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Socio-Economic Status of the Farmers Having Soil Health Card in District Kanpur Nagar of Uttar Pradesh

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Abstract

The Government of India is launched Soil Health Card Scheme on 19 February in 2015 at Suratgarh Rajasthan. Soil Health Card is detailed printed report of status of soil fertility and twelve parameters which affect the soil and crop productivity. The study was conducted in purposely selected Kanpur Nagar district of Uttar Pradesh by purposely selecting a block from district. Thus, in all, six villages were selected. From each selected village, twenty farmers were selected randomly. Thus, total 120 respondents were selected randomly and data collected by personal interview with the help of well semi structured schedule/questionnaire. Results reveals that majority of respondents were found in middle age 40(%), married (93.33%), literate (81.67%), Hindu (81.66%), OBC caste (43.33%), nuclear (71.66%) and small sized family (61.66%), were marginal farmers (49.16%), had Pucca housing pattern (36.66%), had took no participation in any organization (42.50%), engaged in farming + animal husbandry (60.84%), had income between 1,00,000 to 2,00,000Rs (40.84%), having medium level of economic motivation (70.83%), scientific orientation (72.50%) and risk orientation (57.50%). In extension contact, most of the respondents were given preference to Gram Pradhan, family, and TV in aspect of formal sources, informal sources, and mass media exposure respectively. In Material possession, Respondents have good number of pumping set/diesel engine for farm power, Sickle and khurpi for agricultural work, bicycle and motorcycle for transportation, Chair, cots and wall watch for housing material and Mobile for communication media possessions.

Key words : *socio-economic status, farmers, soil health card, extension contact.*

Introduction

Soil is the lifeblood for all crops as it provides all the necessary micro nutrient, macro nutrient and water. Soil is considered to be a dynamic resource whose health determines the productivity of the plant. The functional capacity of a soil to sustain the natural productivity, environmental quality, and promotes plant and animal health within the ecosystem is called soil health (Doran and Parkin, 1994). Healthy soil contains all the elements for growth and development of crop or the soil derived of one or more nutrient either reduce the production or degraded quality of crops. Therefore, proportion and quantity of macro and micro nutrients altogether refer to the soil health (Patel *et al.,* 2017). The success of green revolution in 1965 which introduced high yielding variety seeds and the efficient use of irrigation and fertilizer to increase the productivity of the crop have resulted in making India self-reliant in terms of food grains. The total demand for food grain by 2021-2022 is expected to be 253 million tonnes (Kumar *et al.,* 2009) and 333 million tonnes in 2050 (The Economic Times, 2015). Hence, the production of food grains should be further increased to feed the growing population whose growth rate is much higher that the production of food grains.

Thus, in a developing country like India with a high rate of population growth new improved technology and the efficient and sustainable use of resources like fertilizer should be used to increase the production of food grain. So, the Department of Agriculture & Co-operation under the Ministry of Agriculture and Farmers' Welfare, Government of India introduced a new scheme with an aim of improving the health of the soil 'The Soil Health Card Scheme' (SHC) on 17 February 2015. It scheme was implemented by all the State's Department of Agriculture and Union Territory Governments. The aims of the scheme it to promote soil test based and even-handed use of fertilisers to enable farmers to get hold of higher yields at lower cost. Also the main objective of the scheme was to test the nutrient of the soil and recommend the correct amount of fertilizer required. The Government had allocated an amount of Rs. 568 crore (US$ 82 million) for the scheme. In 2016 Union budget of India, has been allocated Rs.100 crore to the states for making soil health cards and set up new soil testing labs (Soil Health Card scheme Wikipedia).

Socio-economic status is the field of study that examines social and economic factors to better understand how the combination of both influences something. The socio- economic characteristics pertaining to demography, means of production and investment of income and expenditure pattern of people living in a particular location strongly influence their responses to technological changes and participation in development schemes. It becomes necessary for extension workers to recognize the respondents with attitude and the respondents who are lagging behind the course of development. Socio-economic status gives a picture of an individual and his family in respect of social and economic position in a community. However, the socio-economic status of farmers having Soil Health Card was found to be less in the entire state due to various reasons. Therefore, the present attempted to identify the socio- economic development in terms of understanding the present condition of a particular area.

Materials and Methods

The study was conducted in state Uttar Pradesh. Uttar Pradesh is a state in northern India. The state is divided in to 18 divisions and 75 districts. Uttar Pradesh state was purposely selected with many reasons. Over 70 percent Population of Uttar Pradesh directly or indirectly depends on agriculture and allied sector. So out of 75 districts of UP, Kanpur district was selected for study. Kanpur is a major industrial town of UP. The area is selected for this study because the researcher is familiar with the area and culture therefore it has facilitated him to obtain factual data from the respondents. The urban district of Kanpur Nagar serves as the headquarters of the Kanpur division, Kanpur range and Kanpur Zone. There are 10 Community Developmental Blocks in the district. These are Ghatampur, Kalyanpur, Vidhnu, Kakwan, Sarsol, Bilhaur, Bhitargaon, Chaubeypur, Patara, Shivrajpur. Out of these ten developmental blocks, Bilhaur block was selected purposely because the researcher has knowledge about the locality and culture. There are about 405 villages in Bilhaur community development block. Out of 405, 6 sample village are selected through random sampling which are namely Sujawalpur, Dhukapur, Shuklapur, Newada Udau, Pura, Lachhimanpur Mishran. a total of 120 farmers will be selected through random sampling techniques, 20 framers from each village.

Results and Discussion

The distribution of respondents are on the basis of differential information possessed by them and it was calculated by working out Arithmetic Mean, Standard Deviation, Percentage, Minimum and Maximum.

Age : Table-1 indicated that majority of respondents are comes into middle aged group with the number of 48 which make 40.00 percentage followed by old age group which make 34.16percentagethen young age group that hold 25.83 percentage respectively.

Education : Table-1 revealed that most respondents were literate (81.67%) and rest of respondents were illiterate (18.33%). In Literate category 27.5 percent respondent educated with secondary education followed by Highschool (17.50%), primary education (16.66%), Intermediate (13.33%), Graduate and above (06.66%) respectively. In comparison of literacy rate of district (52.49%) and block (51.37%), respondents have better education.

Caste : Table-1 is shown that the highest number of respondents were belonged to OBC caste (43.33%) followed by SC/ST caste (33.33%) and only 23.33 percent respondents were belonged to General caste. So, we say that OBC and SC/ST caste were dominant in this area.

Marital Status : Table-1 shown that 93.33 percent respondents were married and 6.66 percent respondents were unmarried respectively.

Land Holding : There are four type of farmers according to size of land holding. Table-1 stated that 49.16 percent respondents were marginal farmers. Small farmers (33.33%) were found highest after marginal farmers followed by medium farmers (10.83%) and large farmers (6.66%) respectively.

Family Type : Table-1 is indicated that the most respondents were belonged to Nuclear family withstanding of 71.66 percent while remaining of the 28.33 percent respondents were belonged to Joint family. So, we can say that most of the people were belonged to Nuclear family in research area.

Family Size : Table-1 indicated that most of the respondents were lies into small size category with the 61.66 percent followed by medium size with 30.00 percent and rest respondents were lies into large family size with 08.33 percent.

Income : Table-1 indicated that the average income of respondents was 1,60,000 Rs. and Standard deviation was 1.10. 40.00 percent farmers have income category Up to 1,00,001 Rs to 2,50,000, followed by up to 1,00,000 Rs, to 2,50,001 Rs to 5,00,000 Rs category (15.83%), and above 5,00,001 Rs category (06.66%), respectively.

Social Participation : A cursory glance over the data depicted in the table-1. show that 42.50 percent respondents take no participation in any organization while 37.50percent respondents were participated in one organization and15.00 percent respondent were participated in two organization and only 5.00 percent respondent were involved in more than two organization. Most respondents were not participated in any organization.

Farm Power Possession : Table-1 is indicated that 40.00 percent respondents had Pumping set/diesel engine followed by electric motor (26.16%), tractor (20.00%),

Table-1 : Distribution of Respondents according to their socio-economic condition. N=120

Variables	Respondents	
	f	%
1. Age		
Young age (below 34)	31	25.83
Middle age (35 to 60)	48	40.00
Old age (above 61)	41	34.16
2. Education		
Illiterate	22	18.33
Literate	98	81.67
Primary school	20	16.66
Middle school	33	27.50
High school	21	17.50
Intermediate	16	13.33
Graduate & Post graduate	08	06.66
3. Caste		
General caste	28	23.33
Other Backward caste	52	43.33
Scheduled caste	40	33.33
4. Marital Status		
Married	112	93.33
Unmarried	08	6.66
5. Land Holding		
Marginal Farmers (below 1)	59	49.16
Small farmers (1.01 to 2.00)	40	33.33
Medium Farmers (2.01 to 3.00)	13	10.83
Large farmers (above 4 ha.)	08	06.66
6. Family Type		
Nuclear family	86	71.66
Joint family	34	28.33
7. Size of Family		
Small family (below 4)	74	61.66
Medium family (5 to 8)	36	30.00
Large family (above 9)	10	08.33
8. Annual Income		
Up to 1,00,000 Rs.	45	37.50
1,00,001 Rs to 2,50,000 Rs	48	40.00
2,50,001 Rs to 5,00,000 Rs	19	15.83
Above to 5,00,000 Rs	08	06.66
9. Social Participation		
No participation	51	42.50
Participation in one organization	45	37.50
Participation in two organization	18	15.00
Participation in more than two organization	06	05.00
10. Farm Power Possession		
Bullock	08	6.66
Electric motor	35	29.16
Pumping set/ Diesel engine	48	40.00
Power tiller	05	04.16
Tractor	24	20.00

Table-1 : Contd....

Variables	Respondents	
	f	%
11. Farm Implement Possession		
Cultivator	08	6.66
Seed drill	06	5.00
Thresher	07	5.83
Rotavator	02	1.66
Winnower	07	5.83
Chaff cutter	57	47.50
Disc Plough	01	0.83
Combine machine	04	3.33
Desi Plough	02	1.66
M.B. Plough	03	2.50
Pata	16	13.33
Sprayer	51	42.50
Spade	109	90.83
Sickle	120	100
Khurpi	120	100
12. Transportation Material Possession		
Car	08	6.66
Truck	01	0.83
Pick up	02	1.66
Tractor Trolley	15	12.5
Bike/Scooter	73	60.83
Bicycle	114	95
Bullock cart	07	5.83
13. House Hold Material Possession		
Double bed	37	30.83
Sofa set	22	18.33
Dressing Table	06	05.00
Gas cylinder	58	48.33
Electric press	62	51.66
Pressure cooker	39	32.50
Crockery	27	22.50
Fan	108	90.00
Cooler	34	28.33
Solar light	04	03.33
Heater	01	00.83
Cots	120	100.00
Sewing machine	50	41.66
Chair	120	100.00
Wall watch	120	100.00
14. Communication Media Possession		
Radio	64	53.33
T.V.	104	86.66
D.T.H.	91	75.83
Mobile phone	120	100.00
Computer	02	01.66
Laptop	21	17.50
News Paper	06	05.00
15. Economic Motivation		
Low (up to 17)	29	24.17
Medium (18-21)	85	70.83
High (22 and above)	06	05.00

Table-1 : Contd....

Variables	Respondents	
	f	%
16. Scientific Orientation		
Low (up to 19)	24	20.00
Medium (20-24)	87	72.50
High (25 and above)	09	07.50
17. Risk Orientation		
Low (up to 19)	37	30.84
Medium (20-23)	69	57.50
High (24 and above)	14	11.66
18. Extension Contact	MPS	Rank
Formal Sources		
B.D.O.	1.10	VI
A.D.O.	1.73	IV
V.D.O.	2.48	II
Gram Pradhan	3.71	I
Co-operatives	1.25	V
Fertilizers/Seed Stores	2.30	III
Informal Sources		
Family Members	6	I
Neighbours	5.12	II
Friends	4.60	III
Relatives	2.29	V
Local leaders	2.90	IV
Progressive farmers	1.58	VI
Mass Media Exposure		
Radio	04.72	II
T.V.	05.50	I
News paper	03.25	III
News bulletins	00.37	XI
Farm magazines	00.44	X
Circular letters	00.23	XII
Agricultural Books	00.62	IX
Posters	00.81	VII
Farmers Fair	00.78	VIII
Demonstration	00.92	VI
Folders	00.95	V
Others	01.80	IV

f= Frequency, **%=** Percentage, **MPS**= Mean Per Score

Bullock (06.66%) and power tiller (04.16%) were observed respectively.

Farm Implements Materials : Table-1 revealed that cent percent respondent have Sickle and khurpi in their home followed by spade (90.83%), chaff cutter (47.5%), sprayer (42.50%), pata (13.33%), cultivator (06.66%), Thresher and winnower (05.83%), seed drill (05.00%), combine machine (03.33%), MB plough (02.50%), rotavator and deshi plough (01.66%) and disc plough (00.83%) respectively.

Transportation Material Possession : Table-1 revealed that most of the respondent have bicycle (95.00%) followed by bike/scooter (60.83%), Tractor with trolley (12.50%), car (06.66%), bullock cart (05.83%), pickup (01.66%) and truck (00.83%) respectively.

Note : It would be better to note that the maximum farmers having marginal or small piece of land but their condition of farm power, farm implements and transportation materials was considerably good because the farmers use these materials for providing services to other farmers on hired basis.

House Hold Materials Possession : Table-1 revealed that cent percent respondent has cots, chair and wall watch while 90 percent have fan, followed by electric press (51.66%), gas cylinder (48.33%), sewing machine (41.66%), pressure cooker (32.50%), double bed (30.83%), cooler (28.33%), crockery (22.50%), sofa set (18.33%), dressing table (05.00%), solar light (03.33%) and heater (00.83%) respectively.

Communication Media Possession : Table-1 revealed that cent percent respondents have mobile phone followed by 86.66 percent have T.V., 75.83 percent have DTH, 53.33 percent have radio, 17.50 percent have laptop, 05.00 percent uses newspaper for information and rest 01.66 percent have computer in their home for communication.

Economic Motivation : The mean of scientific orientation was 18.85 and Standard deviation was 01.99 with a range of minimum 13 and maximum 23. The table-1 revealed that most of respondents were lies into medium category (70.83%) followed by low category (24.17%) and high category (05.00%) respectively.

Risk Orientation : The mean score of risk orientation is 20.91 and Standard deviation is 02.24 with a range of minimum 15 and maximum 25. Table-1 show that 57.50 percent respondents were lies into medium category which followed by low category (30.84%) and high category (11.66%) respectively.

Scientific Orientation : The mean of scientific orientation was 21.60 and Standard deviation was 2.32 with a range of minimum 15 and maximum 26. The table-1 revealed that most of respondents were lies into medium category (72.50%) followed by low category (20.00%) and high category (07.50%) respectively.

Extension Contact : Extension contact is dividing into three categories viz. formal sources, informal sources, and mass media exposure. These categories were resulted by Mean Percentile Score (MPS) as rank wise in descending order.

Table-1 revealed that mean percentile score of formal sources 2.09, the descending order of formal sources were Gram Pradhan (3.71) followed by VDO (2.48), Fertilizers/seed stores (2.30), ADO (1.73), Co-operatives (1.25) and BDO (1.10) respectively.

The mean score of informal sources is 3.74 and descending order of informal sources were Family member (6), Neighbors (5.12), Friends (4.60), Local leaders (2.90), Relatives (2.29), and Progressive farmers (1.58) respectively.

The mean score of mass media exposure were 1.70 and their descending order were T.V. (05.50), Radio (04.72), Newspaper (03.25), Others (01.80), Folders (00.95), Demonstration (00.92), Posters (00.81), Farmers Fair (00.78), Agricultural Books (00.62), Farm magazines (00.44), News bulletins (00.37) and Circular letters (00.23) respectively. The overall mean of extension contact was observed 2.51.

Conclusions

Village is the prime institute striving for integrated rural development. Study focuses on socio-economic status of farmers. The study indicated, It was observed that majority of farmers were middle aged and literate including formal and informal education. Other backward caste farmers were dominantly engaged in farming. majority of nuclear family system were found in existence having less than 4 members in their families. Maximum respondents were marginal farmers. Farmers were found such who had earning of Rs. 1,00,001 to 2,50,000. pumping set/diesel engine for farm power were dominant farm power along with farm implements. The bycycle was main conveyance with all respondents. The T.V. possessed by majority. The majority of farmers were have no participate in any organization. The majority of respondents had formal source of information is gram pradhan, informal source of information is family members and television are major source of information in mass media. The economic motivation (70.83 per cent), scientific orientation (72.50%) and risk-orientations (57.50%) were observed of medium levels.

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Consequence of Optimum Levels of Fertilizer on Ascorbic Acid, Protein, Proline and Phenolics Analysis of Chilli (*Capsicum annuum* L.) cv. Pant C1 under North-West Himalaya

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Abstract

A field experiment was conducted to study the "Consequence of optimum levels of fertilizer on ascorbic acid, protein, proline and phenolics analysis of chilli (*Capsicum annuum* L.) Cv. Pant C 1". The experiment was conducted with a randomize block design (RBD) in field and completely randomized design (CRD) in laboratory three replication with twenty treatments combinations. There were two levels of nitrogen (40 & 80 kg nitrogen per hectare), one level of phosphorus (35 kg P_2O_5 per hectare), two levels of potassium (35 and 60 kg K_2O per hectare) and two levels of farmyard manure (20 and 25 tonne per hectare). The higher content of ascorbic acid and total extractable colour of chilli fruits under T_9 treatment. Potassium contents shoot and fruit portion of chilli increased with increased levels of potassium. The higher uptake of nitrogen, phasphorus and potash by chilli plants was observed with the application of nitrogen, phasphorus, potash and farmyard manure. Among all treatment combinations, fertilizer dose of nitrogen, phoshphorus, potassium and farmyard manure 80:35:35 kg and 25 t ha^{-1} (T_9 treatment) was found to be most and best of chilli cultivation. The present studies consequence of optimum levels of fertilizer on biochemical analysis (ascorbic acid, protein, proline and phenolics) of chilli found significant effect on T_9 treatment in all over 20 treatments with control.

Key words : *Fertilizer, ascorbic acid, protein, proline, phenolics, chilli, North, West, Himalaya.*

Introduction

Chilli (*Capsicum annuum* L.) is an essential charming piquant vegetable extensively cultivated in India and belongs to the family Solanacae. Mexico is considered as the centre of origin and Guatemala, the centre of diversity. According to the Food and Agriculture Organization (FAO) of the United Nations (FAO, 2003), worldwide the percentage change in the area and production of chilli are consistently increasing but the productivity of chilli in India is 9.18 t ha^{-1} where as it is 14.4 t ha^{-1} of the world. The reduction trend in the last few decades seems to be due to some pathogenic agencies as well as seasonal fluctuations. Plant pathogens decreased fabrication crosswise the world annually by more than 20 percent on average, however, individual fields may sustain losses of 50 to 100 percent from one or more pests (Dhaliwal and Koul, 2007). Plant parasitic nematodes are one of the major biological constraints around the world in almost all types of crop plants and they cause severe losses in the productivity of chilli (Tiyagi *et al*., 2009; Moon *et al*., 2010). Organic sources of nutrients like farmyard manures, composts, and botanical residues are extensively used in various crops. Under integrated nutrient management programmes, the best available alternative lies in the complimentary use of bio-fertilizers and organic manures in suitable combinations with chemical fertilizers. This ensures higher productivity, minimizes expenditure on costly fertilizer inputs and improves the efficiency of added fertilizers and at the same time yields good soil health (Bandyopadhyay and Puste, 2002; Luxminarayana and Patiram, 2006).

It is an essential ingredient of Indian curry, which is characterized by tempting colour and titillating pungency. India exports chillies to USA, Russia, Canada, Italy, Netherlands, Singapore, Saudi Arabia, UAE, Israel, Japan and West Germany in the form of dry pods, chilli powder and oleoresins. India being a largest chilli producer has vast potential to increase production in order to facilitate export besides meeting domestic requirements. Chilli is being used in food and beverage industries for its oleoresin which imparts characteristic colour and flavour to food. India is a leading country in the world with an area of 9.15 lakh hectares with production of 10.18 lakh tonnes of dry chilli (Peter & Nybe, 2002).

Materials and Methods

The present investigation was carried out during Kharif, 2013 and 2014 at the Sabli Village, tok Guryali and subsequent seed quality were evaluated after harvesting at seed testing laboratory of Scientific and Applied Research Centre (SARC), Meerut, Uttar Pradesh. The observations was recorded on the

Ascorbic Acid : Freshly harvested green chilli was used for ascorbic acid estimation. It was determined

Table-1 : Consequence of optimum levels of fertilizer on ascorbic acid (mg) for old day's roots, shoots and leaf samples of chilli (Pant C 1).

Treatment	Ascorbic Acid (mg)						Ascorbic Acid (mg)						Ascorbic Acid (mg)					
	Days old roots (Days after roots)						Days old shoots (Days after shoots)						Days old leaf (Days after leaf)					
	15	30	45	60	75	90	15	30	45	60	75	90	15	30	45	60	75	90
T_1 Control	1.50	2.03	2.47	2.57	3.20	3.67	2.47	3.33	8.50	5.53	3.83	2.93	2.70	2.80	5.33	3.07	2.83	2.50
T_2 40 kg Nitrogen ha^{-1}	1.73	2.33	2.57	2.67	3.73	3.87	2.73	4.27	9.22	6.27	3.93	3.43	3.17	3.50	5.50	4.20	3.93	2.67
T_3 80 kg Nitrogen ha^{-1}	2.13	2.53	2.83	2.83	3.50	3.73	2.67	4.60	9.50	6.45	3.87	3.50	3.67	3.73	5.53	4.10	3.90	3.00
T_4 35 kg P_2O_5 ha^{-1}	1.77	2.33	2.50	3.17	3.67	4.37	2.87	4.30	9.20	6.50	3.90	3.37	3.97	3.93	5.70	4.23	4.17	3.50
T_5 35 kg K_2O ha^{-1}	2.50	2.60	2.53	3.13	3.50	3.93	3.00	4.53	9.43	7.20	4.47	3.33	4.00	4.63	5.87	4.40	4.67	3.87
T_6 60 kg K_2O ha^{-1}	2.10	2.33	2.53	3.07	3.83	4.40	3.23	4.83	9.57	7.30	4.23	3.87	4.67	4.90	6.20	4.67	4.77	4.23
T_7 25 t FYM ha^{-1}	1.83	2.73	2.90	3.40	3.53	5.07	3.70	4.07	9.57	7.43	4.53	3.47	4.90	5.03	6.43	4.87	4.83	4.60
T_8 40kg:35kg: 35kg: 25t, N:P:K:FYM ha^{-1}	3.03	3.70	4.07	4.50	5.07	7.23	7.10	7.50	11.63	9.53	4.93	5.10	6.83	6.90	10.27	9.13	8.70	7.83
T_9 80kg:35kg: 35kg: 25t, N:P:K:FYM ha^{-1}	3.73	3.47	4.23	4.87	6.43	7.60	7.27	8.03	12.57	9.63	6.60	5.60	7.70	7.93	10.80	9.30	8.87	8.27
T_{10} 35 kg : 35 kg : 25 t, P:K: FYM ha^{-1}	2.10	2.40	3.07	3.77	3.33	5.03	3.67	4.07	10.73	7.57	5.28	4.07	6.20	6.70	7.27	6.20	6.00	4.83
T_{11} 35 kg : 60 kg : 25 t, P:K:FYM ha^{-1}	2.37	2.60	2.93	3.30	4.33	4.97	3.50	5.07	10.37	7.70	5.10	4.23	5.07	5.70	7.33	6.17	5.70	5.30
T_{12} 40 kg : 35 kg : 25 t, N: P:FYM ha^{-1}	2.83	3.20	3.43	3.73	3.63	6.53	6.60	6.23	11.17	8.33	4.70	4.30	5.80	5.67	8.13	5.27	4.77	4.83
T_{13} 80 kg : 35kg : 25 t, N: P:FYM ha^{-1}	3.13	3.53	3.73	4.07	4.37	6.87	6.90	6.03	11.47	8.33	5.27	4.23	7.20	7.00	8.27	5.27	4.77	4.67
T_{14} 80 kg : 35 kg , N: P ha^{-1}	2.57	2.73	3.33	3.50	4.23	6.03	4.70	5.30	11.47	8.43	4.23	4.40	5.80	6.00	6.20	4.13	3.77	3.50
T_{15} 80 kg : 35 kg , N: K ha^{-1}	3.10	2.93	3.27	3.53	4.23	5.67	4.43	5.77	11.43	8.53	4.87	4.40	6.03	6.53	6.23	4.30	4.07	3.93
T_{16} 80 kg : 60 kg , N: K ha^{-1}	2.47	2.73	3.23	3.60	4.37	4.97	5.23	5.50	11.30	8.70	4.17	4.23	7.00	6.83	6.43	4.23	3.73	3.50
T_{17} 40 kg : 25 t, N: FYM ha^{-1}	2.63	2.77	3.43	3.50	4.53	5.57	5.07	4.73	11.43	8.47	3.87	4.23	6.80	6.93	6.80	4.27	3.73	3.70
T_{18} 35 kg : 25 t, P: FYM ha^{-1}	2.63	3.20	3.27	3.47	4.63	5.53	4.43	4.60	10.43	8.33	4.40	4.20	5.77	5.97	6.77	4.33	3.97	3.57
T_{19} 60 kg : 25 t, K: FYM ha^{-1}	2.50	2.77	3.20	3.83	4.37	5.10	5.27	4.43	10.47	8.50	4.70	4.97	5.90	5.93	6.33	5.23	4.97	4.63
T_{20} 40 kg : 35 kg : 35 kg , N: P:K ha^{-1}	2.47	2.93	3.23	4.13	4.57	5.13	5.97	4.73	11.43	8.63	4.30	4.30	5.57	5.53	6.67	5.27	4.60	3.93
GM	2.46	2.79	3.14	3.53	4.15	5.26	4.54	5.09	10.54	7.87	4.56	4.11	5.44	5.61	6.90	5.13	4.84	4.34
Sem ($\pm$)	0.36	0.26	0.26	0.28	0.16	0.43	0.20	0.61	0.58	0.61	0.44	0.49	0.38	0.39	0.56	0.41	0.36	0.60
CD (0.05)	1.02	0.73	0.76	0.81	0.46	1.22	0.59	1.75	1.67	1.75	1.26	1.41	1.08	1.10	1.60	1.16	1.04	1.72
CV (%)	25.15	15.90	14.58	13.94	6.69	13.99	7.81	20.80	9.57	13.45	16.73	20.81	12.03	11.91	14.05	13.72	13.00	24.06

Table-2 : Consequence of optimum levels of fertilizer on ascorbic acid (mg) for green, red fruits and protein (mg) for old day's roots and shoots of chilli (Pant C1).

Treatment	Ascorbic Acid (mg)				Protein (mg)						Protein (mg)					
	Red Ripe Fruit		Green Fruit		Days old roots (Days after roots)						Days old shoots (Days after shoots)					
	Fruit Wall	Seed	Fruit Wall	Seed	15	30	45	60	75	90	15	30	45	60	75	90
T_1 Control	3.20	3.50	8.13	9.50	96.20	78.50	65.23	53.27	40.70	30.92	46.77	40.22	37.98	33.90	32.18	28.87
T_2 40 kg Nitrogen ha^{-1}	3.33	3.63	8.33	10.67	100.32	80.63	64.03	58.73	43.70	37.65	50.07	45.43	41.22	41.30	39.25	36.27
T_3 80 kg Nitrogen ha^{-1}	3.43	3.80	8.53	11.03	102.03	82.48	69.53	60.57	45.83	40.12	52.35	46.27	40.17	39.78	38.45	34.45
T_4 35 kg P_2O_5 ha^{-1}	3.53	3.73	8.67	10.77	107.70	84.02	70.73	64.10	47.48	40.55	57.23	50.18	39.20	35.62	34.47	31.73
T_5 35 kg K_2O ha^{-1}	3.60	3.70	8.87	10.80	111.55	86.40	73.13	62.33	50.25	43.55	60.68	54.33	40.90	38.08	36.47	32.27
T_6 60 kg K_2O ha^{-1}	3.53	3.67	8.67	10.93	115.05	88.60	75.67	58.93	52.53	45.50	61.90	55.13	42.57	39.42	37.23	34.13
T_7 25 t FYM ha^{-1}	3.50	3.73	8.90	11.07	193.23	101.77	81.77	72.10	65.57	59.13	80.70	56.47	45.65	42.97	40.20	34.87
T_8 40 kg:35kg: 35kg: 25t, N:P:K:FYM ha^{-1}	4.80	6.27	11.63	18.63	215.73	113.53	100.27	83.87	73.70	67.38	95.12	80.62	51.57	49.95	47.18	42.90
T_9 80 kg:35kg: 35kg: 25t, N:P:K:FYM ha^{-1}	5.07	6.53	12.47	19.13	235.62	116.97	103.70	87.32	77.27	70.67	102.30	86.77	76.80	70.92	65.27	59.77
T_{10} 35 kg : 35 kg : 25 t, P:K: FYM ha^{-1}	3.57	3.77	8.37	10.83	201.85	107.25	94.32	77.58	67.33	62.60	87.07	80.53	60.80	59.08	53.05	48.10
T_{11} 35 kg : 60 kg : 25 t, P:K:FYM ha^{-1}	3.37	3.70	8.60	11.07	197.57	103.67	83.63	74.00	64.10	59.42	85.70	74.07	62.88	61.10	55.77	49.90
T_{12} 40 kg : 35 kg : 25 t, N: P:FYM ha^{-1}	3.83	3.90	10.53	13.47	222.63	110.20	97.13	80.53	70.63	62.00	89.67	75.92	53.48	51.53	47.88	42.53
T_{13} 80 kg : 35kg : 25 t, N: P:FYM ha^{-1}	4.17	4.13	10.67	13.10	210.30	112.87	99.57	83.20	72.90	63.53	88.05	79.73	53.02	51.77	47.57	41.80
T_{14} 80 kg : 35 kg , N: P ha^{-1}	3.77	4.33	10.63	14.40	198.77	105.43	92.50	75.77	65.53	60.97	91.37	55.53	49.18	46.43	41.37	36.27
T_{15} 80 kg : 35 kg , N: K ha^{-1}	4.00	4.27	10.60	13.43	118.95	98.73	85.47	69.07	58.90	53.98	71.10	48.77	48.82	46.73	43.25	37.83
T_{16} 80 kg : 60 kg , N: K ha^{-1}	3.93	4.20	10.90	13.07	122.18	92.73	79.70	63.07	53.10	49.00	68.42	48.67	46.25	44.00	39.97	34.45
T_{17} 40 kg : 25 t, N: FYM ha^{-1}	3.97	4.00	10.93	12.53	187.32	94.97	81.33	65.30	55.07	50.30	72.93	45.05	41.17	39.47	36.78	31.83
T_{18} 35 kg : 25 t, P: FYM ha^{-1}	3.27	3.57	8.40	12.30	189.87	100.13	86.87	70.47	60.40	54.15	70.37	50.30	46.70	44.88	40.75	34.13
T_{19} 60 kg : 25 t, K: FYM ha^{-1}	3.47	3.53	8.67	12.67	194.02	96.27	83.33	66.60	56.50	51.82	76.67	49.67	46.37	44.63	41.13	36.23
T_{20} 40 kg : 35 kg : 35 kg , N: P:K ha^{-1}	3.67	3.73	8.77	10.87	125.88	89.20	75.85	59.87	49.40	44.58	66.63	44.38	42.85	40.70	35.88	31.00
GM	3.75	4.09	9.56	12.51	162.34	97.22	83.19	69.33	58.54	52.39	73.75	58.40	48.38	46.11	42.70	37.97
Sem (±)	0.15	0.16	0.29	0.59	4.98	6.99	6.89	6.95	7.50	5.69	3.67	3.66	3.35	3.56	3.22	2.74
CD (0.05)	0.44	0.44	0.82	1.69	14.24	19.97	19.72	19.88	21.44	16.26	10.49	10.46	9.58	10.17	9.23	7.82
CV (%)	7.16	6.58	5.17	8.23	5.32	12.45	14.36	17.37	22.19	18.81	8.63	10.85	11.99	13.36	13.09	12.48

Table-3 : Consequence of optimum levels of fertilizer on protein (mg) for old day's leaf samples, green, red fruits and proline (mg) for old days shoots samples of chilli (Pant C1).

