Stover yield (kg/ha)
Control	17059	3379	1.25	453	1741
Water Spray	17342	2662	1.18	455	2053
2% urea spray	21448	6568	1.44	570	2149
100% RDF*	24528	8323	1.51	656	2229
50% RDF + 2% urea spray	27492	11343	1.70	731	2731
50 % RDF + 2% Multiplex spray	29522	13453	1.84	790	2673
50% RDF + 2% urea + 2% Multiplex spray	31038	13769	1.80	823	3171
100% RDF +2% urea spray	34734	17409	2.00	916	3814
100% RDF + 2% Multiplex spray	34625	17220	1.99	924	3248
100% RDF + 2% urea + 2% Multiplex spray	36109	17584	1.95	23.02	1.55
-	-	-	-	48.36	3.27
-	-	-	-	453	1741

randomized block design with three replications. Recommended dose of fertilizer is 40 kg N, 20 kg P₂O₅, 20 kg K₂O and 20 kg S per hectare. Indian mustard variety 'Varuna' was sown on 10.11.2017 with using seed rate of 5.0 kg ha⁻¹ at the row spacing of 45 cm. All the recommended package of practices was followed to raise the crop.

Results and Discussion

Effect of nutrient management treatments on yield :

Results revealed the application of nutrients management treatments considerably altered seed yield of mustard (Table-1). The highest seed yield of 956 kg/ha was achieved with the application of 100% RDF + 2% urea + 2% multiplex spray (924.3 kg/ha), which was statistically comparable to the application of 100% RDF + 2% multiplex spray (916.2 kg/ha) and significantly superior to the other treatments (Table-3). Singh *et al.* (2007), Dawson *et al.* (2009) and Mohiuddin *et al.* (2010) found a good link between the number of siliqua and seed weight per plant and mustard seed yield among the various yield parameters. The application of both foliar and basal doses of nutrients, rather than the complete required dose of fertilizer as basal, resulted in better seed yield. Khan (1996) observed that basal applications of 60 kg N, 10 kg N, and 600 ppm Ethrel as foliar applications resulted in the maximum seed yield. Foliar spray was found to be superior to seed yield in mustard by Khan and Qassem (2008) and Dadheech *et al.* (2014).

Effect of nutrient management treatments on economics : Results revealed the application of nutrients management treatments considerably altered gross return, net return and B:C ratio of mustard (Table-1). Application of 100% RDF + 2 % urea + 2 % multiplex spray resulted in the highest gross return (RS. 36109/ha) and net return (RS. 17584/ha) followed by 100% RDF +2% urea spray and 100 %RDF + 2% Multiplex spray. Whereas, highest B:C ratio was obtained with the

application of 100% RDF +2% urea spray followed by 100% RDF + 2% urea + 2% multiplex spray and 100% RDF + 2% Multiplex spray. Under water spray and control, the minimum gross return, net return and B:C ratio were obtained. In modern agriculture, feasibility of any method can be judge on the basis of additional return due to that practice over the established one. Similar results were found by Trivedi and Sharma (1997), Singh *et al.* (1998) and Kumar *et al.* (1999).

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Efficacy of Different Bio-Control Agents against *Meloidogyne incognita* and *Fusarium oxysporum* on Tomato

Naresh Kumar*, Ratan Lal Sharma and Prahlad

Department of Plant Pathology, College of Agriculture, JNKVV, Jabalpur, M.P.-482004

*Corresponding Author Email : nareshbijarniya49@gmail.com

Abstract

Biological control is considered as new efficient method that becomes widely used for controlling plant parasitic nematodes, as aim to decrease the extent of environment degradation and the effect of the excessive toxic nematicides. So, this study was done to investigate the role of some bacterial genera as bio-control agent against *Meloidogyne incognita*. The results of in pot house experiments indicated that, all tested bacteria have a greatly significant effectiveness for suppressing *M. incognita*. Pot house results showed that significantly increased (80.32 cm) plant height was recorded with *Pacilomyces lilacinus* followed by *Bacillus subtilis* (72.23 cm), *T. harzianum* (68.77 cm) and *P. chlamydosporia* (64.52 cm) over control. The effects of *T. viride*, *T. harzianum* and *Pacilomyces lilacinus* tills were though non-significant but superior over control (52.54 cm). Maximum root length (20.67 cm) was recorded with *Pacilomyces lilacinus* followed by *Bacillus subtilis* (17.63 cm) and *T. harzianum* (14.67 cm).

Key words : *Fusarium oxysporum*, *Meloidogyne incognita*, bio control agents.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most popular vegetable crops grown in the world, next to potato. It is used as a fresh vegetable and also can be processed and canned as a paste, juice, sauce, powder or as a whole [3]. The ripe fruits are good source of vitamin A, B and C which add wide varieties of colour and flavour to the food. Recently, it started gaining more medicinal value because of the antioxidant property of ascorbic acid and lycopene content [1]. Tomatoes are parasitized by a number of pathogens, including *Fusarium oxysporum* f. sp. *lycopersici* [12], the causal agent of fusarium wilt, which is one of the most important pathogen of as tomato pathogen [5]. Due to high temperature and humidity, *Fusarium oxysporum* f. sp. *lycopersici* can cause significant damage. *Fusarium oxysporum* f. sp. *lycopersici* is soil borne pathogen which can persist for many years in the soil without host. Most infections originate from the population associated with infected tomato debris. Healthy plants can become infected by *Fusarium oxysporum* if the soil, is infested with the pathogen [4].

Browning of the vascular tissue is strong evidence of Fusarium wilt [12]. The Root knot nematode, *Meloidogyne Incognita* is important pest of vegetables in subtropical and tropical climates including India and inflect significant yield losses [1]. *Meloidogyne incognita* is the most dominant species accounting for 64 per cent of total population which is widely prevalent inflicting serious loss to tomato fruit yield [9]. The fungus also develops

synergistic relationship with *Meloidogyne* species leading to root-knot wilt disease complex [7].

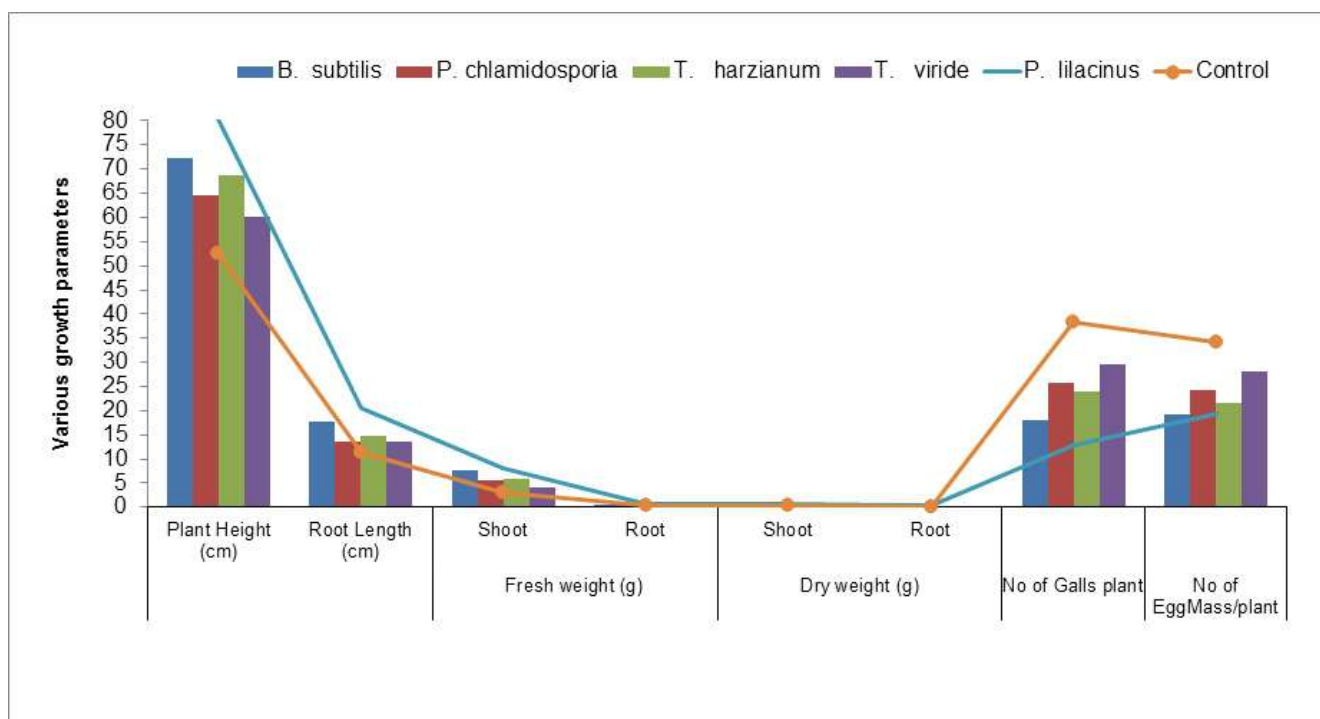
Materials and Methods

The experiment was conducted in ten cm earthen pots containing 500 cm sterilized soil employing six bio-control agents viz, *Trichodema viride*, *Trichodema harzianum*, *Paecilomyces lilacinus*, *Psuedomonas fluorescence*, *Bacillus subtilis*, and *Pochonia chlamydosporia* were used in present studies. The fungus *P. lilacinus* and *Trichoderma viride* were isolated from the soils of JNKVV, Jabalpur farm by sprinkling it on Petri plates containing sterilized Potato Dextrose Agar (PDA) medium. Both the organism were purified and maintained on PDA plants. The fungus *T. viride* was multiplied on wheat seeds. The seeds were boiled in water for half an hour and excess moisture was drained out. The boiled seeds of wheat were filled in polypropylene bags @ 500g seeds per bag and autoclaved at 1.05 kg/ cm² for 20 minutes. After cooling the bags were inoculated with pure culture of *T. viride* and incubated at 24°C for 10 days. When sufficient growth was achieved the seeds along with fungus were mixed with the pot soil 2g/pot. Before mixing the fungus spore load was determined by haemocytometer. Similarly the fungus *P. lilacinus* was also isolated from the soil of JNKVV, Jabalpur which was mass multiplied on wheat seeds following the technique described earlier and at maximum growth spore load mixed with the pot soil @ 2 g per pot. Commercial formulations of *Pochonia chlamydosporia*, *Psuedomonas fluorescence* and *Bacillus subtilis* were obtained from Department of Nematology, Tamil Nadu

Table-1 : Efficacy of different bio control agents against *Meloidogyne incognita* and *Fusarium oxysporum* f. sp. *Lycopersici* on plant growth parameters.

S. No.	Treatments	Plant Height (cm)	Root Length (cm)	Fresh weight (g)		Dry weight (g)		No. of Galls/ Plant	No. of egg Mass/ plant
				Shoot	Root	Shoot	Root		
1.	<i>Bacillus subtilis</i>	72.23	17.63	7.60	0.67	0.74	0.24	18.14	20.56
2.	<i>Pochonia chlamydosporia</i>	64.52	13.70	5.48	0.62	0.57	0.17	25.84	24.24
3.	<i>Trichoderma harzianum</i>	68.77	14.67	5.79	0.65	0.63	0.18	24.11	21.65
4.	<i>Trichoderma viride</i>	60.05	13.70	4.15	0.61	0.56	0.13	29.70	28.22
5.	<i>Paecilomyces lilacinus</i>	80.32	20.67	8.12	0.69	0.77	0.26	12.80	19.35
6.	Control	52.54	11.47	3.08	0.47	0.41	0.11	38.33	34.13
	S.E(m)±	1.12	1.36	1.05	0.01	0.04	0.01	1.37	1.62
	CD at 5 %	3.492	4.237	3.294	0.038	0.152	0.36	4.292	5.048

Mean of three replications.

**Fig.-1 : Efficacy of different bio control agents against *Meloidogyne Incognita* and *Fusarium oxysporum* f. sp. *lycopersici* on plant growth parameters.**

Agricultural University with a spore load 2×10^7 /g soil colony forming units (CFU). These formulations were mixed with the pot soil @ 2g/pot. After mixing the test bio agents in to the soil infested with *Fusarium oxysporum* the pot soil was sprayed by freshly hatched and surface sterilized second stage juveniles of *M. incognita*. The population of root-knot nematode (2h /g soil) was determined by using method as described earlier. The soil with test bio agents and *M. incognita* was filled in ten cm earthen pots and sown with tomato seedling. Each treatment was replicated five times and randomized on

glass house bench. The experiment was terminated 45 days after inoculation and observations on plant height, root length, shoot weight (fresh and dry), root weight(fresh and dry), number of galls, number of egg masses were recorded.

Results and Discussion

The pot experiment on the management of *M. incognita* and *F. oxysporum* a disease complex was conducted under glass house conditions and the data is presented in the table-1 and fig.-1, The data indicated that significantly

increased (80.32 cm) plant height was recorded with *Pacilomyces lilacinus* followed by *Bacillus subtilis* (72.23 cm), *T. harzianum* (68.77 cm) and *P. chlamydosporia* (64.52 cm) over control. The effects of *T. viride*, *T. harzianum* and *Pacilomyces lilacinus* tills were though non-significant but superior over control (52.54 cm). Maximum root length (20.67 cm) was recorded with *Pacilomyces lilaceus* followed by *Bacillus subtilis* (17.63 cm) and *T. harzianum* (14.67 cm). Rest of the treatment were observed to be inferior to *Pacilomyces lilacinus* but significantly superior over control (11.47 cm). On fresh weight basis maximum shoot weight (8.12 g) was recorded with *Pacilomyces lilacinus* followed by *Bacillus subtilis* (7.60 g), *T. harzianum* (5.79 g) and *P. chlamydosporia* (5.48 g). These treatments were significantly superior over rest of the treatments and control (3.08 g). Similar trend was noted with fresh weight of root where *Pacilomyces lilacinus* showed its efficacy over control and rest of the treatments. The root weight in this treatment was noted to be 0.69 g. The effect of *Pacilomyces lilacinus* and *Bacillus subtilis* remained at par but significantly superior over control (0.47 g).

Similarly on dry weight basis maximum (0.77 g) shoot weight was recorded with *Pacilomyces lilacinus* which was significantly superior over rest of the treatments and control (0.41 g). Dry weight of root showed similar results where maximum (0.26 g) root weight was noted with *Paecilomyces lilacinus* followed by *Bacillus subtilis* (0.24 g), *T. harzianum* (0.18 g) and *P. chlamydosporia* (0.17 g). Minimum weight was recorded with control (0.11 g).

Number of galls was significantly and drastically reduced in *Paecilomyces lilacinus* (12.80) as against control where maximum (38.33) galls were recorded. *Bacillus subtilis* recorded 18.14, *T. Harzianum* (24.11) and *P. chlamydosporia* (25.84) galls per plant on an average basis. Rest of the treatments were inferior over these but superior over control. Minimum egg masses/gall (19.35) was noted with *Paecilomyces lilacinus* followed by *Bacillus subtilis* (20.56) against maximum egg masses (34.13) in control. Rest of the treatments were inferior over these but superior over control.

The data presented in the table indicated that *Paecilomyces lilacinus* significantly increased the growth parameters of the tomato viz., plant height, root length, fresh and dry weight of shoot and roots with significant decreases in the number of galls and final nematode population. These result are in accord with the finding of Latha *et al.* [6] who observed increase in growth parameters and decrease in nematode multiplication of *Hetrodera cajeni* in presence of *Macrophomina phaseolina* on *Vigna mungo*.

Similar result has also been observed by Verma *et al.* [14]. *P. lilacinus* has been reported to produce peptidal antibiotic viz; lilacin and paecilotoxin that are toxic to nematode [14], *Bacillus subtilis* and *T. harzianum* showed its efficacy in reducing the nematode galling and enhancing the growth characters of the tomato. These findings have also been supported by the result shown of Siddiqui and Mohmood [11] on chickpea with *M.incognita* and *M. Phaseolina*, Poornima *et al.* [8] on banana with *Fusarium oxysporum* and *Helicotylenchus multicinctus*. Sharon *et al.* [10] reported that *Trichoderma harzianum* reduced galling of root-knot nematode *Meloidogyne javanica* on tomato plants. Spiegel and Chet [13] used different *Trichoderma* isolates against the root knot nematode *M. javanica*, and the results showed that a decrease in root galling index as well as eggs per gram of root.

Conclusions

Paecilomyces lilacinus significantly increased the growth of the tomato Viz., plant height, root length, fresh and dry weight of shoot and roots with significant decreases in the number of galls and final nematode population. *Bacillus subtilis* was also noted to be superior and took second rank in improving the plant growth and reduced nematode population. The nematode pathogenic fungus *Paecilomyces lilacinus* and *Bacillus subtilis* were found to have a significant effect in reducing galls and enhancing plant growth.

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Effect of STCR Based Nutrient Management on Yield and Economics of Rice

Saroj Choudhary^{1*}, Shekhar Singh Baghel², Amit Kumar Upadhyay^{2*} and Kartikeya Choudhary³

¹Department of Soil Science and Agricultural Chemistry, Banaras Hindu University, Varanasi, U.P.- 221005

²Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur, M.P.-482004

³Department of Agronomy, Banaras Hindu University, Varanasi, U.P.-221005

*Corresponding Author Email : upadhyayamit8@gmail.com

Abstract

A field experiment was conducted at the research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, during *Kharif* season of 2016 to study the effect of integrated nutrient management on direct-seeded rice productivity and profitability in the black soil of Madhya Pradesh. The experiment was laid out in randomized block design with six treatments viz., T₁: Absolute control, T₂: GRD, T₃: Targeted yield 50 q ha⁻¹, T₄: Targeted yield 60 q ha⁻¹, T₅: Targeted yield 50 q ha⁻¹ with 5 t FYM ha⁻¹ and T₆: Targeted yield 60 q ha⁻¹ with 5 t FYM ha⁻¹ with four replications. The treatments receiving 157:125:70 kg N, P₂O₅ and K₂O ha⁻¹ along with 5 t FYM ha⁻¹ showed improved yield (57.25 q ha⁻¹) and comparable benefit-cost ratio (1.66) when compared growth recommended dose of NPK (1.53). The lowest net returns (6259 Rs ha⁻¹) and B: C ratios (1.16) were recorded under control.