Treatment	Protein (mg)						Protein				Proline (mg)					
	Days old leaf (Days after leaf)						Green Fruit		Red Fruit		Days old shoots (Days after shoots)					
	15	30	45	60	75	90	Fruit Wall	Seed	Fruit Wall	Seed	15	30	45	60	75	90
T_1 Control	72.03	68.03	64.67	62.63	60.10	57.00	59.03	62.80	91.50	100.07	146.00	42.03	36.17	32.60	28.33	25.10
T_2 40 kg Nitrogen ha^{-1}	73.83	69.67	66.47	64.73	62.33	59.53	59.67	63.57	92.80	101.37	148.33	44.27	37.47	33.83	29.40	28.70
T_3 80 kg Nitrogen ha^{-1}	75.67	71.67	68.57	66.63	63.93	61.47	60.10	64.63	94.60	105.93	150.57	46.00	39.23	35.53	30.73	29.93
T_4 35 kg P_2O_5 ha^{-1}	77.60	73.80	70.70	68.40	64.80	62.77	60.57	64.77	93.73	109.17	152.83	48.00	40.63	37.53	32.07	27.37
T_5 35 kg K_2O ha^{-1}	79.90	75.83	72.47	70.53	65.70	64.10	60.33	65.03	95.63	112.93	155.07	49.93	42.07	38.93	32.93	27.67
T_6 60 kg K_2O ha^{-1}	81.93	77.80	74.60	72.13	67.07	65.33	60.87	65.23	97.77	115.07	157.47	51.77	43.13	40.63	34.13	27.93
T_7 25 t FYM ha^{-1}	83.70	79.70	76.63	74.20	68.00	66.23	60.50	65.50	97.00	116.53	158.93	53.77	44.20	41.80	34.60	28.43
T_8 40kg:35kg: 35kg: 25t, N:P:K:FYM ha^{-1}	111.83	106.60	96.23	92.62	90.17	87.33	65.40	83.97	125.93	188.50	193.47	76.43	65.13	57.27	40.93	37.47
T_9 80kg:35kg: 35kg: 25t, N:P:K:FYM ha^{-1}	118.67	112.47	100.17	96.23	93.27	91.10	65.57	84.60	131.83	196.00	197.00	80.37	68.67	59.70	41.67	42.93
T_{10} 35 kg : 35 kg : 25 t, P:K: FYM ha^{-1}	106.90	101.97	93.37	90.33	86.60	83.70	60.60	65.43	98.80	122.97	185.27	68.77	56.97	50.73	37.67	37.73
T_{11} 35 kg : 60 kg : 25 t, P:K:FYM ha^{-1}	100.07	95.03	90.10	87.43	80.13	77.87	61.07	65.67	110.43	127.80	175.43	70.00	59.07	52.33	38.40	33.97
T_{12} 40 kg : 35 kg : 25 t, N: P:FYM ha^{-1}	102.60	97.50	91.13	89.20	80.97	79.10	61.40	65.90	114.47	138.00	179.03	72.17	60.40	53.40	39.10	35.77
T_{13} 80 kg : 35kg : 25 t, N: P:FYM ha^{-1}	97.90	93.17	87.77	85.47	77.13	74.70	61.23	66.13	116.07	142.53	182.37	74.40	62.50	54.00	40.10	35.67
T_{14} 80 kg : 35 kg , N: P ha^{-1}	84.80	80.87	77.57	75.43	67.03	64.60	61.33	66.40	118.43	154.63	160.20	55.87	45.50	41.93	35.07	31.13
T_{15} 80 kg : 35 kg , N: K ha^{-1}	85.77	81.77	78.53	76.40	68.23	65.47	61.77	66.60	120.77	145.40	162.17	57.77	47.00	43.27	34.50	31.70
T_{16} 80 kg : 60 kg , N: K ha^{-1}	87.73	83.47	80.73	78.23	69.57	66.43	61.70	66.87	121.30	147.33	164.63	59.73	48.40	45.43	33.23	31.43
T_{17} 40 kg : 25 t, N: FYM ha^{-1}	89.80	85.77	83.90	80.53	70.83	67.57	62.50	67.10	118.67	154.20	166.57	61.60	49.97	46.47	34.07	29.90
T_{18} 35 kg : 25 t, P: FYM ha^{-1}	91.73	87.47	86.27	82.37	72.30	68.23	61.43	65.83	98.77	116.30	168.60	63.53	52.10	47.67	35.00	31.23
T_{19} 60 kg : 25 t, K: FYM ha^{-1}	93.83	89.30	87.93	84.20	73.57	69.83	61.90	66.10	100.43	118.70	170.33	65.23	53.73	50.33	35.97	30.10
T_{20} 40 kg : 35 kg : 35 kg , N: P:K ha^{-1}	95.57	91.13	90.13	86.20	74.83	70.80	61.60	66.33	99.73	127.87	172.27	66.73	55.80	50.97	36.80	29.10
GM	90.59	86.15	81.89	79.19	72.83	70.16	61.43	67.42	106.93	132.07	167.33	60.42	50.41	45.72	35.24	31.66
Sem (±)	4.67	4.54	4.35	4.66	3.33	3.36	0.92	0.45	1.93	3.78	5.26	3.91	6.67	6.26	5.03	5.51
CD (0.05)	13.35	12.98	12.43	13.32	9.51	9.60	2.64	1.27	5.52	10.82	15.03	11.19	19.07	17.89	14.39	15.76
CV (%)	8.93	9.13	9.19	10.19	7.91	8.29	2.61	1.14	3.13	4.96	5.44	11.22	22.93	23.71	24.74	30.16

volumetrically by reducing 2, 6-dichlorophenol indophenol dye to get a pink end point (Sadasivam and Manikam, 1992) and expressed as mg per 100 g.

Determination of Total Ascorbic Acid : Fujita and Iwatake (1935) 200 mg fresh tissue was homogenized in 4% oxalic acid and centrifuged at 500 rpm for 5 min. Pellet was discarded and in the supernatant oxalic acid was added and final volume was made to 4 ml.

Determination of Total Protein : 50 mg fresh tissue was homogenized in 5 ml chilled common extraction- cum-assay buffer i.e. trismaleate buffer (0.2 M) pH 7.2 and centrifuged at 1000 rpm at low temperature for 5 min. Pellet was discarded and supernatant was collected.

Estimation of Proline content : Bates *et al.* (1973) 50 mg of fresh plant material was extracted in 10 ml of 3 percent (aqueous) sulpho salicylic acid.

Estimation of Total Phenolic Content : Bray and Thorpe, (1954) for this, 50 mg fresh plant material, dried over filter paper, was homogenized in mortar and pestle with small amount (2 ml) of 80 percent ethanol.

Results and Discussion

Biochemical status (Chilli plants and Fruit study) : Different quality attributes of the chilli plants (leaf, shoots and roots) and fruits (green and red) were investigated during the maturation stages.

Ascorbic acid in root, shoot and leaves : In shoots of chilli plants the amount of ascorbic acid was greater than leaves and roots. The amount of ascorbic acid in shoot recorded 12.57 mg (45 days) followed by 10.80 mg in leaves (45 days) and 7.60 mg in roots (90 days) in T_9 treatment (Table 01). Ascorbate content of roots, shoots and leaf also increased in T_9 treatment with plant age, the ascorbate content increased progressively, plant age 15 to 90 days old roots with different levels of fertilizer application and less ascorbic acid than the control (T_1 treatment). The ascorbate content increased progressively, plant age 15 to 45 days and decreased 60 to 90 days old leaves and shoots with different levels of fertilizer application and less ascorbic acid than the control (T_1 treatment). The shoot and leaves, there was zig-zag pattern. Similar results were reported by (Kachoosangi *et al.,* 2008), (Thomas *et al.,* 1998) and (Todd *et al.,* 1977)

Ascorbic acid in green fruit and red ripe fruit : Ascorbic acid content was observed at different fruit stages such as at green stage and red ripened stage. Maximum ascorbic acid content was observed 19.13 mg in seeds of green chilli. In red ripe fruit maximum ascorbic acid content was observed 6.53 mg also in seeds in T_9 treatment. Similar results were reported by (Kachoosangi *et al.,* 2008), (Thomas *et al.,* 1998) and (Todd *et al.,* 1977)

Protein in root, shoot and leaves : In roots of chilli plants the amount of protein was greater than leaves and shoots. The amount of protein in root recorded 235.62 mg, 118.67 mg in leaves and 102.30 mg in shoots of chilli plant at 15 days in T_9 treatment. Days after radicle emergence in root, shoot and leaf and the range of protein from 30.92 to 235.62, 28.87 to 102.30 and 57.00 to 118.67 mg of 15 to 90 days after roots, shoots and leaves samples. Days old roots, shoots and leaves the protein content increased with increasing fertilizer levels, but protein content decreased with increasing old roots, shoots and leaf days (table-2).

Protein in green fruit and red ripe fruit : The protein characteristics have been presented in table 02 reveals differences for treatments. Protein content increased in fruit wall and seeds with different levels of fertilizer.

Protein in green fruit : Maximum protein (65.57 mg) content was observed in fruit wall of T_9 treatment, followed by T_8 treatment (65.40 mg) grown plants. In fruit wall and seeds same pattern was observed i.e. in control (T_1 treatment) grown plants the amount of protein decreased but in compared to all treatments. Maximum protein value in seeds (84.60 mg) was found under T_9 treatment followed by T_8 treatment (83.97 mg). While the minimum average value of protein in fruit wall and seed (59.03 and 62.80 mg) was observed under T_1 (control) treatment. The treatments attain a protein range from 59.03 to 65.57 mg to fruit wall and 62.80 to 84.60 mg seeds.

Protein in red ripe fruit : In fruit wall it decreased value of protein amount compared to seeds. The treatments attain a protein range from 91.50 to 131.83 mg in fruit wall and 100.07 to 196.60 mg seeds. It was found that T_1 (control) treatment minimum protein in fruit wall and seeds (91.50 and 100.07 mg) while maximum value of protein in fruit wall and seeds (131.83 and 196.60 mg) was observed for T_9 treatment, followed by T_8 treatment (125.93 mg fruit wall and 188.50 mg seeds).

Proline in shoot and leaf : In shoots of chilli plants the amount of proline was greater than leaf. The amount of proline in shoot recorded 197.00 mg and 185.33 mg was recorded in leaf of chilli plant at 15 days in T_9 treatment. Similar results were reported by Sharma *et al.,* 2012. Shoots showed differences in their amounts of proline under salt stress. In shoots proline increased markedly under the fertilizer stress upto T_9 treatment, at control T_1 treatment it decreased compared to other treatment with fertilizer application sowed table 03 and 04. The chilli leaves showed differences in their amounts of proline under salt stress. In leaf proline increased markedly under the fertilizer stress upto T_9 treatment, at control T_1 treatment it decreased compared to other treatment with fertilizer application sowed table 03 and 04.

Phenolics in shoot and leaf : Maximum amount of phelonics was observed 55.33 mg in leaf of chilli plant and 40.40 mg was recorded in shoots of chilli plant at 90 days under T_9 treatment. The amount of phenolics in 15 days old leaves and shoot sample decreased, Phenolic contents were more in leaves compared to shoots in maximum sets. Maximum phenolics were recorded in 90 days old shoot samples. Fertilizer increased the level of phenolics in 15, 30, 45, 60 and 75 days old shoot, the amount of phenolics was affected differently by the optimum levels of fertilizers. In days after radicle emergence shoots phenolics increased markedly under the increasing levels of fertilizer application (table 04).

This has not been previously discussed optimum levels of fertilizer on biochemical analysis in chilli plants. Previous work has constantly quantified ascorbic acid based upon the fabric extracted & assumed 100% extraction. Salinity treatments caused the better proline content in Chili plant. The growth of fertilizer have companionable solutes with proline is known to purpose in osmotic amendment, safeguard of cellular macromolecules from injure by salts, storage of nitrogen and scavenging of free radicals. Many plants, both halophytes and glycophytes, add proline as a nontoxic and protective osmolyte under salinity, including mangrove (Parida *et al,* 2002) and mulberry (Harinasut *et al,* 2003). Proline accretion in reaction to minor salt application may contribute absolutely to salt tolerance, whereas the high deliberation in leaf tissues under high salinity treatment may be partly due to leaf damage.

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Character Association and Path Coefficient Analysis Studies among Grain Yield and Yield Associated Traits in Bread Wheat (*Triticum aestivum* L.)

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Abstract

The experimental material for this study consisted of 45 F_1s generated by crossing 10 parental lines, including HD2967, UP 2748, WH 1105, UP 2565, UP 2572, UP 2628, UP 2526, HD 3059, WH 1021 HD 3086 followed by half diallel mating (excluding reciprocals crosses). Character association and path coefficient analysis were carried out for the assessed of genotypes for yield and yield associated traits. Grain yield per plant had positive and significant associated with productive tillers per plant followed by 1000 grain weight, flag leaf area cm, spike length (cm), grains per spike, biological yield per plant, harvest index while plant height was negative significant days to heading at genotypic and phenotypic level. Path coefficient analysis revealed highest positive direct effect on grain yield per plant via biological yield per plant followed by harvest index.

Key words : *Wheat, path coefficient, genotypic correlation and phenotypic correlation.*

Introduction

Wheat (*Triticum aestivum* L.) is a self-pollinated Poaceae family member and one of the most widely consumed cereals in many countries, including India. Avinashe *et. al.* (2015).Wheat, which has higher protein content than maize (corn) or rice, the other major cereals, is the leading source of cereal and vegetable protein in human meals on a worldwide scale. Mecha *et. al.* (2017). Only three species, *Triticum aestivum, Triticum durum,* and *Triticum dicoccum,* are widely cultivated. Triticum aestivum (bread wheat) takes up more than 90% of the land, followed by *Triticum durum* (9–10%) and a little amount of wheat under Triticum dicoccum. (Devesh *et. al.* 2021). Direct selection for yield in breeding programmes might be misleading because of the complicated correlation between grain yield and its components. Naimatullah *et. al.* (2018). Correlation studies and path analysis help to understand the relationship between distinguishing traits and grain yield. The magnitude and direction of the association between various yield contributing characteristics and yield can be determined using correlation. The path coefficient (or) standardised partial regression coefficient measures the direct effect of a regression model on its response variable, whereas the indirect effects of a predictor variable are measured by the second component. When the variable for which indirect selection is used has a high heritability and a high correlation with yield, a higher yield response is obtained. The least combination of heritability and correlation coefficient values required for indirect selection to outperform direct selection (Searle 1965). As a result, correlation and path coefficient analysis were used to examine grain yield and its contributing traits in wheat.

Materials and Methods

Ten genotypes of wheat (*Triticum aestivum* L.), namely HD2967, UP 2748, WH 1105, UP 2565, UP 2572, UP 2628, UP 2526, HD 3059, WH 1021, and HD 3086, were selected on the basis of their differences in origin, adaptability and morphology. These parents all have genetic variability in terms of yield level and different desirable yield components. These genetic materials maintained by Department of genetics and plant breeding, G.B. Pant University of agricultural technology, Pantnagar (U.K.). In this study, all possible single crosses were made during the year 2017-18 to 10 x 10 half diallel mating. During the 2018-2019 growing season, 45 F_1 with ten different parents were used in a randomized block design (RBD) experiment at Crop research farm, Janta Vedic College, Baraut Baghpat (UP). In each replication, the experimental material was sowed in three rows, with parents and F_1s. Each row was 2.0 m long, with a 25cm inter-row gap and a 10 cm intra-row distance. Data was obtained on five plants chosen at random of following traits; Days to heading, days to maturity, Plant height, flag leaf area (cm), number of productive tillers per plant, spike length, number of grains per spike, 1000-grain weight, biological yield per plant harvest index and grain yield per plant. The genotypic correlation coefficient was calculated based on the formulae given by Snedecor (1961). Path analysis is carried out according to procedure describe by Dewey and Lu (1959). Lenka and Mishra (1973) have suggested scales for path coefficient analysis. The value direct or indirect effects 0.00 to 0.09 (negligible), 0.10 to 0.19 (Low), 0.20 to 0.29 (moderate), 0.30 to 0.99 (high) and more than 1.00.

Table-1 : Estimation of genotypic and phenotypic correlation coefficient for grain yield and yield associated traits.

Traits	Days to heading	Days to maturity	Plant height (cm)	Productive tillers/ plants	Flag leaf Area (cm)	Spike length (cm)	Grains per spike	1000-grain weight	Biological yield/ Plant	Harvest Index	Grain yield/ Plants	
Days to heading	G		0.373*	0.248*	-0.108ns	-0.186ns	-0.213*	-0.197ns	0.0035ns	-0.139ns	-0.193ns	-0.176*
	P		0.359*	0.235*	-0.085ns	-0.171ns	-0.188ns	-0.186ns	0.010ns	-0.128ns	-0.172ns	-0.161*
Days to maturity	G			0.318*	-0.033ns	-0.186ns	-0.213*	-0.197ns	0.0305ns	-0.029ns	0.173ns	0.115*
	P			0.269*	-0.024ns	0.075ns	0.121ns	0.010ns	0.0371ns	-0.027ns	0.145ns	0.095ns
Plant height (cm)	G				-0.312**	-0.300**	-0.253**	-0.246*	-0.233*	-0.206*	-0.132ns	-0.260**
	P				-0.288**	-0.294*	-0.245**	-0.243*	-0.230*	-0.204*	-0.129ns	-0.257*
Productive tillers per plant	G					0.604**	0.638**	0.638**	0.590**	0.788**	0.409**	0.832**
	P					0.567**	0.586**	0.579**	0.545**	0.731**	0.374*	0.772**
Flag leaf area (cm)	G						0.642**	0.461**	0.434**	0.437**	0.434**	0.623**
	P						0.623**	0.449**	0.429**	0.431**	0.418**	0.614**
Spike length (cm)	G							0.557**	0.622**	0.490**	0.677**	0.791**
	P							0.532**	0.602**	0.478**	0.643**	0.767**
Grains per spike	G								0.555**	0.627**	0.457**	0.734**
	P								0.548**	0.622**	0.429**	0.724
1000- grain weight	G									0.392*	0.580**	0.686**
	P									0.389*	0.562**	0.681**
Biological yield per plant	G										0.120ns	0.794**
	P										0.110ns	0.790**
Harvest index	G											0.669**
	P											0.661**

*: ignificant at 5% level of significance, **: Significant at 1% level of significance.

Results and Discussion

The nature of relationships among traits is determined using correlation and path analysis, which plays an essential role in the selection of desirable parents for hybridization in the wheat improvement programme. The phenotypic (pr) and genotypic (gr) correlations between the various characters shows in Table1. Grain yield per plant had positively significantly correlated with productive tillers per plant (gr =0.832 pr=0.772) followed by 1000-grain weight (gr=0.686 pr=0.681), flag leaf area (cm) (gr= 0.623 pr= 0.614), spike length (cm) (gr= 0.791 pr=0.767), grains per spike (gr= 0.734 pr= 0.724), biological yield per plant (gr= 0.794 pr=0.790), harvest index (gr= 0.669 pr=0.661) while plant height was negative significant (gr= -0.260 pr= -0.257), days to heading (gr= -0.176 pr=-0.161) at genotypic and phenotypic level. Similar positive and significant findings were reported earlier by Shamuyarira *et. al.* (2019) for productive tillers per plant, Ahmad *et. al.* (2016) for 1000-grain weight, Singh *et. al.* (2020) for flag leaf area Sherwan *et. al.* (2017) for spike length, Nagar *et. al.* (2018) for grains per spike, Shrief *et. al.* (2019) for biological yield per plant and Amin *et. al.* (2019) for harvest index whereas Kumar *et. al.* (2016) for plant height and Rathod, *et. al.* (2019) for days to heading and Kumar *et. al.* (2018) for days to maturity reported negative and significant at the genotypic and phenotypic level. A negative association between grain yield and days to heading is desirable for earliness. As a result, significant phenotypic connections across characters were mostly attributed to genetic origins, which could be attributable to pleiotropic effects rather than linkage between genes impacting distinct characters. Each form of genotypic association was thought to be related to the effects of pleiotropy. Mutagenesis would be employed to achieve a new combination of features in the situation of negative correlation generated by pleiotropy. If the genotypic correlation was caused by linkage,

Table-2 : Estimation of genotypic and phenotypic path coefficient analysis for grain yield and yield associated traits.

Traits		Days to heading	Days to maturity	Plant height (cm)	Productive tillers per plants	Flag leaf Area (cm)	Spike length (cm)	Grains per spike	1000-grain weight	Biological yield per Plant	Harvest Index	Grain yield per Plants
Days to heading	G	0.018042	0.015712	-0.00763	-0.00037	-0.00902	-0.01147	-0.00039	0.000336	-0.09027	-0.09094	-0.176
	P	-0.01617	0.01153	-0.00542	-0.00020	-0.00917	-0.00987	-0.00320	0.00103	-0.08199	-0.08059	-0.16170
Days to maturity	G	0.006732	0.042107	-0.00976	-0.00012	0.003889	0.007207	0.00025	0.002855	-0.01887	0.081443	0.115528
	P	0.00581	0.03211	-0.00619	-0.00006	0.00404	0.00633	0.00019	0.00366	-0.01780	0.06774	0.09583
Plant height (cm)	G	0.004483	0.005646	-0.0307	-0.00108	-0.01453	-0.01364	-0.00048	0.05511	-0.13366	-0.06241	-0.26041
	P	0.00381	0.00865	-0.02300	-0.00067	-0.01571	-0.01284	-0.00418	-0.02270	-0.13067	-0.06067	-0.25799
Productive tillers per plant	G	-0.00197	-0.00143	0.009601	0.003439	0.029211	0.034334	0.00125	0.05511	0.510245	0.192224	0.832021
	P	-0.00138	-0.00078	0.00664	0.00233	0.03024	0.03065	0.00994	0.05369	0.46659	0.17499	0.77292
Flag leaf area (cm)	G	-0.00337	0.003387	0.009225	0.002077	0.022303	0.034512	0.000902	0.04057	0.283463	0.204285	0.62341
	P	-0.00278	0.00243	0.00678	0.00132	0.05331	0.03258	0.00771	0.04224	0.27549	0.19569	0.61478
Spike length (cm)	G	-0.00385	0.005646	0.00779	0.002196	0.03105	0.053749	0.001091	0.058095	0.317916	0.318037	0.791721
	P	-0.00305	0.00389	0.00565	0.00137	0.03325	0.05224	0.00914	0.05932	0.30532	0.30043	0.76755
Grains per spike	G	-0.00357	0.000937	0.00758	0.002197	0.022303	0.029982	0.001956	0.051884	0.406537	0.214989	0.734792
	P	-0.00305	0.00389	0.00565	0.00137	0.03325	0.05224	0.00914	0.05932	0.30532	0.30043	0.76755
1000- grain weight	G	0.00020	0.001288	0.007162	0.002029	0.021011	0.033443	0.001087	0.093371	0.254243	0.272555	0.686253
	P	0.00017	0.00119	0.00530	0.00127	0.02288	0.03148	0.00941	0.09843	0.24886	0.26290	0.68190
Biological yield per plant	G	-0.00252	-0.00123	0.006338	0.00271	0.02117	0.026391	0.001228	0.00271	0.647492	0.056732	0.794982
	P	-0.00208	-0.00090	0.00471	0.00170	0.02302	0.02500	0.01068	0.03839	0.63812	0.05148	0.79012
Harvest index	G	-0.00349	0.0073	0.004079	0.054175	0.021029	0.03639	0.000895	0.001407	0.078199	0.469747	0.669731
	P	-0.00279	0.00466	0.00299	0.00087	0.02234	0.03360	0.00738	0.05541	0.07034	0.46707	0.66186

*: Significant at 5% level of significance, **: Significant at 1% level of significance

breeding procedures such as bi-parental mating or disruptive selection might be used to break the linkage.

Path coefficient analysis : The correlation does not allow for the partitioning of genotypic and phenotypic correlation coefficients into direct and indirect effects, path coefficient analysis (Dewy and Lu, 1959) is used to investigate them further. Table-2 shows the genotypic direct and indirect effects of several traits on grain yield. Several crop species have benefited from path coefficient analysis. The information provided through this technique aids in indirect selection for grain yield genetic improvement. Indirect selection is used to improve yield by selecting components traits, whereas direct selection is used to improve yield per unit. Path coefficient analysis revealed that highest positive direct effect was noted for biological yield per plant (g=0.647, p=0.6381) and harvest index (g=0.469 p=0.4670) while negligible direct effects shown in 1000-grain weight (g=0.0933, p=0.0984), spike length (g=0.0537, p= 0.0522), flag leaf area (g= 0.0483, p= 0.0533), days to maturity (g=0.0421 p= 0.0321), days to heading (g=0.0180 p= -0.0161), plant height (g= -0.037 p=-0.023) productive tillers per plant (g= 0.0034 p= 0.0023), grains per spike (g=0.00195 p= 0.01716). Similar findings were also reported by Baranwal *et. al.* (2012), Avinashe *et. al.* (2015), Sherwan *et. al.* (2017), and Singh *et. al.*(2020). The indirect effect of other characters was negligible. As a result, the direct effect was predominantly responsible for the genotypic association with grain yield. The highest indirect effect revealed by productive tillers per plant via biological yield per plant (0.510), low indirect effects of harvest index (0.192), spike length (0.034), and flag leaf area. Secondly, highly indirect effects on grain yield, through grains per spike via biological yield per plant (0.406), moderate indirect effects of harvest index (0.214). Similar finding were also reported by Fellahi *et. al.* (2013) Bhutto *et. al.* (2016), and Rathod *et. al.*(2019).The present investigation of biological yield per plant, productive tillers per plant, and harvest index exhibits the greatest direct and indirect positive effects against grain yield. Hence, these traits would help to improve the grain yield in a future breeding program.

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Influence of Foliar Spray of Plant Growth Regulators and Nutrients on Morpho Physiological Parameters and Yield of Paddy (*Oryza sativa* L.) at Two Situations

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Abstract

A field experiment was conducted at Agricultural Research Station, Gangavati, UAS, Raichur, Karnataka, during *kharif* 2019 to study the influence of foliar spray of Plant Growth Regulators (PGRs) and nutrients on morpho-physiological parameters and yield of paddy (*Oryza sativa* L.). The experiment was laid out in factorial RCBD and replicated thrice, where main plots as two dates of transplanting *i.e.* D_1 (Normal) and D_2 (Late) and sub plots as foliar spray of nutrients and PGRs along with control *viz.,* T_1: NPK-19:19:19 (20000 ppm), T_2: 6-BAP (20 ppm), T_3: salicylic acid (250 ppm), T_4: mepiquat chloride (1000 ppm), T_5: borax @ (10000 ppm) and T_6: control. The results were obtained at 65 DAT indicated that D_1 (Normal DOT) showed higher values as compare to D_2 (Late DOT) in all foliar sprays. Among different foliar sprays, T_1 (NPK-19:19:19 @ 20000 ppm) recorded significantly higher morphological parameters *viz.,* plant height (102.55 cm), total dry matter production (32.98 g hill^{-1}), total leaf area (56.27 hill^{-1}), number of leaves (58.10 plant^{-1}) and least number of senescent leaves (13.30). Whereas the next best treatment was noticed in T_2 (6-BAP @ 20 ppm) over rest of the treatments. The higher grain yield (21.55 plant^{-1}) was recorded in T_1 (NPK-19:19:19 @ 20000 ppm) than other foliar sprays. It was concluded that D_1 (Normal DOT) was the best situation and among the foliar application of different agrochemicals, T_1 (NPK-19:19:19 @ 2.0%) was found to be the best treatment, it was ideal at 35, 45 DAT and at 55 DAT.

Key words : *Dates of transplanting, foliar spray, nutrients, PGRs and grain yield.*

Introduction

Rice (*Oryza sativa* L.) is the major source of food for nearly half of the world's population. The slogan "Rice is life" comes from the understanding that rice based cropping system are essential to everyone directly or indirectly for the food security, livelihood improvement, cultural heritage and sustainable development for the global peace. Rice plays a major role in national economy in many developing countries. Rice (*Oryza sativa* L.) is the major source of food for nearly half of the world's population. Rice based cropping system are essential to everyone directly or indirectly for the food security, where it provides 30-75 per cent of the total calories to more than 3 billion Asians (Khush, 2014). Rice is cultivated round the year in one or the other part of the country in various ecologies spread over 46.2 m ha with a production of 117.32 million tons with productivity of 2585 kg ha^{-1} (Anon., 2019). In Karnataka, rice is cultivated in the command areas of cauvery, Tungabhadra Project (TBP) and Upper Krishna Project (UKP) where transplanting is predominant method of establishment. Foliar application of nutrients was helps in avoiding the depletion of these nutrients in leaves, thereby resulting in an increased photosynthetic rate, better nutrient translocation of these nutrients from the leaves to the developing seeds. (Manonmani and Srimathi, 2009). Growth regulaters are known to enhance the source-sink relationship and stimulate the translocation of assimilates thereby helping in effective flower formation. The application of inorganic nutrients in combination with plant growth regulator will also enhances the nutrient availability, in turn increases the productivity (Chandrasekhar and Bangarusamy, 2003). Spraying of 3.0% NPK (19:19:19) without basal dose of fertilizer application recorded highest seed yield as compared to only basal dose of application (Das and Jana, 2015).The relevant study on mepiquat chloride showed that as it decreases plant height and the occurrence of lodging and likewise enhanced yield more than the control (Mukherjee, 2020). Some findings open a new window for the role to exogenous application of salicylic acid in providing tolerance to the plants against various pathogens (Singh *et al.* 2015).

Materials and Methods

The experiment was laid out in factorial RCBD design with three replications, six treatments including control and two dates of transplanting i.e. normal and late transplanting of rice. Foliar application of different agrochemicals at 35,45 and 55 days after transplanting was done to improve morphological parameters and yield. The observations were recorded 10 days after each spray and at harvest. The data on following observations was recorded during the course of study by using standard procedures and five pants from each net plot were selected randomly. The parameters includes plant height, total dry matter production, number of leaves plant^{-1}, total leaf area hill^{-1} and number of senescence leaves. Grains were sun dried for recording of grain yield plant^{-1}.

Results and Discussion

The data on plant height, total dry matter production and grain yield with different treatments and at different times of transplantation is presented in table-1 as well as the interactions between these treatments and their interactions with each other, to provide an understanding of how plants are affected by dates of transplanting and foliar spray of PGRs and nutrients. At 65 DAT, significantly higher plant height (97.02 cm) was observed in D_1 (normal DOT) and lower plant height (93.92 cm) was observed in D_2 (late DOT). Then, plant height is superior over other treatments followed by T_1 (NPK-19:19:19 @ 20000 ppm) (103.23 cm), T_2 (6-BAP @ 20 ppm) (101.37 cm) and T_4 (mepiquat chloride @ 1000 ppm) (100.36 cm). The least plant height (86.47 cm) was observed in T_6 (control) in normal date of transplanting among the treatments & same trend was observed in late date of transplanting. There was no significant difference in the interaction between dates of transplanting and foliar spray of agrochemicals on plant height.

Significant difference was observed between the treatments of different agrochemicals at all the stages of growth and also between the dates of transplanting at 65 DAT. The variation in the plant height might be due to the genetic makeup and their interaction with growing conditions, their expression and the influence of the exogenous application of agrochemicals.. These results are in agreemented with the findings of Zamaninejad *et al*. (2013) and Christopher *et al*. (1997) on morphological characteristics of maize.

At 65 DAT, D_1 (normal DOT) had considerably higher total dry matter production (28.53 g hill^{-1}) while D_2 recorded significantly lower plant height (25.71 g hill^{-1}) (late DOT). Among different agrochemicals, higher total dry matter production was recorded in T_1 (NPK-19:19:19 @ 20000 ppm) (34.50 g hill^{-1}) followed by T_2 (6-BAP @ 20 ppm) (32.53 g hill^{-1}) and T_4 (mepiquat chloride @ 1000 ppm) (30.42 g hill^{-1}). T_6 (control) had significantly lower total dry matter production (21.16 g hill^{-1}) among different agrochemicals in the usual date of transplanting, and the similar tendency was seen in the late date of transplanting. On total dry matter production, there was no significant difference in the interaction between transplanting dates and agrochemicals.

One of the primary obstacles to realising the variety RNR 15048's productivity potential is the poor partitioning of photo assimilates to the expanding reproductive portions. Exogenous administration of agrochemicals, their expression, and their interaction with growth circumstances can improve grain filling capacity and yield by manipulating the source-sink relationship (Ramesh and Thirumuguran, 2001). The overall dry matter output climbed gradually from 65 DAT through harvest, according to the data. This could be because stored photo assimilates are being directed toward the development of reproductive organs. These findings are consistent with Akanda *et al.* (1986), who found that three split nitrogen applications were more successful than two splits in increasing plant height and TDM output of boro rice.

With respect to grain yield plant^{-1}, D_1 (normal DOT) had a significantly higher (20.93) grain yield while D_2 had a significantly lower (18.46) grain yield (late DOT).On the grain yield plant^{-1}, there was no significant difference between the different agrochemicals, nor was there any interaction between the dates of transplanting and the agrochemicals. The carbohydrates in rice grains originate from photosynthesis which is predominantly carried out in leaves (sources). Therefore, grain filling and rice yield depend on the efficient transport of carbohydrates from the leaves to seeds (sinks).

The infrastructure of plant is decided by morphological parameters coupled with more photosynthetic activity which lead to higher biomass production and also efficient partitioning of dry matter in to reproductive parts. These results are in agreemented with the findings of Vaiyapuri and Sriramachandrasekharan (2003) who revealed that, salicylic acid sprayed @ 0.1% registered the highest grain yield. Venkatakrishnan and Balasubramaniam (1996) opined that the highest mean seed yield of sunflower due to combined application of along with 0.2% borax spray. Higher dose of IAA @ 50ppm applied to the rice by Pandey *et al*. (2001) which showed significant increase in the plant height and produced highest grain yield.

The data on number of leaves plant^{-1}, the total leaf area hill^{-1} and number of senescent leaves with the different treatments in different dates of transplanting and their interactions presented in table-2 as influenced by the two environmental conditions. At 65 DAT, where significantly higher (43.58) number of leaves plant^{-1} was observed in D_1 (normal DOT) and lower (38.60) number of leaves plant^{-1} was observed in D_2 (late DOT). Then, treatment T_1 (NPK 19:19:19 @ 20000 ppm) showed significant difference as compare to the all other treatments. The lowest number of leaves plant^{-1} was observed at control in the both different environmental

Table-1 : Influence of agrochemicals on plant height, total dry matter production at 65 days after transplanting and grain yield plant^{-1} of paddy at two situations.

Treatments	Plant height (cm)			Total dry matter production (g hill^{-1})			Grain yield plant^{-1} (g)		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1-Foliar application of NPK-19:19:19 @ 20000 ppm	103.23	101.87	102.55	34.50	31.47	32.98	22.92	20.18	21.55
T_2- Foliar application of 6-BAP @ 20 ppm	101.37	99.23	100.30	32.53	28.83	30.68	22.49	19.71	21.10
T_3-Foliar application of salicylic acid @ 250 ppm	93.12	90.40	91.77	24.45	22.58	23.47	19.53	17.27	18.40
T_4-Foliar application mepiquat chloride @ 1000 ppm	100.36	97.34	98.83	30.42	27.70	29.05	21.81	19.55	20.68
T_5-Foliar application of borax @ 10000 ppm	97.60	93.39	95.48	28.20	24.21	26.20	19.87	17.43	18.65
T_6-Control	86.47	81.36	83.90	21.16	19.54	20.35	18.94	16.66	17.80
Mean	97.02	93.92	-	28.53	25.71	-	20.93	18.46	-
	D	T	D x T	D	T	D x T	D	T	D x T
S. Em (±)	1.00	1.73	2.45	0.84	1.46	2.07	0.69	1.19	1.68
CD @ 5%	2.95	5.12	NS	2.49	4.31	NS	2.01	NS	NS

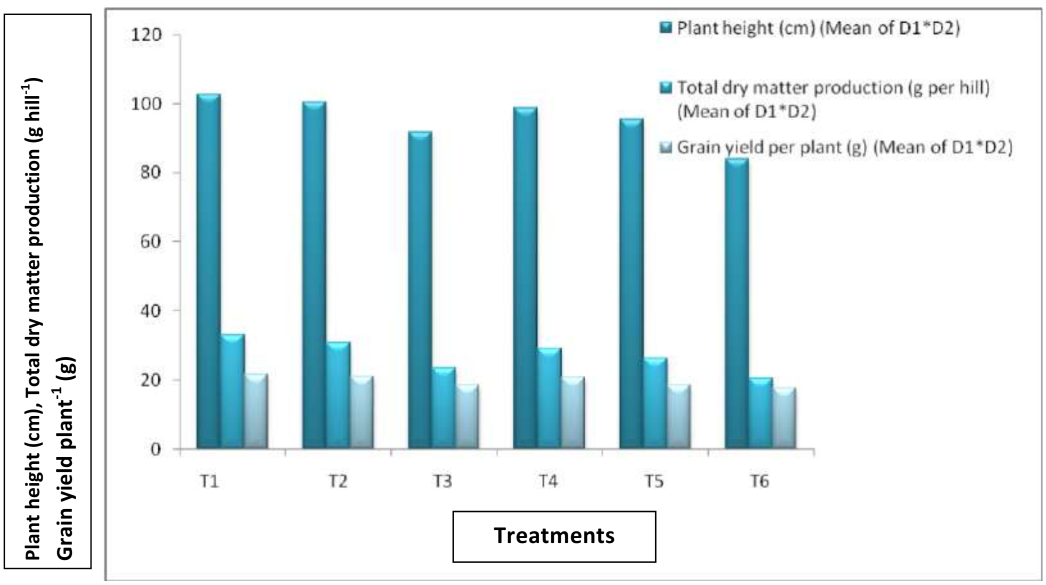

Fig.-1 : Influence of agrochemicals on plant height, total dry matter production at 65 days after transplanting and grain yield plant^{-1} of paddy at two situations.

condition. There was no significant difference in the interaction between dates of transplanting and agrochemicals on number of leaves plant^{-1}.

The rate of leaf production is of much importance in rice plant that determines the physiological activity of the plant, ultimately having greater influence on grain yield. Similar results were obtained by Ali *et al*. (2014) it might be due to combined application of growth regulator (6-BAP) which reduces the ageing of leaves and maintains greenness of leaves for longer period. Muthulakshmi and Lingakumar (2016) reported that the effect of foliar application of salicylic acid avoids senescence process which led to enhance the number of green leaves in blackgram, then more decline occur at harvest due to the process of senescence.

At 65 DAT, the total leaf area hill^{-1} was showed significant differences among the treatments at different situations. The treatment T_1 (NPK 19:19:19 @ 20000 ppm) showed the highest total leaf area hill^{-1} (56.98 dm^2) among treatments and the least total leaf area hill^{-1} (25.61 dm^2) was observed in T_6 (control) in normal date of transplanting among the treatments & same trend was observed in late date of transplanting. The treatments T_2 (6-BAP @ 20 ppm) (51.47 dm^2) & T_4 (mepiquat chloride @ 1000 ppm) (48.06 dm^2) were on par with each other. There was no significant difference in the interaction between dates of transplanting and agrochemicals and also between dates of transplanting on the total leaf area hill^{-1}.

Table-2 : Influence of agrochemicals on number of leaves plant-1, the total leaf area hill^{-1} and number of senescent leaves of paddy at two situations at 65 days after transplanting.

Treatments	Number of leaves plant^{-1}			Total leaf area hill^{-1}			Number of senescent leaves		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_{1-} Foliar application of NPK-19:19:19 @ 20000 ppm	60.49	55.71	58.10	56.98	55.56	56.27	12.82	13.78	13.30
T_2-Foliar application of 6-BAP @ 20 ppm	54.77	49.06	51.92	51.47	50.47	50.97	17.47	18.63	18.05
T_3-Foliar application of salicylic acid @ 250 ppm	35.64	31.52	33.58	34.11	31.16	32.63	43.55	46.82	45.18
T_4-Foliar application mepiquat chloride @ 1000 ppm	52.78	45.47	49.12	48.06	47.88	47.97	21.19	24.61	22.90
T_5-Foliar application of borax @ 10000 ppm	31.70	26.33	29.02	41.88	41.02	41.45	38.90	39.17	39.03
T_6-Control	26.13	23.50	24.82	25.61	20.05	22.83	50.51	51.35	50.93
Mean	43.58	38.60	-	43.02	41.02	-	30.74	32.39	-
	D	T	D x T	D	T	D x T	D	T	D x T
S. Em (±)	1.06	1.82	2.60	1.09	1.89	2.67	0.72	1.25	1.77
CD @ 5%	3.12	5.39	NS	NS	5.54	NS	NS	3.69	NS

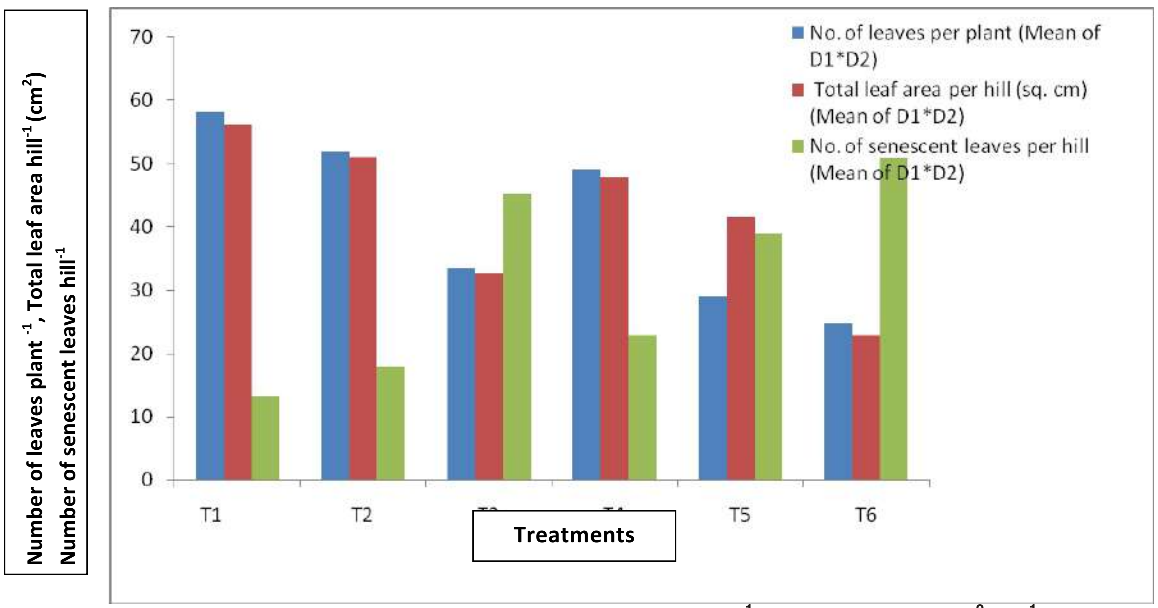

Fig.-2 : Influence of agrochemicals on number of leaves plant^{-1}, total leaf area (cm^2 hill^{-1}) and number of senescent leaves hill^{-1}of paddy at two situations at 65 days after transplanting.

The leaf area being the photosynthetic surface plays an important role in determining the total biomass production and quantity of photosynthates available for grain production These results are in agreemented with the findings of Ayad and Saad (2011) who reported that the foliar application of boron in sunflower during budding stage on different genotypes recorded the significantly higher leaf area and capitulum diameter. The same results were recorded by Martin *et al.* (2010).

At 65 DAT, there were substantial differences in the quantity of senescent leaves among the treatments in various settings. The treatment T_6 (control) had the largest number of senescent leaves (50.51) among the treatments, while T_1 (NPK 19:19:19 @ 20000 ppm) had the lowest number of senescent leaves (12.82) in the usual date of transplanting, and the similar tendency was seen in the late date of transplanting. T_3 (Salicylic acid @ 250 ppm) (43.55) and T_5 (Borax @ 10000 ppm) (38.90) therapies were comparable. There was no discernible difference in the interaction between transplanting dates and agrochemicals, as well as between transplanting dates on senescent leaves.

The findings demonstrated that as the plant became older, the number of senescent leaves rose. These results are in agreemented with the findings of Pan *et al.* (2013) who reported that 6-BA partially alleviated the detrimental effects of rice senescence by modulating the activity of enzymatic antioxidants. The same results showed by Ray *et al.* (1983).

Conclusion

The conclusion drawn from this investigation that, higher plant height in D_1 (Normal DOT) as compare to D_2 (Late DOT) in all the treatments. T_1 (NPK-19:19:19 @ 20000 ppm) spray showed significantly higher value for both dates of transplanting as compared to the T_6 (Control) and the next best treatment was T_2 (6-BAP @ 20 ppm) among the different agrochemicals. The total dry matter production, number of leaves plant^{-1}, the total leaf area hill^{-1} and grain yield were also showed same trend the between different situation & among different treatments. But it was observed that more number of senescent leaves in D_2 (Late DOT) as compare to D_1 (Normal DOT) in all the treatments. T_6 (Control) spray showed significantly higher number for both dates of transplanting as compared to the T_1 (NPK-19:19:19 @ 20000 ppm) among the different agrochemicals.

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Screening and Bioassay of Entomogenous Fungi, *Beauveria bassiana* (Bals.) Vuill and *Metarhizium anisopliae* (Metchnikoff) Sorokin on Cardamom Root Grub, *Basilepta fulvicorne* Jacoby

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Abstract

Bioassays with entomopathogenic fungi, *B. bassiana* and *M. anisopliae* on Cardamom root grub, *B. fulvicorne* were conducted to assess the LC_{50}, LC_{90} and LT_{50} values and fiducial limits and regression parameters. The results of the study indicated that the mortality of the insects was dependent on the concentration of the spore suspension of the fungus. The cumulative per cent mortality varied with dose and time for both adult beetles and grubs for both the fungi. The dose and time taken for mortality of the adults and grubs of *B. fulvicorne* was lower for *B. bassiana* when compared to *M. anisopliae.* The LC $_{50}$ of *B. bassiana* estimated were 6.53×10^{8} and 1.87×10^{6} spores ml^{-1} against the adults and grubs of *B. fulvicorne* respectively and a spore concentration of 3.99×10^{8} and 6.09×10^{8} spores ml^{-1} of *M. anisopliae* was required to cause 50 per cent mortality of the adults and grubs of *B. fulvicorne* respectively at the highest test dose evaluated.

Key words : *B. fulvicorne,* Bioassay, *B. bassiana*, *M. anisopliae*

Introduction

Cardamom root grub, *Basilepta fulvicorne* Jacoby (Family: Chrysomelidae) is one of the major pests of small cardamom, causing upto 60 % crop loss in the cardamom growing tracts of Kerala. The grubs are known to cause a substantial yield loss of about 66 % in field level (7). Root grubs are mainly controlled by applying chemical pesticides in huge quantities, as roots are crucial for the growth and yield of the crop. The repeated applications of such chemicals are harmful for the beneficial flora and fauna, along with the deleterious effects to the ecosystem.

B. bassiana and *M. anisopliae* are promising entomopathogenic fungi extensively used for the biocontrol of a wide range of economically important insect pests (2,6) and differences exists in host specificity, virulence and time taken for pathogenesis among both the fungi towards various pests of crops (4). A perusal of literature on the pathogenicity of *B. bassiana* and *M. anisopliae* to the pest in the present study showed that not much work has been undertaken earlier on the assessment of the pathogenicity of both the fungi to the cardamom root grub, *B. fulvicorne*.

Materials and Methods

The isolates of the fungi, *B. bassiana* isolate, PDBC Bb 5 and *M. anisopliae* isolate, PDBC Ma 4 used for the studies were obtained from National Bureau of Agriculturally Important Insect Pests (NBAII). The fungal isolates were subcultured and maintained on Potato Dextrose Agar (PDA) media at 27 ± 5ºC. Mass production of the fungi for laboratory experiments was done in Potato Dextrose Broth (PDB).

The adults as well as the immature stages of all the test insects were captured initially from the field. The insects thus collected were kept in rearing jars along with their respective host plants for fifteen days in order to screen the diseased insects. The field collected healthy adult beetles were reared on polypet jars of size 30 cm height and 15 cm diameter, the mouth of which were covered with muslin cloth. Cardamom leaves and jack fruit leaves were provided as food. Soil and stubbles of Cardamom plants were also placed inside these jars for enabling egg laying. The plant parts bearing egg masses were removed periodically to rear the emerging grubs in trays. The grubs of *B. fulvicorne* were reared on cardamom rhizomes bearing fresh roots that were kept in soil in plastic trays of size 30 cm diameter and 20 cm deep. On pupation in soil, they were collected and kept in jars for adult emergence. The decayed plant parts were removed periodically to keep the trays clean.

Bioassay of the two fungi *viz., B. bassiana* and *M. anisopliae* was carried out against the adults and grubs of the cardamom root grub to determine the LC_{50}, LC_{90} and LT_{50} values. The doses for bioassay against the adults and grubs were fixed based on preliminary studies. Five serial dilutions of the corresponding fungal spore suspensions were prepared from 14 day old stock culture of the fungus grown in potato dextrose broth (PDB). The third instar grubs and newly emerged adults from the culture stock of the insects were used for the study. The fungal spore suspension was uniformly sprayed on to the

Table-1 : Cumulative per cent mortality, LT_{50} and probit analysis of dose-mortality responses of adults of *B. fulvicorne* treated with different spore concentrations of *B. bassiana.*

Concentration (spores ml^{-1})	Cumulative per cent mortality at different intervals after treatment (Days)			LT 50 (Days)
	7	14	18	
2.2×10^8	17.78	40.00	100.00	12.845
2.2×10^7	13.33	26.67	91.11	14.298
2.2×10^6	8.89	17.78	82.22	15.538
2.2×10^5	6.67	11.11	77.78	16.257
2.2×10^4	6.67	8.89	66.67	17.275
Control	0	0	0	0

Probit analysis

Days after treatment	LC_{50} (spores $ml^{-1} \times 10^8$)	Fiducial limit for LC_{50} (spores ml^{-1} $\times 10^8$)	LC_{90} spores (spores ml^{-1} $\times 10^8$)	Fiducial limit for LC_{90} (spores ml^{-1} $\times 10^8$)	^{2}	Regression equation
7	6.53	5.93 - 6.81	12.65	11.48 - 13.23	1.288	Y = 2.368 + 1.759 x
14	2.82	1.93 - 5.66	6.35	4.27 - 13.53	5.033	Y = 3.024 + 2.534 x
18	0.02	0.01 - 0.04	0.19	0.13 - 0.22	2.455	Y = 5.402 + 2.389 x

Table-2 : Cumulative per cent mortality, LT_{50} and probit analysis of dose-mortality responses of grubs of *B. fulvicorne* treated with different spore concentrations of *B. bassiana.*

Concentration (spores ml^{-1})	Cumulative per cent mortality at different intervals after treatment (Days)				LT 50 (Days)
	3	5	10	14	
10^6	20.00	44.45	64.44	100.00	6.598
10^5	11.11	26.67	42.22	95.55	8.827
10^4	6.67	22.22	26.67	75.55	11.258
10^3	0.00	6.67	17.78	64.45	12.860
10^2	0.00	4.45	15.55	53.33	13.848
Control	0	0	0	0	0

Probit analysis

Days after treatment	LC_{50} (spores $ml^{-1} \times 10^8$)	Fiducial limit for LC_{50} (spores ml^{-1} $\times 10^8$)	LC_{90} spores (spores ml^{-1} $\times 10^8$)	Fiducial limit for LC_{90} (spores ml^{-1} $\times 10^8$)	^{2}	Regression equation
3	1.87	1.73 - 2.01	3.23	2.97 - 3.67	8.312	Y = 1.751 + 3.372 x
5	1.11	0.98 - 1.24	2.43	2.18 - 2.59	11.367	Y = 1.079 + 4.293 x
10	0.63	0.59 - 0.68	1.78	1.56 - 1.84	7.686	Y = 6.699 + 4.985 x
14	0.002	0.001 - 0.004	0.06	0.04 - 0.12	2.924	Y = 3.977 + 2.698 x

adults and grubs using an atomizer and were then released into rearing jars with fresh food. Three replications were maintained for each adults and grubs. The insects treated with distilled water alone served as control for the experiment. The mortality of the adults / grubs was recorded every day. The log dose probit mortality data was statistically analysed after necessary correction using Abbott's formula (1) and the LC_{50}, LC_{90} and LT_{50} values and fiducial limits and other regression parameters were worked out using SPSS Statistics Version 21 (5) as explained by Fang *et al.* (3).

Results and Discussion

The mortality of the adult *B. fulvicorne* inoculated with *B. bassiana* was noticed from the seventh day onwards and the rate of mortality ranged from 6.67 to 17.78 per cent, the mortality increased to 8.89 to 40.00 per cent and 66.67 to 100 per cent on the fourteenth and eighteenth day after treatment, respectively (Table-1). The shortest time span required for the mortality of half the population of the test insect was 12.845 days at the highest concentration of 2.2×10^8 spores ml^{-1} and the longest duration of 17.275 days was required for the lowest spore concentration of 2.2×10^4 spores ml^{-1}. A spore concentration of 6.53×10^8 spores ml^{-1} was recorded as the LC_{50} value at 7 DAT. Whereas the LC_{50} values obtained for the fourteenth and eighteenth DAT were 2.82×10^8 and 0.02×10^8 spores ml^{-1}, respectively. The LC_{90} values on 7, 14 and 18 DAT were 12.65×10^8, 6.35×10^8 and 0.19×10^8 spores ml^{-1}, respectively.

The mortality of the third instar grubs of *B. fulvicorne* was observed from the third day after inoculation with *B.*

Table-3 : Cumulative per cent mortality, LT_{50} and probit analysis of dose-mortality responses of adults of *B. fulvicorne* treated with different spore concentrations of *M. anisopliae.*

Concentration (spores ml^{-1})	Cumulative per cent mortality at different intervals after treatment (Days)			LT 50 (Days)
	7	14	18	
2.7×10^8	31.11	53.33	95.55	23.465
2.7×10^7	17.78	31.11	82.22	29.111
2.7×10^6	8.89	15.55	73.33	40.056
2.7×10^5	4.47	8.89	68.89	43.163
2.7×10^4	2.22	8.89	53.33	52.314
Control	0	0	0	0

Probit analysis

Days after treatment	LC_{50} (spores $ml^{-1} \times 10^8$)	Fiducial limit for LC_{50} (spores $ml^{-1} \times 10^8$)	LC_{90} spores (spores $ml^{-1} \times 10^8$)	Fiducial limit for LC_{90} (spores $ml^{-1} \times 10^8$)	^{2}	Regression equation
7	3.99	3.64 - 4.35	7.58	6.89 - 7.74	6.682	Y = 1.429 + 3.947 x
14	2.42	2.13 - 2.71	5.39	5.11 - 5.54	8.109	Y = 1.040 + 5.161 x
22	1.18	1.02 - 1.25	1.67	1.17 - 1.79	7.134	Y = 4.624 + 3.647 x

Table-4 : Cumulative per cent mortality, LT_{50} and probit analysis of dose-mortality responses of grubs of *B. fulvicorne* treated with different spore concentrations of *M. anisopliae.*

Concentration (spores ml^{-1})	Cumulative per cent mortality at different intervals after treatment (Days)				LT 50 (Days)
	5	10	14	20	
1.5×10^8	6.67	33.33	37.78	97.78	11.170
1.5×10^7	6.67	15.55	33.33	91.11	17.667
1.5×10^6	4.45	8.89	17.78	84.45	21.387
1.5×10^5	0	4.45	13.33	73.33	28.972
1.5×10^4	0	4.45	8.89	66.67	38.305
Control	0	0	0	0	0

Probit analysis

Days after treatment	LC_{50} (spores $ml^{-1} \times 10^8$)	Fiducial limit for LC_{50} (spores $ml^{-1} \times 10^8$)	LC_{90} spores (spores $ml^{-1} \times 10^8$)	Fiducial limit for LC_{90} (spores $ml^{-1} \times 10^8$)	^{2}	Regression equation
5	6.09	4.85 - 7.99	10.11	8.32 - 12.16	5.295	Y = 1.946 + 1.351 x
10	2.10	1.53 - 3.56	3.99	2.86 - 7.08	3.536	Y = 1.426 + 4.185 x
14	2.11	1.83 - 2.39	4.99	4.45 - 5.13	8.649	Y = 1.937 + 2.958 x
20	0.08	0.05 - 0.13	0.56	0.29 - 0.62	7.530	Y = 2.939 + 6.998 x

bassiana but there was no mortality at the lower concentration of 10^2 spores ml^{-1} (Table-2). The per cent mortality was 6.67 and 20 at 10^4 and 10^6 spores ml^{-1}. As time elapsed mortality also increased and on the fourteenth day cent per cent mortality was observed in the grubs treated with 10^6 spores ml^{-1}. At the lowest dose of 10^2 spores ml^{-1} mortality to the tune of 53.33 per cent was observed. The minimum period of 6.598 days was recorded for obtaining 50 per cent kill of the grubs at the highest spore concentration of 10^6 spores ml^{-1} whereas a period of 13.848 days was required to kill half the population of the test insects at the lowest dosage of 10^2 spores ml^{-1}. The LC_{50} values derived from the probit analysis of log dose-mortality of the insects on the third, fifth, tenth and fourteenth DAT were $1.87 \times 10^{6,}$ 1.11×10^6, 0.63×10^6 and 0.002×10^6 spores ml^{-1}, respectively and the LC_{90} values recorded for the corresponding days were 3.23×10^6, 2.43×10^6, 1.78×10^6 and 0.06×10^6 spores ml^{-1}, respectively.