Key words : STCR, fertilizers, manure, rice, productivity and profitability.

Introduction

Among the cereals, rice (*Oryza sativa* L.) is the major source of calories for 40 % of the world population. In India, rice is cultivated on 44 million ha and contributes 104.32 million tonnes of grain production with a productivity of 2.37 t ha⁻¹. Cultivation of high-yielding dwarf varieties responsive to fertilizer and excess use of inorganic fertilizers has depleted the inherent soil fertility. Several long-term experiments conducted all over India indicated a decrease in rice productivity due to the continuous use of chemical fertilizers. The decline or stagnation in yield has been attributed to nutrient mining and reduced use of organics (John *et al.* 2001). Exploiting the production potential of high-yielding rice varieties through nutrient 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. The rice-wheat cropping system being cereal-cereal crop rotation having the high fertilizers demand, exhausted the soil fertility consequently decline in the organic carbon and soil productivity. On the other hand, the application of sub-optimal and imbalance doses of nutrients created multinutrient deficiency in the soil resulting in deterioration in soil fertility. Integrated nutrient management (INM) aims for efficient and judicious use of all the major sources of plant nutrients in an integrated manner. Therefore, the combined use of organic manure and inorganic fertilizer help in maintaining yield stability (Gill and Walia, 2014, Singh, 2017). The use of inorganic sources like manure was found to be the best option to restore fertility and improved the productivity of crops. In

addition, organic acids released during the course of decomposition of manure favour the mobilization of other soil nutrients. An attempt was thus made to study the effect of STCR based inorganic fertilizer and FYM on rice productivity and profitability in vertisol of Madhya Pradesh.

Materials and Methods

A field experiment was conducted in seasons of *kharif* 2016 at the research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. The initial properties of the experimental field soil are given in table-1. The experiment was conducted with six treatments comprised of; T₁: Absolute control; T₂: General recommended dose (120:60:40 kg N, P₂O₅ and K₂O ha⁻¹); T₃: Targeted yield 50 q ha⁻¹ (115:90:49 kg N, P₂O₅ and K₂O ha⁻¹); T₄: Targeted yield 60 q ha⁻¹ (157:125:70 kg N, P₂O₅ and K₂O ha⁻¹); T₅: Targeted yield 50 q + 5 t FYM ha⁻¹ (115:90:49 kg N, P₂O₅ and K₂O ha⁻¹); T₆: Targeted yield 60 q + 5 t FYM ha⁻¹ (157:125:70 kg N, P₂O₅ and K₂O ha⁻¹) in randomized block design replicated three times. The nitrogen, phosphorus and potassium fertilizer were applied to the rice field using urea, single superphosphate and muriate of potash. The half dose of nitrogen and a full dose of phosphorus and potassium were applied before sowing of rice, remaining dose of nitrogen was top-dressed in two equal splits at tillering and panicle initiation stage. Rice variety "Kranti" was directly seeded on July 15, 2016. The yield attributes were recorded with five randomly selected plants and the seed and straw yield of each plot. The data pertaining to yield were subjected to statistical analysis as per the standard procedure.

Economics analysis : The economics of different treatments were worked out in terms of cost of cultivation, gross monetary returns (GMR) and net monetary returns (NMR) on per hectare area basis and benefit-cost ratio to assess the economic viability of the treatments.

Cost of cultivation (Rs. ha⁻¹) : The cost of cultivation for each treatment was determined based on the different inputs used for raising the crop in one hectare area under different treatments.

Gross monetary returns (Rs. ha⁻¹) : The values could be realized from the produce obtained under each treatment was computed on the basis of the existing market price of the produce. The total value of the produce (both grain and straw) was gross monetary returns per hectare under different treatments.

Net monetary returns (Rs. ha⁻¹) : The net monetary return per hectare under each treatment was determined by subtracting the cost of cultivation under a particular treatment from the gross monetary returns of the same treatment.

Benefit: cost ratio : To estimate the benefits could be obtained under different treatments from each rupee of expenditure incurred, the benefit: cost ratio (B:C ratio) of each treatment was calculated as below :

$$B : C = \frac{\text{Gross monetary return (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

Results and Discussion

Effect of STCR based nutrient management on rice yield : The data on the yield of the rice as influenced by various treatments are presented in Figure-1. The higher targeted yield of 60 q + 5 t FYM ha⁻¹ (T₆) could not be achieved and deviated by ± 4.80 % negatively, whereas the targeted yield of 50 q + 5 t FYM ha⁻¹ (T₅) was obtained comfortably. The grain yield target was achieved only in treatment T₅ which was significantly increased over control. The maximum grain yield of 57.25 q ha⁻¹ was recorded with the application of 157:125:70 kg N:P₂O₅:K₂O + 5 t FYM ha⁻¹, whereas the minimum grain yield of 27.81 q ha⁻¹ was registered under control.

The effect of treatments on straw yield also followed a similar trend as that of grain yield. The higher yield of straw (76.23 kg ha⁻¹) was obtained with a higher level of inorganic fertilizers along with FYM (T₆), which was significantly superior to T₁ (control), T₂ (GRD) and T₃, respectively. However, this treatment was statistically at par with T₄ and T₅. The minimum straw yield of 42.95 q ha⁻¹ was obtained in T₁ (control). The numerically higher value of biological yield (133.48 q ha⁻¹) was recorded under T₆, whereas minimum (70.76 q ha⁻¹) in control,

followed by (100.96 q ha⁻¹) in GRD, respectively. The increment in rice yield might be due to better and timely nutrient availability to the crop from the farm yard manure as compared to chemical fertilizers. The favourable effect of integrated nutrient management through both inorganic fertilizers and organic manures on higher crop growth and yield was also reported by Kumar et al. (2008) and Savina Ahmed et al. (2014). Sarwar et al. (2008); Ali et al. (2012) also claimed increased yields of rice with the use of organic manures alone or in combination with chemical fertilizers.

Effect of STCR based nutrient management on economics : The data pertaining to economics viz., cost of cultivation, gross monetary returns (GMR), net monetary returns (NMR) and benefit: cost ratios (B:C ratio) and energy efficiency analysis of rice cultivation as affected by various treatments have been presented in Table-3.

Cost of cultivation : The data on the cost of cultivation of rice varied due to different treatments with and without FYM are presented in Table-3. Results showed that treatment T₆ having 157:125:70 kg N:P₂O₅:K₂O + 5 t FYM ha⁻¹ required maximum expenditure (Rs. 56321 ha⁻¹), while treatment T₁ having control needed minimum investment of Rs. 39751 ha⁻¹. The cost of cultivation of other remaining treatments of Rs. 45467 in T₂ (GRD), Rs. 46987 in T₃, Rs. 49821 in T₄, and Rs. 53487 ha⁻¹ in T₅, respectively.

Gross monetary returns : The data on gross monetary returns (GMR) as affected by different treatments are presented in Table-3. The GMR is the value of marketable produce under each treatment and is directly related to the quantity of the produce obtained and the existing rate of marketable produce under a particular treatment. A perusal of data indicated that GMR per unit area was higher with the application of a higher level of NPK along with FYM. Maximum GMR per unit area (Rs. 93498 ha⁻¹) was obtained under treatment T₆ with closely followed by T₄ (Rs. 87800 ha⁻¹). However, the minimum GMR value per unit area (Rs. 46010 ha⁻¹) was obtained under without applied fertilizers having control, followed by (Rs. 69414 ha⁻¹) in T₂ having GRD, respectively.

Net monetary returns : The data indicated that among all the treatments, treatment T₄ containing 157:125:70 kg N:P₂O₅:K₂O ha⁻¹ gave the maximum net monetary returns (NMR) per unit area (Rs. 37979 ha⁻¹), followed by (Rs. 37177 ha⁻¹) in T₆, whereas, the lowest value of NMR per unit area was recorded (Rs. 6259 ha⁻¹) in control.

Benefit: cost ratio : Data pertaining to the economics of rice cultivation clearly indicated that the STCR based treatments of NPK with and without FYM increased the

Table-1 : Initial Chemical properties of experimental soil at 0-15 cm depth.

Particulars	Method employed	
	0-15 cm	Method
Soil pH (pH w 1:2.5 at 25°C)	7.57	Glass electrode pH meter (Jakson, 1973)
Electrical Conductivity (dS m ⁻¹ at 25°C)	0.321	Electrical conductivity meter (Jakson, 1973)
Organic Carbon (g kg ⁻¹)	5.41	Potassium dichromate rapid titration method (Walkley and Black, 1934)
Available Nitrogen (kg ha ⁻¹)	217.83	Alkaline permanganate method (Subbiah and Asija, 1956)
Available Phosphorus (kg ha ⁻¹)	21.45	Soil extracted with 0.5 M NaHCO ₃ and colour development by ascorbic acid (Watanabe and Olsen's, 1965)
Available Potassium (kg ha ⁻¹)	311.57	Neutral normal ammonium acetate method by using Flame photometer (Hanway and Heidel, 1952)

Table-2 : Treatments detail.

Treatments	Nutrients applied (kg ha ⁻¹)			FYM (t ha ⁻¹)
	N	P ₂ O ₅	K ₂ O	
T ₁ : Control	0	0	0	0
T ₂ : GRD	120	60	40	0
T ₃ : T.Y. 50 q ha ⁻¹	115	90	49	0
T ₄ : T.Y. 60 q ha ⁻¹	157	125	70	0
T ₅ : T.Y. 50 q + FYM* 5 t ha ⁻¹	115	90	49	5
T ₆ : T.Y. 60 q + FYM* 5 t ha ⁻¹	157	125	70	5

*Composition of FYM : N : 0.57, P: 0.51 and K : 0.69%

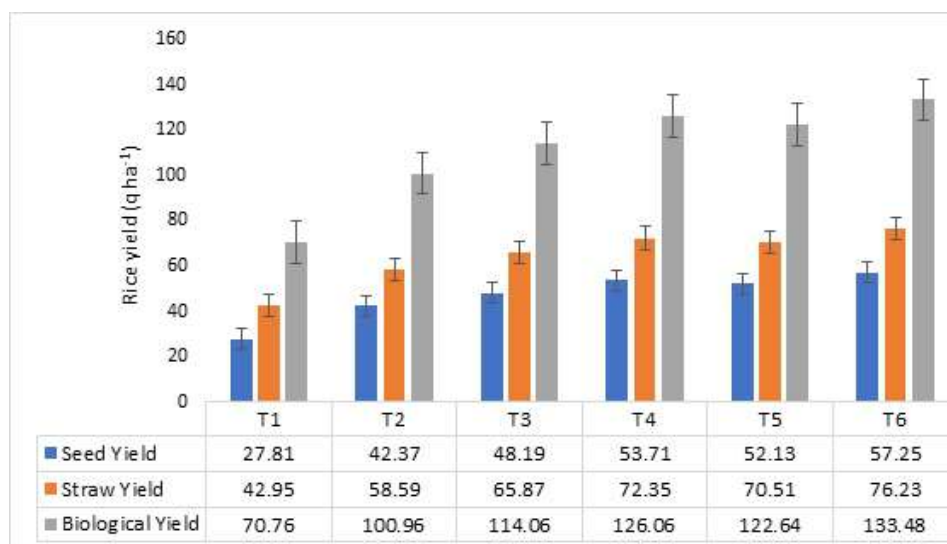


Figure-1 : Effect of STCR based nutrient management on rice yield.

benefit: cost ratio (Table-3). The data revealed that the higher levels of NPK (157:125:70 kg N:P₂O₅:K₂O ha⁻¹) having T₄ resulted in maximum benefit per rupee investment (1.76), closely followed by the treatment T₃ (1.68), while minimum value of B:C ratio (1.16) was obtained under T₁ (control).

The higher levels of NPK (T₄) resulted in maximum net monetary returns per unit area (Rs. 37335 ha⁻¹) and benefit per rupee investment (1.75) as compared to without inorganic fertilizers. Similar results were also reported by Kalhapure et al. (2013), Dwivedi et al. (2015) and Senthilvalavan and Ravichandran (2016). Earlier researchers noted variation in economics of summer rice

due to nutrient management treatments (Baishya et al., 2015; Mondal et al., 2015).

Conclusions

Integrated nutrient management practices showed a positive and favourable effect on improving the yield of rice and the economics of direct-seeded rice. The treatment having chemical fertilizers along with farmyard manure showed a higher benefit-cost ratio as compared to the application of RDF only. The soil test-based combined application of fertilizers and manure achieve higher productivity and sustainability in direct-seeded rice. The practice of fertilizing a crop on the basis of yield targets is precise, meaningful and eco-friendly which needs to be

Table-3 : Effect of STCR based nutrient management on economics.

Treatments	Cost of cultivation (Rs. ha ⁻¹)	Gross monetary returns (Rs. ha ⁻¹)	Net monetary returns (Rs. ha ⁻¹)	B : C Ratio
T ₁ : Control	39751	46010	6259	1.16
T ₂ : GRD (120:60:40 kg N:P ₂ O ₅ :K ₂ O ha ⁻¹)	45467	69414	23947	1.53
T ₃ : T.Y. 50 q ha ⁻¹ (115:90:49 kg N:P ₂ O ₅ :K ₂ O ha ⁻¹)	46987	78872	31885	1.68
T ₄ : T.Y. 60 q ha ⁻¹ (157:125:70 kg N:P ₂ O ₅ :K ₂ O ha ⁻¹)	49821	87800	37979	1.76
T ₅ : T.Y. 50 q + 5 t FYM ha ⁻¹ (115:90:49 kg N:P ₂ O ₅ :K ₂ O ha ⁻¹)	53487	85246	31759	1.59
T ₆ : T.Y. 60 q + 5 t FYM ha ⁻¹ (157:125:70 kg N:P ₂ O ₅ :K ₂ O ha ⁻¹)	56321	93498	37177	1.66

popularized among farmers to enhance the integrated nutrient management taking into account balanced nutrients through the complementary and synergistic effect of combined use of mineral, organic and biological source of nutrients for sustained crop production.

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Study of Genetic Divergence in Coriander (*Coriandrum sativum* L.)

Sohan Lal Kajla¹, Dhirendra Singh² and Moti Ram Natwaria³

¹Division of Genetics and Plant Breeding, RARI, Durgapura (SKNAU, Jobner) Rajasthan

²Department of Genetics and Plant Breeding, S.K.N. College of Agriculture (SKNAU, Jobner) Rajasthan

³Department of Genetics and Plant Breeding, College of Agriculture (SKRAU, Bikaner) Rajasthan

Abstract

Two hundred seventy five genotypes of coriander (*Coriandrum sativum* L.) were evaluated in Augmented Block Design with five blocks during Rabi season of 2014-15 at Research Farm, S. K. N. College of Agriculture, Sri Karan Narendra Agriculture University, Jobner to study the genetic divergence analysis for ten growth and yield characters namely, days to 50% flowering, plant height, branches per plant, umbels per plant, umbellets per umbel, seeds per umbel, days to maturity, 1000-seed weight, volatile oil content and seed yield per five plants. Selection in cluster IV which had maximum genotypes and recombination strategies between genotypes of cluster X and IX or cluster XII and VIII may generate highly variable combination probability for getting transgressive segregates is also high in these kind of recombination between diverse parents.

Key words : Coriander, genetic divergence.

Introduction

Coriander (*Coriandrum sativum* L., $2n = 22$) is a cross pollinated Apiaceae family plant of Mediterranean origin and an important crop of India as well as of Rajasthan State, India. Coriander is cultivated both for seed as well as for leaves. Fresh coriander leaves are more commonly known as cilantro. The seeds are extensively employed as a condiment in the preparation of curry powder, pickling, spices, sausages, seasoning and are also used to flavor pastry, biscuits, buns, cakes and liquors, particularly gin. Genetic improvement for yield and essential oil is the major breeding objective. Genetic diversity is also very important for any crop improvement programs as it helps in the development of superior recombinants. The crosses between parents with maximum genetic divergence are generally the most responsive for genetic improvement (Arunachalam, 1981). Population improvement is generally followed in coriander for genetic improvement by using mass or recurrent selection. Information on genetic divergence in coriander is very helpful in identifying diverse population; which can be recombined together for creating new population for enhancement of genetic variability and thus performing selection in these diverse populations for identifying better plant types (Gauhar *et al.* 2018). The present study was conducted in 275 coriander genotypes to know the extent of genetic diversity existing in the crop which can be utilized for genetic improvement.

Materials and Methods

The experiment was conducted in All India Coordinated Research Project on Spices, Department of Plant

Breeding and Genetics, S.K.N. College of Agriculture, Jobner (Rajasthan). The accessions were evaluated during Rabi season (2014-15) at Research Farm in an augmented block design (Federer, 1956). The material was divided into 5 blocks. Each group of accessions was assigned to each block. Each row was 3.0 m long and spaced 30 cm apart. Plant to plant distance was kept to 10 cm by thinning at 25th day after sowing. Observations were recorded on different morphological characters and seed yield per five plant. Five plants were randomly selected from each plot to record the data on plant height, branches per plant, umbels per plant, umbellets per umbel, seeds per umbel, test weight and seed yield per five plants, while data on days to 50% flowering and days to maturity were recorded on whole line basis. Recorded descriptors were subjected to principal component analysis and average linkage hierarchical method of cluster analysis to determine the common pattern of variation among the accessions. Clustering of accessions was done according to Tocher's method as described by Rao (1952).