From the seventh day onwards, mortality was noticed in *M. anisopliae* treated adult *B. fulvicorne* and it ranged between 2.22 to 31.11 per cent in the different test doses from 2.7×10^4 to 2.7×10^8 spores ml^{-1}(Table-3). This increased and ranged between 8.89 to 53.33 and 53.33 to 95.55 per cent at 14 and 22 DAT respectively. The time taken for attaining 50 per cent kill of the test insects at the highest spore concentration of 2.7×10^8 spores ml^{-1} was 23.465 days, whereas in the lowest concentration of 2.7×10^4 spores ml^{-1} took 52.314 days. The LC_{50} values of *M. anisopliae* for *B. fulvicorne* was obtained as 3.99×10^8, 2.42×10^8 and 1.18×10^8 spores ml^{-1} on 7, 14 and 22 days respectively after treatment.

The LC $_{90}$ values for the corresponding days were 7.58 × 10^8, 5.39 × 10^8 and 1.67 × 10^8 spores ml^{-1}.

The grubs of *B. fulvicorne* were found to be dead on the fifth day after treating with *M. anisopliae,* and the mortality ranged between 4.45 to 6.67 per cent in the different spore concentrations ranging from 1.5 × 10^6 to 1.5 × 10^8 spores ml^{-1} whereas there was no mortality in the lower doses of 1.5 × 10^4 and 1.5 × 10^5 spores ml^{-1} (Table-4). The mortality rate gradually increased and ranged from 4.45 to 33.33 per cent, 8.89 to 37.78 per cent and 66.67 to 97.78 per cent at 10, 14 and 20 days after inoculation with the fungus with spore concentrations ranging from 1.5 × 10^4 to 1.5 × 10^8 spores ml^{-1}. Inorder to kill half the population of the grubs of *B. fulvicorne* 11.17 days was taken at the highest spore concentration of 1.5 × 10^8 spores ml^{-1}, whereas in the lowest concentration of 1.5 × 10^4 spores ml^{-1} the maximum time span of 38.305 days was taken. The LC $_{50}$ values computed based on the log dose-mortality data of the fungus and the test insect showed that a spore concentration of 6.09 × 10^8, 2.10 × 10^8, 2.11 × 10^8 and 0.08 × 10^8 spores ml^{-1} were essential at 5, 10, 14 and 20 DAT, respectively, to attain 50 per cent kill of the grubs of *B. fulvicorne* and that a higher concentration of 10.11 × 10^8, 3.99 × 10^8, 4.99 × 10^8 and 0.56 × 10^8 spores ml^{-1} could bring 90 per cent mortality of the test insects at 5, 10, 14 and 20 days after inoculation, respectively.

Conclusions

The studies on the screening of cardamom root grub to the entomopathogenic fungi proved that the pest is highly susceptible to both the test fungi involved in the present experiment. Mortality of *B. fulvicorne* treated with *B. bassiana* was observed from the seventh day onwards. It was found from the probit analysis, that a spore concentration of 6.53 × 10 ^{8} spores ml^{-1} was required to cause fifty per cent mortality of the adults and a concentration of 12.65 × 10^8 spores ml^{-1} was required to bring 90 per cent mortality. The grubs of *B. fulvicorne* were highly susceptible to the infection of *B. bassiana* as it was evident from the mortality observed from the third day after treatment and the lower dose of 1.87 × 10 ^{6} spores ml^{-1} required for the grubs when compared to the adults. The computed LC $_{50}$ of *M. anisopliae* for the adults of *B. fulvicorne* it was 3.99 ×10 ^{8} at 7 DAT. The grubs succumbed to the infection of *M. anisopliae* at a lower dose compared to the adults as in the case of *B. bassiana* infection. The LC $_{50}$ computed for the grubs *of B. fulvicorne* was 6.09 × 10 ^{8} spores ml^{-1} at 5 DAT.

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Morphological Correlation Study of Wheat Varieties Against Rice Weevil

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Abstract

The ten wheat varieties were correlated based on various morphological characters of seed during storage against *Sitophilus oryzae*. The study also carried out through F test on population growth and weight loss against this pest. The highest number of adults were emerged in the variety GW1 and proved to be most preferred variety to *S. oryzae* followed by GADW3, GW451 and GW366. The percentage of loss in weight of different wheat varieties due to rice weevil ranged from 11.11 to 50.18. The lowest weight loss was recorded in GW11 variety followed by GW366, GW496 and GW322, LOK-1, HI1544 and GW173. The higher weight loss was recorded in GW451, GW1 and GADW3 which may found more preferred by *S. oryzae*. The correlation between seed hardness and weight loss due to this pest was highly significant (r= -0.86**) and negatively correlated with weight loss. There was no any significant relationship between the different characters of seed *viz.,* length of seed, width and weight of 100 seeds of different varieties with the weight loss of grain due to infestation of *S. oryzae*. Whereas, the correlation between seed hardness and weight loss by this pest was highly significant (r= -0.86**) which showed negatively correlated with weight loss. It indicated that the varieties having higher seed hardness were least preferred by adults and *vice-versa*.

Key words *: Morphological characters, correlation, wheat, Sitophilus oryzae*

Introduction

Wheat (*Triticum aestivum* Linnaeus) belongs to the poaceae family which is the second most produced food among the cereal crops after maize (Gilles *et al*., 2001). Wheat is the major staple food crop which providing almost half of all calories to the people in the region of North Africa, West and Central Asia. Wheat is first most importance cereal crop consumed in the world. Global production of wheat was 772.64 million metric tonnes in 2020 –'21 and it was 107.18 million metric tonnes in India during 2019 –'20 (Statista, 2021). Stored product pests can cause post-harvest losses estimated up to 9 and 20 per cent in developed and developing countries (Phillips and Throne, 2010). The post-harvest losses of food grain was estimated about 12-16 million metric tonnes each year in India (Singh, 2010). In India, the post-harvest losses caused by unscientific storage, insect- pests, rodents, micro-organisms etc., account for about 10 per cent of total food grains. About 500 species of insects have been associated with stored grain products. Nearly 100 species of insect pests of stored products are known cause economic losses. Rice weevil, *S. oryzae* (Curculionidae: Coleoptera) is a serious insect pest of various food grains under storage and it causing up to 50 per cent loss in weight (Koura and El-Halfwny, 1967). Correlation study on morphological characters of different wheat verities provide information regarding its preference for feeding which will help as protective measures for its susceptibility.

Materials and Methods

The correlation study was carried out on different morphological characters of different wheat varieties against *S. oryzae* based on population growth and weight loss of grain by this pest. The experiment was carried out in the laboratory of Department of Entomology. B.A. College of Agriculture, Anand Agricultural University, Anand during 2020-2021.

Evaluation based on population growth of rice weevil, *S. oryzae* : For each variety, three samples of wheat grain (50 g one sample for one repetition) was filled in plastic tube individually. Twenty adults of *S. oryzae* (5 to 10 days old) were released in each tube for egg laying which was covered with two-fold muslin cloth kept in position using rubber band. The adult introduced for oviposition were discarded from each tube after 7 days of exposure. The tube was covered with two-fold muslin cloth to facilitate aeration and prevent escape of adult. The observations on number of adults (live + dead) developed in each repetition were made after 6 months of storage. The data on number of adults developed after 6 months of storage were subjected to ANOVA after transforming them to logarithm.

Evaluation based on weight loss of grain against rice weevil, *S. oryzae* : The hundred (100) grains were collected randomly after six month of storage from each sample and segregated into weevilled grain and germ eaten grain. The weevilled, germ eaten (Plate 3.3C and D) and 100 undamaged grains were weighed using mono

Table-1 : Susceptibility of wheat varieties to *S. oryzae* based on population growth, weight loss and various morphological characters.

Treatment	Number of adults emerged out*	Weight loss (%) @	Length (mm)	Width (mm)	100 Seed weight (g)	Seed hardness (N)
T_1 GW366	2.49ab (315.35)	23.58e (16.01)	7.48	3.71	4.61	75.33
T_2 GW322	2.39bc (245.69)	25.63e (18.72)	6.51	3.31	4.29	79.00
T_3 GW496	2.40bc (253.33)	25.19e (18.12)	6.65	3.49	3.90	79.66
T_4 GW451	2.55a (358.34)	45.10a (50.18)	6.67	3.12	6.06	65.00
T_5 HI1544	2.37bc (234.74)	27.99d (22.04)	6.66	3.26	4.05	84.33
T_6 GW173	2.39bc (249.68)	30.40c (25.62)	7.03	3.22	4.15	72.66
T_7 GW11	2.35c (224.90)	19.47f (11.11)	7.23	3.17	4.21	86.66
T_8 GADW3	2.62a (420.04)	39.91b (41.17)	9.80	3.36	4.37	71.33
T_9 GW1	2.62a (421.50)	41.36b (43.68)	8.18	3.21	4.46	69.00
T_{10} LOK-1	2.41bc (259.53)	27.83d (21.80)	7.70	3.30	5.37	76.33
S. Em. ±	0.04	0.67	0.06	0.05	0.14	1.32
F Test (T)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)	2.79	3.82	1.40	2.92	5.34	3.01
Correlation coefficient (r)	—	—	0.40	-0.41	0.51	-0.86**

Notes : 1. Figures in parentheses are retransformed values those outside are log*and arc sin@ transformed values.
2. Treatment mean(s) with letter(s) in common are not significant by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance.
3. N: Newton

pan electronic balance. Based on data, the per cent loss in weight was calculated by using the below mentioned formula given by Srivastava *et al.* (1973). The data on per cent loss in weight were subjected to ANOVA after arc sin transforming.

$$L = \frac{(W + G) - 100}{S(W_1 + G_1)}$$

Where,

L = Per cent loss in weight

W = Percentage (by number) of weevilled grains

G = Percentage (by number) of germ eaten grains

S = Weight of 100 undamaged grains (g)

W_1 = Weight of weevilled grains (g)

G_1 = Weight of germ eaten grains (g)

Evaluation based on seed size, seed weight and seed hardness of grain against rice weevil,

S. oryzae : The size of wheat seeds determined in terms of length (l) and width (w) was measured by INDOSAW seed image analyzer and is expressed in units of mm. The samples of hundred seeds taken from each variety randomly and weighed out with the help of mono pan electronic balance. To record the seed hardness, three grains from the stored bulk was selected randomly and analyzed using a standard texture analyzer. Hardness was measured by comparison, individual grains made to crack by applying pressure and the cracking point was recorded. The hardness is expressed in Newton. Correlation between physical characters of the varieties and weight loss made by the pest was also worked out.

Results and Discussion

Evaluation based on population growth of rice weevil: The data on number of adults developed due to initial oviposition in a week by twenty adults of *S. oryzae* and after 6 months of wheat storage in laboratory are presented in Table 1 revealed that significant lowest number (224.90) of adults emerged in GW11 which was at par with HI1544, GW322, GW173, GW496 and LOK-1 varieties resulted 234.74, 245.69, 249.68, 253.33 and 259.53 number of adults emerged respectively. The next inturn in increasing order of adult emergence was GW366 (315.35). The highest number of adults were emerged in the variety GW1 (421.5) and proved to be most preferred wheat variety to *S. oryzae* which was at par with GADW3 (420.04) and GW451 (358.34). The GW451 variety was also at par with GW366 recorded 315.35 adult emergence. The present investigations are also accordance with findings of Sharma (1984), Tiwari and Sharma (2002) who found similar variation in adult emergence on wheat varieties indicates the susceptibility/resistance of that variety. Similarly, Patel (2006), Yadav and Bhargava (2008) and Verma *et al.* (2012) also reported that the maximum and minimum number of adult emergence of this pest on different varieties of wheat.

Evaluation based on weight loss : The data on per cent loss in weight due to infestation by *S. oryzae* after storage for six months period (Table 1) clearly indicated that the lowest significant 11.11 per cent weight loss was recorded in variety GW11 followed by GW366 (16.01%), GW496 (18.12%) and GW322 (18.72 %) which were found at par with each other. The variety LOK-1 and HI1544 registered 21.80 and 22.04 per cent weight loss and was found at par with each other followed by GW173 (25.62). Among the screened varieties under present investigation, higher weight loss was observed in GW451 (50.18%), GW1 (43.68%) and GADW3 (41.17) which proved as more preferred by *S. oryzae*. According to Yadav *et al*. (2018) the percentage of loss in weight of different wheat varieties due to rice weevil ranged from 8.33 to 16.29 being maximum weight loss in Raj-1482, while minimum weight loss in Raj-4037. The weight loss due to damage by rice weevil may be differed due to varieties under study.

Evaluation based on seed size, seed weight and seed hardness of wheat grain against rice weevil : The different characters of seed *viz.,* length of seed, width and weight of 100 seeds and seed hardness of different varieties of wheat are presented in Table 1. The results revealed that there was no any significant relationship between the different characters of seed *viz.,* length of seed, width and weight of 100 seeds (r = -0.41 to 0.51) of different varieties with the weight loss of grain due to infestation of *S. oryzae.* Whereas, the correlation between seed hardness and weight loss was highly significant (r= -0.86**) and negatively correlated with weight loss. This indicates that the varieties having higher seed hardness were least preferred by adults and *vice-versa.* The results of correlation between seed hardness and weight loss due to *S. oryzae* in the present investigation are in accordance with the findings of Verma *et al.* (2012) who stated that grain hardness was significantly negatively correlated with weight loss which support the present findings. According to Dwivedi and Shukla (2019) the hardness of wheat varieties (HD-2733 and K-307) showed negative association against *S. oryzae* infestation which also confined the present study.

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Floristic Diversity of *Santalum album* L. Populations in District Bilaspur, Himachal Pradesh

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Abstract

The ecological study of a species is an essential requirement for its long -term survival in a particular area. Keeping in view the socioeconomic importance of the Indian sandalwood and existence of few natural populations of this species restricted to particular sites in the state of Himachal Pradesh, India, the study on phytosociology and natural regeneration status of *Santalum album* L. was carried out in five locations of district Bilaspur. In every natural population, ten quadrats of 10 m × 10 m (100 m^2) size determined by species area curve method were randomly laid to study this tree species. In each quadrat, a sub-quadrat of 5 m × 5 m (25 m^2) and 2 m × 2 m (4 m^2) for size for shrubs and regeneration study were selected, respectively. Studies showed the dominance of *Santalum album* L. tree species in all the five natural populations. Among shrubs *Lantana camara* L. was observed growing in close association with *Santalum album* L. Whereas, natural regeneration of this species in all the studied natural populations was limited due to the lack of good mother trees and human interference to a greater extent.

Key words : *Santalum album, floristic diversity, natural regeneration.*

Introduction

Santalum album L. commonly referred as Chandana/sandalwood is widely accepted valuable tree belongs to family Santalaceae. This family consists of 29 genera and 400 species, out of which 19 species are specific to genus *Santalum* (1). This genus (*Santalum*) is distributed across South and Southeast Asia, Oceania and Australia (2,3). *S. album* L. is native to the tropical belt of peninsular India, Eastern Indonesia and Northern Australia. It is indigenous to India covering an area of 9600 Km^2 (4), mostly (90%) grown in states like Karnataka and Tamil Nadu (5,6,7). In Himachal Pradesh, Sandalwood found in some areas of district Bilaspur and Kangra mainly at Jawala Ji region (8).

Sandalwood is an evergreen, hemi root parasite tree which can parasitize over 300 species ranging from grass to another sandalwood species (7, 9). Hosts of this tree are different, both in nursery and plantation stages. *Cajamus cajan* and *Casuarina equisetifolia* are recorded as the best host plants during nursery and plantation stages, respectively (10). Natural regeneration in sandalwood occurs by means of seeds which are usually dispersed by birds and normally takes 4-8 weeks to germinate (11). Sandalwood tree is mainly exploited for its heartwood which yields the renowned East Indian Sandalwood oil, valued for its sweet fragrant, persistent, spicy, warm, woody note, tenacious aroma and fixative property. Growing sandalwood tree under natural conditions can produce an increment of one kg of heartwood/ year and a girth of one cm/ year (12). The timber of Sandalwood is the world's second most expensive timber (5). Besides its vital importance on economic ground, it has been used as an object in ritualistic offerings, and also an ointment for beauty. Its heartwood is closely grained and thus found to be the best wood for the carving of idols, cabinet panels, chess boards pen-holders, paper weights and picture frames (13).

In India, isolated populations of sandalwood have been reported in various states such as Bihar, Gujarat Haryana, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal, Assam and Himachal Pradesh. The increasing awareness among the masses about its economic and cultural importance, people in the past have made some attempts to introduce this tree in North India. The existence of Sandalwood populations in some particular areas of Kangra and Bilaspur districts of Himachal Pradesh was results of introduction. In late 1940s, Sandalwood trees were first introduced in Jawalamukhi area of district Kangra by an army officer during World War II (14). Later on, Sandalwood trees got naturalized but could not spread beyond these confined sites besides the fact that, the entire sub-tropical sub montane hill zone has well suited soil and climate requirements of this tree species. The ecological study of this species is an essential requirement for its long-term survival in a particular area. In this lane the survey was accomplished on phytosociological and natural regeneration status of Sandalwood in five locations of district Bilaspur, Himachal Pradesh for studying the distribution pattern, natural regeneration status and ecological status vis-a-vis edaphic and woody plant association of this tree species.

Materials and Methods

Study area : The study was conducted in five natural populations (Changer, Oel, Danoh, Lakhanpur and Dholra) of *Santalum album* L. distributed in district Bilaspur, Himachal Pradesh. The area lies between north latitude 31°18'00" and 31°55'00" and east longitude 75°55'00" and 76°28'00", where top story of forest is occupied by *Pinus roxburghii* and *Terminalia chebula* and other associate tree species. The major forest communities in the study area are *Santalum album*, *Albizia lebbeck*, *Albizia chinesis*, *Ficus carica*, *Bombax ceiba*, *Dalbergia sissoo*, *Cassia fistula* and *Acacia catechu.*

Climate of the district is temperate to sub-tropical. The minimum and maximum temperature varies from 1.3? C in January to 34.7 ?C in May. In rainy season humidity increases and the weather becomes hot sultry. The area receives rainfall during monsoon period extending from June to September and also non-monsoon period (winter). The annual average rainfall in the area is about 1106.28 mm and about 81.5% rainfall occurs during monsoon period. Two types of soils are observed in the district viz, alluvial soil and non-calcic brown soil. Most of the area in the district is covered with alluvial soil and only hilly area in the district is covered with non-calcic brown soil. Soil is rich in nutrients and is fertile.

Phytosociological studies of natural populations

Community analysis **:** The status of plant diversity and regeneration in natural populations of the study areas, community analysis was carried out during rainy season, 2020-2021. In every natural population, ten quadrats (10 m × 10 m) determined by species area curve method were randomly laid to study tree species. In each quadrat, a sub-quadrat of 5 m × 5 m and 2 m × 2 m size for shrubs and regeneration study were selected, respectively. The vegetation data was quantitatively analyzed for density (D), per cent frequency (%) and abundance (A). Relative frequency (RF), Relative density (RD) and Relative basal area (RBA) were determined following methods proposed by Phillips (15), while Importance Value Index (IVI) was calculated by following Curtis (16). Indices of similarity and dissimilarity were calculated by using formulae as per Mishra (17) and Sorensen (18). Species Richness was estimated as per the method named Margalef's index of richness' (D_{mg}) proposed by Magurran (19), Diversity as per Shannon -Wiener (20) and Index of Diversity as per Simpson (21).

Natural regeneration study of natural populations : The adequacy of regeneration of *Santalum album* L. within its natural population was judged on the basis of number of established plants per unit area. According to Chacko (22), desired number of established plants is 2500/ha and the quadrate is considered fully stocked when it contains one established plant. Observations on regeneration were made in a quadrat size of 2 × 2 m.

Results and Discussion

Natural populations of *Santalum album* L. in district Bilaspur : The major tree species that represent the natural populations of *Santalum album* L. are *Acacia catechu, Albizia chinensis, Eucalyptus* spp., *Bombax ceiba, Grewia optiva, Ficus carica* and *Melia azedarach*. These species occur mixed with other important or associated species in the natural populations. The tree and shrub species that occurs in five natural populations of *S. album* are presented in Tables 1-5. A range of 5-8 tree species and 2-4 shrub species were found predominant in all five locations of district Bilaspur. The maximum number out of total tree species were found in Lakhanpur whereas, minimum number of species were reported in Dholra. Maximum values for parameters like density, abundance, basal area, per cent frequency and IVI (Importance Value Index) were observed in case of *Santalum album* in all the five locations namely, Changer, Oel, Danoh, Lakhanpur and Dholra. High values of these parameters attributed to the dominance of one species over the other species in their respective habitat. In this study, *Santalum album* found as dominant species. In general, *Santalum album* found as older crop in their habitat.

Minimum values for above mentioned parameters were observed for species *Cassia fistula* in Changer, *Melia azedarach* in Oel, *Mangifera indica* in Danoh, *Leucaena leucocephala* in Lakhanpur and *Moringa oleifera* in Dholra. This implies that *Cassia fistula*, *Melia azedarach Mangifera indica*, *Leucaena leucocephala* and *Moringa oleifera* were also grown in association with *Santalum album* in one or another natural populations under study. *Santalum album* was found as dominant tree species in all the five locations surveyed whereas, *Albizia chinensis* was observed as co-dominant tree species in areas like Changer, Danoh and Dholra. Other tree species like *Bombex ceba* and *Acacia catechu* were also found co-dominant in Oel and Lakhanpur, respectively.

Among shrub species, maximum number of shrubs (four) was recorded in location Oel whereas, minimum

Table-1 : Floristic diversity of trees and shrubs in Changer.

Sr. No.	Tree species	Density (individual/ha)	Abundance (AB)	Basal area (m^2/ha) trees/(cm^2/ha) shrubs	Percent frequency	Relative Density	Relative frequency	Relative basal area	IVI
				Trees					
1.	*Acacia catechu*	80	1.60	0.18	50.00	12.70	16.67	10.56	39.93
2.	*Albizia chinesis*	120	1.71	0.34	70.00	19.05	23.33	19.58	61.96
3.	*Cassia fistula*	10	1.00	0.01	10.00	1.59	3.33	0.58	5.50
4.	*Eucalyptus spp.*	50	1.25	0.20	40.00	7.94	13.33	11.73	33.00
5.	*Grevillea robusta*	20	2.00	0.01	10.00	3.17	3.33	0.78	7.29
6.	*Santalum album*	330	3.30	0.87	100.00	52.38	33.33	50.34	136.06
7.	*Terminalia arjuna*	20	1.00	0.11	20.00	3.17	6.67	6.41	16.25
	Total	630	11.86	1.74	300.00	100	100	100	300
				Shrubs					
1.	*Adhatoda vasica*	490	4.90	34.01	100.00	62.03	50.00	54.6	166.62
2.	*Lantana camara*	300	3.00	28.28	100.00	37.97	50.00	45.4	133.38
	Total	790	7.90	62.29	200.00	100	100	100	300

Table-2 : Floristic diversity of trees and shrubs in in Oel.

Sr. No.	Tree species	Density (individual/ha)	Abundance (AB)	Basal area (m^2/ha) trees/(cm^2/ha) shrubs	Percent frequency	Relative Density	Relative frequency	Relative basal area	IVI
				Trees					
1.	*Albizia chinesis*	90	1.50	0.27	60.00	11.84	15.38	13.58	40.81
2.	*Bombax cieba*	90	1.29	0.26	70.00	11.84	17.95	12.70	42.49
3.	*Cassia fistula*	60	1.20	0.14	50.00	7.89	12.82	7.01	27.73
4.	*Ficus carica*	50	1.25	0.11	40.00	6.58	10.26	5.70	22.53
5.	*Grewia optiva*	80	1.60	0.18	50.00	10.53	12.82	9.22	32.57
6.	*Melia azedarach*	50	2.50	0.11	20.00	6.58	5.13	5.60	17.31
7.	*Santalum album*	340	3.40	0.94	100.00	44.74	25.64	46.18	116.56
	Total	760	12.74	2.04	390.00	100	100	100	300
				Shrubs					
1.	*Adhatoda vasica*	70	3.50	6.73	20.00	8.33	9.09	9.5	26.97
2.	*Lantana camara*	250	3.12	31.16	80.00	29.76	36.36	44.2	110.31
3.	*Murraya koennigii*	480	4.80	29.01	100.00	57.14	45.45	41.1	143.73
4.	*Ziziphus mauritiana*	40	2.00	3.62	20.00	4.76	9.09	5.1	18.99
	Total	840	11.43	70.52	220.00	100	100	100	300

number (two) was noticed in Changer and Dholra (Tables 1-5). The highest values for density, abundance, basal area, per cent frequency and IVI were recorded for shrub species like *Murraya koennigii* (Oel and Danoh), *Lantana camara* (Lakhanpur and Dholra) and *Adhatoda vasica* (Changer). In surveyed areas like Danoh, Lakhanpur and Dholra, *Lantana camara* and *Murraya koennigii* were recorded as dominant and co-dominant shrubs, respectively. Other species of shrubs named *Adhatoda vasica* and *Murraya koennigii* were dominantly present in Changer and Oel areas of district Bilaspur where, *Lantana camara* was also observed to be co-dominantly growing along with other shrub species. Shrub *Lantana camara* noted to be grown in close association with *S. album*. The high density of shrubs may be explained on an account of more space and tree cover allowing more shrubs to grow on the surface floor. Sharma and Thakur (23) have reported density value ranging from 270-316 trees per hectare and shrub density of 3440-5120 for different natural populations of *T. chebula* in district Kangra. The high basal area denotes the presence of higher number of matures trees and shrubs in natural populations

Vegetation indices of trees and shrubs : Population wise descending order of tree species diversity was Oel, Lakhanpur, Dholra, Changer and Danoh which is presented in Table-6. Species diversity of shrubs ranged from 0.66 to 1.03, maximum in Oel and minimum in Changer. The high diversity can be attributed to low disturbance, habitat conditions and species characteristics (24). Among all the locations surveyed maximum values for tree species dominance and tree species richness were recorded for Changer whereas, in

Table-3 : Floristic diversity of trees and shrubs in Danoh.

Sr. No.	Tree species	Density (individual/ha)	Abundance (AB)	Basal area (m^2/ha) trees/ (cm^2/ha) shrubs	Percent Frequency	Relative Density	Relative frequency	Relative basal area	IVI
				Trees					
1.	*Albizia chinesis*	120	1.33	0.37	90.00	19.05	28.13	21.21	68.39
2.	*Bombax cieba*	50	1.00	0.18	50.00	7.94	15.63	10.58	34.14
3.	*Ficus carica*	60	1.50	0.19	40.00	9.52	12.50	11.23	33.25
4.	*Grewia optiva*	40	1.33	0.12	30.00	6.35	9.38	7.13	22.86
5.	*Mangifera indica*	10	1.00	0.03	10.00	1.59	3.13	2.16	6.87
6.	*Santalum album*	350	3.50	0.83	100.00	55.56	31.25	47.68	134.49
	Total	630	9.67	1.76	320.00	100	100	100	300
				Shrubs					
1.	*Adhatoda vasica*	50	2.50	2.73	20.00	7.35	9.52	4.3	21.20
2.	*Lantana camara*	260	2.89	40.69	90.00	38.24	42.86	64.5	145.58
3.	*Murraya koennigii*	370	3.70	19.68	100.00	54.41	47.62	31.2	133.22
	Total	680	9.09	63.10	210.00	100	100	100	300

Table-4 : Floristic diversity of trees and shrubs in Lakhanpur.

Sr. No.	Tree species	Density (individual /ha)	Abundance (AB)	Basal area (m^2/ha) trees/ (cm^2/ha) shrubs	Percent Frequency	Relative Density	Relative frequency	Relative basal area	IVI
				Trees					
1.	*Acacia catechu*	100	1.25	0.25	80.00	14.93	20.51	15.14	50.58
2.	*Albizia chinesis*	60	1.50	0.17	40.00	8.96	10.26	10.50	29.72
3.	*Bombax cieba*	10	1.00	0.04	10.00	1.49	2.56	2.67	6.73
4.	*Dalbergia sissoo*	30	1.00	0.12	30.00	4.48	7.69	7.17	19.34
5.	*Ficus carica*	70	1.40	0.17	50.00	10.45	12.82	10.38	33.65
6.	*Grewia optiva*	60	1.00	0.14	60.00	8.96	15.38	8.31	32.65
7.	*Leucanea leucocephala*	20	1.00	0.01	20.00	2.99	5.13	0.97	9.08
8.	*Santalum album*	320	3.20	0.76	100.00	47.76	25.64	44.84	118.24
	Total	670	11.35	1.70	390.00	100	100	100	300
				Shrubs					
1.	*Adhatoda vasica*	80	2.67	4.10	30.00	11.27	15.00	6.1	32.35
2.	*Lantana camara*	320	3.2	36.91	100.00	45.07	50.00	54.7	149.82
3.	*Murraya koenigii*	310	4.43	26.41	70.00	43.66	35.00	39.2	117.83
	Total	710	10.30	67.42	200.00	100	100	100	300

case of shrubs highest values for dominance and richness were observed for zDholra and Oel, respectively. The population wise equitability in tree and shrub species was recorded high in Dholra (Table-6).

Natural regeneration : The life criteria of a species must be measured by its effectiveness of in "recruiting" new individuals into the population of concerned species. The more effective this strategy, the longer the population will be able to maintain itself in natural population. In all the natural populations surveyed, Danoh registered maximum number of recruits. In case of number of Un-established regeneration, Lakhanpur consisted of maximum number whereas, it was completely absent at Dholra (Table-7). The highest values for established regeneration, establishment index, stocking, established stocking per cent and regeneration success per cent values were register at Lakhanpur area which was due to the presence of good number of mother tree and less human disturbance such as grazing, walking over and other human activities, etc., which led to the growth of good flourished seedlings of Sandalwood. Rest of the locations were quite disturbed by human activities. Another reason for presence of good seedlings was the slope of this location as Sandalwood needs sloppy areas for good drainage due to which it flourishes well (25). These findings are supported by Hanumantha (26) who inquired the regeneration status of Sandalwood in various plant habitats at Forest Training institute, Dharwad, Karnataka. Guleria (27) observed sandalwood regeneration at Horticultural and Forestry Research Station, in Bhota, Hamirpur district and found that sandalwood regeneration is found to be better in the presence of host plants association. Requirement of host for proper growth of sandal was demonstrated in a field study by Ananthapadmanabha *et al.* (28). These results are

Table-5 : Floristic diversity of trees and shrubs in Dholra.

Sr. No.	Tree species	Density (individual/ha)	Abundance (AB)	Basal area (m^2/ha) trees/ (cm^2/ha) shrubs	Percent Frequency	Relative Density	Relative frequency	Relative basal area	IVI
				Trees					
1.	*Albizia chinensis*	120	1.71	0.49	70.00	26.09	25.93	29.53	81.54
2.	*Eucalyptus spp.*	60	1.50	0.42	40.00	13.04	14.81	25.18	53.04
3.	*Melia azedarach*	80	2.00	0.27	40.00	17.39	14.81	16.40	48.61
4.	*Moringa oleifera*	30	1.50	0.07	20.00	6.52	7.41	4.32	18.25
5.	*Santalum album*	170	1.70	0.41	100.00	36.96	37.04	24.56	98.56
	Total	460	8.41	1.67	270.00	100	100	100	300
				Shrubs					
1.	*Lantana camara*	330	3.30	35.49	100.00	57.89	58.82	71.8	188.53
2.	*Murraya koenigii*	240	3.43	13.93	70.00	42.11	41.18	28.2	111.47
	Total	570	6.73	49.42	170.00	100	100	100	300

Table-6 : Vegetation indices of trees and shrubs under natural Populations of *Santalum album* L.

Population	Vegetation Index							
	Shannon – Wiener Index(H)		Simpson's Dominance (cd)		Species Richness (d)		Equitability (e)	
	Trees	Shrubs	Trees	Shrubs	Trees	Shrubs	Trees	Shrubs
Changer	1.40	0.66	0.28	0.51	1.45	0.23	0.72	0.95
Oel	1.66	1.03	0.22	0.38	1.39	0.68	0.85	0.74
Danoh	1.30	0.99	0.28	0.44	1.21	0.47	0.73	0.81
Lakhanpur	1.61	0.97	0.22	0.42	1.08	0.30	0.77	0.88
Dholra	1.46	0.68	0.24	0.53	0.65	0.25	0.91	0.98

Table-7 : Regeneration studies of *Santalum album* L. in its natural populations.

Location	Recruits/ha	Un-established /ha	Established /ha	Establishment index (I_1)	Stocking index (I_2)	Established stocking per cent	Regeneration success percentage
Changer	125.00	100.00	25.00	0.00	0.02	0.00	2.00
Oel	125.00	150.00	25.00	0.06	0.03	0.72	2.50
Danoh	200.00	125.00	50.00	0.29	0.03	2.23	3.25
Lakhanpur	125.00	150.00	100.00	0.36	0.06	4.03	5.50
Dholra	25.00	0.00	25.00	0.19	0.01	1.92	1.00

supported by findings of Sharma and Thakur (30), Singh (31) who also reported absence of natural regeneration of Harar in its natural populations due to the disturbance in the natural population sites by the humans and other factors which restrict the flourishing of seedling in its natural habitat.

Conclusions

Due to over-exploitation and illicit felling as well as ruthless exploitation of the valuable species posing significant threat to the natural population of *Santalum album* L. The present study confirms the presence of mature and over mature trees of *S. album* L. that too in limited number and absence of regeneration and young trees in some of the studied natural populations in district Bilaspur thereby indicating urgency of conservation, sustainable management and regeneration by artificial means for this economically valuable tree species. Among shrubs, *Lantana camara* L. is found to grown along with the *S. album* L. trees which implies that there might be chance that *S. album* L. have functional parasitic association with the roots of *L. camara*.

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Antifeedant Activity of some Botanicals against Cabbage butterfly, *Pieris brassicae* (Lepidoptera: Pieridae) *In vitro*

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Abstract

The present investigation was undertaken to evaluate the antifeedant activity of some botanicals against Cabbage butterfly, Pieris brassicae In vitro. A field experiment was conducted in VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal in Complete Randomized Design. The antifeedant activity of four plant extracts viz., Artemisia (*Artemisia vulgaris*), Kapoor (*Cinnamomum camphora* J.), Walnut (*Juglans regia* L.) and Stinging Nettle (*Urtica dioica*) were tested on cabbage butterfly, Pieris brassicae by Leaf Dip method. It indicated that the plant extracts at different concentrations with preference index values namely Kapoor 2.5% (0.462), Stinging nettle 1% (0.49) and Stinging nettle 2.5% (0.478) proved to be strongly antifeedant while Artemisia 1% (0.73), Artemisia 2.5% (0.649), Walnut 0.5% (0.946), Walnut 1% (0.564) and Walnut 2.5% (0.569) were placed under 'moderately antifeedant' category whereas Artemisia 0.5% (0.73), Kapoor 0.5% (0.78), Kapoor 1% (0.77) and Walnut 0.5% (0.946) were slightly antifeedant. The results of this study showed that the maximum leaf area consumption was observed in walnut 0.5% (32.33cm2) whereas the minimum consumption was observed in Kapoor 2.5% (10.83 cm^2) in comparison of control (36cm^2).Our results revealed that the plant parts can be used effectively for controlling the insect population in a cost effective and environment friendly manner.

Key words : *Pieris brassicae, antifeedant, leaf dip, plant extracts, leaf area.*

Introduction

Cabbage butterfly, *Pieris brassicae* L. is a serious insect pest of Cole crops. The pest damages the whole plant and causes defoliation. The yield loss of cabbage butterfly *P. brassicae* L. can reach upto 40% annually on cole crops per year (Hasan and Ansari, 2010). About 38 insect-pests of cole crops are reported till date and among them the cabbage white butterfly, *Pieris brassiceae* (Linn.) is one of the most destructive and devastating as it causes damage at all the growth stages (Lal and Ram, 2004). Their eggs are laid upright in batches of about 40-100 and colour varies from white or pale yellow to a bit orange color before hatching. The larvae undergo five instars and four moultings in between them. The third instar larvae are seen to eat voraciously and they lead to significant quantity of damage to their host crop. The single larva of *Pieris brassicae* feeds 74cm^2 -80cm^2 area of a leaf (Younas *et al.,* 2004). Pupae are pale green or grayish white and seen with black and yellow markings. The female butterfly also has two black spots on each forewing. They often skeletonize the plants of stems, veins and finally may kill the plants (Lin *et al.,* 2001).

Plants can be exploited on the basis of their natural essences for insect control as these are environmentally safe methods (Sadek, 2003). Many plant substances have been considered for use as antifeedants, insecticides, or repellents, which include alkaloids, flavonoids, phenols, terpenes and other related compounds (Adeyemi, 2010).

Due to the known harmful effects of conventional pesticides, there is a growing need of alternatives to pesticides to reduce the risks. Major limitation to use of synthetic pesticides is the development of resistance to many insect pests (Huang *et al.*, 1998). This leads to increase in the pest population thus causing a devastating effect on the production of crops. So the good alternative to synthetic pesticides is natural products in order to reduce the negative impacts on our health and environment. Out of which the best natural products are plant parts which consists of bio active compounds identified for its effective method to control the insect pest of the major crops (Karunamoorthi, 2012). The detrimental effect of various plant extracts on insects can be displayed in various manners including the mortality, toxicity, antifeedant growth inhibitor and reduction of reproducing capacity of insects and fertility (Bhandari, 2018).

Materials and Methods

An experiment on the antifeedant activity against the pest *P. brassicae* was conducted at the Laboratory of Plant protection, Department of Entomology, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal during 2020-2021. Antifeedant effect of the plant extracts was studied against the second and third instar of test insect.

Collection of plant materials for the preparation of extracts : The criteria of selection of plant species having a bioactive compound was based on literature. Desired plants at the peak of its vegetative growth stage were collected from various locations.

Preparation of plant extracts : Extracts of different plant parts of Artemisia (*Artemisia vulgaris),* Kapoor (*Cinnamomum camphora* J.*)*, Walnut (*Juglans regia* L.*)* and Stinging Nettle (*Urtica dioica)* were collected from around the campus and brought to the laboratory. The plant leaves were washed to remove the dust and to remove the excess water content placed on blotting paper. Addition of about 250 gm of plant leaves in the 500 ml of water was done and allowed to boil upto half of the original volume and then cooled. The material was filtered through muslin cloth and filled in the glass bottle. For conducting experiment, different concentrations (0.5%, 1% and 2.5%) were prepared by adding water (Yadav and Patel, 2017). Extracts were stored in the glass beakers at 4°C in the refrigerator until their utilization in bioassays.

Screening of plant extracts for their antifeedant activity against cabbage butterfly, *Pieris brassicae* L. : The antifeedant activity of various plant extracts was evaluated under laboratory conditions against the cabbage butterfly (range of temperature 27-30°C and RH 75-80%). 'No-choice' feeding bioassay following (Singh *et al*. 1995) technique was used for the determination of antifeedant activity. Cabbage leaves were utilized to treat and feed the larvae during the experimentation. Required concentrations were prepared from the stock solution. The fresh and mature leaves of the test plants were plucked and thoroughly washed and dried with the help of filter paper and the leaf discs (area = 7x7 cm^2) were cut from them. Ten larvae per extract were used and experiment was carried out in three replications. Leaves were first washed with distilled water and dried for about one hour and dipped in the test solution of various extracts for about 10 seconds. These leaf discs were kept in the centre of presterilized corning glass petri dishes (dia. 9 cm) containing an inner lining of moist filter paper. The testing was done by leaf-dip method at the desired concentrations of 0.5%, 1.0% and 2.5% (Yadav and Patel, 2017). Pre-starved (3 hours) larvae of uniform size were released in each Petri-dish and were allowed to feed until more than 75 per cent leaf discs were eaten away in control. The data on the mean leaf area consumed was plotted and recorded on graph paper in different concentrations. The observations were recorded on leaf area consumed with the help of graph paper. The calculations were made on the following parameters :

(i) Feeding percentage (F.P.) following Purwar and Srivastava (2003)

$$\text{F.P.} = \frac{\text{Initial leaf area provided for feeding - Leaf area left after feeding}}{\text{Initial leaf area provided}} \quad 100$$

(ii) Feeding inhibition (F.I.) following Isman *et al*. (1990). Pande and Srivastava (2003)

$$\text{F.I.} = \frac{C - T}{C + T} \quad 100$$

Where,

C = consumption of control disc

T = consumption of treated disc

(iii) C-value (Preference index) following Kogan and Goeden (1970)

$$V = \frac{2M}{M + B}$$

Where,

B = Eaten area of control leaf disc

M = Eaten area of treated leaf disc

The index measures the relative amount of feeding on 2 species of plants present in the arena in a 0 to +2 scale. A value of 1 indicates that feeding on test plant was equivalent to the feeding on the standard. The preference for the test plant is indicated by C -value > 1 and a C- value < 1 indicates less acceptance to the test plant (Desmukh, 1976).

On the basis of C-values, the experimental plant extracts were assigned categories as under Category (C-value) :

Antifeedant	C-Value
Extremely antifeedant plant extracts	0.1-0.25
Strongly antifeedant plant extracts	0.26-0. 50
Moderately antifeedant plant extracts	0.51-0.75
Slightly antifeedant plant extracts	0.76-0.99
Preferred plant extracts	=1

Statistical Analysis : The experiment was conducted in completely randomized design (CRD). The mean values of data were subjected to analyses of variance which were evaluated using online computer programme OPSTAT. The experimental results are presented with the help of tables and graph wherever found necessary.

Results and Discussion

Among the plant extracts assessed they showed an effective reduction in feeding over control (MLAC = 36cm^2). Highest feeding inhibition was observed with Kapoor 2.5% (53.74%) while the Walnut 0.5% (5.37%) showed the least feeding inhibition. Plant extracts with preference index values namely Kapoor 2.5% (0.462), Stinging nettle 1% (0.490) and Stinging nettle 2.5% (0.478) proved to be strongly antifeedant while

Table-1 : Effect of selected plant extracts on feeding behaviour of *Pieris brassicae* larvae.

S. No.	Plant Species	MLAC (cm²)/larval			Mean Feeding (%)			Mean Feeding over Control (%)			Feeding Inhibition (%)			Preference Index			Antifeedant Category		
		0.5%	1%	2.5%	0.5%	1%	2.5%	0.5%	1%	2.5%	0.5%	1%	2.5%	0.5%	1%	2.5%	0.5%	1%	2.5%
1.	Control	36.00	36.00	36.00	73.40	73.40	73.40	-	-	-	-	-	-	-	-	-	-	-	-
2.	*Artemisia vulgaris*	22.50	20.83	17.33	45.90	42.50	35.30	62.50	57.90	48.00	23.07	26.70	35.08	0.769	0.73	0.649	Slightly antifeedant	Moderately antifeedant	Moderately antifeedant
3.	*Cinnamomum camphora*	23.33	22.66	10.83	22.10	45.60	46.20	30.10	62.000	62.90	22.74	21.40	53.74	0.786	0.77	0.462	Slightly antifeedant	Slightly antifeedant	Strongly antifeedant
4.	*Juglans regia*	32.33	20.83	14.16	65.97	42.50	28.90	89.80	57.90	39.30	5.37	26.70	43.54	0.946	0.73	0.564	Slightly antifeedant	Moderately antifeedant	Moderately antifeedant
5.	*Urtica dioica*	14.33	11.66	11.33	29.24	23.10	23.80	39.80	31.40	32.40	43.05	52.10	51.07	0.569	0.49	0.478	Moderately antifeedant	Strongly antifeedant	Strongly antifeedant

Artemisia 1% (0.733), Artemisia 2.5% (0.649), Walnut 0.5% (0.733),Walnut 1% (0.730) and Walnut 2.5% (0.564) were placed under 'moderately antifeedant' category whereas Artemisia 0.5% (0.769), Kapoor 0.5% (0.786), Kapoor 1% (0.770) and Walnut 0.5% (0.946) were slightly antifeedant (Table 1). Maximum leaf area consumption was observed in Walnut 0.5% (32.33 cm^2) whereas the minimum consumption was observed in Kapoor 2.5% (10.83 cm^2) in comparison of control (36 cm^2). Highest mean feeding was observed in control (73.4%) whereas in treatments highest mean feeding % was seen in walnut 0.5% (65.97%) and lowest recorded in Kapoor 0.5% (22.1%) as in (Table-1). All plants tested were effective in reducing the mean leaf area consumption and mean feeding over control against the cabbage butterfly (Table-2).

Results of our study are in agreement with the findings of Sharma *et al.* (2015) who reported that at 10% concentration the *C. camphora* (hexane, diethyl ether and acetone) was extremely antifeedant against the larvae of insects *viz*. Tobacco caterpillar; *Spodoptera litura* and Bihar hairy caterpillar *Spilarctia obliqua.*

Ramangouda and Srivastava (2008) found out the effect of aqueous plant extracts (1% and 2 %) namely *Cinnamomum camphora, Syzygium cumuni, Artemisia annua, Stearia media, Pogostemon patchouli, Cymbopogon winterianus* and *Cnicus benedictus* for their effect on feeding behavior, survival, growth and developmental parameters against the larvae of *S. litura* results showed that at 1% concentration all the plant extracts resulted in reduced feeding.

The above finding of the present investigation are in conformity with the Basera and Srivastava (2009) who worked on aqueous extract of nine medicinal plants for their antifeedant activity and effect on the growth development and economic parameters of the pest mulberry silkworm, *Bombyx mori* L. The antifeedant activity at 1% dry wt. and feeding inhibition against full grown worms of *B. mori* recorded in *C. camphora* was 15.07 and 8.14% respectively.

Present findings is similar with the findings of Huesing *et al.* (1991) showed the insecticidal activity of stinging nettle lectins with rice lectins. The mortality of cowpea weevil *(Callosobruchus maculatus*) significantly increased with the dose of *U. doica.*

A further experimental finding by Bozsik (1996) studied the efficiency of different stinging nettle extracts. The undiluted stinging nettle cold water extract was tested against different species of aphid on plum, red currant and spiraea. It was concluded that the cold water extract reduced highly the *C. ribis* population.

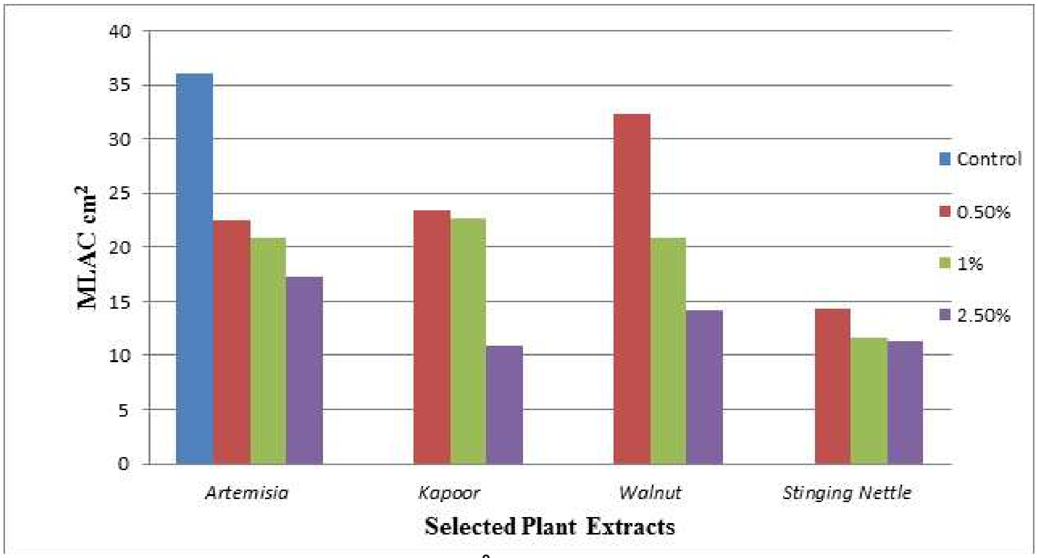

Fig.-1 : MLAC (cm^2) at 0.5%, 1% and 2.5%.

Table-2 : Effect of Plant Extracts on Feeding behaviour of *Pieris brassicae* larvae.

		MLAC (cm²)/larval		
S. No.	**Plants**	**0.50%**	**1%**	**2.50%**
1.	Control	36.00	36.00	36.00
2.	Artemisia	22.50*	20.83*	17.33*
3.	Kapoor	23.33*	22.66*	10.83*
4.	Walnut	32.33	20.83*	14.16*
5.	Stinging Nettle	14.33*	11.66*	11.33*
	SE(d)	6.02		
	CD (0.05)	12.44		

*Significant at 5% level of significance as compared with control.

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Studies and Variability, Heritability and Correlations among Agro-Morphological Traits Water Stress in Wheat (*Triticum aestivum* L.)

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Abstract

Wheat (*Triticum aestivum* L.) germplasm consisting of 10 parent and 45 F_1 genotypes were analysed for genetic variability, heritability and correlation among various contributing characters; and to determine component characters on which selection can be based on genetic improvement in yield. The data recorded from mature plant and various yield traits viz., days to 50% flowering, plant height, number of spike per plant, spike length, number of spikelets per spike, number of grains per spike, grain yield per plant, biological yield per plant, harvest index, 1000-grain weight, shoot length and root length revealed high heritability with high genetic advance for plant height, shoot length and high heritability coupled with moderate genetic advance for days to 50% flowering, plant height and biological yield per plant. Mostly traits exhibited positive and highly significant association but few negative associations. The highly significant positive association was observed between number of spikelets per spike, number of grains per spike, grain yield per plant at both genotypic and phenotypic levels. However, the highest negative association was recorded between spikelet per spike and harvest index, harvest index and biological yield per plant in normal (NC) condition.

Key words : *Genetic variability, heritability, correlation, genotypic, phenotypic.*

Introduction

Wheat (*Triticum aestivum* L.) is an important food crop for human consumption. Wheat is a self-pollinated crop of the member of Poaceae family and one of the most leading cereals of many countries of the world including India, and comes under *Triticum* genera. Among cultivable species hexaploid wheat (*Triticum aestivum* L., 2n=42) is the most common wheat and occupies more than 90% of the total area under wheat cultivation. Wheat is generally grown in every state of the country. However, Uttar Pradesh Punjab, Haryana, Madhya Pradesh Rajasthan, Bihar, Gujarat, Maharashtra, Jharkhand and Chhattisgarh are the major wheat producing states of the country. Due to the presence of gluten content, a major wheat protein, in common wheat, its main preparation is chapatti and baked breads. The hexaploid wheat came into existence by virtue of spontaneous evolutionary process with having three genomes (AABBDD) coming from different species and diploid condition of hexaploid wheat arose through a natural amphidiploids process. In wheat gene responsible for dwarfness is *Rht1 and Rht2.*

India ranks second in wheat area and production after China. India's share in world wheat production is about 11.39% and in area is about 12.5% (FAOSTAT, 2015) (12). In India wheat occupies a total area of 31.53 million hectare with a record production of 95.85 million tons and productivity of 3040 kg/ha during 2014-15. It has good nutrition profile with 12.1 per cent protein, 1.8 per cent lipids, 1.8 per cent ash, 2.0 per cent reducing sugars, 6.7 per cent partisans, 59.2 per cent starch, 70 per cent total carbohydrates and provides 314K cal/100g of food. It is also a good source of minerals and vitamins *viz*., calcium (37 mg/100g), iron (4.1 mg/100g), thiamine (0.45mg/100g), riboflavin (0.13mg/100g) and nicotinic acid (5.4mg/100mg) (Lorenz and Kulp, 1991) (1). Drought is the cause for large grain losses every year, especially in developing countries and the current trend in global climate change will likely lead to further losses. The worldwide water shortage and uneven distribution of rainfall makes the improvement of drought tolerance especially important. Breeding for drought tolerance is a major objective in arid and semi-arid regions of the world due to inadequate precipitation, shortage of irrigation water and high water demand for crop evapo-transpirational in such climates. The basic knowledge of genetics is useful for the development of new varieties. Water stress is the major limiting factor in crop production worldwide. Yield is the principle selection index used under drought stress conditions.

Materials and Methods

The experimental material considered of 10 accessions of wheat. The material was grown in complete randomized design with three replication at the experimental farm of Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), during *Rabi* season of 2014-2015 under two environments i.e. normal (NC) and water stress (WS) conditions. Each individual plot considered of 3 rows, each of 5m length. All the recommended agronomic and cultural practices were followed for raising a good crop. Data were recorded on twelve randomly selected plants per replication of each genotype for the following 12 agronomic traits namely days to 50% flowering, plant height, number of spike per plant, spike length, number of spikelet per spike, number of grains per spike, grain yield per plant, biological yield per plant, harvest index, 1000-grain weight, shoot length, root length.

Results and Discussion

The analysis revealed significant differences among the genotypes for all the traits under study (Table-1).

In the present investigation, analysis of variance for parents and F_1s showed highly significant differences among the treatments for all the characters. Substantial amounts of variations in wheat different agronomic traits have also been reported. Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability (h^2) and genetic advance as percent of mean (GA) are given table-2.

The data revealed that PCV was highest for biological yield per plant (22.75) followed by grain yield per plant (20.75), root length (17.25) in normal water condition. Whereas, the PCV value for biological yield per plant (20.54) followed by number of spike per plant (20.31) and grain yield per plant (19.75) in water stress condition. Similar trend has been recorded for GCV. The PCV estimates were relatively higher than the GCV for all the characters.

To determine the amount of heritable variation, estimates of GCV alone are not sufficient. Heritable variation can be determined with greater degree of accuracy when heritability is studied in conjunction with genetic advance. Genetic variability is very important for the improvement of crop plants. More variability in the population, the greater chance for producing desired plant types.

The heritability, which is the ratio of genotypic and phenotypic variance is mainly due to additive gene effects in narrow sense, but in the broad sense it include both additive as well as non-additive gene effects (2). The heritability values estimated in the present study are expressed in broad sense. Moreover, broad sense heritability and narrow sense heritability are generally negatively correlated (3). If heritability was mainly due to additive effects, it would be associated with high genetic gain; on the other hand, if it is due to non-additive gene effects, genetic gain would be low (4).

Heritability which is the heritable portion of phenotypic variance is a good index of transmission of characters from parents to offspring (5). In this study, heritability estimates are highest (97%) for plant height and lowest (39%) for spike length in normal condition (Table-2). Whereas, the heritability estimates are highest for (98%) for plant height and shoot length and lowest (35%) for harvest index. In general, the heritability values for all the characters studied are of high order, mostly above 90%.

The data estimates on genetic advance (as percentage of mean) expected from selecting 5% of the best genotypes for all 12 characters are presented in (Table-2). Highest value of genetic advance (as % of mean) was recorded for biological yield per plant followed by grain yield per plant, root length, number of spike per plant in normal condition; Whereas, number of grains per spike followed by grain yield per plant, biological yield per plant and root length in water stress condition (6).

The phenotypic correlation among traits is influenced by genotypic and environmental correlation coefficient. The genotypic correlation is usually attributed to pleiotrophy (7). The estimates of phenotypic and genotypic correlation coefficients for 12 agronomic characters are presented in Table-3.

Positive and significant phenotypic correlation among themselves were observed between plant height and days to 50% flowering; number of spike per plant and biological yield per plant; spike length and harvest index; biological yield per plant and grain per spike; harvest index and shoot length; 1000-grain weight and spikelet per spike; flag leaf area and plant height; days to maturity and harvest index; ash content and gluten per cent; gluten content and membrane stability index; chlorophyll content and relative water content; excised leaf water retention and number of spike per plant; proline content and drought susceptibility index; under normal and water stress condition (8).

Grain yield per plant was significant and positively correlated at phenotypic level (table 04) with plant height, spike per plant, root length, proline content, drought susceptibility index, flag leaf area, days to maturity and gluten per cent under water stress condition (9).

After that, the genotypic correlation coefficient studies that grain yield per plant had highly and positive correlation with plant height, spike length, harvest index, 1000-grain weight, shoot length, membrane stability index, gluten percentage in both the condition. Whereas, proline content and drought susceptibility index in water stress condition (10).

The plant height showed significant negative association with spikelet per spike, grains per spike and biological yield per plant under normal as well as water

Table-1 : Analysis of variance for different twelve characters wheat (*Triticum aestivum* L.) under normal (NC) and water stress (WC) conditions in diallel analysis.

Source of variance	d.f.	Conditions	Days to 50% flowering	Plant height (cm)	No. of spikes /plant	Spike length (cm)	No. of spikelets/ spikes	No. of grains /spike	Grain yield/ plant (g)	Biological yield/ plant (g)	Harvest index (%)	1000-grain weight (g)	Shoot length (cm)	Root length (cm)
Replications	2	NC	0.80	1.14	0.21	0.04	0.91	0.07	0.12	1.38	0.23	1.21	1.26	0.45
		WC	1.47	0.75	1.52	0.08	0.04	0.18	0.04	4.58	0.69	3.66	0.02	0.62
Treatments	54	NC	22.15	268.07	13.04	1.05	6.57	169.24	27.06	334.23	26.17	14.09	168.81	10.97
		WC	16.59	240.02	12.18	0.97	14.31	229.98	17.52	206.35	1.17	22.42	150.60	8.76
Error	108	NC	1.41	1.89	1.74	0.35	1.87	3.33	1.18	12.20	0.65	1.54	1.23	1.11
		WC	1.16	1.58	1.77	0.21	1.83	8.34	1.33	19.76	0.44	1.61	0.83	0.32

Table-2 : Mean performance, range, CV, GCV, PCV, Heritability, Genetic advance for twelve characters in wheat (*Triticum aestivum* L.) under normal (NC) and water stress (WC) conditions.