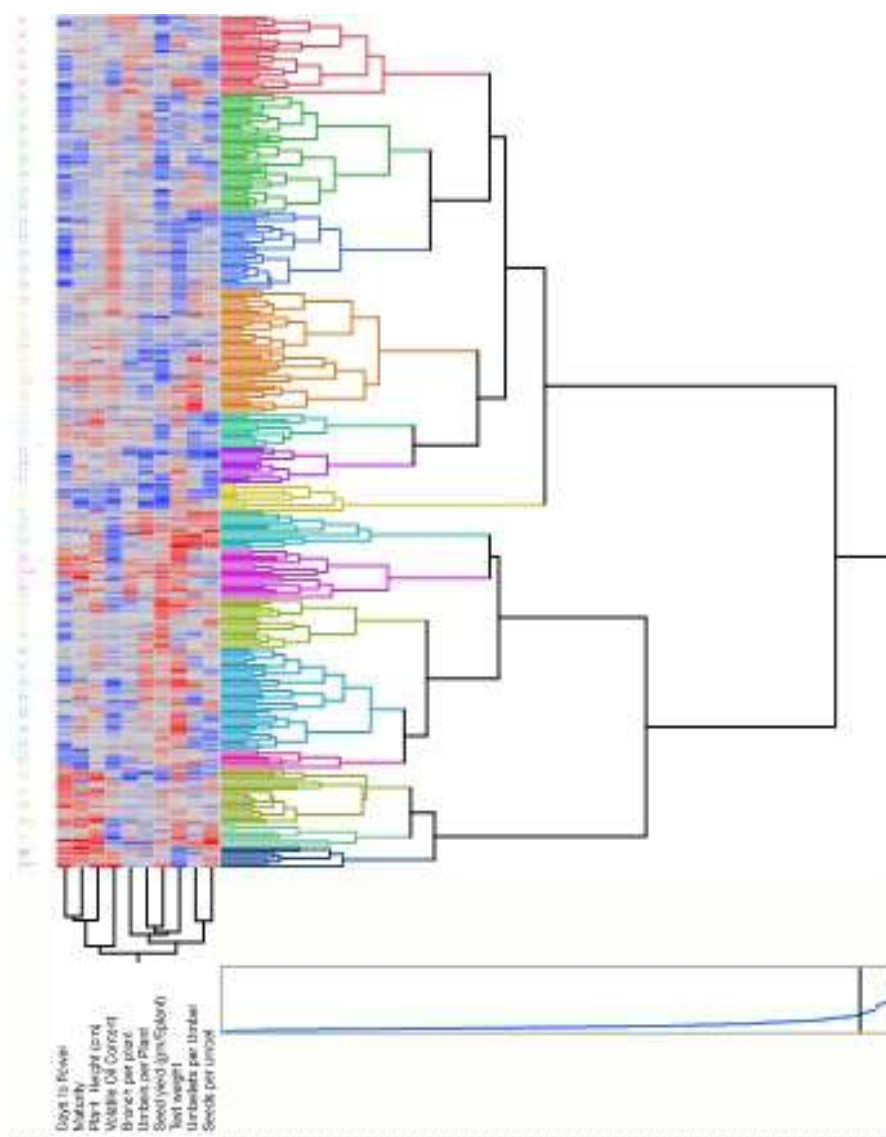
Results and Discussion

All the 275 genotypes were grouped in to fifteen clusters (Table-1). The maximum numbers of genotype *i.e.*, 40 were found in cluster IV. Whereas, cluster II, cluster XI, cluster I, cluster III, cluster XIII, cluster IX, cluster X, cluster VI, cluster VIII, cluster V, cluster VII, cluster XIV, cluster XV and cluster XII had 38, 33, 25, 25, 18, 16, 16, 12, 12, 11, 9, 7, 7 and 6 genotypes, respectively.

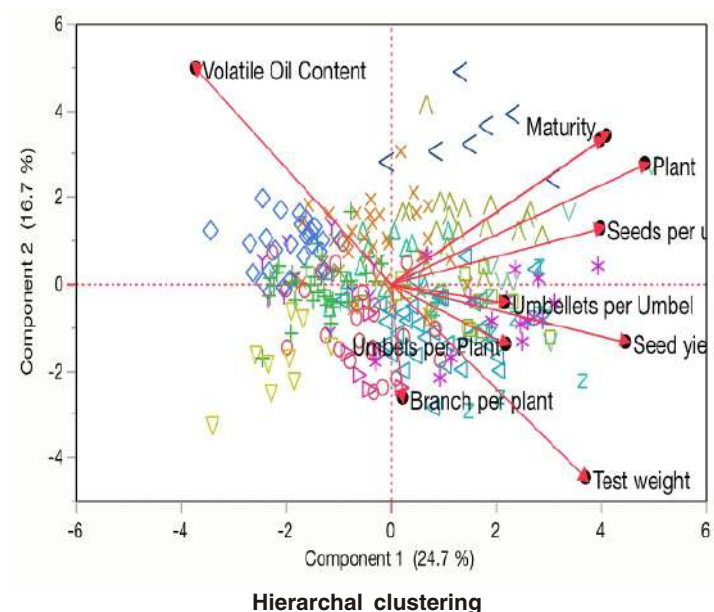
The clustering pattern could be utilized in selecting the parents and deciding the cross combinations which may generate the highest possible variability for various

Table-1 : Cluster mean for 10 different characters in 275 genotypes of coriander.

Cluster	Count	Days to flowering	Plant height	Branch per plant	Umbels per plant	Umbellets per umbel	Seeds per umbel	Seed yield (gm/5 plants)	Maturity	Test weight	Volatile oil content
I	25	70.600	93.152	5.304	33.968	5.336	33.512	53.920	138.560	11.802	0.284
II	38	69.711	95.853	4.258	37.168	5.305	31.305	51.132	137.395	11.077	0.321
III	25	68.560	94.144	4.344	32.032	4.784	33.040	57.360	138.120	9.523	0.360
IV	40	73.550	103.265	4.190	29.755	5.770	36.158	55.650	139.325	11.281	0.327
V	11	77.818	113.200	4.545	35.691	4.527	26.818	52.000	139.364	12.354	0.314
VI	12	70.750	92.333	3.783	25.500	4.650	24.683	55.167	139.417	12.305	0.312
VII	9	73.111	68.489	4.289	22.733	4.978	29.200	45.000	136.333	12.753	0.234
VIII	12	73.750	107.317	4.600	41.850	6.467	49.333	67.250	138.500	13.430	0.244
IX	16	80.938	108.900	5.350	36.425	5.188	33.700	72.938	140.938	13.391	0.248
X	16	70.625	105.288	4.063	34.931	5.263	40.663	83.125	138.875	12.054	0.275
XI	33	71.545	103.933	4.248	39.552	4.867	33.970	66.727	139.152	13.415	0.261
XII	6	71.667	98.167	4.067	35.700	5.400	28.600	69.500	134.667	12.355	0.244
XIII	18	86.611	114.900	3.833	31.067	5.078	35.822	60.222	140.667	12.361	0.298
XIV	7	80.429	117.200	4.300	28.714	5.229	52.629	62.857	141.429	13.346	0.238
XV	7	89.000	118.514	4.229	34.571	5.114	44.971	65.286	142.000	8.850	0.350



Hierarchical clustering



traits. The genotypes with high values of any cluster can be used in hybridization program for further selection and improvement. In the present study, cluster X indicated high cluster mean values for seed yield 83.125(gm/5 plants) (Table-1). Cluster III showed lowest cluster mean values 68.560 followed by cluster II (69.711) and cluster I (70.600). Cluster XV and cluster XIII exhibited highest cluster mean values for days to heading. Cluster VIII expressed the highest cluster mean values for umbels per plant, umbellets per umbel and test weight. Therefore, intercrossing of genotypes involved in these cluster would be useful for inducing variability in respective characters and their rational improvement for increasing the seed yield. High cluster means for various characters were also reported by Fufa (2013), Arif *et al.* (2014), Meena *et al.* (2017), Gauhar *et al.* (2018) and Chauhan *et al.* (2019).

Conclusions

Coriander being a cross pollinated crop is subjected to population improvement strategies following mass selection or recurrent selection in general. Genetic improvement for seed yield is the basic objective of coriander breeding. Genetic diversity analysis helps in identifying diverse genotypes and also to group genotypes showing genotyping similarity for target attributes. Thus, it can be suggested that for selection in cluster IV which had maximum genotypes and recombination strategies between genotypes of cluster X and IX or cluster XII and VIII may generate highly variable combination, probability for getting transgressive segregates is also high in these kind of recombination between diverse parents.

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To Study Growth and Decomposition of Major Pulse Crops in Karnataka

Harkesh Kumar Balai^{1*}, Hari Singh¹, Kailash Chand Bairwa², Anju Yadav¹ and G.L. Meena¹

¹Department of Agricultural Economics and Management, RCA, MPUAT, Udaipur, Rajasthan

²Department of Agricultural Economics, Agriculture University, Jodhpur, Rajasthan

*Corresponding Author Email : harkeshbalai15@gmail.com

Abstract

The study was conducted the growth of area, production and productivity of major pulse crops i.e. gram, black gram, green gram and pigeon pea crops in Karnataka. The study was based on secondary data from 1988-89 to 2017-18. The study period (1988-89 to 2017-18) has been divided into four periods i.e. period-I (1988-89 to 1997-98), period-II (1998-99 to 2007-08), period- III (2008-09 to 2017-18) and overall period (1988-89 to 2017-18). Compound annual growth rates (CAGR) of area, production and productivity of selected pulse were worked out for different periods as well as for entire period of analysis by fitting exponential function. To measure the relative contribution of area, yield and interaction towards the total output change with respect of selected major pulse crops i.e. gram, black gram, green gram and pigeon pea in Karnataka, Minhas and Vaidyanthan, (1965) model has been used. The study revealed that the positive and significant growth rate were observed in area, production and productivity of gram and pigeon pea while decreasing growth was observed in production and productivity of black gram and green gram in the Karnataka. The area effect was more dominant than yield and interaction effect in gram and black gram crops while interaction effect was most powerful to increase in the production of green gram and pigeon pea of Karnataka.

Key words : Compound growth rate, decomposition.

Introduction

Production of pulses is one of the important segments of Indian agriculture after cereals and oilseeds. The pulses comprise of Chickpea, Pigeon pea, Lentil, Green gram bean, Black gram bean and Field pea. These pulses are an important commodity group of crops that provide high quality protein with complementing cereal proteins for pre-dominantly substantial population of the country (Balai *et al.*, 2021). Pulses are popularly known as “Poor man’s meat” and “rich man’s vegetable” as a result of being a major source of proteins, vitamins and minerals especially for vegetarian diets in India (Singh *et al.*, 2016). Pulses prove to be a boon for mankind as they are highly nutritive processing important gift of nature. They not only increase the fertility of the soil by nitrogen fixation but also increase the porosity of the soil due to their invasive tap root system. Due to low requirement of water and ability to withstand serves revealed that decline in pulses consumption lead to increase in malnutrition due to decline in protein intake. (Shalendra *et al.*, 2013). India is presented about 24 percent of undernourished populace in the universe (Sharma *et al.*, 2016 and Ahlawat *et al.*, 2016). To make the public aware of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition, The United Nations declared 2016 as “International year of pulses (IYP). India is the largest producer, consumer and importer of the pulses in the world. India was the largest producer (25%),

consumer (27%) and importer (14%) of pulses in the world. (Mohanty and Satyasai 2015).

Among the pulses, chickpea and pigeon are the important crops accounting for 50 per cent of pulse area and 60 per cent of total production. Madhya Pradesh, Uttar Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, Bihar, Chattisgarh, Gujarat and Tamil Nadu. Pulses are grown in Kharif and Rabi seasons. chickpea, drypea, lentil and lathyrus are known as Rabi pulses. (Anonymous, 2018)

The pulses crop was cultivated over 85.40 million hectares along with 87.40 million tones production and 1023 kg/ha productivity. Chickpea, pigeon pea and lentil are major contributing crops in total world pulses production with the share of 16.69, 10.40 and 1 7.72 percent respectively (Anonymous 2019).

India secured the top position in area and production with 35 percent and 29 percent in the world respectively. India plays a significant role in the world pulse market. In India food grains occupy 65 per cent of total gross cropped area comprising cereals in 50 per cent and pulses in about 15 per cent. Pulses were cultivated over >27 million hectare area with production of 23.02 million tones and productivity of 823 kg/ha. (Anonymous, 2019).

In India, Madhya Pradesh secured first position in area with 6600 thousand hectare followed by Rajasthan,

Maharashtra, Karnataka and Uttar Pradesh with 5907.62, 4002.23, 3556.66 and 2991 thousand hectare, respectively. In production Rajasthan secured first rank with 4497.13 thousand tones followed by Madhya Pradesh, Maharashtra, Uttar Pradesh and Karnataka with 4108.41, 3736, 2447.32 and 2155.89 thousand tones, respectively (Anonymous, 2019-20).

Considering decomposition analysis in agricultural output, it has remained an important part of interest to researchers and policy makers. A breakdown of growth into various component of area and yield facilitates in output projection with alternative targets and policies (Jamal and Zaman, 1992). Thus, decomposition of agricultural growth among its constituent forces is of great importance. The paper is divided in two sections. It begins with examinations of growth in area, production and productivity of kharif pulse crops namely black gram, green gram and pigeon pea in Rajasthan. And, secondly the estimate the relative contribution of area, yield and their interaction to produce the output of black gram, green gram and pigeon pea in Rajasthan. There are many studies such as Mathur and Henry (2005), Singh and Ranu (2009), Sharma *et al.* (2013) and Bairwa, *et al.* (2020) were presented growth performance of pulses at national level. It is prime component of researchers and policy makers to frame at the state level improved technology and improved varieties. So that farmers can get benefits for improving their skills and living standards in the society through improved technology and Therefore, the present study is confined to Rajasthan state only.

The major challenges in Karnataka is to provide an improved production technology for achieving sustained production of pulse crops. The present study has been conducted to answer the research questions whether there was significant growth in Rajasthan in area, production and productivity of pulse crops over the period as well as contribution of area and yield towards change in total pulses production in Karnataka.

Materials and Methods

The study was based on secondary data collected from different sources i.e. Directorate of Agriculture and cooperation, GOI, Directorate of pulses development Bhopal, various issues of Agriculture Statistical Year Book and Agriculture Statistics at a Glance, etc. The time series data of area, production and productivity of selected pulse crops have been taken for 30 years from 1988-89 to 2017-18. The study period (1988-89 to 2017-18) was divided into four periods i.e. period-I (1988-89 to 1997-98), period-II (1998-99 to 2007-08), period- III (2008-09 to 2017-18) and overall period (1988-89 to 2017-18). Two different analyses had been carried out in the study viz. (a)

Compound annual growth rates was calculated period wise to study the growth in area, production and yield of selected pulses and (b) Decomposition analysis. Compound growth rates (CGR) of area, production and productivity of selected pulse were worked out for different periods as well as for entire period of analysis by fitting exponential function. To measure the relative contribution of area, yield and interaction towards the total output change with respect of individual pulse crop, Minhas and Vaidyanthan, (1965) model had been used. The study was restricted to major pulse crops i.e. gram, black gram, green gram and pigeon pea crops.

Compound Growth Rate : Compound annual growth rates was estimated to know the growth pattern on area, production and productivity of major pulse crops in Karnataka. The growth rate was estimated by using exponential trend model (Balai *et al.*, 2021).

Exponential trend equation : $Y = ab^x$

The compound growth rate was obtained for the logarithmic form of the equation as below:

$$\log Y = \log a + x \log b$$

Where,

Y = area/production/yield

a = Intercept

b = regression coefficient / (1 + r)

x = Year

r = Compound growth rate / (Antilog b)-1

The percent compound growth rate (r) will be as,

$$r = [(\text{Anti log of } b) - 1] \times 100$$

Student't' test was used for testing significance level of growth in area, production and productivity of selected rabi pulse crops (Balai, *et al.* 2021).

$$t = \frac{\text{CGR}}{\text{ISE (SGR)}}$$

Where,

't' = Student 't' test

CGR = Compound growth rate

SE (CGR) = Standard error of Compound growth rate

Standard error of Compound growth rate is calculated by using following formula (Rao *et al.*, 1981).

$$\text{SE (CGR)} = \frac{100b}{\ln 10} \text{ SE}(\ln b)$$

Decomposition Analysis : To study the contribution of area, yield and the interaction of area and yield towards increasing the pulses production, a decomposition

analysis was used as expressed below (Minhas and Vaidyanthan, 1965) :

$$P = AB \cdot Y + YB \cdot A + A \cdot Y$$

$$= (\text{Yield effect}) + (\text{Area effect}) + (\text{Interaction effect})$$

Where,

$$A = AC - AB$$

$$P = PC - PB$$

$$Y = YC - YB$$

AB, PB and YB are the area, production and yield of pulses for the base year.

AC, PC and YC are the area, production and yield of pulses for the current year.

A = Change in area

P = Change in production

Y = Change in yield

Results and Discussion

Compound Annual Growth Rate : The growth rate in area, production and productivity of major pulse crops i.e. gram, black gram, green gram and pigeon pea for the study period from 1988-89 to 2017-18 were calculated. The result of compound annual growth rate for gram, black gram, green gram and pigeon pea of Karnataka were presented in the table-1 and 4.

Growth rates of major pulses in Karnataka : The compound annual growth rates of area, production and productivity of gram, black gram, green gram and pigeon pea were not remain definite during the entire study period in Karnataka. Thus, the compound annual growth rates in area, production and productivity of selected pulse crops are analyzed periodically and presented in the Table-1 to 4.