S. No.	Characters	Conditions	Mean performance	Range		GA as (%) of mean	GCV (%)	PCV (%)	Heritability (%)	Genetic Advance (GA)
				Min.	Max.					
1.	Days to 50% flowering	NC	91.69	85.66	98.00	5.38	2.86	3.14	82.00	4.93
		WC	91.75	84.00	97.00	4.59	2.47	2.73	81.00	4.21
2.	Plant height (cm)	NC	91.10	76.66	120.33	21.07	10.33	10.44	97.00	19.20
		WC	87.40	74.00	113.33	20.80	10.19	10.30	98.00	18.18
3.	No. of spikes/plant	NC	12.50	8.33	17.33	26.43	15.51	18.76	68.00	3.30
		WC	11.27	8.00	17.00	27.69	16.52	20.31	66.00	3.12
4.	Spike length (cm)	NC	10.48	8.83	11.96	5.96	4.59	7.30	39.00	0.62
		WC	10.32	8.76	11.80	7.44	4.88	6.60	54.00	0.76
5.	No. of spikelet/Spike	NC	20.73	17.66	24.00	8.33	6.60	6.03	45.00	1.73
		WC	18.17	14.00	23.00	19.25	11.12	13.47	69.00	3.49
6.	No. of grains/spike	NC	60.98	41.66	74.00	24.39	12.19	12.55	94.00	14.87
		WC	49.57	29.33	63.00	33.85	17.33	18.29	89.00	16.78
7.	Grain yield/plant (g)	NC	15.09	11.00	22.00	37.60	19.46	20.75	87.00	5.67
		WC	13.13	9.00	21.00	32.61	17.68	19.75	80.00	4.28
8.	Biological yield/plant (g)	NC	48.04	25.00	70.00	42.09	21.56	22.75	89.00	20.22
		WC	44.07	31.00	71.66	32.11	17.89	20.54	75.00	14.15
9.	Harvest index (%)	NC	31.68	28.67	40.77	18.26	9.20	9.55	92.00	5.78
		WC	29.89	28.75	31.70	2.03	1.65	2.77	35.00	0.60
10.	1000-grain weight (g)	NC	35.12	31.00	39.00	10.24	5.82	6.81	73.00	3.60
		WC	31.90	26.00	38.00	15.32	8.25	9.16	81.00	4.88
11.	Shoot length (cm)	NC	68.00	59.76	94.53	22.39	10.99	11.11	97.00	15.22
		WC	65.69	57.50	88.46	21.97	10.75	10.84	98.00	14.43
12.	Root length (cm)	NC	12.16	8.83	18.13	26.50	14.90	17.25	74.00	3.22
		WC	11.58	8.36	16.20	28.27	14.48	15.28	89.00	3.27

stress condition, it had non-significant association. The plant height had highly significant positive association with days to 50% flowering in normal condition and grains per spike with spikelet per spike in water stress condition. The spikelet per spike and spike length showed highest significant negative correlation in normal condition (11). In water stress condition, the plant height and grain yield per plant showed highest significant negative correlation.

Conclusions

In this experiment, to decide the different characters beheviour and performance in normal (NC) and water stress (WC) condition. Generally the 50% flowering, biological yield per plant, root length is positively correlated in water stress condition & rests of all are positive correlated with normal condition. So due to help of

Table-3 : Estimate of Genotypic correlation (upper diagonal) and Phenotypic correlation (lower diagonal) for 12 traits in bread wheat under normal (NC) condition in bread wheat.

Character	Days to 50% Flowering	Plant Height (cm)	Spikes/ Plant	Spike Length (cm)	Spikelet/ Spikes	Grains/ Spike	Biological Yield/ Plant (g)	harvest Index	1000 Grain Weight	Shoot Length (cm)	Root Length (cm)
Days to 50% Flowering	GC1.000 PC1.000	0.7175	-0.0292	0.0036	0.0142	-0.3150	-0.2415	0.2334	0.2191	0.6603**	-0.4419
Plant Height (cm)	0.6567	GC1.000 PC1.000	0.1920	0.0773	-0.0413	-0.4451	-0.4487	0.4564**	0.1483	0.8793**	-0.3530
Spikes/ Plant	0.0006	0.1569	GC1.000 PC1.000	0.1170	-0.2686	-0.1376	-0.1019	0.4547**	0.0084	0.1416	-0.0452
Spike Length (cm)	0.0255	0.0431	0.1715	GC1.000 PC1.000	-0.4772	-0.2625	0.1470	0.0229	0.0144	0.1736	-0.0647
Spikelet/ Spikes	0.0573	-0.0225	-0.0509	0.1218	GC1.000 PC1.000	0.2698	0.2809	-0.4346	0.3461	-0.0131	0.1040
Grains/ Spike	-0.2585	-0.4267	-0.0756	-0.0821	0.2762	GC1.000 PC1.000	0.3621*	-0.3171	-0.1818	-0.4240	0.0079
Biological Yield/ Plant (g)	-0.2063	-0.4161	-0.0042	0.1881	0.2820*	0.3779	GC1.000 PC1.000	-0.4608	-0.0196	-0.3876	0.0097
Harvest Index	0.1988	0.4255	0.3571*	0.0086	-0.2818	-0.2977	-0.4318	GC1.000 PC1.000	0.0386	0.4039**	-0.1676
1000 Grain Weight	0.1969	0.1422	0.0946	0.1036	0.2702	-0.1025	0.0348	0.0192	GC1.000 PC1.000	0.1271	-0.1458
Shoot Length (cm)	0.5893	0.8620	0.1254	0.1216	0.0026	-0.4068	-0.3582	0.3856	0.1091	GC1.000 PC1.000	-0.3055
Root length (cm)	-0.3119	-0.3069	0.0504	0.0616	0.1541	0.0592	0.0441	-0.1393	0.0093	-0.2474	GC1.000 PC1.000
Grain yield per plant (gm)	-0.1712	-0.3111	0.0756	0.1706	0.1649	0.2751	0.9330	-0.1126	-0.0001	-0.2686	-0.0373
	-0.1365	-0.2868	0.1406	0.2134	0.2276	0.3012S	0.9332	-0.0966	0.0555	-0.2439	0.0176

Table-4 : Estimate of Genotypic correlation (upper diagonal) and Phenotypic correlation (lower diagonal) for 12 traits in bread wheat under water stress (WC) condition in bread wheat.

Character	Days to 50% Flowering	Plant Height (cm)	Spikes/ Plant	Spikes Length (cm)	Spikelets/ Spikes	Grain/ Spike	Biological Yield/ Plant (g)	harvest Index	1000 Grain Weight (gm)	Root Length	Shoot Length
Days to 50% Flowering	GC1.000 PC1.000	0.3482	0.0864	0.1826	0.0641	-0.0365	0.1160	0.1040	0.0567	-0.1401	0.3239
Plant Height (cm)	0.3267	GC1.000 PC1.000	0.4288	0.0980	-0.1272	-0.5038	-0.5240	0.3814*	0.1715	-0.3084	0.8574**
Spikes/ Plant	0.0957	0.3705	GC1.000 PC1.000	0.0539	-0.0390	-0.1447	-0.1815	0.3727*	0.0371	0.0213	0.4436
Spikes Length (cm)	0.1863	0.1257	0.1697	GC1.000 PC1.000	0.1970	0.2059	0.2215	-0.0086	-0.3109	-0.1012	0.0135
Spikelets/ Spikes	0.0918	-0.0590	0.1038	0.3665	GC1.000 PC1.000	0.6339**	0.2388	-0.1114	-0.0773	-0.1538	-0.1792
Grain/ Spike	-0.0080	-0.4532**	-0.0387	0.2558	0.6365	GC1.000 PC1.000	0.5757	-0.2298	-0.1286	0.0163	-0.4448
Biological Yield/ Plant (g)	0.1354	-0.4188	0.0022	0.3568	0.3745	0.5902	GC1.000 PC1.000	-0.3943	-0.1914	0.0507	-0.4601
harvest Index	0.1378	0.2329	0.2071	-0.0466	-0.0448	-0.1066	-0.2190	GC1.000 PC1.000	-0.0291	0.0105	0.5545**
1000 Grain Weight (gm)	0.0474	0.1467	0.0361	-0.2515	-0.0741	-0.1232	-0.2040	0.0166	GC1.000 PC1.000	0.0704	0.1803
Root Length	-0.1161*	-0.2759	0.0578	0.0244	-0.0495	0.0459	0.0961	0.0187	0.0419	GC1.000 PC1.000	-0.2406
Shoot Length	0.2997	0.8477	0.3597*	0.0351	-0.1229	-0.4068	-0.3825	0.3400*	0.1520	-0.2136	GC1.000 PC1.000
Grain yield per plant (gm)	0.1383	-0.5019**	-0.1396	0.2154	0.2308	0.5809	1.0029	-0.2640	-0.1993	0.0361	-0.4202
	0.1490	-0.4077	0.0247	0.3712	0.3924	0.6018	0.9662	-0.1336	-0.1859	0.0898	-0.3544

*,**, significantly at 5% & 1% probability levels, respectively.

this study we can used and provide better result where water scarcity is a major problem. Whereas, with the help of better management practices, improve water use efficiency and other plant breeding approach also we have sustain better result in water stress condition.

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Survey to Determine the Prevalence and Variability of Fusarium Wilt in Pigeonpea in the North Eastern Dry Zone

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Abstract

A rapid roving survey was conducted using GPS and GIS for three consecutive years, 2019, 2020 and 2021 at major pigeonpea growing areas of south India and deccan plateau belonging to Raichur district Lingasuguru taluk, Karnataka. Pigeonpea crop was prone to many diseases *viz*., collar rot, Fusarium wilt, dry root rot, sterility mosaic disease (SMD) and phytophthora blight. The maximum mean Fusarium wilt incidence of 44.0% was observed in Ammenagad village during 2020 over three years. The monocropping with the susceptible varieties such as Gulyal local, has been main reason for outbreak of disease.

Key words : *GIS, GPS, Fusarium, pigeonpea.*

Introduction

Pigeonpea (Arhar) commonly known as red gram or tur is a very old crop of this country. After gram, arhar is the second most important pulse crop in the country. Pigeonpea is a bushy shrub with thin stems and trifoliate leaves with a densely branching base. The plant's leaflets are oblong or elliptical in shape, and the stems' leaves are alternate and spirally organised (plate-1). Pigeonpea is prone to 100s of diseases and pests. The losses caused by the diseases are from 10 to 100 %. Collar rot, Fusarium wilt, dry root rot, sterility mosaic disease (SMD), and phytophthora blight are major loss causing diseases of pigeonpea. Among them Fusarium wilt caused *Fusarium udum* causes heavy losses upto 10 to 100% (Kannaiyan, 1984).

Materials and Methods

During the months of September, October and November 2019, 2020 and 2021. A Fixed plot survey was conducted for the occurrence of Fusarium wilt of pigeonpea was conducted using GPS coordinates in major pigeonpea growing areas of in thirty villages of Lingasusgur taluk, *viz.,* Echanal, Upperi, Gorebal, Gudihal, Buddini, Adavibhavi, Neeralakere, Baiyapur, Hilalpur, Ammenagad, Yaradoni, Karadkal, Kuppigudda, Hatti, Anwari, Kasaba Lingasuguru, Sarjapura, Chikka hesarur, Kalli lingasugur, Mincheri Amarawati, Gonwara, Parampur, Kachapur, Margantanal, Nagarhal, Harnapur, Santekallur, Mudgal, Mattur of during Survey was conducted at flowering to pod filling stage of the crop to determine the status of incidence of fusarium wilt. Observations were drawn for the disease incidence (Fig. 1, Table 1 & 2).

The following formula was used to calculate the disease incidence

$$\text{Disease incidence} = \frac{\text{number of plants wilted}}{\text{total number of plants}} \quad 100$$

$$\text{Disease incidence} = \frac{\text{number of plants rotted}}{\text{total number of plants}} \quad 100$$

Collection and isolation of diseased specimen : For three years in a row, the field survey was conducted in September and October. Plant samples affected by wilt were collected from various farmers' fields. Plant samples were brought to the lab after being collected and properly cleansed under running tap water. The roots and basal stalk portion of wilted plants were detached and dried in the shade for 3-4 days before being preserved for future use. A conventional tissue isolation method was used to isolate the pathogen. Pigeonpea plants with characteristic vascular wilt symptoms were collected from several places and used to isolate the disease. With the use of a sterile scalpel, the wilt-infected stem and roots were split open lengthwise.

The plant parts showing brown discoloration of vascular tissues were cut into small bits, surface sterilized by dipping in 1% sodium hypochlorite for one minute, then rinsed with 3 changes of sterile distilled water, blot dried and then transferred aseptically on to Petriplates containing sterilized PDA medium at equidistance @ 5 bits/Petriplate. The inoculated Petriplates were incubated at 25 ± 2^{o}C in an incubator.

Results and Discussion

A. Symptoms of Fusarium wilt observed in the field : The typical wilt symptoms were observed when the plants were of 4-6 weeks old. During the flowering and maturity


(a) Pigeonpea Flower


(b) Pod


(c) Pods


(d) Raecemes


(e) Healthy plant


(d) Mature pods

Plate-1 : Pigeonpea crop at different stages (a. Pigeonpea flower, b. Pod formation stage, c. Pods, d. Raecemes, e. matured pods and f. healthy pigeonpea plant).

Table-1 : Disease rating scale for Fusarium wilt of pigeonpea as reported by Pande et al. (2012) is furnished below.

Disease incidence (%)	Disease reaction
0 – 10	Resistant
10.1 – 20.0	Moderately resistant
20.1 – 40.0	Moderately susceptible
40.1 – 100	Susceptible

stage highest mortality of mature plants was seen. The infected plant depicted the withering and drying of green plant parts exactly as if they were suffering from drought. In the beginning it starts with yellowing of leaves and later dark purple band occur on the stem (Plate 2, Fig.-1). Drying starts from the collar region and extends upward to the branches and it gradually results in drying of leaves, stem, and branches and finally lead to death of the plant. Partial wilting is also common in the field due to lateral root infection. Tap root infection results in complete wilting of the plants (Plate-3, Fig-2). Stem discoloration can be observed in streaks or patches, which are clearly visible when the bark is peeled off.

Occurrence and distribution of diseases of pigeonpea : The pigeonpea crop is grown as solo crop in some areas especially in major pigeonpea growing areas of Lingasugur *viz*., Echanal, Upperi, Gorebal, Gudihal etc., A survey was conducted during September–November 2019, 2020 and 2021 to know the status of major diseases of pigeonpea and its incidence under field condition.

During the *Kharif* 2019 highest incidence of Fusarium wilt was observed in Upperi (25.00%) and village followed by Karadkal (21.86%) village. On contrary, the least wilt incidence of 0.50% was reported in Neeralakere village of Lingasuguru taluk of Raichur district. Similar studies were conducted by Bindhu *et al.* during 2017, 2018 and 2019 where in the taluk wise pooled data of *Fusarium* wilt for three consecutive years depicts that the highest wilt incidence was recorded in Chittapur taluk (20.9) followed by Jewargi taluk (20.8%) of Kalaburagi district. Mild wilt incidence was observed in Lingasugur (12.5 %) and Manvi (11.7 %) of Raichur district (table-4).

The highest incidence of 44.0% was observed in Ammenagad village, followed by Amaravathi village with incidence of 38.85%. while the least incidence of 2.00 per cent was recorded by Yaradoni village during the year 2020.

Fig.-1 : Cartographic representation of Lingasugur taluk.

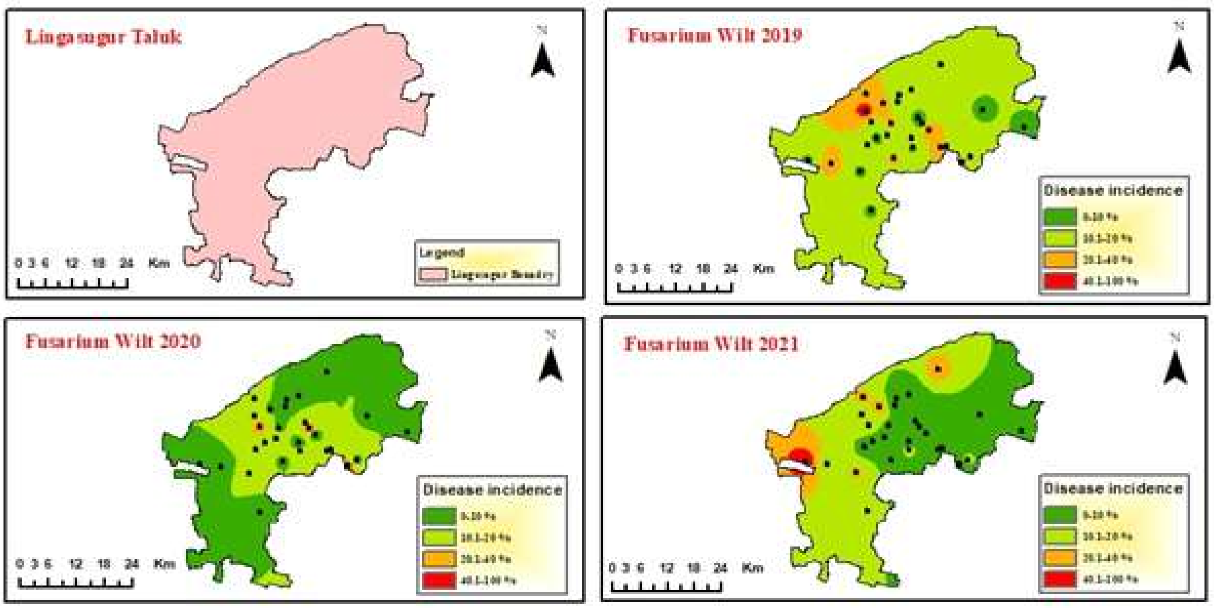

Fig.-2 : Cartographic representation of Fusarium wilt infected villages of Lingasugur taluk during 2019, 2020, 2021.

Gorebal village recorded the highest wilt incidence of 37.50 per cent during the year 2021 followed by 32.57 per cent by Parampur village. No incidence was recorded by Gonwar village of Lingasuguru taluk. These observations are in accordance with the studies of (Bidari, 1995; Butler, 1918 and Gaur and Sharma, 1989), Kannaiyan and Nene, 1981, Pawar *et al.* (2013), Muhammad and Mahesh 2005, Ravikumar, 2015. Sushreeta *et al*. conducted survey in different districts of Uttar Pradesh and recorded the highest wilt incidence of 59.6 per cent in Sultanpur district and in all other districts (Varanasi, Barabanki, Gorakhpur and Mirzapur) wilt incidence was ranged between 10.7per cent - 59.6per cent at different growth stages *viz*., flowering, pre-podding, podding and post podding stages. The results on survey were in confirmation with the studies conducted by Mohammed and Mahesh to identify the hot spots of *Fusarium* wilt of pigeonpea in different districts of Southern Karnataka for three consecutive *Kharif* seasons from 2004-05 to 2006-07.

Monocropping has been practiced in the villages pertaining to Raichur district also Fusarium wilt incidence is generally more in farmer's field with the local cultivars such as, Kari togari, Gulyal local and Kattibheeja as compared to improved cultivars. In addition cultivar Asha is considered to be a very good resistant source against Fusarium wilt across all the surveyed villages. Also the same old local varieties such as Gulyal local are the main reason for the outbreak of Fusarium wilt in larger aspect. Along with that lack of knowledge among the people about new resistant varieties such as GRG 811 and GRG 152 which is resistant for wilt.

(a) Purple banding on the **(b) Wilting of stem tissue** **(c) Partial wilting of symptom** **(d) Complete wilting**

Plate-2. Typical symptoms of Fusarium wilt in pigeonpea.

Plate-3 : Field depicting complete wilting of pigeonpea due to Fusarium wilt.

Conclusions

GIS and GPS serves as a common platform for convergence of multi-disease surveillance activities. It is a fantastic tool for visualising and analysing epidemiological data and finding trends, dependencies, and inter-connectivity The current study provides the data on the occurrence, prevalence and distribution of Fusarium wilt incidence in major pigeonpea growing areas of Lingasuguru taluk and to find out the hot spots of *F. udum* in different places. The pathogen is gaining more importance especially in the current scenario of climate change. Even though various control measures are taken so far, more focus on the breeding aspects so that the diseases will be prevented naturally with the innate resistance. The management of PB is essential to provide increased and stable pigeonpea yields throughout the pigeonpea growing regions. The PB management should not be completely rely on the use of fungicides, as the development of fungicide resistance in Phytophthora spp. has been commonly observed. Hence, IDM programs suitable for adoption by resource poor farmers should be emphasized. It is advised that the PB management in pigeonpea should be based on the location specific disease predictive models.

HPR should be emphasized over other control measures as the most environmental-friendly and economic disease control strategy. Selection of resistant sources for genetic improvement programs should be based on resistance to PB at seedling, vegetative, flowering and podding stages since many lines resistant in seedling/vegetative stage can be susceptible/or show disease symptoms at later growth stages. However, there is a need of developing inoculation and screening procedures for exploiting HPR.

Table-2 : Survey for the incidence of Fusarium wilt in major pigeonpea growing areas of Lingasugur taluk for three consecutive years (2019, 2020, 2021).

Sl. No.	Village	Latitude	Longitude	Variety	Soil type	Disease incidence *Fusarium* wilt (%)		
						2019	2020	2021
1.	Echanal	16.173942364432193	76.43873237474632	TS-3R	Red soil	10.00	35.00	27.50
2.	Upperi	16.195950895623753	76.42731689341558	TS-3R	Red soil	25.00	17.65	15.65
3.	Gorebal	16.210222278967045	76.4620712654747	TS-3R	Black soil	15.10	10.70	37.50
4.	Gudihal	16.041091544068223	76.70345648337864	Gulyal	Red soil	3.50	15.50	7.23
5.	Buddini	15.930278402283928	76.79040297165551	Gulyal	Black soil	14.50	7.73	10.00
6.	Adavibhavi	16.15015140433791	76.47089052388418	TS-3R	Black soil	10.30	23.75	7.28
7.	Neeralakere	16.142883443350737	76.44859109597215	TS-3R	Red soil	0.50	17.60	2.76
8.	Baiyapur	16.09639096716929	76.35622072402442	Gulyal	Black soil	16.78	2.30	16.70
9.	Hilalpur	16.048605680994083	76.68559660686059	GRG-811	Black soil	10.90	3.75	7.23
10.	Ammenagad	16.110460303015557	76.72233214142393	Gulyal	Black soil	2.70	44.00	10.00
11.	Yaradoni	16.16289791685124	76.74275984536386	GRG-811	Black soil	17.89	2.00	5.73
12.	Karadkal	16.158898262952874	76.55318342625417	TS-3R	Black & Red soil	21.86	3.50	7.72
13.	Kuppigudda	16.124855481169455	76.57791141416969	TS-3R	Black soil	18.67	17.50	10.23
14.	Hatti	16.19606711668055	76.66148181786735	GRG-811	Black soil	4.69	10.00	7.75
15.	Anwari	16.16289791685124	76.74275984536386	TS-3R	Black soil	5.43	5.50	10.00
16.	Kasaba Lingasuguru	16.125087003642744	76.51989984688865	TS-3R	Black soil	4.67	17.35	15.73
17.	Sarjapura	16.12881323371069	76.58623699068504	TS-3R	Black soil	10.00	13.50	2.75
18.	Chikka hesarur	16.105560305304603	76.63670543558348	TS-3R, Gulyal	Red soil	7.5	7.70	13.77
19.	Kalli lingasugur	16.10463738003517	76.48367929683305	TS-3R	Black soil	14.23	10.00	7.70
20.	Mincheri	16.214231301449345	76.49222808397408	Gulyal	Red soil	12.24	5.23	1.50
21.	Amarawati	16.095829548369114	76.62065509659355	TS-3R	Black soil	14.60	38.85	8.23
22.	Gonwara	16.092036073054974	76.60091403887675	Gulyal	Black soil	7.50	8.26	0.00
23.	Parampur	16.28460259144882	76.57685714214615	TS-3R	Red soil	10.70	7.23	32.57
24.	Kachapur	16.08047442376144	76.41595888336927	TS-3R	Black soil	5.55	22.56	26.78
25.	Margantanal	16.13028153083976	76.43089342330724	Gulyal	Black soil	13.60	12.70	7.28
26.	Nagarhal	16.101009000236722	76.31321954948018	TS-3R	Black soil	5.75	3.75	48.50
27.	Harnapur	16.0257876807873	76.28978777171872	TS-3R	Black soil	7.50	4.56	1.28
28.	Santekallur	16.05504425236521	76.6586486999207	TS-3R	Black soil	17.00	17.86	28.67
29.	Mudgal	16.00353348427886	76.43574699932957	TS-3R, Gulyal	Red soil	6.32	5.76	12.73
30.	Mattur	16.039327219273414	76.50678016398346	TS-3R	Red soil	10.50	17.78	1.20

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Design and Development of Milk Flake Formation System for Production of Rabri

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Abstract

Rabri is a concentrated sweetened milk dessert containing several layers of clotted cream. The traditional method of rabri preparation is done in small batches and is time-consuming. In the present study, a milk flake formation system was designed and developed to produce rabri and reduce the total production time. The system consists of a vertical scraped surface heat exchanger, scraper blade assembly, drive motor, milk-distributing unit and control unit. Fixed parameters were steam pressure (1.5 kg/cm2), scraper speed (130 rpm) and milk flow rate (400 l/h). The developed system was evaluated, and the variable parameters were the type of milk (buffalo milk and cow milk) and initial total solids of concentrated milk (18, 22, 26 and 30 %). The responses for this study were production time, the final yield of product, condensate quantity, condensate outlet temperature, and flakes quantity. It was observed that production time decreased significantly ($p<0.05$) when the concentration of milk changed. As a result, there was a significant ($p<0.05$) reduction in concentration-time, power and steam consumption. The rate of flake production was 12.34 g/min. Buffalo milk at 26 % total solids (T.S.) was found as an optimised parameter based on numerical optimisation (desirability = 0.65).

Key words : *Rabri, clotted cream, vertical scraped surface heat exchanger, concentrated milk.*

Introduction

Milk is considered a complete food, and India has ranked first in terms of milk production for last decades, with a current annual production of 198.4 MT (NDDB, 2019-2020). Out of this total produced milk, 50-55% of milk is converted into traditional milk products. In India, the unorganised dairy sector and village households utilise a large quantity of milk. Around 70% of the total produced milk is coming from marginal or small-scale milk producers (Sain et al., 2020). Out of total milk utilised by the organised sector, indigenous dairy products are India's largest selling and the most profitable segment after liquid milk accounting for 55% of milk utilisation which is converted into Dahi, Makkhan, Ghee, Khoa, Chhana, Rabri, Paneer and variety of sweets. Many traditional dairy products, particularly khoa-based sweets like burfi, peda, pantoa, gulabjamun etc., Channa and channa-based sweets like Rasogolla, Rasmallai etc. and Paneer, kheer, Dahi has enormous market presence and tremendous consumer base in India and overseas as well. The other popular Indigenous milk products, such as rabri, basundi, shrikhand, kunda, paladapyasam etc. are region specific.

The conversion of surplus milk into these indigenous products not only extends the shelf life at ambient temperature but also adds value and makes it more profitable as compared to its fluid form. The characteristic features of the cottage level technology involve the application of simple equipment, low-grade energy sources and simple process control concepts. These small-scale technologies cannot be applied to industrial production. Therefore, wide varieties of Indian milk products have undergone needed technological changes, resulting in the development of equipment for the same (Aneja, 1992). Still, there is a need to develop equipment for commercial production for many popular traditional Indian dairy products. One such product is rabri.

Rabri, a popular dairy delicacy of North India, is still manufactured by halwais on a small shop level. Rabri is a concentrated and sweetened whole milk delicacy containing several layers of clotted cream and skimmed off from slowly evaporated milk (De, 1980; Aneja, 1992). For the preparation of rabri, small quantities of whole milk are maintained nearest to the boiling point in fairly large-sized evaporating pans as the milk evaporates slowly, skin forms on the surface. This skin is carefully removed by a flat-edged scraper and stuck on the cooler edges of the pan so as to get partially desiccated (Srinivasan and Anantakrishan, 1964). For large-scale production of Rabri, vacuum concentration of milk followed by blending it with required quantities of sugar and malai was attempted by Gayen and Pal (1991b).

Rangappa and Achaya (1971) studied that during rabri preparation, milk is not stirred, and the solid product is separated from the milk by peeling off a thin film of coagulated material successively from the surface using bamboo splints. The weight of rabri will be one-fourth to one-third of the milk used. Buffalo milk is mostly used for the production of rabri, owing to its high total solids and superior taste in the final product.

Chopde *et al*. (2016) developed an in-line system for the production of rabri by integrating scraped surface heat exchanger with conical process vat. Saroj et al. (2010) optimised the process parameters of a three-stage scraped surface heat exchanger for continuous rabri production.

The conventional method of rabri making is very time-consuming and energy-intensive. Removal of clotted cream is tedious and requires slow heating at simmering temperatures. The batch process takes 3-4 hrs for 3 kg rabri from 10 kg milk. Clotted cream (Malai), an important intermediate product that predominantly contributes to desired flaky texture of rabri, is obtained by simmering milk at 80-85 °C in a shallow pan. The formation of clotted cream layer requires prolonged slow heating and is a major constraint for the process mechanisation of rabri. Using the traditional process, large-scale production of rabri is not possible. Therefore, it was envisaged to develop a milk flake formation system for the production of rabri.

Materials and Methods

Experimental setup

Milk flake formation system : The setup of the milk flake formation system consisted of vertical SSHE, scraper assembly, balance tank, feed pump, milk distribution unit and milk pipelines (Fig.-1).

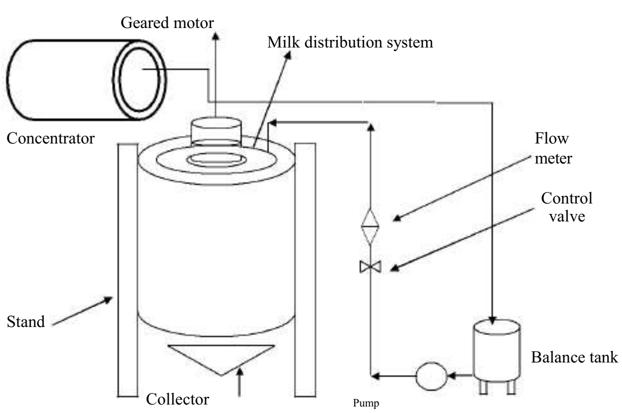

Figure-1 : Conceptual diagram of milk flakes formation system integrated with concentrator.

1. Vertical scraped surface heat exchanger : Vertical SSHE was used to make milk flakes (specifications mentioned in table 1). Prime mover gear-motor assembly drives the scraper assembly of SSHE, and Variable Frequency Drive (VFD) controlled motor speed. Other components of SSHE are vapour vent, steam trap, pressure gauge, air vent and safety valve.

Table-1 : Technical specification of vertical SSHE.

Particulars	Details
Type	Thin film
No. of blades	2 (1Scraping and 1 film forming)
MOC (Blades)	SS 304
MOC (Inner cylinder)	SS 304
MOC (Outer Jacket)	Mild steel
Inner cylinder (di)	0.34 m
Inner cylinder (do)	0.44 m
Inner length (Li)	1.19 m
Jacket	(Di) 0.44 m
Jacket	(Do) 0.56 m
Jacket length	0.78 m

2. Rotor-Scraper Assembly : It consists of one flat blade for scraping and one butterfly wing-shaped structure joined to each other at two points through two stainless steel bars. The bar transmits power from one end of the scraper assembly to another end and bears the weight of blades. The details for scraper blade assembly are given in table-2.

Table-2 : Technical specification of the scraper blade assembly.

Particulars	Dimensions (cm)
Total shaft length	60
Shaft diameter	3.2
Length of scraper blade	70
Breadth of scraper blade	3
Thickness scraper of blade	0.5

3. Milk distribution system : The milk distribution system (Fig.-2) was used to distribute the milk uniformly across the SSHE walls. The technical specification of the milk distribution system is given in Table-3.

Table-3 : Technical specification of the milk distribution system.

Particulars	Dimensions (cm)
Outer diameter of distributor	30
Inner diameter of distributor	28
No. of holes	70
Holes diameter	0.25
Distance between each hole	0.15

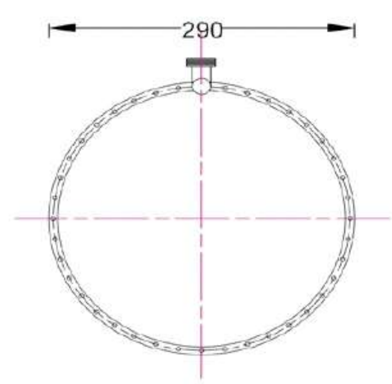

Figure-2 : Milk distribution system.

Table-4 : Experimental design for the research work.

Process Parameters		Levels
Variable parameters	Type of milk	Buffalo milk
		Cow milk
	Milk T.S.	18%
		22%
		26%
		30%
Fixed parameters	Scraper speed	RPM-130
	Steam pressure	1.5
	Milk flow rate	400 l/h

4. Geared motor : The geared motor drove the SSHE scraper assembly to operate the scraper within a predetermined rotational speed range (max. 100 rpm).

5. Variable frequency drive (VFD) : A Variable-Frequency Drive (VFD) is a device, which is used to regulate the frequency being supplied to a motor and thereby controls the speed of the motor. VFDs may be referred to by a variety of other names, such as variable speed drives, adjustable speed drives, or inverter drives.

6. Feed pump : The sanitary type centrifugal pump (5000 l/h) was used as the feed pump. The flow control valve fitted in the pipeline control the milk flow rate. The flow rate was kept constant at 400 l/h during the trials.

7. Flow control and return valve : A three-way valve (SS304) was connected to the milk distribution system and another line from the valve connected to the balance tank. The main purpose of the three-way valve at the distribution line was to control the concentrated milk flow through the distribution system.

8. Balance tank : A tank (SS 304) of 50-litre capacity with 0.65 m diameter and 0.80 m depth was used as a balance tank. It was connected with the feed pump to the distribution system for milk flow; the control balance tank was connected to the feed tank through the three-way valve. Milk was re-circulated through the milk flake formation system.

Measured parameters

1. Inlet feed temperature
2. Production time
3. Quantity of milk flakes
4. Flakes production rate

9. Product tank : A tank (SS 304) of 90-litre capacity with 0.56 m diameter and 0.38 m depth was used as an intermediate tank. It was placed at the outlet of SSHEE.

10. Steam pressure gauge : Pressure gauges were used to indicate the steam pressure inside the shell maintained to carry out the present investigation. The pressure gauge consists of a safety valve and air vent valve for proper functioning.

11. Concentrator (Horizontal SSHE) : The scraper assembly of SSHE was used to concentrate milk, is driven by prime mover gear-motor assembly and motor speed was controlled by a Variable Frequency Drive (VFD). Other components of SSHE are vapour vent, steam trap, pressure gauge, air vent and safety valve.

Experimental procedure : Trials were planned according to the experimental design shown in table-4.

Optimisation of process parameters : Design Expert 10 statistical analysis software was used for the optimisation of process parameters. The software prepared the factorial experimental design, and after trials, data were analysed. Only significant parameters were considered during the optimisation process. The criteria for process optimisation are shown in Table-5.

Table-5 : Criteria for process optimization.

Parameters	Goal	Lower Limit	Upper Limit	Importance
Inlet feed temperature (°C)	maximise	65.67	69.33	3
Production time (min)	minimise	40	61.67	3
Quantity of milk flakes (gm)	maximise	256.67	487.17	3
Flakes production rate (gm/min)	maximise	4.20	12.34	3
Condensate quantity (gm)	minimise	6113.33	10365.30	3
Product yield (%)	maximise	22.83	31.17	3

Performance evaluation parameters

1. Inlet feed temperature : Milk inlet temperature (°C) was measured by placing a pt-100 temperature probe in the milk feed tank of SSHE. The temperature probe was interfaced with the data logger, and the sampling time was set to 5 s. The average value of milk inlet temperature was calculated using the recorded data.

2. Production time : The process of production was achieved by re-circulating the milk in vertical SSHE at fixed scraper speed. The time taken to achieve the final concentration of milk (35% T.S.) and the production of flakes was measured as production time in minutes.

3. Quantity of milk flakes : The quantity of milk flakes was calculated with the help of an electric weighing balance. The flakes that were collected in the sieve were transferred to an already weighed vessel, and the weight reading was taken for the total production of milk flakes.

4. Flakes production rate : The flakes production rate was calculated based on the total quantity of flakes produced in gm and the total time taken in minutes by the system for production.

$$\text{Flake production rate } \frac{9}{\text{min}} = \frac{\text{Total flakes obtained in gm}}{\text{Total time taken in minutes}}$$

5. Condensate quantity : SSHE steam consumption was estimated by measuring the quantity of condensate collected at the steam trap. At the start of the trial, 2 kg of water was taken in a bucket, and a condensate hose pipe was dipped into the water. Water is taken in the bucket to avoid the formation of flash vapour of condensate, and it gives an accurate quantity of condensate. The quantity of condensate collected was calculated as the difference between the initial and final weight of the bucket. The steam consumption was measured in kilogram (kg).

6. Product yield : Product yield was calculated by the ratio of the total production of rabri to milk taken for production.

$$\text{Production yield (\%)} = \frac{\text{Final product (kg)}}{\text{Initial quantity of milk (kg)}} \quad 100$$

Results and Discussion

Inlet feed temperature : The inlet feed temperature of milk did not vary significantly during the trials (Fig. 3). Milk, after a concentration at a temperature of 101oC was transferred to the feed tank of the milk flake formation system. As the pipelines and the feed tank were not insulated, it resulted in a drop in temperature. The temperature of the feed was between 60°C to 70°C for both types of milk (buffalo and cow milk). Therefore, a higher preheating temperature is recommended for rapid flakes formation system.

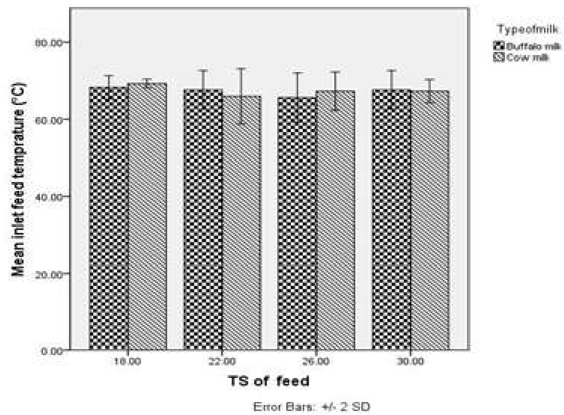

Fig.-3 : Effect of type of milk and T.S. of feed on inlet feed temperature.

Production time : Production time was calculated by the time taken by the flakes formation system for the production of the final product rabri. Production time decreased significantly ($p<0.05$) with an increase in feed T.S. (Fig.-4). It was due to a higher concentration of milk resulting in a higher rate of flake production. It was observed that higher milk T.S. increased the residence time in the system, and a thick layer of milk film was formed in the system. During continuous scraping operation, the thicker film was easily scraped off compared to film form by lower T.S. Milk.

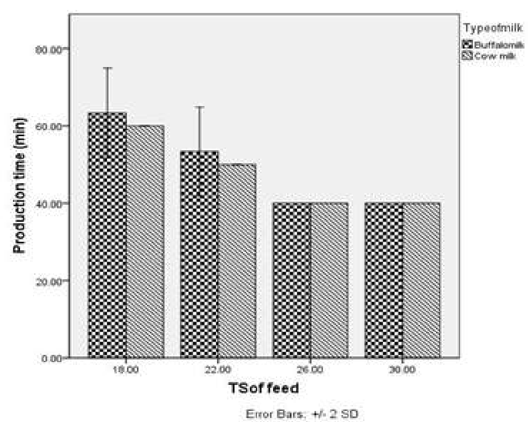

Fig.-4 : Effect of type of milk and T.S.of feed on production time.

Quantity of milk flakes : The quantity of milk flakes increased significantly ($p<0.05$) with the increase in feed T.S. From Fig.-5, it is evident that the quantity of milk flakes was comparable in the case of both types of milk, buffalo as well as the cow. Flake quantity was slightly higher in buffalo milk. It may be due to more total solids and fat content in buffalo milk. It was observed that flakes were easier to scrape off in the case of buffalo milk as compared to cow milk. It may be due to higher fat/oil content in the film, and it reduced the tendency for the milk film to stick to the hot metallic surface. SSHE is most suitable for handling the viscous product with or without particles, products that tend to foul the heat transfer surface (Pujrath et al., 1990; Rajorhia et al., 1991; Dodeja, 2006). As the SSHE cylinder was made by welded sheet, there were few areas on the internal surface, which were not smooth. Sometimes it resulted in certain problems. Good scraping of milk flake was not possible in certain areas due to uneven internal surface. It caused fouling and the formation of burnt particles. It also created a problem during the CIP of the milk flake formation system. It is recommended to develop a flake formation system using a seamless pipe.

Flakes production rate : Flakes production rate was significantly ($p<0.05$) affected by the type of milk and feed T.S. Figure 6 shows that the flakes production rate was maximum for buffalo milk. It may be due to more total solids contents in milk. The maximum flakes production rate was 13.30 and 13.20 g/min for buffalo and cow milk, respectively.

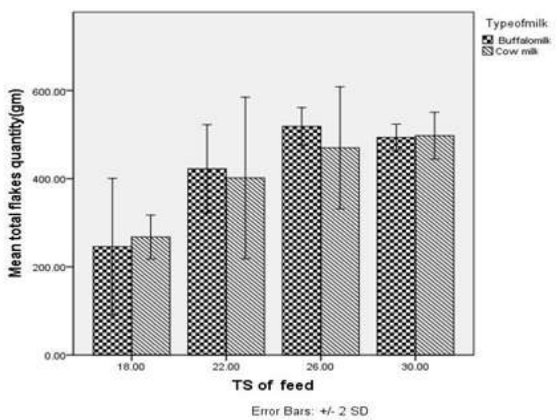

Fig.-5 : Effect of type of milk and T.S. of feed on production on total flakes quantity.

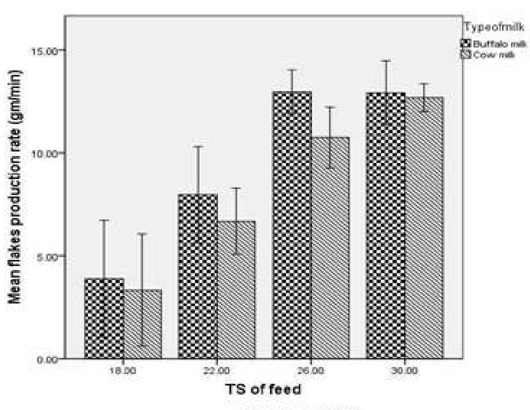

Fig.-6 : Effect of type of milk and T.S. of feed on flakes production rate.

Condensate quantity : The condensate quantity was significantly ($p<0.05$) affected by the type of milk and feed T.S. Condensate quantity was calculated by taking a reading of every 10 min of condensate quantity. The condensate quantity decreased by increasing the concentration of milk in the milk flakes formation system. As initial total solids content in feed increased, a lower evaporation rate was required for milk flake formation. It could be one of the reasons for the reduction in condensate quantity. The maximum value of condensate obtained was 12.30 kg at 18 T.S. and minimum (6.1 kg) at 26 T.S. For cow milk, it was maximum (10.27 kg) at 18 T.S. and 5.1 kg at 26 T.S.

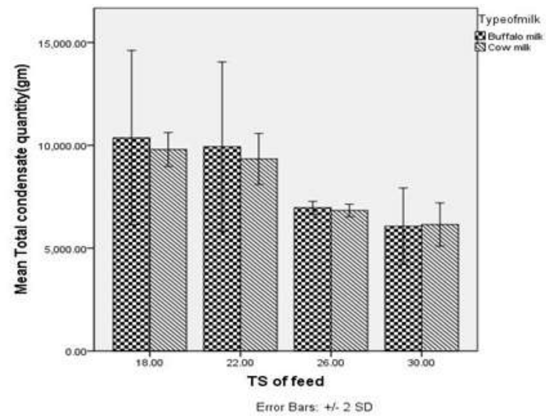

Fig.-7 : Effect of type of milk and T.S. of feed on total condensate quantity.

Product yield : Product yield (percentage) was calculated based on the ratio of final product rabri to initial milk quantity. A higher product yield is desirable for better cost economics in commercial rabri production. Maximum and minimum product yield was 35.50 % and 25.50 %, respectively. It was in the range of 21-25.50% for cow milk. Product yield was higher for buffalo milk which may be due to more total solids contents in buffalo milk.

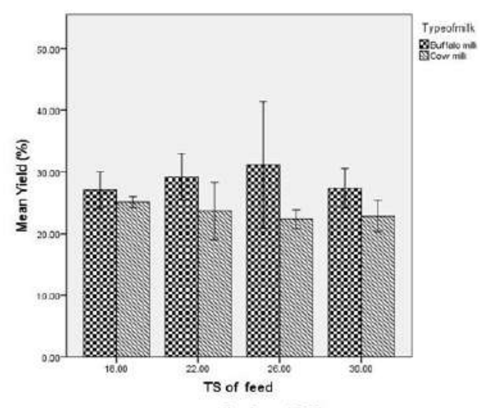

Fig.-8 : Effect of type of milk and T.S. of feed on mean yield.

Conclusions

The milk flake formation system was designed for the production of traditional milk product rabri. Traditional Indian dairy products require the pre-concentration process to convert into a delicious sweetmeat. The use of a milk flake formation system can help to reduce the energy requirement as well as the time of processing.

Table-5 : Optimisation solution of milk flake formation system using Design expert.

Type of Milk	TS of Milk	Inlet Feed	Production time	Qty. of Milk Flakes	Flakes Production Rate	Condensation Quantity	Yield
(B & C)	18-30	(°C)	(min)	(gm)	(gm/min)	(gm)	(%)
BUFFALO	26.00	65.67	40.00	487.17	12.34	6333.33	31.17
BUFFALO	22.00	67.67	51.67	412.17	8.00	9933.33	29.17
BUFFALO	30.00	67.67	40.00	487.50	12.68	6113.33	27.33
COW	26.00	67.33	40.00	487.17	12.34	6633.33	22.33
COW	22.00	66.00	51.67	412.17	8.00	7073.33	23.68
BUFFALO	18.00	68.33	61.67	256.67	4.20	10365.30	27.02
COW	18.00	69.33	61.67	256.67	4.20	9800.00	25.07
COW	30.00	67.33	40.00	487.50	12.68	8846.67	22.83

Results of the preliminary trials in steam jacketed kettle confirmed the feasibility of production of milk flake for rabri. Based on that milk flake formation system was designed and developed. The system was based on a vertical SSHE. Effect of type of milk (buffalo milk & cow milk) and different total solids concentrations of milk on inlet feed temperature, flakes quantity, production time, the final yield of product and condensate quantity were studied. The production time was reduced, and flake quantity and product yield were maximum in the case of buffalo milk. Design expert software 10 was used for the optimisation of the final product. Buffalo milk at 26 T.S. concentrations was selected for an optimised product with 65 % of desirability.

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Response of Different Substrates on Germination, Growth and Flowering of Marigold

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Abstract

The present investigation was carried out to study the effect of different substrate combinations on seed germination, growth and flowering of different varieties/ genotypes (Pusa Narangi, Pusa Basanti, Hisar Jaffri-2 and MGH 10/206) of marigold at passively ventilated greenhouse of Agri-tourism Center, CCS Haryana Agricultural University, Hisar. Five substrates *i.e.* cocopeat, perlite, vermiculite, vermicompost and send were used to create the different treatments in different proportions. The results indicate that genotype MGH 10/206 took lesser days for first flowering with longer duration having more number of flowers per plant with the T_2 substrate (cocopeat + vermiculite + perlite, 3:1:1).

Key words : *Substrates, marigold, germination, flowering, yield.*

Introduction

Marigold (*Tagetes erecta* L.) seems to have gained the cultural status of one of the world's most commercially valuable flowers. It accounts for over half of the nation's loose flower production in the Indian subcontinent. It is mainly used to make garlands, beatification, religious offerings and social functions. Marigold has an advantage over loose flower in vogue from the point of view of commercial marketing and revenue generation, followed by chrysanthemum, jasmine, tuberose, crossandra and barlery (Bhattacharjee, 2003). It is widely grown for its natural dye extraction, essential oils, and exquisite blooms and also used by physician to heal and cure basic diseases as part of herbal therapies (Raghava and Saxena, 2001). In heavy soil without enough drainage, the development of root system is suppressed and plants are most susceptible to soil borne diseases (Beattle and White, 1992). Growing media also plays important role for seed germination. Growing medium not only acts as a growing place but also as a source of nutrient for plant growth, media composition used influences the quality of seedling (Wilson *et al.,* 2001). Generally, media for seedling are composed of soil, organic matter, pond soil and sand. The soil is usually used as a basic medium because it is cheapest and easy to procure. Supplementing of the sand is aimed to make media more porous, while the organic matter (vermicompost) is added so as to enrich adequate nutrients for the seedling. There is better relationship between the manure and rooting rather than conventional soil mix and less susceptibility of the seedling to the soil borne pests and diseases. Several studies on the growth media had been conducted on the various horticultural crops by previous researchers.

Cocopeat is an agricultural by-product obtained after the extraction of fiber from the coconut husk (Abad *et al.,* 2002) as a growing medium, cocopeat can be used to produce a number of crop species with acceptable quality (Yahya *et al.,* 1999; Yau and Murphy, 2000). Although the cultivation in soil is inexpensive, but it brings about some risks like-soil borne disease, insect and pest. Cocopeat is considered as a good growing media component with acceptable pH, EC and other chemical attributes (Abad *et al.,* 2002). Substrate has a direct effect on the development and performance of root system (Abad *et al.,* 2002). The most primary roots in each plant, the length of the longest root string, root and shoot dry weight was obtained from perlite, Fine peat + perlite and peat substrates (Ercisli *et al.,* 2005) and fresh root weight (Selda and Anapali, 2010). The results of many experiments revealed that cocopeat used alone or as a component of soil or other soilless medium, suitable for roses (Blom, 1999), gerbera (Labeke-Van and Dambre-Van, 1998), many potted plants (De-Kreij and Leeuven, 2001; Treder, 2003). Keeping in view the influence of different media *viz.,* sand, cocopeat, perlite, vermiculite, vermicompost and FYM was studied on germination, growth and flowering in marigold.

Materials and Methods

The experiment was carried out in a passively ventilated greenhouse at Agri-tourism Center, CCS Haryana Agricultural University, Hisar (Haryana). In the study, Pusa Narangi, Pusa Basanti, Hisar Jaffri-2 and MGH 10/ 206 cultivars was used during the year 2015-16 to 2017-18. The plants were cultivated in different growing media. Five substrates sand, cocopeat, perlite, vermiculite and vermicompost were used to create the seven different treatments in different proportion (by volume) for the cultivation. The seven-substrate mixtures with five replications /treatments (with 5 plants/ replications) were arranged in single rows on a greenhouse trough. The treatments were :

T_1 – cocopeat + vermicompost + perlite (1:1:1)

T_2 – cocopeat + vermiculite + perlite (3:1:1)

T_3 – cocopeat + vermiculite + perlite (1:1:1)

T_4 – sand + vermicompost (9:1)

T_5 – sand + FYM (9:1)

T_6 – sand + vermiculite (9:1)

T_7 – sand (control)

The seeds of marigold were sown in planting with above media combination under greenhouse condition during the September–October after treating with fungicide. The greenhouse with facility of controlling temperature, humidity and light with automation system for irrigation and fertigation was used. After recording of data of seedling plants, the plants were transplanted in open field. The transplanted plants were kept under uniform condition during the study period where all the management practices were carried out as per the package of practices. The data were analyzed according to the procedure for analysis of completely randomized design (CRD) as given by Panse and Sukhtme (1984). The overall significance of difference among the treatments was tested, using critical differences (C.D.) at 5% level of significance. The results were statistically analyzed with the help of a windows based computer package OPSTAT (Sheoran *et al.,* 1998).

Results and Discussion

The data presented in Table-1 showed that cultivar Pusa Narangi showed highest germination (73.4%), which was statistically at par with Pusa Basanti (73.1%) followed by Hisar Jaffri-2 (62.9%), whereas, lowest germination was reported from MGH 10/206 (35.1%). The seed sown in the substrate combination, cocopeat: vermiculite: pertlite (3:1:1), resulted into highest germination followed by T_3 (63.9%), while minimum per cent germination (52.9%) was observed from control. Seeds of Pusa Basanti in substrate combination T_2, resulted highest germination percentage (84.2%) over all other media and cultivars, except Pusa Narangi cultivar in T_2 (80.2%).

Different substrate combinations significantly affect the days taken to 50 per cent germination in different cultivars of marigold (Table-2). The minimum days for 50% germination (6.3 days) was observed from T_2 (cocopeat: vermiculite: perlite, 3:1:1) followed by T_5 (8.7 days) and maximum days for 50% germination (12.0 days) was found in sand alone (control). In case of cultivars/ genotypes lowest days for 50% germination (8.5 days) was observed in Hisar Jaffri – 2 followed by Pusa Narangi (9.0 days). Hisar Jafri-2 cultivar of marigold with media cocopeat: vermiculite: perlite (3:1:1) significantly taken less days for 50 per germination (3.8 days) over all other treatment combinations.

The seedling length of different cultivars of marigold significantly influenced with various substrate combinations and interaction between the cultivars and substrates (Table-3). The results showed that Hisar Jaffri-2 cultivar of marigold resulted highest seedling length (7.1 cm) followed by MGH 10/206 (6.7 cm), whereas, lowest seedling length was measured in cultivar Pusa Basanti (5.7 cm). Seeds grown in cocopeat + vermiculite + perlite (3:1:1), substrate combination resulted higher seedling length (7.8 cm) compared to the other media combinations. When cultivar Hisar Jaffri -2 grown with substrate cocopeat + vermiculite + perlite (3:1:1), resulted maximum seedling length (8.8 cm) and found superior than all other treatment combinations.

The various treatments exerted significant influence on root length of different cultivars of marigold (Table-4). In terms of cultivars, the longest roots (7.2 cm) were observed in MGH 10/ 206 followed by Hisar Jaffri – 2 (6.1 cm), while shortest roots (5.0 cm) were observed in Pusa Narangi cultivar. The seedlings grown in T_2 (cocopeat + vermiculite + perlite, 3:1:1) showed highest root length (8.8 cm) followed by T_1 (7.8 cm). The treatment combination of genotype MGH 10/206 and cocopeat + vermiculite + perlite, 3:1:1 substrate found best for root length (10.2 cm) than all other treatment combinations.

Days taken to bear first flower exhibited significant differences caused due to different substrate combination and cultivars (Table-5). The earliest flowering was observed in cultivar Pusa Basanti (87.0 days), however it was found statistically at par with Pusa Narangi (87.1 days) and MGH 10/206 (87.6 days). The plants grown in cocopeat + vermiculite + perlite, 3:1:1 substrate took lesser days to bear first flower (82.3 days) followed by T_5 (88.1 days). All the cultivars except Hisar Jafri-2 with media T_2 (cocopeat + vermiculite + perlite, 3:1:1) resulted into lesser days to first flowering.

There were significant differences in duration of flowering in marigold observed due to combination of different substrates, cultivars and their interactions (Table 6). The highest duration for flowering (34.3 days) was observed in MGH 10/206, which was statistically similar with Hisar Jaffari-2 (34.2 days) and lowest duration of flowering was reported in Pusa Narangi (27.9 days). In case of substrate combination, T_2 was found superior to increase the duration of flowering (35.9 days) than other substrate mixtures. Maximum duration of flowering was observed in Hisar Jaffari-2 plants, when grown in T_2 (cocopeat + vermiculite + perlite, 3:1:1), however it was found statistically at par with T_1V_3 (37.5 days), T_2V_4 (37.2 days) and T_4V_4 (37.2 days).

Table-1 : Effect of growing media on germination per cent in different genotypes/varieties of marigold.

Treatment	Germination (%)				
	Pusa Narangi	Pusa Basanti	Hisar Jaffri-2	MGH 10/206	Mean
T_1-Cocopeat + Vermicompost + Perlite (1:1:1)	69.8	72.5	68.6	38.5	**62.4**
T_2-Cocopeat + Vermiculite + Perlite (3:1:1)	80.2	84.2	73.5	48.9	**71.7**
T_3-Cocopeat + Vermiculite + Perlite (1:1:1)	77.5	78.5	63.2	36.2	**63.9**
T_4-Sand + Vermicompost (9:1)	71.5	73.4	62.5	33.5	**60.2**
T_5-Sand + FYM (9:1)	78.4	73.6	53.6	31.5	**59.3**
T_6-Sand + Vermiculite (9:1)	73.2	68.5	61.2	27.4	**57.6**
T_7-Sand (Control)	63.5	61.2	57.5	29.4	**52.9**
Mean	73.4	73.1	62.9	35.1	
CD (p = 0.05)	A = 2.31		B = 1.74		A× B = 4.61

A = Treatment, B = Variety

Table-2 : Effect of growing media on days to 50% germination in different genotypes/varieties of marigold.

Treatment	Days taken to 50% germination				
	Pusa Narangi	Pusa Basanti	Hisar Jaffri-2	MGH 10/206	Mean
T_1-Cocopeat + Vermicompost + Perlite (1:1:1)	10.8	12.5	6.5	14.2	**11.0**
T_2-Cocopeat + Vermiculite + Perlite (3:1:1)	5.8	6.9	3.8	8.5	**6.3**
T_3-Cocopeat + Vermiculite + Perlite (1:1:1)	7.8	7.8	9.5	11.3	**9.1**
T_4-Sand + Vermicompost (9:1)	11.1	8.5	6.8	12.9	**9.8**
T_5-Sand + FYM (9:1)	6.9	9.2	8.5	9.8	**8.7**
T_6-Sand + Vermiculite (9:1)	10.2	10.5	12.5	8.7	**11.2**
T_7-Sand (Control)	10.5	11.9	11.9	11.2	**12.0**
Mean	9.0	9.6	8.5	11.7	
CD (p = 0.05)	A = 0.26		B = 0.20		A× B = 0.53

A = Treatment, B = Variety

Table-3 : Effect of growing media on seedling (cm) length in different genotypes/ varieties of marigold.

Treatment	Seedling length (cm)				
	Pusa Narangi	Pusa Basanti	Hisar Jaffri-2	MGH 10/206	Mean
T_1-Cocopeat + Vermicompost + Perlite (1:1:1)	5.5	5.7	6.2	7.5	**6.2**
T_2-Cocopeat + Vermiculite + Perlite (3:1:1)	7.5	7.1	8.8	8.0	**7.8**
T_3-Cocopeat + Vermiculite + Perlite (1:1:1)	6.6	4.8	7.7	6.5	**6.4**
T_4-Sand + Vermicompost (9:1)	6.1	6.4	7.3	7.8	**6.9**
T_5-Sand + FYM (9:1)	4.5	5.4	7.5	7.0	**6.1**
T_6-Sand + Vermiculite (9:1)	5.3	6.0	6.5	5.3	**5.8**
T_7-Sand (Control)	4.9	4.2	5.5	4.5	**4.8**
Mean	5.8	5.7	7.1	6.7	
CD (p = 0.05)	A = 0.27		B = 0.21		A× B = 0.54

A= Treatment, B = Variety

Flower diameter differed significantly in all the verities/ genotypes with different substrate combinations and their interactions (Table-7). Pusa Narangi and Pusa Basanti resulted into significantly higher flower diameter (4.0 cm and 3.9 cm, respectively) over Hisar Jaffri-2 (3.3 cm) and MGH 10/206 (3.3 cm). Plants grown in T_2 (cocopeat + vermiculite + perlite, 3:1:1), produced largest flower compared to the other treatment combination. The combination of cultivar Pusa Narangi with T_1 (4.4 cm) and T_2 (4.3 cm), whereas, Pusa Basanti with T_2 (4.4 cm) produced maximum flower diameter over other treatment combinations.