Gram : Findings of the growth rate in area, production and productivity of gram were reported in the Table-1. It could be observed from this table that throughout study period, the area, production and productivity of gram were significantly increased at 11.17, 18.30 and 4.71 per cent, respectively in the Karnataka. In the same period area and production of gram were significantly increased in Karnataka. At the same time, production might be increased due to positive and significant growth in area and productivity of this crop.

During first period, area, production and productivity of gram were increased significantly at the growth rate of 18.85, 31.52 and 10.66 per cent, respectively. In same period, production of gram might be increased due to remarkable improvement in area and productivity of gram in Karnataka. In the meantime, appreciable growth in

productivity was accounted a significant role to expand the area of gram in Karnataka.

During the period-II, area and production under gram were increased significantly at the rate of 15.08 and 11.69 per cent, respectively whereas productivity was declined non-significant with -2.73 per cent in the state. In this period, production of gram was also increased due to positive and significant growth in area of gram in the state.

In the period-III, area, production and productivity of gram were recorded negative and non-significant growth of -7.53, -1.60 and -0.23 per cent, respectively. During this period, negative growth in gram production may be characterized due to negative growth in area and productivity of gram crop in Karnataka. Balai *et al.* (2021) reported similar findings in area, production and productivity of gram in Rajasthan during period 1988-89 to 2017-18.

Black gram : Growth rate in area, production and productivity are presented in the Table-2. It was revealed from the table that during entire study period, positive and non-significant growth was found in the area (0.69%) whereas production and productivity reported negative and non-significant growth with -0.69 and -1.37 per cent, respectively in the state. In this period, the production of black gram might be declined due to negative growth in productivity of black gram.

In the period-I, area and production of black gram were increased significantly at the rate of 19.12 and 17.76 per cent, respectively while productivity declined non-significantly at -1.60 per cent per annum in the state. In this time production of black gram was increased; it might be due to remarkable and significant improvement in area of black gram in the state.

In the period-II, area, production and productivity of black gram was declined non-significantly at the rate of -0.46, -14.69 and -14.30 per cent, respectively in the state. In this period, negative growth in area and production of black gram may be reported due to drastic decline in productivity of black gram.

During period-III, production and productivity of black gram were increased non-significantly whereas area was declined with 19.12, 20.23 and -0.92 per cent, respectively in the state. In this period production of black gram was increased in Karnataka; it could be due to remarkable improvement in productivity of black gram in the state. However, area under this crop was declined, it might be due to positive growth in area under its competitive crop (green gram).

Green gram : The growth in area, production and productivity of green gram are presented in the Table-3. It was revealed from this table that during overall period

Table-1 : Compound annual growth rate of area, production and productivity of Gram in Karnataka.

(CAGR in Per cent)

Period	Area	Production	Productivity
Period-I	18.85* (0.020)	31.52* (0.033)	10.66** (0.019)
Period-II	15.08* (0.016)	11.69** (0.022)	-2.73 (0.021)
Period-III	-7.53 (0.050)	-1.60 (0.052)	-0.23 (0.016)
Overall	11.17* (0.007)	18.30* (0.008)	4.71* (0.004)

Source : Author's own commutation from compiled time series data.

Note : Figures in parenthesis are standard error of selected growth model.

* Significant at 1 per cent level of significance and **significant at 5 per cent level of significance.

Table-2 : Compound annual growth rate of area, production and productivity of Black gram in Karnataka.

(CAGR in Per cent)

Period	Area	Production	Productivity
Period-I	19.12* (0.007)	17.76* (0.054)	-1.60 (0.053)
Period-II	-0.46 (0.015)	-14.69 (0.058)	-14.30 (0.051)
Period-III	-0.92 (0.022)	19.12 (0.054)	20.23 (0.051)
Overall	0.69 (0.005)	-0.69 (0.011)	-1.37 (0.011)

Source : Author's own commutation from compiled time series data.

Note : Figures in parenthesis are standard error of selected growth model.

* Significant at 1 per cent level of significance and **significant at 5 per cent level of significance.

Table-3 : Compound annual growth rate of area, production and productivity of Green gram in Karnataka.

(CAGR in Per cent)

Period	Area	Production	Productivity
Period-I	-1.37 (0.030)	-22.73** (0.049)	-21.66** (0.034)
Period-II	10.15 (0.026)	-5.16 (0.066)	-14.10 (0.057)
Period-III	6.17 (0.030)	16.68 (0.043)	9.65 (0.039)
Overall	3.99** (0.006)	-1.37 (0.011)	-5.16 (0.009)

Source : Author's own commutation from compiled time series data.

Note : Figures in parenthesis are standard error of selected growth model.

* Significant at 1 per cent level of significance and **significant at 5 per cent level of significance

Table-4 : Compound annual growth rate of area, production and productivity of Pigeon pea in Karnataka.

(CAGR in Per cent)

Period	Area	Production	Productivity
Period-I	-5.59 (0.016)	-3.17 (0.036)	3.04 (0.036)
Period-II	7.15* (0.008)	16.95** (0.033)	8.89 (0.028)
Period-III	10.15** (0.021)	20.23** (0.041)	8.89 (0.026)
Overall	6.41* (0.003)	12.72* (0.007)	5.93* (0.005)

Source : Author's own commutation from compiled time series data.

Note : Figures in parenthesis are standard error of selected growth model.

*Significant at 1 per cent level of significance and **significant at 5 per cent level of significance.

affirmative and significant growth rate in area with 3.99 per cent where as production and productivity were declined with the magnitude of -1.37 and -5.16 per cent, respectively. In this time production of green gram was decreased in Karnataka, it might be due to reduction in productivity of this crop.

During first period, the production and productivity of green gram were declined significantly at -22.73 and -21.66 per cent, respectively whereas area under green gram was also declined non-significantly at the rate of -1.37 per cent in the state. During this period, production of green gram was also declined in Karnataka, it could be

due to negative growth in area and productivity of green gram. At the same time area under this crop might be declined due to negative growth in productivity of green gram.

During period-II, positive and non-significant growth rate was noticed in the area (10.15%) of green gram although the production and productivity were decreased non-significantly at the rate of -5.16 and -14.10 per cent, respectively in the state. The production of green gram in period-II was reported negative growth rate; it may be due to remarkable reduction in productivity of this crop.

During third period, the results stated positive and

Table-5 : Per cent contribution of area, yield and their interaction on production of Gram in Karnataka (1988-89 to 2017-18).
(In Per cent)

Period	Area effect	Yield effect	Interaction effect
Period-I (1988-89 to 1997-98)	98.65	-37.64	38.99
Period-II (1998-99 to 2007-08)	102.92	26.54	-29.46
Period-III (2008-09 to 2017-18)	67.51	3.34	29.15
Overall (1988-89 to 2017-18)	77.00	10.77	12.23

Source : Author's own commutation from compiled time series data.

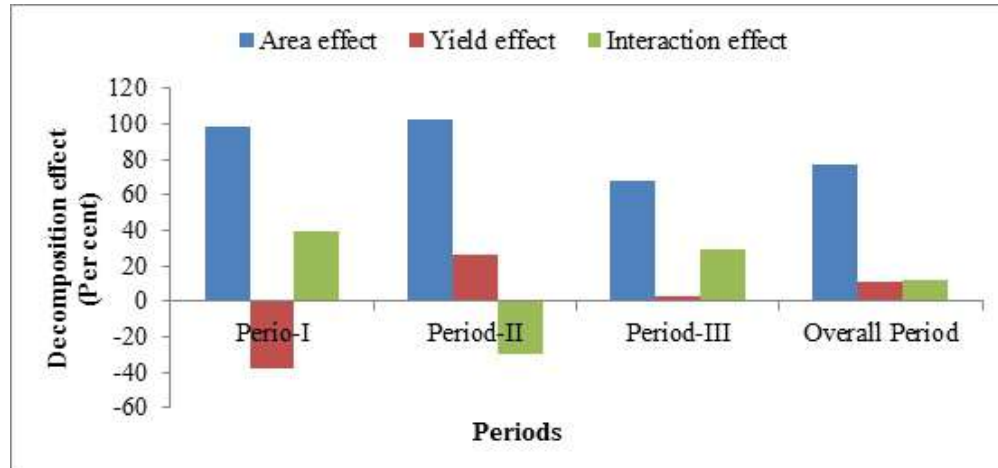


Figure-1 : Decomposition effect of gram in Karnataka.

non-significant growth rate in all three aspects viz., area, production and productivity with 6.17, 16.68 and 9.65 per cent, respectively in the state. The affirmative growth in area and productivity of green gram might be major contributor to boost up the production of green gram in the state. In the meantime, area under green gram may be increased due to remarkable improvement in productivity. Balai *et al.* (2021) reported similar results in area, production and productivity of green gram during 1988-89 to 2017-18.

Pigeon pea : Table-4 depicted the results of growth in area, production and productivity of Pigeon pea. It was indicated in the Table that during entire study period, area, production and productivity of pigeon pea were significantly increased at the rate of 6.41 per cent, 12.72 per cent and 5.93 per cent per annum respectively. In this period, production of pigeon pea was characterized positive and significant growth; it may be due to positive and significant growth in area and productivity of pigeon pea in Karnataka. At the same time area under pigeon pea might be increased due to significant contribution made by productivity in pigeon pea.

In the period-I, area and production of pigeon pea were non significantly decreased at the rate of -5.59 and -3.17 per cent, respectively whereas productivity was increased non-significantly at the rate of 3.04 per cent per annum in the overall period. At the same time, production of pigeon pea was declined due to negative growth in area

although area under pigeon pea may be declined due to significant and appreciable raise in area of its competitive crop (black gram).

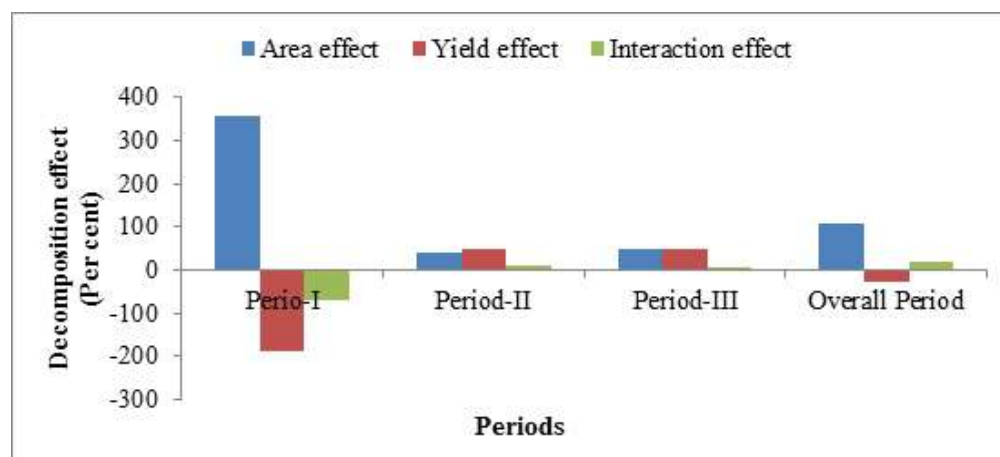
During period-II, performance of growth rate of area and production of pigeon pea were significantly increased at the rate of 7.15 and 16.95 per cent, respectively but productivity was increased non-significantly at the rate of 8.89 per cent annually. Production of pigeon pea was significantly increased, it might be due to positive and significant growth in area of this crop. At the same time, affirmative growth in productivity was also contributed to boost up the production of pigeon pea in Karnataka. During this period, area under pigeon pea may be increased due to positive and appreciable growth in productivity of pigeon pea. In the period-III, area and production under pigeon pea were significantly increased at the rate of 10.15 per cent and 20.23 per cent respectively. At the same time the productivity of this crop was non significant increased at the rate of 8.89 per cent annually. In this period, production was recorded remarkable increase in Karnataka, it might be contributed by positive and significant growth in area. During same period significant growth in area might be contributed with positive growth in area and productivity of pigeon pea. Kalmkar (2001) recorded positive and significant growth rate in area, production and productivity of pigeon pea in Maharashtra during 1961-62 to 1997-98.

Decomposition Analysis : The growth analysis (area,

Table-6 : Per cent contribution of area, yield and their interaction on production of Black gram in Karnataka (1988-89 to 2017-18). (In Per cent)

Period	Area effect	Yield effect	Interaction effect
Period-I (1988-89 to 1997-98)	359.13	-190.63	-68.50
Period-II (1998-99 to 2007-08)	41.27	48.85	9.88
Period-III (2008-09 to 2017-18)	47.56	49.23	3.21
Overall (1988-89 to 2017-18)	105.95	-25.87	19.92

Source : Author's own commutation from compiled time series data.

**Figure-2 : Decomposition effect of black gram in Karnataka.**

production and yield) of major pulse crops revealed the general pattern of growth and direction of changes in yield and area. But this analysis does not evaluate the contribution of area and yield towards the production growth. So, it is necessary to examine the sources of output growth. To appraise the sources of output growth for major pulses crops, the change in production has been divided in to three effects i.e., area effect, yield effect and interaction effect. The relative contribution of area, yield and their interaction to changes in production of major pulse crops was presented in the table 5 and 8.

Gram : Decomposition of production growth into area, productivity and interaction components in the different periods for gram crop is presented in the Table-5 and figure-1. It was revealed from the Table that, the change in production during overall period was due to area effect (77.00%) interaction effect (12.23%) while yield effect was observed positive (10.77%).

The increase in production of gram in Karnataka due to area effect and interaction effect while yield effect had negative impact on output of the gram in period-I. The area effect and interaction effect were contributed 98.62 and 38.99 per cent, respectively. the yield effect had observed negative effect on produce of gram with -37.64 per cent. During period-II, area effect and yield effect were mainly responsible for the output growth of gram accounting for 102.92 per cent and 26.54 per cent of the total output growth of gram in Karnataka while interaction

effects on production was negative accounting -29.46 per cent. During period-III, change in the production of gram was mainly due to the area effect. The yield and interaction effect also had positive bearing on production. The area effect contributed high as 67.51 per cent while yield and interaction elements had positive contribution to the extent of 3.34 and 29.15 per cent, respectively. Shekhawat (2016) in area effect, yield effect and their interaction effect of Gram in Rajasthan state during 2002-03 to 2012-13.

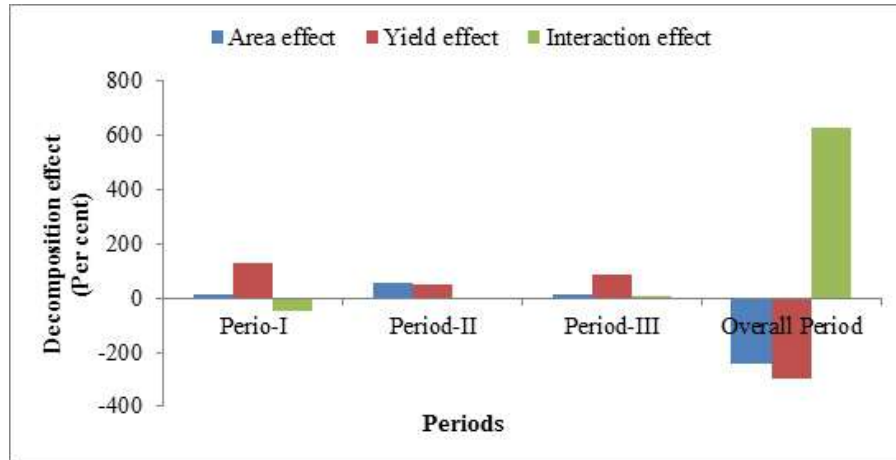
Black gram : Table-6 and figure-2 represented the contribution area, productivity and their interaction to the output growth of black gram in Karnataka. It was revealed from the table that, during overall growth in output of black gram was mainly achieved through area and interaction, while yield effect had negative effect on change of production. The area and interaction effect contributed 105.95 and 19.92 per cent, respectively, while yield effect had negative impact of -25.87 per cent.

During period-I, area effect was mainly responsible for the output production of black gram accounting for 359.13 per cent of the total output growth while yield effect and interaction effect had negative effect on production with -190.63 and -68.50 per cent, respectively. In period-II yield effect, area and interaction effect were continued to be as the powerful factor in increasing production of black gram with 48.85, 41.27 and 9.88 per cent, respectively. During period-III the yield effect and area was solely

Table-7 : Per cent contribution of area, yield and their interaction on production of Green gram in Karnataka (1988-89 to 2017-18). (In Per cent)

Period	Area effect	Yield effect	Interaction effect
Period-I (1988-89 to 1997-98)	15.79	131.03	-46.82
Period-II (1998-99 to 2007-08)	53.37	50.58	-3.95
Period-III (2008-09 to 2017-18)	13.88	84.12	2.00
Overall (1988-89 to 2017-18)	-241.82	-295.46	627.28

Source: Author's own commutation from compiled time series data.

**Figure-3 : Decomposition effect of green gram in Karnataka.**

accountable to boost up the production of the black gram although interaction effect had positive contribution. The yield effect and area effect contributed 49.23 and 47.56 per cent, respectively, while interaction elements had positive contribution to the extent of 3.21 per cent. More et al. (2015) in area effect, yield effect and their interaction effect of pigeon pea in Gujarat state during 1960-61 to 2010-11.

Green gram : Table-7 and figure-3 presents the contribution of various forces to the output growth of green gram in Karnataka state. It was revealed from the table that, the growth in output of green gram during overall period was mainly achieved through interaction effect alone, while yield effect and area effect had negative effect on change of production. The interaction effect contributed 627.28 per cent. The yield effect and area effect had negative impact of -295.46 and -241.82 per cent.

During period-I, increase in production of green gram was mainly due to yield effect and area effect with 131.03 per cent and 15.79 per cent contribution respectively while interaction effect was negative on production of green gram with -46.82 per cent contribution. During period-II, change in production of green gram was mainly due to area effect and yield effect with 53.37 per cent and 50.58 per cent contribution respectively while interaction effect had negative impact on production of green gram with -3.95 per cent contribution. During period-III the yield effect was solely

accountable to boost up the production of the green gram although area and interaction effect had positive contribution. The yield effect was contributed 84.12 per cent while area and interaction elements had positive contribution to the extent of 13.88 and 2.00 per cent, respectively. Similar results were reported by Balai, *et al.* (2021) in area effect, yield effect and their interaction effect of Green gram in Rajasthan state during 1987-88 to 2017-18.

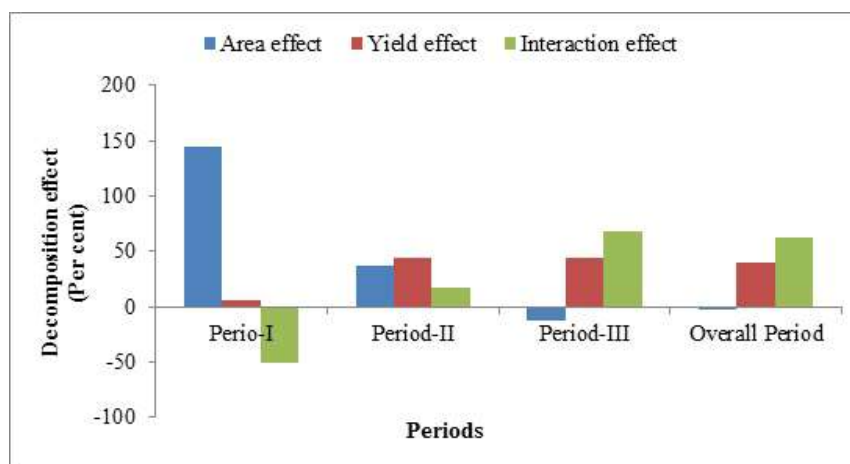
Pigeon pea : The relative contribution of area, yield and their interaction to produce of pigeon pea calculated and presented in the Table-8 and figure-4. It was revealed from the table that, during overall period the growth in production of pigeon pea was mainly achieved through interaction and yield effect. The contribution of interaction effect and yield effect in the production growth were 62.35 and 39.56 per cent. The contribution of area effect was negative on production of pigeon pea with -1.91 per cent.

During period-I, increase in production of pigeon pea was mainly due to area effect and yield effect with 144.24 per cent and 6.52 per cent contribution respectively while interaction effect was negative on production of green gram with -50.76 per cent contribution. During period-II the yield effect was solely accountable to boost up the production of the pigeon pea although area and interaction effect had positive contribution. The yield effect contributed 44.86 per cent while area and interaction elements had positive contribution to the extent of 37.31 and 17.83 per cent, respectively. During

Table-8 : Per cent contribution of area, yield and their interaction on production of Pigeon pea in Karnataka (1988-89 to 2017-18). (In Per cent)

Period	Area effect	Yield effect	Interaction effect
Period-I (1988-89 to 1997-98)	144.24	6.52	-50.76
Period-II (1998-99 to 2007-08)	37.31	44.86	17.83
Period-III (2008-09 to 2017-18)	-12.21	43.89	68.31
Overall (1988-89 to 2017-18)	-1.91	39.56	62.35

Source : Author's own commutation from compiled time series data.

**Figure-4 : Decomposition effect of pigeon pea in Karnataka.**

period-III the growth in production of pigeon pea was mainly achieved through interaction and yield effect. The contribution of interaction effect on the production growth was 68.31 per cent. The yield effect was positive (43.89%) and area effect was negative (-12.21%). Similar results were reported by Balai, *et al.* (2021) in area effect, yield effect and their interaction effect of Pigeon pea in Rajasthan state during 1987-88 to 2017-18.

Conclusions

The study revealed that the positive and significant growth rate were observed in area, production and productivity of gram and pigeon pea while decreasing growth was observed in production and productivity of black gram and green gram in the Karnataka. The area effect was more dominant than yield and interaction effect in gram and black gram crops while interaction effect was most powerful to increase in the production of green gram and pigeon pea of Karnataka.

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Interaction Effect of Fertilizer and Herbicides on Nutrients Uptake by Wheat and Yield of Wheat

Sarita^{1*}, Ishwar Singh² and Moti Lal Mehriya³

¹College of Agriculture, Jodhpur, Agriculture University, Jodhpur-342304, Rajasthan, India

²Directorates of Extension Education, Jodhpur, Agriculture University, Jodhpur-342304, Rajasthan, India

³Agricultural Research Station, Mandor, Agriculture University, Jodhpur-342304, Rajasthan, India

*Corresponding Author Email : saritachoudhary739@gmail.com

Abstract

Optimum fertilization and herbicidal weed management plays an important role in yield enhancement of wheat in the arid region under loamy sand soil. In the present study, A field experiment was conducted at Instructional Farm, College of Agriculture-Jodhpur, Rajasthan (Agriculture University, Jodhpur) during *Rabi* seasons of 2018-19 and 2019-20. The experiment consisted of three fertility levels [75% RDF (90-30 kg N-P₂O₅/ha), 100% RDF (120-40 kg N-P₂O₅/ha) and 125% RDF (150-50 kg N-P₂O₅/ha)] and seven herbicidal treatments (trisulfuron @ 15 g/ha 35 DAS; sulfosulfuron 75% + metsulfuron methyl 5% @ 32 g/ha 35 DAS; clodinafop-propargyl 15% + metsulfuron methyl 1% @ 64 g/ha 35 DAS; carfentrazone @ 20 g/ha 35 DAS; metsulfuron methyl @ 4 g/ha 35 DAS; weedy check and weed free check). The experiment was laid out in Split Plot Design (SPD) with RDF in main and herbicides in sub plot replicated three times. Findings based on pooled analysis indicate that interaction effect between fertility levels and herbicides on N and P uptake at 50 DAS was found statistically significant. The significantly maximum N and P uptake by wheat was recorded in weedy free (67.47 kg/ha) at 150 kg N + 50 kg P₂O₅/ha against the minimum in weedy check (34.69 kg/ha) at 90 kg N + 30 kg P₂O₅/ha fertilizer application. Successive increase in RDF from 75-100% at clodinafop-propargyl 15% + metsulfuron methyl 1% @ 64 g/ha significantly increased grain yield by 27.0%. Further increase in RDF did not significantly influenced grain yield at this herbicidal application.

Key words : Fertility levels, nutrient uptake, herbicides, wheat, yield.

Introduction

Wheat is a staple food used to make flour for 'roati', 'nans', bread, cookies, pasta and many other products. It is the cheapest source and supplier of the calories and protein for healthy diet (Heyne, 1987). Wheat straw is also major source of fodder for the animal population of country. Wheat grain contains starch (60-90%), protein (11-16.5%), fat (1.5-2%), inorganic ions (1.2-2%), vitamins B complex and E (Rueda-Ayala *et al.*, 2011). Due to complexity and diversity of weed flora, more than one herbicides are required either in sequence or as mixture for weed management. Many sulphonylurea herbicides have widely been used in wheat due to their low application rate and less persistency in environment. Sulphonylurea herbicides are also considered as the substitute for existing herbicides because of their capability to manage grassy as well as broad-leaved weeds, high potency and low mammalian toxicity (Singh *et al.*, 1997). Amongst these, metsulfuron-methyl and sulfosulfuron, the newly emerging herbicides of sulphonylurea group are of great importance as these herbicides give excellent control of weeds in wheat by inhibiting acetolactate synthase (ALS) mechanism. Nitrogen is the important nutrient, its deficiency often

limits crop production. It enhances vegetative growth and photosynthetic activity in wheat and increases the water use efficiency of wheat. Weed density, diversity index and community structure of farmland are significantly affected by soil nutrient content. The presence of weeds can deprive more than one third of NPK uptake by the wheat. Manipulation of crop fertilization is a promising cultural practice to reduce weed interference in crops so that nutrient uptake by crops can be maximized and increase the competitive ability of crops against weeds. Fertilization increases crop yield and it is associated with simultaneous increase in the number and dry weight of weeds. However, increase in fertilizer rate greatly improves the uptake of nitrogen, phosphorus and potash by weeds compared to wheat crop. Competitive ability of less nutrient-responsive weeds species with wheat was not affected by increased nutrient rate, regardless of highly nutrient-responsive weed species, which become more competitive with wheat crop. Fertilizer may advantage weeds to a larger extent than crops, because nutrient absorption is faster in weeds than in crop (Nadeem *et al.*, 2016); weeds in the first three weeks of growth take one-third of fertilizer applied to crops; for each kilogram of dry matter of wheat, 5.5 kg N and 1.2 kg P are

required while *Chenopodium album* L. required 7.6 kg N and 1.6 kg P (Nadeem et al., 2016).

Materials and Methods

Experimental details : The field experiments were carried out at Instructional Farm, College of Agriculture, Jodhpur (Agriculture University, Jodhpur). The soil of the experimental field was loamy sand having pH 8.2, low available nitrogen, medium phosphorus and potash. Geographically experimental site was located between 26°15' N to 26°45' North latitude and 73°00' E to 73°29' East longitude at an altitude of 231 meters above mean sea level. This region falls under agro-climatic zone Ia (Arid Western Plains Zone) of Rajasthan. The climate of Jodhpur is typically arid with hot dry and sunny summers. The treatments comprising of three fertilization levels [75% RDF (90-30 kg N-P₂O₅/ha), 100% RDF (120-40 kg N-P₂O₅/ha) and 125% RDF (150-50 kg N-P₂O₅/ha)] in main plots and seven different herbicidal treatments (triflurothol @ 15 g/ha 35 DAS, sulfosulfuron 75% + metsulfuron methyl 5% @ 32 g/ha 35 DAS, clodinafop-propargyl 15% + metsulfuron methyl 1% @ 64 g/ha 35 DAS, carfentrazone @ 20 g/ha 35 DAS, metsulfuron methyl @ 4 g/ha 35 DAS, weedy check and weed free) in sub plots were laid out in Split Plot Design and replicated thrice. Nitrogen and phosphorus fertilizer were applied through DAP and urea. Half of N and full dose of P were applied as basal dose at the time of sowing. Remaining quantity of N was applied as top dressing in standing crop through urea in two equal split doses at the time of first and second irrigation. Post emergence application of herbicides were done at 35 DAS as per treatment using flat fan nozzle & foot sprayer with spray volume of 600 litres of water per hectare. Weed free plots were weeded regularly to keep them weed free throughout the crop pendency. Wheat was sown at a row to row spacing of 22.5 cm using 100 kg seeds/ha. The sowing was done on 20 November 2018 and 18 November 2019.

The uptake of nitrogen and phosphorus after harvest in grain and straw was estimated by using the following relationship :

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content in straw (\%)} \times \text{Drymatter (kg / ha)}}{100}$$

Statistical analysis : The experimental data recorded for growth, yield and quality characters were subjected to statistical analysis in accordance with the 'Analysis of variance' technique. Significance of differences among treatment effects was tested by 'F' test as described by Panse and Sukhatme (1985) for split plot design experiments. The data of weed density and weed dry

weight were subjected to square root transformation $\sqrt{x}$, if one or more values are found to be 0 or 100 then 0.5 showed to be added to all values i.e. $\sqrt{x+0.5}$. The critical difference (CD) was calculated wherever the difference was found significant. Assuming homogeneity in the experimental data of two years, pooled analysis was done (Gomez and Gomez, 1984). The analysis of variance of different components for all parameters discussed are given in the appendices at the end.

Results and Discussion

Effect on nutrient uptake by wheat : The pooled data (Table-1) explicate that the significantly maximum N uptake by wheat was recorded in weedy free (67.47 kg/ha) at 150 kg N + 50 kg P₂O₅/ha against the minimum in weedy check (34.69 kg/ha) at 90 kg N + 30 kg P₂O₅/ha fertilizer application. Nitrogen uptake by wheat was significantly increased upto 100% RDF at all herbicides except triflurothol 15g/ha. Triflurothol 15g/ha did not significantly influence N uptake at 50 DAS at all fertility levels on pooled basis. Application of sulfosulfuron 75% + metsulfuron methyl 5% @ 32 g/ha (66.23 kg/ha) and clodinafop-propargyl 15% + metsulfuron methyl 1% @ 64 g/ha along with 100% RDF (64.40 kg/ha) was on par with each other but significantly enhanced N uptake over weedy check by 40.23 and 44.74%, respectively. The pooled data (Table-2) explicate that the phosphorus uptake by wheat was significantly greater in the clodinafop-propargyl 15% + metsulfuron methyl @ 64 g/ha treated plot with 150 kg N + 50 kg P₂O₅/ha, followed by sulfosulfuron 75% + metsulfuron methyl 5% @ 32 g/ha at same level of RDF. The minimum phosphorus uptake by wheat was recorded in carfentrazone 20 g/ha herbicidal treatment at 90 kg N + 30 kg P₂O₅/ha. Post-emergence application of metsulfuron methyl @ 4 g/ha and carfentrazone @ 20 g/ha showed non-significant difference in phosphorus uptake at 120 kg N + 40 kg P₂O₅/ha RDF on pooled basis. Higher uptake of N, P and K was mainly due to increased dry matter accumulation, N and P concentration in plant and grain. Adequate fertilization in soil might have increased availability of these nutrients and they were readily absorbed by the plant. The increased root length with increasing level of RDF might have provided higher absorption area resulting higher uptake of these nutrients. The increased availability of nutrients in the root zone coupled with accelerated metabolic activities at the cellular level might have increased the nutrient uptake and their accumulation in the vegetative parts of plant.

The pooled data (Table-2) explicate that the phosphorus uptake by wheat was significantly greater in the clodinafop-propargyl 15% + metsulfuron methyl @ 64 g/ha treated plot with 150 kg N + 50 kg P₂O₅/ha, followed

Table-1 : Interaction effect of fertility levels and herbicides on nitrogen uptake by wheat at 50 DAS (pooled basis).

Treatments	Fertility levels (N : P ₂ O ₅) kg/ha		
	75% RDF	100% RDF	125% RDF
Herbicides			
W ₁ -Trisulfuron 15 g/ha	44.36	47.42	50.95
W ₂ -Sulfo. + Met. 32 g/ha	45.44	59.77	66.23
W ₃ -Clodina. + Met. 64 g/ha	44.76	61.69	64.40
W ₄ -Carfentrazone 20 g/ha	40.46	50.65	53.50
W ₅ -Met. 4 g/ha	44.04	57.02	60.26
W ₆ -Weedy check	34.69	42.62	45.28
W ₇ -Weed free	45.96	62.95	67.47
SEm±		2.55	
CD (P=0.05)		7.18	

Table-2 : Interaction effect of fertility levels and herbicides on phosphorus uptake by wheat at 50 DAS (pooled basis).

Treatments	Fertility levels (N : P ₂ O ₅) kg/ha		
	75% RDF	100% RDF	125% RDF
Herbicides			
W ₁ -Trisulfuron 15 g/ha	3.96	3.93	4.44
W ₂ -Sulfo. + Met. 32 g/ha	4.91	5.78	6.21
W ₃ -Clodina. + Met. 64 g/ha	4.98	6.04	6.46
W ₄ -Carfentrazone 20 g/ha	3.75	4.68	4.96
W ₅ -Met. 4 g/ha	4.66	5.39	6.00
W ₆ -Weedy check	2.91	3.31	3.77
W ₇ -Weed free	5.25	6.25	6.69
SEm±		0.28	
CD (P=0.05)		0.78	

Table-3 : Interaction effect of fertility levels and herbicides on grain yield (pooled basis).

Treatments	Fertility levels (N : P ₂ O ₅) kg/ha		
	75% RDF	100% RDF	125% RDF
Herbicides			
W ₁ -Trisulfuron 15 g/ha	2992	3583	3603
W ₂ -Sulfo. + Met. 32 g/ha	3584	4465	4517
W ₃ -Clodina. + Met. 64 g/ha	3670	4662	4792
W ₄ -Carfentrazone 20 g/ha	3290	3750	3775
W ₅ -Met. 4 g/ha	3577	4245	4250
W ₆ -Weedy check	2554	3183	3200
W ₇ -Weed free	3958	4695	4708
SEm±		148	
CD (P=0.05)		416	

by sulfosulfuron 75% + metsulfuron methyl 5% @ 32 g/ha at same level of RDF. The minimum phosphorus uptake by wheat was recorded in carfentrazone 20 g/ha herbicidal treatment at 90 kg N + 30 kg P₂O₅/ha. Post-emergence application of metsulfuron methyl @ 4 g/ha and carfentrazone @ 20 g/ha showed non-significant difference in phosphorus uptake at 120 kg N + 40 kg P₂O₅/ha RDF on pooled basis. The higher N, P & K in better herbicidal treatments might be due to reduction in crop weed competition resulting improvement in nutrient availability, better crop growth and higher dry matter production coupled with higher nutrient concentration.

The results are in close conformity with the findings of Raj *et al.* (2020) who reported that ready-mix application of clodinafop-propargyl @ 60 g/ha+ metsulfuron methyl @ 4 g/ha gave the maximum nitrogen and phosphorus content in grain and straw and the highest uptake by the crop. Sheoran *et al.* (2015) at Hisar carried out field study to work out effect of nitrogen, vermi compost and herbicide (clodinafop propargyl) on grain yield and NPK uptake by wheat (*Triticum aestivum* L.) and revealed that application of N up to the level of 200 mg N/kg soil significantly increased NPK uptake by grain and straw of wheat over lower levels of nitrogen. Kumar *et al.* (2019) concluded at

Meerut that the maximum NPK uptake by grain and straw of wheat with the application of sulfosulfuron + metsulfuron methyl @ 20 + 2 g/ha closely followed by clodinafop + metsulfuron methyl @ 60+4 g/ha.

Effect on yield of Wheat : The data (Table-3) explicate that successive increase in RDF from 75-100% at clodinafop-propargyl 15% + metsulfuron methyl 1% @ 64 g/ha significantly increased grain yield by 27.0%. Further increase in RDF did not significantly influenced grain yield at this herbicidal application. Similar level of response was observed in sulfosulfuron 75% + metsulfuron methyl 5% @ 32 g/ha. Application of sulfosulfuron 75% + metsulfuron methyl 5% @ 32 g/ha (4465 kg/ha) and clodinafop-propargyl 15% + metsulfuron methyl 1% @ 64 g/ha at 100% RDF (4662 kg/ha) produced grain yield on par with each other and weed free check but significantly enhanced seed yield over weedy check by 40.3 and 46.5%, respectively. Samimi and Thomas (2016) and Babar *et al.* (2019). Among chemical management, significant improvement in grain yield, straw yield, and biological yield under foliar spray of different herbicides over control of wheat. Higher yield under both these treatments was due to reduction in competition of weed with crop resulting ample availability of suitable environment for growth which might have influenced production of better number of yield attributes. These results corroborate finding of Katara *et al.* (2015), Raj *et al.*, (2020), Yadav *et al.* (2019).

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Effect of Different Inoculum Levels and Multiplication of *Meloidogyne incognita* on Growth of Tomato

Naresh Kumar* and Balkishan Choudhary

Department of Plant Pathology, COA, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur-482004 M.P.

*Corresponding Author Email : nareshbijarniya49@gmail.com

Abstract

The root knot nematode (*Meloidogyne incognita*) caused reduction in plant height, roots length fresh and dry weights of shoot and roots. Maximum root galls and egg masses were observed with the increasing levels of nematode inoculum. Highest level of nematode inoculum indicated inhibitory and damaging potential on plant growth parameters. One thousand nematode juveniles per 500 g of soil were found to be damaging level of this nematode on tomato.

Key words : *Meloidogyne incognita*, inoculum levels, tomato.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most popular vegetable crops grown in the world, next to potato. It is used as a fresh vegetable and also can be processed and canned as a paste, juice, sauce, powder or as a whole (Barone and Frusciante, 2007). The ripe fruits are good source of vitamin A, B and C which add wide varieties of colour and flavour to the food. Recently, it started gaining more medicinal value because of the antioxidant property of ascorbic acid and lycopene content (Anon, 2002). Tomatoes are parasitized by a number of pathogens, including *Fusarium oxysporum* f.sp. *lycopersici* (Sacc. W.C. Snyder *et al.*, 2003), the causal agent of fusarium wilt, which is one of the most important pathogen of as tomato pathogen (Jones *et al.*, 1982). Due to high temperature and humidity, *Fusarium oxysporum* f.sp. *lycopersici* can cause significant damage. *Fusarium oxysporum* f. sp. *lycopersici* is soil borne pathogen which can persist for many years in the soil without host. Most infections originate from the population associated with infected tomato debris. Healthy plants can become infected by *Fusarium oxysporum* if the soil, is infested with the pathogen (Farr *et al.*, 1989). Browning of the vascular tissue is strong evidence of Fusarium wilt (Snyder and Hans, 2003). The Root knot nematode, *Meloidogyne Incognita* is important pest of vegetables in subtropical and tropical climates including India and inflicts significant yield losses (Akram and Khan, 2006). *Meloidogyne incognita* is the most dominant species accounting for 64 per cent of total population which is widely prevalent inflicting serious loss to tomato fruit yield (Sasser, 1980). The fungus also develops synergistic relationship with *Meloidogyne* species leading to root-knot wilt disease complex (Patel *et al.*, 2000).

Materials and Methods

Effect of different levels of inocula of *Meloidogyne incognita* on growth of tomato : Seven days old tomato seedlings (var. Pusa Ruby) were inoculated with different treatments. The treatments consisted of an uninoculated control and four levels of inocula viz. 10, 100, 1000 and 10,000 second stage juveniles of *M. Incognita*. The extraction of these nematodes and their disinfestations were carried out as per the technique described earlier and inoculation with appropriate treatments level of inocula were carried out the soil around the seedling in a circumference area of four cm was removed and then dispersing nematodes over this area. After appropriate inoculation, the roots were covered by fresh and sterilized soil. Each treatment was replicated four times and randomized on the glass house bench following complete randomized design (CRD). The glass house temperature during this period ranged from 21 to 25°C. The pots were irrigated with 100 ml fresh water every day if needed and there after with equal quantity of water as and when required. The experiment was terminated 45 days after inoculation. The observations on viz., plant height, fresh and dry shoot and root weights, root length, number of galls nematode population in soil and root number of galls and number of egg masses/gall were recorded. The entire root system along with the soil was tapped out of the pot and was washed in a container with a gentle stream of water. For obtaining fresh weight, the roots were pressed gently between two pads of blotting paper and then the weight was recorded using electronic balance.

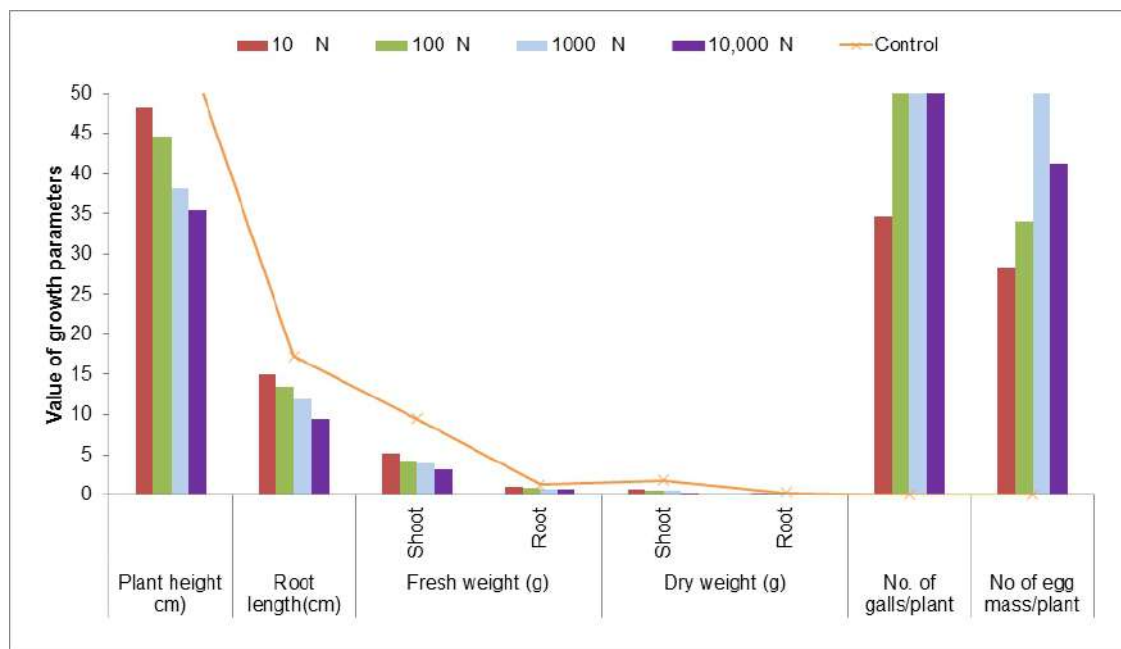
Results and Discussion

Effect of different inoculum levels of *Meloidogyne Incognita* on growth of tomato : The effect of different levels of inocula of *M. incognita* on various growth

Table-1 : Effect of different inoculum levels of *Meloidogyne Incognita* on growth of tomato.

S. No.	Treatments	Plant height (cm)	Root length (cm)	Fresh weight (g)		Dry weight (g)		No of galls/plant	No of egg mass/plant
				Shoot	Root	Shoot	Root		
1.	Control	61.63	17.3	9.48	1.27	1.79	0.27	0	0
2.	10 N	48.27	15.07	5.14	0.99	0.73	0.25	34.67	28.32
3.	100 N	44.67	13.53	4.26	0.84	0.58	0.18	71.33	34.00
4.	1000 N	38.27	11.93	3.91	0.77	0.62	0.15	113.30	50.00
5.	10,000 N	35.43	9.53	3.09	0.76	0.30	0.14	57.67	41.33
	S.E(m)±	5.28	1.411	1.312	0.085	0.179	0.021	18.119	8.701
	CD at 5 %	16.86	4.504	4.189	0.27	0.571	0.066	57.831	27.772

Mean of three replications, N = Nematodes

Fig.-1 : Effect of different inoculum levels of *Meloidogyne Incognita* on growth of tomato.

parameters of tomato is presented in Table-1, and Fig.-1. It is evident from the table that there was a gradual stunting of plants when inoculated with *M. incognita*. In treatment where highest population (10000 N/plant) of the nematode was added plants showed chlorosis and defoliation of leaves. The plants looked sick and devitalized with marked retarded growth. The plant height in this treatment was noted to be 35.43 cm. Followed by 1000 N/plant where the height was recorded to be 38.27 cm. 10 and 100 nematodes/plant recorded 48.27 and 44.67 cm plant heights respectively. Maximum (61.63 cm) plant height was recorded with control, which was significantly superior over all other treatments.

Similarly there was a gradual decrease in root length as the inoculum levels increased. Maximum (17.3 cm) root length was noted in control, which was significantly superior over all other treatments. Minimum (9.53 cm) root length was noted with 10,000 /plant followed by 1000 N/plant (11.93 cm) and 100 N/plant (13.53 cm). The reduction in the root length (15.07 cm) was also noted in

the minimum inoculum level (10 N/plant). There was significant reduction in the fresh shoot weight of tomato plants with increase in inoculum levels. Significantly reduced shoot weight (3.09 g) was noted with 10,000 N/plant followed by 1000 N (3.91 g) and 100 N/plant (4.26 g). ten nematodes/plant recorded (5.14 g) fresh shoot weight. Maximum (9.48 g) fresh shoot weight was recorded in control. The fresh root weight of tomato plant was adversely affected by the nematode infestation. Minimum (0.76 g) root weight was recorded with 10,000 N/plant followed by 1000 N/plant (0.77 g). Reduced root weights were also recorded with 10 N/plant (0.99 g) and 100 N/plant (0.84 g). Maximum fresh root weight was recorded with control (1.27 g).

On dry weight basis, maximum (1.79 g) weight was recorded with control which was significantly superior over all the treatments. Minimum shoot weight was recorded with 10,000 N/plant (0.30 g) followed by 1000 N/plant (0.62 g). The dry shoot weights recorded at 10 N/plant (0.73 g) and 100 N/plant (0.58 g). Similarly there

was a gradual reduction in root weights on dry weight basis as the inoculum level increased. Maximum root weight (0.27 g) was observed with control followed by 10 N (0.25 g), 100 N (0.18 g) and 1000 N (0.15 g) per plant. The root weight declined sharply at 10,000 inoculum level where it was recorded to be 0.14 g. Minimum (34.67) root galls were noted at minimum level of inoculum (10 N/plant). The number of root galls were maximum (113.33) at 1000 N/plant followed by 10,000 N/plant (57.67) and 71.33 galls were noted in the treatment where 100 Nematodes/plant were incorporated. Significantly maximum (50) egg masses /plant were recorded with 1000 N followed by 10,000 N/plant (41.33). Minimum (28.32) egg masses were recorded with 10 N/plant followed by 100 N/plant (34) against no egg masses in control. Root knot disease caused by *Meloidogyne incognita* and Fusarial wilt by *Fusarium oxysporum* f.sp. *lycopersici* are individually important diseases leading to extensive yield losses in tomato. These pathogens when interacting with each other can cause high yield loss due to disease complex and may also lead to breaking of resistance (Ansari *et al.* 2012). This breaking of resistance by *M. incognita* plays a major role in the etiology of the fusarial wilt in tomato posing a serious problem, particularly in the production of resistant cultivars. Similar findings were also brought forward by Hussain and Bora (1995), in case of okra with *M. incognita* and Reddy (1975), in chickpea with *M. javanica* where 1000 and 10,000 juveniles of *Meloidogyne* spp. per pot were applied. Similar inhibitory effects on different crops were also reported by Dhawan and Sethi (1976) and Mani and Sethi (1984). They reported that on inoculums level of two larvae per g of soil was found to be the damaging threshold level of *M. incognita* on chickpea in accordance with above findings in the present study also 1000 nematode Juveniles per 500g of soil were found to be the damaging threshold level of this nematode on tomato. These results are also in accord with the findings of Bhatt *et al.* (1994).

Conclusions

The studies carried out on the effect of different levels of inoculants on plant growth revealed that 1000 second stage juveniles/g of the soil found to be the damaging threshold on tomato. The nematode continues to penetrate the roots at stages of growth but young

seedlings were more susceptible to root knot than mature plants.

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Response of Different Levels of NPK and Neem Cake on Soil Health, Growth and Yield Attributes of Fieldpea (*Pisum sativum* L.) Cv. T-19

Shankar Lal Yadav^{1*}, Praveen Choyal², Shashi S. Yadav³, Komal Yadav⁴, Dinesh Kumar Sharma¹ and Rohan Serawat¹

¹Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj, U.P.

²Department of Horticulture, SHUATS, Prayagraj, U.P.

³Department of Soil Science and Agricultural Chemistry, RVSKVV, Gwalior, M.P.

⁴Department of Horticulture, RVSKVV, Gwalior, M.P.

*Corresponding Author Email : syadav1551@gmail.com

Abstract

A field experiment was conducted at Research farm, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) during the *Rabi* season of 2017-18 with the objective to response of different levels of NPK and Neem cake on soil health, growth and yield attributes of Field pea (*Pisum sativum* L.) Cv. T-19. The experiment was laid out in a Randomized Block Design with nine treatment combinations, consisting of three N P K levels (0, 50 and 100%) and neem cake (0, 50 and 100%). It was observed that for postharvest, soil properties in treatment T₈ (i.e. @N 40kg + P@ 50kg + K@ 40kg and neem cake @2.5 q ha⁻¹) were improved significantly due to organic and inorganic use of inputs. Organic carbon (0.55%), Available nitrogen (301.37 kg ha⁻¹), Phosphorus (27.03 kg ha⁻¹), Potassium (194.17 kg ha⁻¹) and respectively were found significantly higher as compared to other treatment combination.

Key words : Field pea, NPK levels, neem cake, soil parameters.

Introduction

Peas (*Pisum sativum* L.) are grain legume and member of the leguminosae family grown throughout the world. It is a native of central or Southeast Asia. It grows well in cool weather in the presence of ample moisture. Peas are recognized as one of the earliest agricultural crops domesticated by human beings. It is most important cultivated legume next to soybean, groundnut and beans (Hules, 1994). Nutrition value of green peas per 100g contain Energy 339KJ, Dietary Fiber 5.1g, Protein 5.42, Carbohydrates 14.45g, Sugars 5.67g, Fat 0.4g, Vitamin C 40mg, Folic acid 50.7µg, Iron 1.47mg, Potassium 217mg, Magnesium 33mg and phosphorus 108mg. (FAO stat, 2012). India has a major world's crop area under pulses and one fourth of the total production. Pulse crops offer and stable source of protein in vegetarian diet of masses. Besides their well-recognized role in restoring fertility and its physical conditions, pulse crops provide succulent and nutritious to our cattle, therefore, have been described as "Unique jewels of Indian crop husbandry". Pulses add 0.8 to 1.5 tonnes of organic matter to the soil in the form of their roots left after harvesting of the crops, On an average, one hectare crop adds 15 to 30 kg nitrogen in readily available form (Singh, 2001). The population of our country is at an alarming rate, which would be expected to reach 1280 million in 2020 and at this rate of population increase, India will need at least 30 million tonnes of pulses by 2020 (Kumar *et al.* 2004).

Legumes have been recognized as an important component of any cropping system and as a low input approach towards improvement of soil fertility. It appears to have originated many thousands of years ago in central Asia and the Middle East. They were originally dried and stored for long periods, providing nutrition during the non-growing seasons. Peas are now grown throughout the world and are consumed in both fresh and dried conditions. It is widely cultivated in temperate regions for its fresh green seed. Peas are an excellent human food (Kakar *et al.* 2002), either eaten as a vegetable or used in preparation of soup. The peas are full of nutrition because its grain is rich in protein, complex carbohydrates, vitamins, minerals, dietary fibers and antioxidant compounds (Bhatt *et al.* 2013).

The center of production of peas has moved from the traditional Middle East local to Canada, which is now the largest single producer. Pea production in Western Canada has been increasing since 1997. France, China and India are also large producers next to Canada. Peas ranks 4th in the world on a production basis (441.53 thousand tonnes) among grain legumes after soybean, groundnut and French beans and is grown on an area of 528.71 thousand hectares in the world (FAO stat, 2009).

India is the largest producer of pulses and accounts for about 25 per cent of the global share. In India, pulse crops are grown over an area of 26.28 M ha with an

Table-1 : Results of physic-chemical properties of pre-soil samples. (Before sowing of crop).

Particulars	Results	Methods
Sand (%)	58	Bouyoucous hydrometer (Bouyoucous 1927)
Silt (%)	27	
Clay (%)	15	
Texture of soil	Sandy loam	
Particle density (g cm^{-3})	2.42	Graduated measuring cylinder (Muthuaval <i>et al.</i> 1992)
Bulk density (g cm^{-3})	1.37	Core method (Muthuaval <i>et al.</i> 1992)
Soil pH	7.5	Digital pH meter (Jackson 1958)
EC (dS m^{-1})	0.29	Digital conductivity meter (Wilcox 1950)
Organic carbon (%)	0.39	Rapid titration method (Walkley and Black 1947)
Available Nitrogen (kg ha^{-1})	228.4	Available Nitrogen (Subbaih and Asija 1956)
Available Phosphorus (kg ha^{-1})	20	Colorimetric method (Olsen <i>et al.</i> 1954)
Available Potassium (kg ha^{-1})	148.3	Flame photometric method (Toth and prince 1949)

Table-2 : Effect of different levels of N, P, K and Neem cake on physio-chemical properties of soil in Field pea (*Pisum sativum* L.) Cv. T-19.

Treatments	Soil bulk density (g cm^{-3})	Soil particle density (g cm^{-3})	Percent pore space (%)	Soil pH	EC (dS^{-1})	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})	Organic carbon (%)
T ₀ (I ₀ F ₀)	1.27	2.54	44.70	7.80	0.12	247.73	20.50	114.97	0.56
T ₁ (I ₀ F ₁)	1.26	2.57	45.37	7.70	0.13	252.43	21.13	123.53	0.57
T ₂ (I ₀ F ₂)	1.23	2.60	46.07	7.70	0.13	261.13	21.80	131.83	0.60
T ₃ (I ₁ F ₀)	1.22	2.63	46.53	7.67	0.14	266.10	22.23	145.17	0.61
T ₄ (I ₁ F ₁)	1.20	2.65	47.40	7.37	0.15	272.67	22.63	157.23	0.63
T ₅ (I ₁ F ₂)	1.15	2.67	48.13	7.37	0.15	278.33	23.33	167.13	0.65
T ₆ (I ₂ F ₀)	1.08	2.68	48.90	7.43	0.16	287.63	24.50	174.17	0.67
T ₇ (I ₂ F ₁)	1.06	2.71	50.07	7.20	0.16	295.83	25.70	183.10	0.69
T ₈ (I ₂ F ₂)	1.04	2.72	50.70	7.20	0.17	301.37	27.03	194.17	0.70
Mean	0.016	0.003	0.198	0.001	0.166	0.674	0.14	1.333	0.005
C.D at 5%	0.016	0.003	0.198	0.001	0.166	0.674	0.14	1.333	0.005
F test	NS	S	NS	S	NS	S	S	S	NS

annual production of 18.09 Mt and productivity of 689 kg ha⁻¹. In Gujarat, it is cultivated in 2.09 lakh hectares with an annual production of 1.14 lakh metric tonnes leading to average productivity of 546 kg ha⁻¹ (Anonymous, 2011). T-19 Variety of pea is medium tall and double podded. Variety has been developed by Department of Agriculture, U.P. The first blossom appears at 12-14th node after 60 days. Pods are yellowish green, slightly curved, 8.5 cm long with 6-7 wrinkled seeds with 45 % shelling percentage (Anonymous, 2016).

Materials and Methods

The experiment was conducted in the research farm of Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj. The experimental site is located in the sub-tropical region with 25° 28'46.14" N latitude, 81° 54'49.95" E longitude and 98m altitudes above the mean sea level. The experiment was laid out in a Randomized Block Design with nine treatment combinations of organic and inorganic source of fertilizers T₀ – L₀N₀ (control), T₁ – L₀N₁ (N₀P₀K₀ and Neem cake 1.25 t ha⁻¹), T₂ – L₀N₂

(N₀P₀K₀ and Neem cake 2.5 t ha⁻¹), T₃ – L₁N₀ (N₂₀P₂₅K₂₀ and Neem cake 0 t ha⁻¹), T₄ – L₁N₁ (N₂₀P₂₅K₂₀ and Neem cake 1.25 t ha⁻¹), T₅ – L₁N₂ (N₂₀P₂₅K₂₀ and Neem cake 2.5 t ha⁻¹), T₆ – L₂N₀ (N₄₀P₅₀K₄₀ and Neem cake 0 t ha⁻¹), T₇ – L₂N₁ (N₄₀P₅₀K₄₀ and Neem cake 1.25 t ha⁻¹), T₈ – L₂N₂ (N₄₀P₅₀K₄₀ and Neem cake 2.5 t ha⁻¹), consisting of three N P K levels (0, 50 and 100%) and Neem cake (0, 50 and 100%). The Prayagraj will be situated in 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. The recommended dose of fertilizers such as Nitrogen (40 kg ha⁻¹), Phosphorus (50 kg ha⁻¹), Potassium (40 kg ha⁻¹) and Neem cake (2.5 q ha⁻¹) respectively were applied into the field. Half dose of nitrogen and full dose of phosphorus and potassium were applied before sowing of Field pea. The data was calculated. All the agronomic practices were carried out uniformly to raise the crop. After crop harvesting the soil

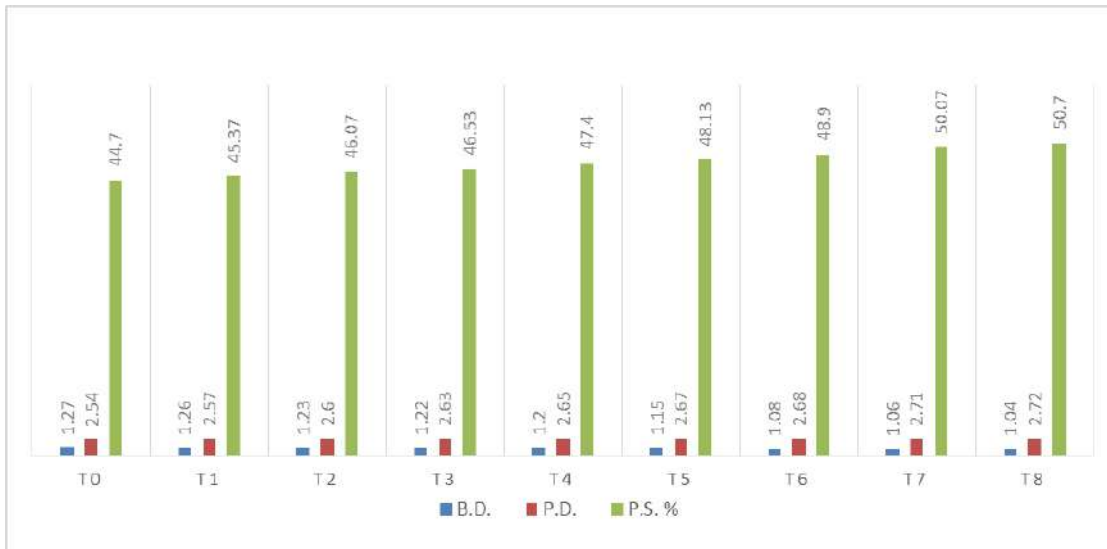


Fig-1 : Effect of different levels of N, P, K, and Neem cake on their interaction between Bulk density, Particle density, Pore space % of Field pea (*Pisum sativum* L.) Cv. T-19.

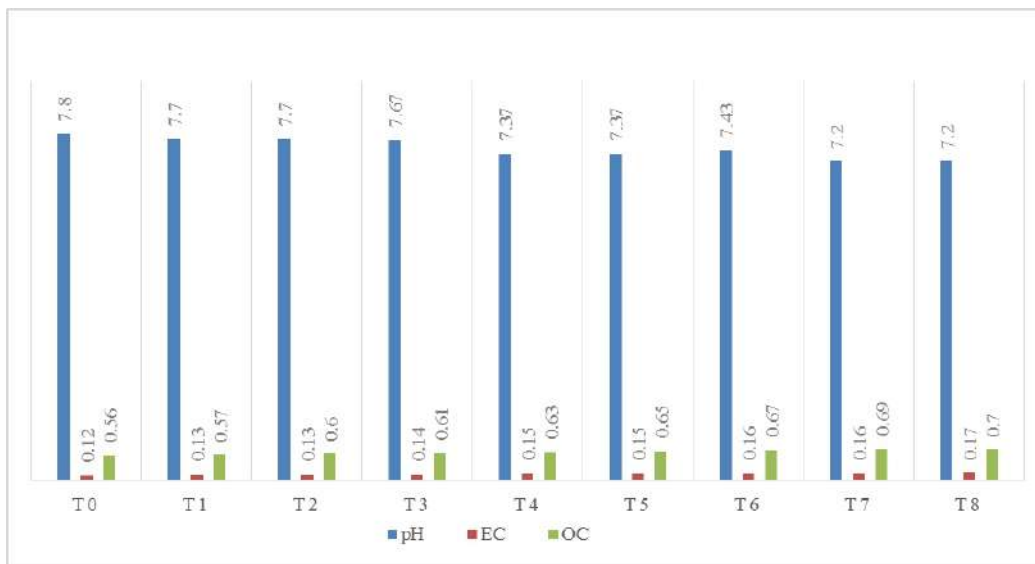


Fig-2 : Effect of different levels of N, P, K, and Neem cake on their interaction between Soil pH, EC, Organic carbon % of Field pea (*Pisum sativum* L.) Cv. T-19.

samples were collected from the soil 0-15 cm depth, air dried kept in an oven at 105°C for 48 hrs. For drying, pass through 2 mm sieve, soils were analyzed by using the following standard procedures.

Results and Discussion

The results given in Table-2 indicate some of the important parameter on physical properties on Field pea (*Pisum sativum*) Cv. T-19 crop. Neem cake and inorganic fertilizers in conjunction on Bulk density (1.04), percentage Pore space (50.70), EC (0.17), Organic carbon percent (0.70), was found non-significant and particle density, Soil pH(7.20), Available nitrogen (301.37 kg ha⁻¹), Available phosphorus (27.03 kg ha⁻¹), Available potassium (194.17 kg ha⁻¹) was found significant. And their

values were recorded respectively in the treatment T₈ that was significantly higher as compared to other treatment combination. Soil pH was recorded 7.20 in the treatment T₈ that were significantly lower as compared to other treatment combination. The slight decreased in soil pH and increased in soil EC (dSm⁻¹), Organic carbon (%), Available Nitrogen (kg ha⁻¹), Available Phosphorus (kg ha⁻¹), Available Potassium (kg ha⁻¹), may be due to increase in levels of organic and inorganic fertilizer and plant growth, which is turn increased the plant residues into soil. It may be concluded from trial that the various level of NPK and Neem cake used from different sources in the experiment, the treatment T₈ – L₂N₂ (N₄₀P₅₀K₄₀ and Neem cake 2.5 t ha⁻¹) was found to be the best, for improvement in physical and chemical properties of soil.

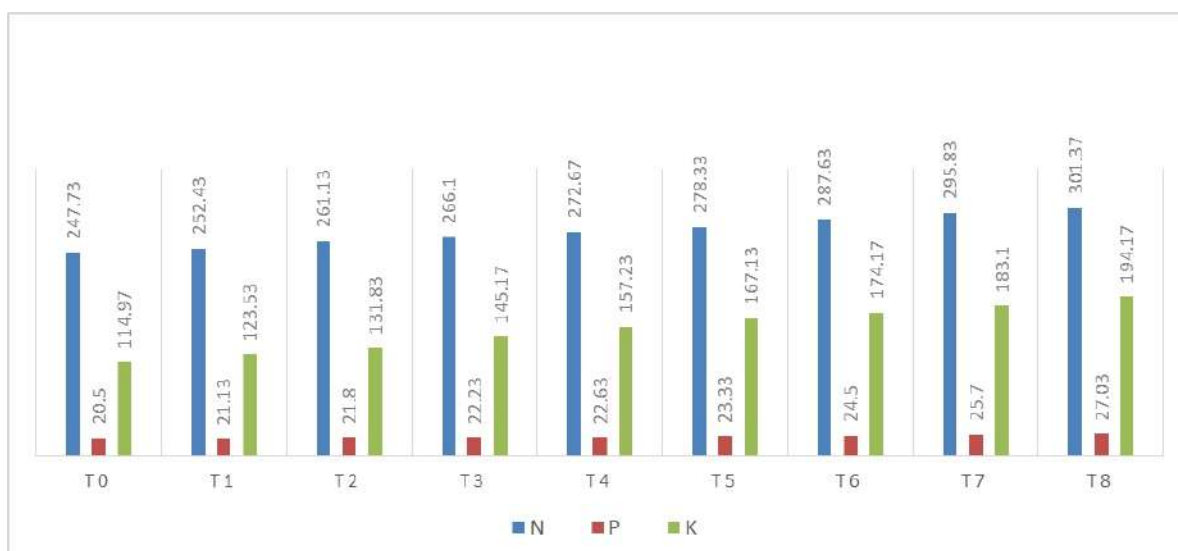


Fig.-3 : Effect of different levels of N, P, K, and Neem cake on their interaction between Nitrogen, Phosphorus, Potassium of Field pea (*Pisum sativum* L.) Cv. T-19.

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Effect of Different Levels of NPK and Neem Cake on Growth and Yield Attributes of Fieldpea (*Pisum sativum* L.) Cv. T-19

Shankar Lal Yadav^{1*}, Komal Yadav², Rohan Serawat¹, Dinesh Kumar Sharma¹, Praveen Choyal³ and Kalyan Singh Seervi⁴

¹Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj, U.P.

²Department of Horticulture, RVSKVV, Gwalior, M.P.

³Department of Horticulture, SHUATS, Prayagraj, U.P.

⁴Department of Plant Breeding and Genetics, SHUATS, Prayagraj, U.P.

*Corresponding Author Email : syadav1551@gmail.com

Abstract

A field experiment was conducted at Research farm, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, SHUATS, Allahabad (U.P.) during the Rabi season of 2017-18 with the objective to response of different levels of NPK and Neem cake on soil health, growth and yield attributes of Field pea (*Pisum sativum* L.) Cv. T-19. The experiment was laid out in a Randomized Block Design with nine treatment combinations, consisting of three N P K levels (0, 50 and 100%) and Neem cake (0, 50 and 100%). It was observed Treatment T₈L₂N₂(i.e. @N 40kg + P@ 50kg + K@ 100kg and neem cake @2.5 q ha⁻¹) was best in terms growth parameters in maximum plant height (86.53 cm), Number of leaves (74.87 cm), No. of branches (17.33), pod length (8.57 cm), number of pods plant⁻¹ (17.80), number of seeds pod⁻¹ and total yield was highest i.e. (70.40 qha⁻¹).

Key words : NPK levels, neem cake, growth and yield of fieldpea.

Introduction

Peas (*Pisum sativum* L.) a grain legume and a member of the leguminosae family grown throughout the world it is a native of central or Southeast Asia. It grows well in cool weather in the presence of ample moisture. Peas are recognized as one of the earliest agricultural crops domesticated by human beings. It is most important cultivated legume next to soybean, groundnut and beans. India has a major world's crop area under pulses and one fourth of the total production. Pulse crops offer stable source of protein in vegetarian diet of masses. Besides their well recognized role in restoring fertility and its physical conditions, pulse crops provide succulent and nutritious to our cattle, therefore, have been described as "Unique jewels of Indian crop husbandry". Pulses add 0.8 to 1.5 tonnes of organic matter to the soil in the form of their roots left after harvesting of the crops, on an average, one hectare crop adds 15 to 30 kg nitrogen in readily available form. The population of our country is at an alarming rate, which would be expected to reach 1280 million in 2020 and at this rate of population increase, India will need at least 30 million tonnes of pulses by 2020. Nutrition value of green peas per 100g contain Energy 339KJ, Dietary Fiber 5.1g, Protein 5.42, Carbohydrates 14.45g, Sugars 5.67g, Fat 0.4g, Vitamin C 40mg, Folic acid 50.7µg, Iron 1.47mg, Potassium 217mg, Magnesium 33mg, Phosphorus 108mg.

Legumes have been recognized as an important component of any cropping system and as a low input approach towards improvement of soil fertility. It appears to have originated many thousands of years ago in central Asia and the Middle East. They were originally dried and stored for long periods, providing nutrition during the non-growing seasons. Peas are now grown throughout the world and are consumed in both fresh and dried conditions. It is widely cultivated in temperate regions for its fresh green seed. Peas are an excellent human food, either eaten as a vegetable or used in preparation of soup. The peas are full of nutrition because its grain is rich in protein, complex carbohydrates, vitamins, minerals, dietary fibers and antioxidant compounds.

Materials and Methods

The investigation on Response of different levels of NPK and Neem cake on soil health, growth and yield attributes of Field pea (*Pisum sativum* L.) Cv. T-19 was carried out in Rabi season of 2017-18 at research site of Department Soil Science and Agriculture Chemistry at Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad. The details of materials and methods adopted during the execution of the experiment are being described in the following headings and sub-headings:

Experimental site : The field experiment was conducted during the Rabi season of the year 2017-18 in the

research form of Soil Science and Agricultural Chemistry Department (SSAC), Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (UP), located at 25°57'N latitude 81°57'E longitude and 98m above the mean sea level.

Climatic condition in the experimental area : Agro climatically, Allahabad district represents the subtropical belt of the South East of Uttar Pradesh, and is endowed with 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 ranges between 20 - 94 %. The average rainfall of this area is around 1100mm annually.

Meteorological conditions : It comes under subtropical climate receiving the mean annual rainfall of about 1100mm, major rainfall from July to end of September. However, occasional precipitation was also not uncommon during winter. The winter months were cold while summer months were very hot and dry. The minimum temperature during the crop season was to be 5.9 °C and the maximum is to be 29.04 °C. The minimum humidity was to be 42.72.0% and maximum was to be 93.28%.

Results and Discussion

Plant height (cm) : Table-1 and fig.-1 shows the plant height recorded at 30 DAS, 60 DAS and 90 DAS as influenced by N P K, and neem cake. The effect of N P K, and neem cake on plant height was in the order of $L_2 > L_1 > L_0$. The application of N P K increased the plant height was significant at 30, 60 and 90 DAS and the maximum plant height recorded was 32.73, 61.35, and 84.19cm plant⁻¹ respectively. The effect of neem cake on plant height at different DAS was in order $N_0 < N_1 < N_2$. The application of neem cake increased the plant height significantly at 30, 60, and 90 DAS and the maximum plant height recorded at 30, 60, and 90 DAS was found to be 28.78, 56.03, and 80.41cm respectively. The interaction between N P K, and neem cake was significant at 60 30 and 90 DAS. The minimum plant height of 18.6, 43.8 and 69.27cm at 30, 60 and 90 DAS was recorded in T_0 (i.e. control) and maximum plant height of 34.26, 64.4 and 86.53 cm at 30, 60 and 90 DAS was recorded in T_8 (i.e. @N 40kg + P@ 50kg + K@ 40kg and neem cake @2.5 q ha⁻¹). Increase in plant height due to increase in NPK, and neem cake fertilizers may be due to adequate supply of nutrients which in turn helps in vigorous vegetative growth of plants and subsequently increase the plant through cell elongation, cell expansion, cell division, photosynthesis and turbidity of plant cell. The increase in nodal length finally plant height. Similar findings were reported by, Tripathi *et al.* (2011), Paliwal *et al.* (2016), Mallick and Raj (2015) and Dhruw *et al.* (2017).

Table-1 : Effect of different levels of N, P, K, and Neem cake on plant height (cm/plant) at 30, 60 and 90 DAS of Field pea (*Pisum sativum* L.) Cv. T-19.

Levels of N, P, K (L)	30 DAS			60 DAS			90 DAS			Mean (N)	
	Levels of neem cake (N)			Levels of neem cake (N)			Levels of neem cake (N)				
	N ₀	N ₁	N ₂	N ₀	N ₁	N ₂	N ₀	N ₁	N ₂		
L ₀	18.6	21.167	23.333	21.033	43.8	45.4	47.867	69.27	72.07	74.33	71.89
L ₁	24.8	26.4	28.767	26.656	51.267	53.733	55.833	76.80	78.70	80.37	78.62
L ₂	30.867	33.067	34.267	32.733	58.1	61.567	64.4	82.27	83.77	86.53	84.19
Mean (L)	24.756	26.878	28.789		51.056	53.567	56.033	76.11	78.18	80.41	
	F-test	S. Em. (±)	C.D. at 5%		F-test	S. Em. (±)	C.D. at 5%	F-test	S. Em. (±)	C.D. at 5%	
Due to N P K (L)	S	0.081	0.246		S	0.138	0.416	S	0.146	0.443	
Due to Neem cake (N)	S	0.081	0.246		S	0.138	0.416	S	0.146	0.443	
Interaction (L x N)	S	0.141	0.426		S	0.238	0.72	S	0.254	0.767	

Number of branches/plant : Table-2 and fig.-2 shows the number of branches plant⁻¹ recorded at 30 DAS, 60 DAS and 90 DAS as influenced by N P K, and neem cake. The effect of N P K, and neem cake on number of branches plant⁻¹ was in the order of $L_2 > L_1 > L_0$. The application of N P K increased the number of branches plant⁻¹ was significant at 30, 60, and 90 DAS and the maximum number of branches plant⁻¹ recorded was 6.30, 11.01 and 16.44 branches plant⁻¹ respectively. The effect of neem cake on number of branches plant⁻¹ at different DAS was in order $N_0 < N_1 < N_2$. The application of neem cake increased the number of branches plant⁻¹ significantly at 30, 60, and 90 DAS the maximum number of branches plant⁻¹ recorded at 30, 60, and 90 DAS was found to be 5.52, 9.60 and 14.86 branches plant⁻¹ respectively. The interaction between N P K, and neem cake was significant at 30, 60 DAS but it was non-significant at 90 DAS. The minimum number of branches plant⁻¹ of 3.13, 5.90 and 10.73 at 30, 60 and 90 DAS was recorded in T_0 (i.e. control) and maximum number of branches plant⁻¹ of 6.57, 12.20, and 17.33 at 30, 60 and 90 DAS was recorded in T_8 (i.e. @N 40kg + P@ 50kg + K@ 40kg and neem cake @2.5 q ha⁻¹). Increase in number of branches plant⁻¹ due to increase in NPK, and neem cake fertilizers may be due to adequate supply of nutrients which in turn helps in vigorous vegetative growth of plants and subsequently increase the number of branches through cell elongation, cell expansion, cell division, photosynthesis and turbidity of plant cell. The increase in nodal length finally plant height. Similar findings were reported by, Dashadi et al. (2013), Achakzai (2012), Ashraf et al. (2011), Mishra et al. (2010), Nazia et al. (2006), and Negi et al. (2004).

Number of leaves/plant : Table-3 and fig.-3 shows the number of leaves plant⁻¹ recorded at 30 DAS, 60 DAS and 90 DAS as influenced by N P K, and Neem cake. The effect of N P K, and neem cake on number of leaves plant⁻¹ was in the order of $L_2 > L_1 > L_0$. The application of N P K increased the number of leaves significant at 30, 60 and 90 DAS the maximum number of leaves plant⁻¹ recorded was 13.81, 41.44 and 73.19 leaves plant⁻¹ respectively. The effect of neem cake on number of leaves plant⁻¹ at different DAS was in order $N_0 < N_1 < N_2$. The application of neem cake increased the number of leaves significantly at 30, 60, and 90 DAS the maximum number of leaves plant⁻¹ recorded at 30, 60, and 90 DAS was found to be 12.51, 32.56 and 66.28 leaves plant⁻¹ respectively. The interaction between N P K, and neem cake was significant at 30, 60 and 90 DAS. The minimum number of leaves plant⁻¹ of 9.20, 16.43 and 45.60 was recorded in T_0 (i.e. control) at 30, 60 and 90 DAS. The maximum number of leaves plant⁻¹ of 14.40, 45.07 and 74.87 at 30, 60 and 90 DAS was recorded in T_8 (i.e. @N

40kg + P@ 50kg + K@ 40kg and neem cake @2.5 q ha⁻¹). Increase in number of leaves plant⁻¹ due to increase in NPK, and neem cake fertilizers may be due to adequate supply of nutrients which in turn helps in vigorous vegetative growth of plants and subsequently increase the number of leaves through cell elongation, cell expansion, cell division, photosynthesis and turbidity of plant cell. Similar findings were reported by, Hamed et al. (2012), Achakzai (2012), Ashraf et al. (2011), Mishra et al. (2010).

No. of pods/plant : Table-4 and fig.-4 shows the No. of pods plant⁻¹ as influenced by N P K, and Neem cake. The effect of N P K, and neem cake on No. of pods plant⁻¹ was in the order of $L_0 < L_1 < L_2$. The application of N P K increased the No. of pods plant⁻¹ was significant the maximum No. of pods plant⁻¹ recorded was 16.73 plant⁻¹. The effect of neem cake on No. of pods plant⁻¹ was in order $N_0 < N_1 < N_2$. The application of neem cake increased the No. of pods plant⁻¹ significant the maximum No. of pods plant⁻¹ recorded was found to be 14.39 plant⁻¹. The interaction between N P K, and neem cake was non-significant. The minimum No. of pods plant⁻¹ 8.20 plant⁻¹ was recorded in T_0 (i.e. control). The maximum No. of pods plant⁻¹ 17.80 was recorded in T_8 (i.e. @N 40kg + P@ 50kg + K@ 40kg and neem cake @2.5 q ha⁻¹). Application of full doses of inorganic fertilizers along with the neem cake was responsible for increase in No. of pods plant⁻¹ in treatment T_8 which was significantly superior over all other treatments. Similar findings were reported by, Tripathi et al. (2011), Paliwal et al. (2016), Mallick and Raj (2015) and Dhruw et al. (2017).

Table-4 : Effect of different levels of N, P, K, and Neem cake on No. of pods plant⁻¹ Field pea (*Pisum sativum* L.) Cv. T-19.

Levels of N, P, K (L)	Levels of neem cake (N)			Mean (N)
	N_0	N_1	N_2	
L_0	8.20	9.27	10.80	9.42
L_1	12.13	13.47	14.57	13.39
L_2	15.70	16.70	17.80	16.73
Mean (L)	12.01	13.14	14.39	
	F-test	S. Em. (±)	C.D. at 5%	
Due to N P K (L)	S	0.081	0.245	
Due to Neem cake (N)	S	0.081	0.245	
Interaction (L x N)	NS	0.141	-	

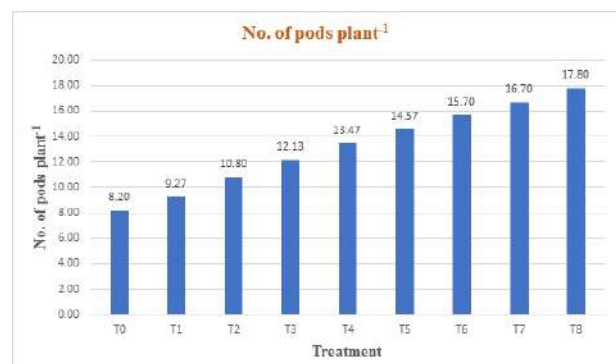


Fig.-4 : Effect of different levels of N, P, K, and Neem cake on No. of pods plant⁻¹ Field pea (*Pisum sativum* L.) Cv. T-19.

Pods length/plant : Table-5 and fig.-5 shows the pod length plant⁻¹ as influenced by N P K, and Neem cake. The effect of N P K, and neem cake on pod length plant⁻¹ was in the order of $L_0 < L_1 < L_2$. The application of N P K increased the pod length plant⁻¹ was significant the maximum pod length plant⁻¹ recorded was 8.00 plant⁻¹. The effect of neem cake on pod length plant⁻¹ was in order $N_0 < N_1 < N_2$. The application of neem cake increased the pod length plant⁻¹ significant the maximum pod length plant⁻¹ recorded was found to be 7.39 plant⁻¹. The interaction between N P K, and neem cake was significant. The minimum pod length plant⁻¹ 5.67 q ha⁻¹ was recorded in T_0 (i.e. control). The maximum pod length plant⁻¹ 8.57 was recorded in T_8 (i.e. @N 40kg + P@ 50kg + K@ 40kg and neem cake @2.5 q ha⁻¹). Application of full doses of inorganic fertilizers along with the neem cake was responsible for increase in pod length plant⁻¹ in treatment T_8 which was significantly superior over all other treatments. Similar findings were reported by, Tripathi *et al.* (2011), Paliwal *et al.* (2016), Mallick and Raj (2015) and Dhruw *et al.* (2017).

Table-5 : Effect of different levels of N, P, K, and Neem cake on of Pods length plant⁻¹ Field pea (*Pisum sativum* L.) Cv. T-19.

Levels of N, P, K (L)	Levels of neem cake (N)			Mean (N)
	N ₀	N ₁	N ₂	
L ₀	5.67	5.93	6.37	5.99
L ₁	6.60	6.87	7.23	6.90
L ₂	7.40	8.03	8.57	8.00
Mean (L)	6.56	6.94	7.39	
	F-test	S. Em. (±)	C.D. at 5%	
Due to N P K (L)	S	0.042	0.128	
Due to Neem cake (N)	S	0.042	0.128	
Interaction (L x N)	NS	0.073	0.222	



Fig.-5 : Effect of different levels of N, P, K, and Neem cake on Pods length plant⁻¹ Field pea (*Pisum sativum* L.) Cv. T-19.

No. of seeds/pod : Table-6 and fig.-6 shows the No. of seed pod⁻¹ as influenced by N P K, and neem cake. The effect of N P K and neem cake on No. of seed pod⁻¹ was in the order of $L_0 < L_1 < L_2$. The application of N P K increased the No. of seed pod⁻¹ was significant the maximum No. of

seed pod⁻¹ recorded was 8.37 pod⁻¹. The effect of neem cake on No. of seed pod⁻¹ was in order $N_0 < N_1 < N_2$. The application of neem cake increased the No. of seed pod⁻¹ significant. the maximum No. of seed pod⁻¹ recorded was found to be 7.58 pod⁻¹. The interaction between N, P, K, and neem cake was non-significant. The minimum No. of seed pod⁻¹ 5.13 pod⁻¹ was recorded in T_0 (i.e. control). The maximum No. of seed pod⁻¹ 8.83 was recorded in T_8 (i.e. @N 40kg + P@ 50kg + K@ 40kg and neem cake @2.5 q ha⁻¹). Application of full doses of inorganic fertilizers along with the neem cake was responsible for increase in No. of seed pod⁻¹ in treatment T_8 which was significantly superior over all other treatments. Similar findings were reported by, Tripathi *et al.* (2011), Paliwal *et al.* (2016), Mallick and Raj (2015) and Dhruw *et al.* (2017).

Table-6 : Effect of different levels of N, P, K, and Neem cake on No. of seed pod⁻¹ of Field pea (*Pisum sativum* L.) Cv. T-19.

Levels of N, P, K (L)	Levels of neem cake (N)			Mean (N)
	N ₀	N ₁	N ₂	
L ₀	5.13	5.63	6.27	5.68
L ₁	6.60	7.23	7.63	7.16
L ₂	7.97	8.30	8.83	8.37
Mean (L)	6.57	7.06	7.58	
	F-test	S. Em. (±)	C.D. at 5%	
Due to N P K (L)	S	0.033	0.101	
Due to Neem cake (N)	S	0.033	0.101	
Interaction (L x N)	NS	0.058	-	

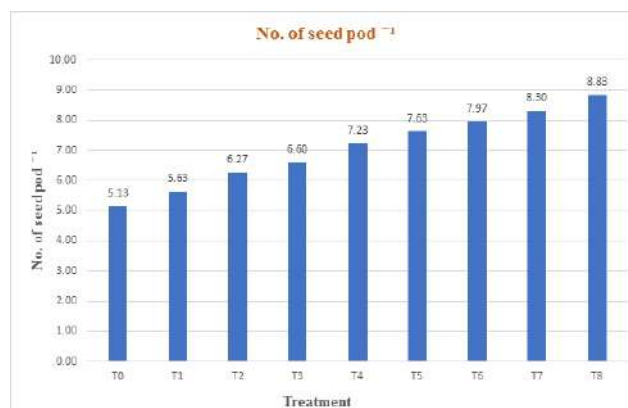


Fig.-6 : Effect of different levels of N, P, K, and Neem cake on No. of seed pod⁻¹ of Field pea (*Pisum sativum* L.) Cv. T-19.

Green pod yield(q/ha) : Table-7 and fig.-7 shows the Greenpod yield (q ha⁻¹) as influenced by N P K, and neem cake. The effect of N P K, and neem cake on Greenpod yield (q ha⁻¹) of plant was in the order of $L_0 < L_1 < L_2$. The application of N P K and increased the Greenpod yield (q ha⁻¹) was significant the maximum green pod yield (q ha⁻¹) recorded was 67.37. The effect of neem cake on greenpod yield (q ha⁻¹) was in order $N_0 < N_1 < N_2$. The application of neem cake increased the Greenpod yield (q ha⁻¹) significant the maximum pod yield (q ha⁻¹) recorded was found to be 61.78. The interaction between N P K,

and neem cake was significant. The minimum Greenpod yield ($q\ ha^{-1}$) 48.91 was recorded in T_0 (i.e. control). The maximum Greenpod yield ($q\ ha^{-1}$) 70.40 was recorded in T_8 (i.e. @N 40kg + P@ 50kg + K@ 40kg and neem cake @2.5 $q\ ha^{-1}$). Application of full doses of inorganic fertilizers along with the neem cake has given the good results regarding Greenpod yield. Similar findings were reported by, Tripathi *et al.* (2011), Paliwal *et al.* (2016), Mallick and Raj (2015) and Dhruw *et al.* (2017).

Table-7 : Effect of different levels of N, P, K, and Neem cake on green pod yield (q/ha) of Field pea (*Pisum sativum* L.) Cv. T-19.

Levels of N, P, K (L)	Levels of neem cake (N)			Mean (N)
	N_0	N_1	N_2	
L_0	48.91	50.40	53.40	5.68
L_1	56.47	58.60	61.53	7.16
L_2	64.20	67.50	70.40	8.37
Mean (L)	56.53	58.83	61.78	
	F-test	S. Em. ($\pm$)	C.D. at 5%	
Due to N P K (L)	S	0.119	0.359	
Due to Neem cake (N)	S	0.119	0.359	
Interaction (L x N)	NS	0.205	0.621	

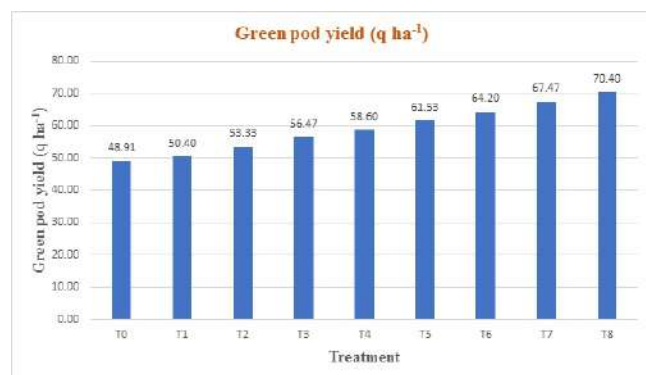


Fig-7 : Effect of different levels of N, P, K, and Neem cake on green pod yield (q/ha) of Field pea (*Pisum sativum* L.) Cv. T-19.

Conclusions

It was concluded from trail that the effect of different levels in the experiment, the best Treatment $T_8L_2N_2$ (i.e. @N 40kg + P@ 50kg + K@ 100kg and neem cake @2.5 $q\ ha^{-1}$) was best in terms growth parameters in maximum plant height (86.53 cm), Number of leaves (74.87 cm), No. of branches (17.33), pod length (8.57 cm), number of pods plant⁻¹ (17.80), number of seeds pod⁻¹ and total yield was highest i.e. (70.40 $q\ ha^{-1}$).

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