Difference in the number of flowers per plant on account of verities/genotypes, substrate combinations and interactive values of the treatments were significant (Table-8). The highest number of flower per plant (108.1) was reported in MGH 10/206 followed by Hisar Jaffri-2 (84.4), while lowest number of flowers per plant (41.8) was observed from Pusa Narangi. The treatment combination cocopeat + vermiculite + perlite, 3:1:1, best

Table-4 : Effect of growing media on root length in different genotypes/ varieties of marigold.

Treatment	Root length (cm)				
	Pusa Narangi	Pusa Basanti	Hisar Jaffri-2	MGH 10/206	Mean
T_1-Cocopeat + Vermicompost + Perlite (1:1:1)	6.5	8.1	7.9	8.6	**7.8**
T_2-Cocopeat + Vermiculite + Perlite (3:1:1)	7.0	9.7	8.3	10.2	**8.8**
T_3-Cocopeat + Vermiculite + Perlite (1:1:1)	5.8	7.0	4.3	7.5	**6.6**
T_4-Sand + Vermicompost (9:1)	4.0	6.7	6.9	7.8	**6.4**
T_5-Sand + FYM (9:1)	3.6	5.0	2.3	6.2	**4.4**
T_6-Sand + Vermiculite (9:1)	3.1	3.2	6.0	7.1	**4.9**
T_7-Sand (Control)	4.8	2.5	4.0	3.3	**3.7**
Mean	5.0	6.0	6.1	7.2	
CD (p = 0.05)	A = 0.27		B = 0.21		A× B = 0.55

A = Treatment, B = Variety

Table-5 : Effect of growing media on days to first flowering in different genotypes/varieties of marigold.

Treatment	Days to first flowering				
	Pusa Narangi	Pusa Basanti	Hisar Jaffri-2	MGH 10/206	Mean
T_1-Cocopeat + Vermicompost + Perlite (1:1:1)	82.7	81.7	115.2	83.6	**90.8**
T_2-Cocopeat + Vermiculite + Perlite (3:1:1)	79.5	78.9	93.2	77.6	**82.3**
T_3-Cocopeat + Vermiculite + Perlite (1:1:1)	91.8	92.5	119.2	94.1	**99.4**
T_4-Sand + Vermicompost (9:1)	89.1	87.4	106.2	88.1	**92.7**
T_5-Sand + FYM (9:1)	85.1	88.9	98.1	80.3	**88.1**
T_6-Sand + Vermiculite (9:1)	87.0	83.7	100.7	98.2	**92.4**
T_7-Sand (Control)	94.8	96.2	110.2	91.4	**98.2**
Mean	87.1	87.0	106.1	87.6	
CD (p = 0.05)	A = 3.66		B = 2.76		A × B = 7.31

A = Treatment, B = Variety

Table-6 : Effect of growing media on duration of flowering in different genotypes/ varieties of marigold.

Treatment	Duration of flowering (days)				
	Pusa Narangi	Pusa Basanti	Hisar Jaffri-2	MGH 10/206	Mean
T_1- Cocopeat + Vermicompost + Perlite (1:1:1)	33.5	32.0	37.5	35.0	**34.5**
T_2- Cocopeat + Vermiculite + Perlite (3:1:1)	35.2	33.1	38.2	37.2	**35.9**
T_3- Cocopeat + Vermiculite + Perlite (1:1:1)	28.8	31.0	35.2	33.6	**32.2**
T_4- Sand + Vermicompost (9:1)	28.3	30.4	33.2	35.8	**31.9**
T_5- Sand + FYM (9:1)	30.1	32.5	34.3	32.4	**32.3**
T_6- Sand + Vermiculite (9:1)	27.5	31.4	31.5	34.3	**31.2**
T_7- Sand (Control)	27.9	29.6	29.5	31.7	**29.7**
Mean	27.9	31.4	34.2	34.3	
CD (p = 0.05)	A = 1.36		B = 1.03	A× B = 2.73	

A= Treatment, B = Variety

suited for the number of flowers per plant (89.5) followed by T_4 (76.4) and T_1 (73.4). Plants grown in T_2V_4 produced highest number of flower per plant (133.1) and found superior from rest of the treatment combinations.

The present studies showed that all combinations of soilless substrates significantly improved growth and yield of marigold ac compared to the sand alone. The variation in the vegetative growth and yield might be due to the properties of different ingredient used in growing substrates exhibit direct and indirect effects on plant growth. The present results are in line with earlier findings of Verdonk *et al.* (1981) and Schie (1999), who reported that the cocopeat in substrate mixture play important role as a organic material with medium ion absorption capacity. It also has aerial porosity and better capacity of water and nutrient maintenance (Por-Hossein *et al.,* 2009; Sharma *et al.,* 2015; Sharma and Godara, 2019). Perlite is considered as a important substrate with excellent features in soilless cultivation since it has high water absorption and also increase watering holding capacity as well as porosity (Inden and Torres, 2004). Larrea (2006) suggested that substrate combination having vermiculite

Table-7 : Effect of growing media on flower diameter in different genotypes/varieties of marigold.

Treatment	Flower diameter (cm)				
	Pusa Narangi	Pusa Basanti	Hisar Jaffri-2	MGH 10/206	Mean
T_1-Cocopeat + Vermicompost + Perlite (1:1:1)	4.4	4.2	3.5	3.4	**3.9**
T_2-Cocopeat + Vermiculite + Perlite (3:1:1)	4.3	4.4	3.6	3.7	**4.1**
T_3-Cocopeat + Vermiculite + Perlite (1:1:1)	4.2	4.1	3.5	3.5	**3.8**
T_4-Sand + Vermicompost (9:1)	3.9	4.0	3.5	3.3	**3.7**
T_5-Sand + FYM (9:1)	4.0	3.7	3.1	3.1	**3.5**
T_6-Sand + Vermiculite (9:1)	3.7	3.6	3.2	3.3	**3.4**
T_7-Sand (Control)	3.5	3.5	2.5	2.9	**3.1**
Mean	4.0	3.9	3.3	3.3	
CD (p = 0.05)	A = 0.083		B = 0.063	A×B = 0.165	

A = Treatment, B = Variety

Table-8 : Effect of growing media on number of flowers per plant in marigold under polyhouse condition.

Treatment	Number of flowers per plant				
	Pusa Narangi	Pusa Basanti	Hisar Jaffri-2	MGH 10/206	Mean
T_1-Cocopeat + Vermicompost + Perlite (1:1:1)	35.5	40.2	96.5	121.2	73.4
T_2-Cocopeat + Vermiculite + Perlite (3:1:1)	48.2	73.8	101.1	133.1	89.5
T_3-Cocopeat + Vermiculite + Perlite (1:1:1)	41.7	43.8	71.3	99.5	64.1
T_4-Sand + Vermicompost (9:1)	45.4	58.9	82.8	118.5	76.4
T_5-Sand + FYM (9:1)	44.1	64.2	86.5	88.3	70.8
T_6-Sand + Vermiculite (9:1)	38.2	48.5	79.4	113.3	69.8
T_7-Sand (Control)	39.3	34.8	73.4	82.9	57.6
Mean	41.8	52.3	84.4	108.1	
CD (p = 0.05)	A = 3.1		B = 2.3	A× B = 6.2	

A = Treatment, B = Variety

increased germination and growth in tomato. Vermicompost consists of available forms of nutrition for plants like nitrates, exchangeable phosphorus, potassium, calcium and magnesium and increased the water retention capacity (Fernandes and Eduardo-Cora, 2004); and also known as a medium effective better growth and yield (Cantliffe *et al.,* 2007; Sharma and Godara, 2019). The combination of different organic and inorganic substrates in appropriate proportion optimizes water and oxygen holding and also allows the plants for better nutrient uptake, sufficient growth and development (Hesami *et al.,* 2012).

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Analysis of Different Chemical Parameters of Dehydrated Flakes of Jack Fruit Cultivars

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Abstract

The present investigation entitled "Analysis of different Chemical parameters of dehydrated flakes of jack fruit cultivars" was carried out in during *summer* season 2016-17 at Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The Experiment was laid out in randomized block design with three replications and thirteen treatments were evaluated in the present study. The present investigation was carried out to explore the "Chemical parameters of dehydrated flakes of different jackfruit genotypes but the highest TSS (74.89° Brix) was recorded in genotype GDJF-8 and In respect to total sugar, reducing sugar the highest total sugar (69.12%), reducing sugar (59.36%) was observed in genotype GDJF-11 and the highest non-reducing sugar (6.33%) was recorded with genotype GDJF-10. in respect to TSS/acid ratio, the highest TSS/acid ratio (191.47) was recorded in the genotype GDJF-13. TSS Maximum ascorbic acid was observed in genotype GDJF-9 (7.36 mg/100) while Highest acidity (0.62 %) for fresh flakes of jackfruit was observed in genotype AKJF-2.

Introduction

Jackfruit is mostly grown in tropical India or close to tropical climates of southern states of country. It is native to parts of South and Southeast Asia and is believed to have originated in the south western rain forests of the Western Ghats in the Indian Subcontinent.

The jackfruits are good source of energy ranges from 95 Kcal, Protein 1.72 g, Fat 0.64 g, Carbohydrates 23.5 g, Fibre 1.5 g, Calcium 34 mg, Iron 0.60 mg, Magnesium 37 mg, Thiamine 0.105 mg, Riboflavin 0.155 mg, Niacin 0.920 mg, Vitamin C 13.7 mg. Fresh fruit is a good source of potassium, magnesium, manganese and iron. Potassium is an important component of cell and body fluids that helps controlling heart rate and blood pressure.

Exploitation of existing variability for improvement of jackfruit in order to encourage commercial orcharding is required. Study of physical and chemical characters are very useful in understanding the selection procedure for high yielding clones in jackfruit.

Many processing techniques can be employed to preserve fruits and vegetables. Drying /dehydration is one of the most important operation that is widely practiced because of considerable saving in packaging, storage etc. Osmotic dehydration is a method of preservation in which the food is dipped in concentrated salt or sugar solutions. Osmotic dehydration is the phenomenon of removal of water from lower concentration of solute to higher concentration through semi permeable membrane resulting in an equilibrium condition on both sides of membrane (Tiwari, 2005). The main advantages of osmotic dehydration include better colour, texture and flavour retention along with minimum heat damage.

Materials and Methods

The experiment entitled "Analysis of different Chemical parameters of dehydrated flakes of jack fruit cultivars" was carried out in Analytical laboratory, Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 2016-17. The different genotypes of jackfruits were collected from the various region of Vidarbha viz., Korchi, Dist. Gadchiroli; Akot, Dist. Akola. During the experiment three replications, thirteen treatments and randomise block design were laid out in the field. The following thirteen genotype were collected that is mentioned in table 01.

List of Genotypes	Treatments notation
AKJF-1 (Akot jackfruit-1)	T1
AKJF-2 (Akot jackfruit-2)	T2
AKJF-3 (Akot jackfruit-3)	T3
AKJF-4 (Akot jackfruit-4)	T4
AKJF-5 (Akot jackfruit-5)	T5
AKLJF-6 (Akola jackfruit-6)	T6
GDJF-7 (Gadchiroli jackfruit-7)	T7
GDJF-8 (Gadchiroli jackfruit-8)	T8
GDJF-9 (Gadchiroli jackfruit-9)	T9
GDJF-10 (Gadchiroli jackfruit-10)	T10
GDJF-11 (Gadchiroli jackfruit-11)	T11
GDJF-12 (Gadchiroli jackfruit-12)	T12
GDJF-13(Gadchiroli jackfruit-13)	T13

Result and Discussion

The result and discussion presented in Table-2 and graphically illustrated in Fig.-1.

Table-2 : Analysis of deferent Chemical parameters of dehydrated flakes of jack fruit cultivars.

Name of genotypes	TSS (°Brix)	Total sugar (%)	Non-reducin g Sugar (%)	Reducing Sugar (%)	Ascorbic acid (mg/100g)	Titratable acidity (%)	TSS/ acid ratio
AKJF-1	70.42	62.28	17.48	44.80 (6.69)	4.16	0.98 (0.99)	74.16
AKJF-2	70.44	60.05	11.90	48.15 (6.94)	5.38	0.78 (0.88)	79.79
AKJF-3	71.76	61.56	10.53	51.03 (7.42)	3.86	0.73 (0.86)	83.81
AKJF-4	73.56	66.82	8.32	58.50 (7.24)	3.92	0.52 (0.72)	102.04
AKJF-5	73.05	64.60	19.44	45.16 (6.72)	6.75	0.98 (0.99)	73.92
AKLJF-6	65.15	46.15	13.5	32.65 (4.20)	1.02	0.78 (0.85)	70.32
GDJF-7	72.17	65.84	18.19	47.65 (6.90)	6.15	0.73 (0.43)	70.51
GDJF-8	74.89	67.84	9.57	58.27 (7.63)	7.25	0.18 (0.43)	84.68
GDJF-9	73.12	65.06	7.81	57.25 (7.89)	7.36	0.21 (0.28)	171.73
GDJF-10	69.54	62.35	6.33	56.02 (7.48)	2.14	0.28 (0.53)	150.91
GDJF-11	72.82	69.12	9.76	59.36 (7.70)	5.65	0.41 (0.64)	127.73
GDJF-12	73.36	65.18	17.00	48.18 (6.94)	1.12	0.15 (0.39)	113.27
GDJF-13	74.25	64.26	13.64	50.62 (7.11)	3.46	0.55 (0.74)	191.47
'F' Test	Non-Sig.	Sig.	Sig,	Sig.	Sig.	Sig.	Sig.
SE (m)±	28.41	0.64	0.47	0.09	0.09	0.01	5.24
CD at 5%	-	1.93	1.41	0.27	0.27	0.03	16.17

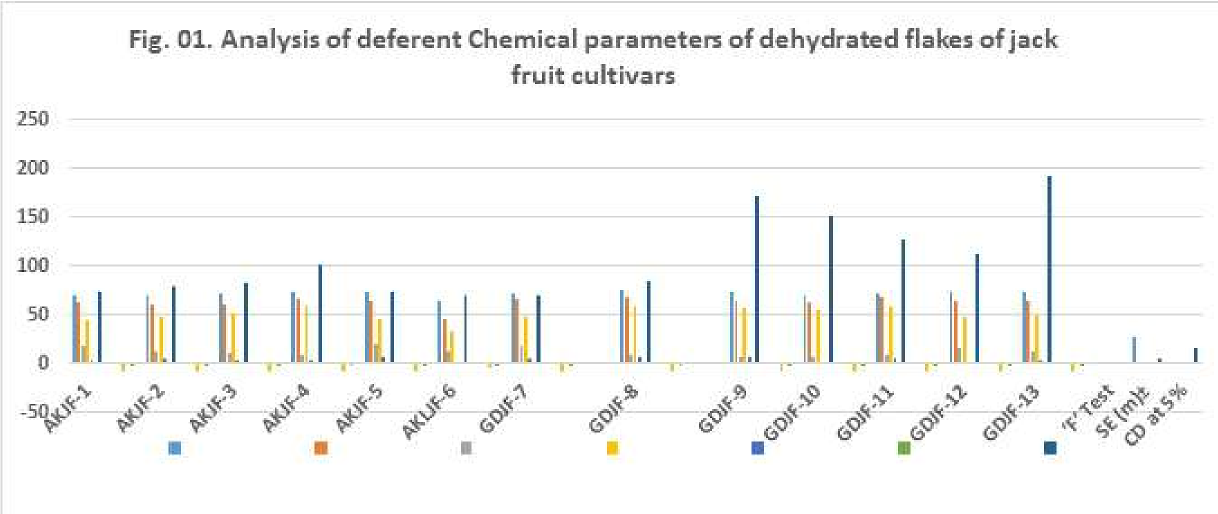
Note : Figures in parenthesis for non-reducing sugar and titrable acidity are square root transformations.

Evaluation of deferent jackfruit cultivars for TSS : The data pertaining to the TSS content of dehydrated flakes of different jackfruit genotype is presented in Table 02 indicate that the TSS content of dehydrated flakes did not varied significantly, However the TSS content recorded for their different genotypes varied between 65.15° to 74.89° Brix. The maximum TSS was recorded in GDJF-8 (74.89 °B) while minimum AKLJF-6 (65.15°B).

Content of dehydrated flake to fresh flake may be due to loss of water from fruit cells during dehydration. This is in confirmation to the finding of Swaroopa et al. (2016) who reported TSS of 60.33 °B in fruit crops. The genotype AKLJF-6 recorded lowest TSS in flakes as the initial TSS content of fresh flakes was low which is a genetically parameter.

Evaluation of different jackfruit cultivars for total sugar, reducing sugar and non-reducing sugar : The data regarding total sugar, reducing sugar and non-reducing sugar in dehydrated flakes of jackfruit of different genotypes is presented in above Table-2 and graphically illustrated in Fig.-1 that significant differences were observed for total sugar content of dehydrated flakes. The maximum total sugar content was recorded in the genotype GDJF-11 (69.12) which was at par with GDJF-8 (67.84%). The genotype AKLJF-6 recorded the lowest total sugar in content (46.15%). The above present findings are in agreement with Sharma *et al*. (2000) in apricot, Mishra *et al*. (2014) in mango and Swami *et al*., (2014) in jackfruit. The variation with the genotype may be due to the variation in TSS content of fresh flakes which is a genetic character.

In respect to reducing Sugar It is found that the variation was varied from of 6.33% to 19.44% and the maximum reducing sugar was observed in the genotype AKJF-5 (19.44%) which was at par with GDJF-7 (18.19%) while the lowest reducing sugar was recorded in GDJF-10



(6.33 %). The present finding indicates variation in the reducing sugar content of dehydrated flakes is might be due to the variation in initial reading sugar level of fresh flakes. This is close to the finding of Mishra *et al.*, (2014) in mango and Swami *et al.*, (2016).

In respect to non-reducing sugarit is observed that the variation in different genotypes for non-reducing sugar ranged between 32.65% to 59.36%. The genotype GDJF-11 recorded maximum non-reducing sugar of jackfruit (59.36%) and the lowest non-reducing sugar was noted I the genotype AKLJF-6 (32.65%).The variation in non-reducing sugar of dehydrated flakes might be due to the initial non-reducing content of fresh flakes. Similar finding are reported by Swami *et al.* (2016).

Evaluation of different jackfruit cultivars for vitamin C (Ascorbic acid) content in dehydrated flacks : In respect to ascorbic acid content of dehydrated flakes, it is observed that the ascorbic acid content ranged from 1.02 to 7.36 mg/100g. The highest value for ascorbic acid was observed in the genotype GDJF-9 (7.36 mg/100) and the lowest ascorbic acid was noted in the genotype AKLJF-6 (1.02mg/100 g). The variation in ascorbic content may be due to initial ascorbic acid content of fresh flakes. Similar results were reported by Mishra *et al.* (2014).

Evaluation of different jackfruit cultivars for Titratable acidity (%) : It is revealed that the titratable acidity differed significantly amongst the genotypes for dehydrated flakes. Significantly maximum titratable acidity (0.98%) was observed in the genotype AKJF-1 and AKJF-5 which was followed by AKJF-2 (0.78%) and AKLJF-6 (0.76%). However, lowest acidity was recorded in GDJF-12 (0.15%). The present findings indicates variability in titratable acidity within different jackfruit genotypes. This is in agreement to the findings of Castro *et al.* (2016) and Swaroopa *et al.* (2016).

Evaluation of deferent jackfruit cultivars for TSS/ acid ratio : It is observed that the genotype GDJF-13 recorded highest TSS/acid ratio (191.47) which was followed by GDJF-9 (171.73), GDJF-10 (150.91), GDJF-11(127.73), GDJF-12 (113.27) and AKJF-4 (102.04). The lowest value was observed in AKLJF-6 (70.32). It is observed that TSS/ acid ratio of the genotypes from Gadchiroli district is more. This may be due to less acidity content of fruits. The TSS /acid ratio is an important parameter that determined taste and acceptability. Low acidity and higher sugar are responsible for the sweet taste of jackfruit as reported by Selvaraj and Pal (1989). This is in confirmation with finding of Jagdeesh *et al.* (2007)[b].

Conclusions

It is concluded that the chemical parameters of dehydrated jackfruit flakes werefound varied as per climatic condition and genetically constituent of genotype or cultivars but the highest TSS (74.89°Brix) was recorded in genotype GDJF-8 and In respect to total sugar, reducing sugar the highest total sugar (69.12%), reducing sugar (59.36%) was observed in genotype GDJF-11 and the highest non-reducing sugar (6.33%) was recorded with genotype GDJF-10. in respect to TSS/acid ratio, the highest TSS/acid ratio (191.47) was recorded in the genotype GDJF-13. TSS

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Effect of Different Level of Nitrogen and Boron on Growth Performance and Yield of Radish cv. Kashi Hans

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Abstract

The experiment was laid out in RBD having 12 treatment and 3 replications. Application of different levels of Nitrogen and Boron have marked effect on Growth and yield of Radish on the different stage. All the growth character such as Height of plant, Number of leaves of plant, Length of leaves and length of root are increased with the increase in nitrogen. Boron shows positive response to the quality characters such as Percent dry matter and Ascorbic acid, on interaction with Nitrogen it showed significant response in all aspect of Growth and Yield. The best results regarding various growth character was found in T_9- 60 kg N, 0kg B, but somehow highest root yield was obtained under T_{11} under the combination- 60 kg N and 10 Kg B. Boron have huge impact on quality of Radish as it shows with the results, best quality were obtained with the application of T_{11}- 60 Kg N And 10 Kg B. An effort was made to estimate the cost of cultivation and cost benefit Ratio with use of each treatment separately and on the basis of result the highest net Profit was obtained with the Treatment T_9 followed by T_{10}. Highest B.C.R. was also recorded with the Treatment T_9.On the basis of above finding it can be concluded that best treatment was $T_{9,}$ with comparatively low input and high yield favours the use of treatment, followed by $T_{11,}$ which is high performer in all aspect of growth and yield but more costly on comparison with second best T_9.

***Key words :** Radish, growth, yield, nitrogen and boron.*

Introduction

Radish *(Raphanus sativus* L.) is a diploid species, Radish *(Raphanus sativus* L.) is a diploid species and is popular in both tropical and temperate region and can be grown through out the year. Radish is one of the most ancient crops as the inscription on inner wall of pyramid shows that radish was used in Egypt about 2000 B.C., some source also reveal that it was cultivated in about 2700 B.C. it is well known root vegetable native from Europe or Asia. Asiatic radish is originated from *Raphanus sativus* f. Raphnistroids and originated from Mediterranean region. It belongs to *Brassicaceae* family and grown throughout in the country for its young fleshy roots mainly.

When we talk about nutrients healthy plants often contain 3-4% nitrogen in tissues, this is higher in comparison to other nutrients. It is essential constitute of protein, nucleic acid, chlorophyll and enzymes etc. when nitrogen is deficit in soil, the harvest is poor in size and quality (Hussain *et al.* 1997). Both low and high application of nitrogen results in loss of production and quality of crop. Nitrogen is related to both production and quality and boron is essential for quality and deficiency of boron can increase the production of thiocynates, which are known giotrogens. Nitrogen is a paramount nutrient for plant since it is a core component of many plant structures and for both their internal and external metabolic.

Boron is essential for normal growth and production of sound, healthy vegetables. Boron is required for pollen tube development, pollen germination, plasma membrane stimulation, floret fertility, anther development, and seed formation. Boron shortage causes a decrease in leaf photosynthetic rate, plant height, the quantity of reproductive structures during the squaring and fruiting stages, and dry matter production (Wang *et al*. 2003). As we can see both nutrients are essential for quality and quantity of production, it is very important for farmer to know right level of nutrient which is essential for good production of radish. Keeping the above point in mind the present investigation “Effect of different levels of nitrogen and Boron on growth performance and yield of Radish (*Raphanus sativus* L.) cv. Kashi Hans”

Materials and Methods

The present investigation “Effect of Nitrogen and Boron on growth performance and yield of Radish cv. Kashi Hans” was Carried out in 2020-21 at research form, Department of Horticulture, Udai Pratap (Autonomous) College, varanasi. The topography of field was uniform with gentle slope and adequate drainage. The experiment was laid out in RBD having 12 treatment and 3 replications. Observation were recorded at five tagged plants from each treatment and each replication for growth, yield and quality. Growth, yield and quality parameters of the following traits were recorded *viz.* Plant height(cm), Number of leaves, length of leaves(cm), length of

Table-1 : Effect of different levels of nitrogen and boron of growth and yield parameter of Radish.

TRT	Plant Height (cm)	No. of leaves	Length of leaves	Root Length (cm)	Root Diameter (cm)	Yield per plot (kg)	Yield per ha (q)	% dry matter	Ascorbic Acid
N_0B_0 (T_0)	21.473	10.48	22.32	14.55	2.12	21.830	238.240	6.10	16.53
N_0B_1 (T_1)	21.830	10.71	22.66	15.19	2.29	24.010	262.317	6.25	16.95
N_0B_2 (T_2)	22.023	11.17	22.84	15.46	2.32	24.147	270.570	6.49	17.28
N_1B_0 (T_3)	23.650	12.33	23.41	16.36	3.09	26.380	382.017	6.19	17.20
N_1B1 (T_4)	24.340	12.70	23.61	17.04	3.18	26.573	383.220	6.66	18.36
N_1B_2 (T_5)	24.937	13.06	24.02	17.22	3.18	26.853	384.683	7.06	19.41
N_2B_0 (T_6)	25.050	13.88	24.97	17.41	3.41	28.933	406.110	6.28	18.14
N_2B_1 (T_7)	25.927	14.13	25.20	17.75	3.46	29.070	406.597	7.25	19.57
N_2B_2 (T_8)	25.977	14.46	25.68	20.58	3.83	30.397	408.430	7.60	21.11
N_3B_0 (T_9)	29.107	16.69	27.23	17.85	3.66	32.010	423.470	6.39	20.00
N_3B_1 (T_{10})	28.853	16.16	26.95	20.13	3.80	32.703	426.787	7.95	20.97
N_3B_2 (T_{11})	28.057	15.58	26.54	20.42	3.82	33.420	430.330	8.26	21.67
SEm	0.4023	0.27	0.2642	0.4651	0.3045	0.9774	3.0088	0.3271	0.7954
CD 5%	1.1798	0.78	0.7750	1.3642	0.8931	2.8667	8.8246	0.9594	2.3327

root(cm), Diameter of root(cm), Fresh weight of root(g), dry weight of root(g), yield per plot (kg) and ha(q), percent dry matter of leaves and Ascorbic acid content(mg). The data on growth, yield and quality components were subjected to Fisher's method of analysis of variance (ANOVA), where the 'F' test significantly for comparison of the treatment means, CD values were worked out at 5% probability level.

Results and Discussion

Higher dose of nitrogen affects the height of plant, number of leaves per plant, length of leaves, length of root and diameter of root and yield of roots/Plant in comparison of lower levels. The maximum plant height (29.10 cm) was observed in the treatment T_9 (60 Kg N + 0 Kg B) followed by T_{10} (28.85 cm) and T_{11} (28.05 cm). Minimum plant height (21.47 cm) was observed in the treatment T_0 (control). The maximum number of leaves per plant (16.69) was observed in T_9 with the application of (60 Kg N + 0 Kg B), followed by T_{10} (16.16) and T_{11} (15.58), the minimum number of leaves (10.48) was observed in T_0 (Control). The length of leaves of radish was significantly affected with different treatments. Maximum length of leaves (27.23 cm) was observed under the treatment T_9 (60 kg N + 0 kg B), followed by T_{10} (26.95 cm) and T_{11} (26.54 cm). Minimum length of leaves (22.32 cm) was recorded under the treatment T_0 (control). Length of root in radish was significantly affected with different treatments. Maximum length of root (20.58 cm) was observed under the treatment T_8 (40 Kg N + 10 Kg B) followed by T_{11} and T_{10}. Maximum diameter of root (3.83 cm) was observed under the treatment T_8 (40 kg N + 10 Kg B) followed by T_{10} and T_{11}. Minimum diameter of root (2.12 cm) was recorded under treatment T_0 (Control). Urea and Borex as source of Nitrogen and Boron, respectively were found most effective in increasing the root diameter of radish. Average weight of root per plant of radish was significantly affected with different treatments. Maximum average weight of root (117.34 g) was observed under the treatment T_{11} (60 Kg N + 10Kg B). Yield per plot in radish was significantly affected with different treatments. Maximum yield per plot in radish (33.42 kg) was noted under the treatment T_{11} (60 Kg N + 10 Kg B), which was significantly superior over all other treatments. Highest root yield (430.33 q) was recorded under T_{11} (60 Kg N + 10 Kg B) which was superior over all other treatments under study. Urea and Borex were found appropriate source of nitrogenous and Boron fertilizer, respectively and their combination T_{11} (60 Kg N + 10 Kg B) emerged as superior over all other treatments combinations for yield and yield attributing components of radish. Above findings are in close agreement with Bosavaraju, *et al.* (2002), Bodhkhe, *et al.* (2010) and Muhammad, *et al.* (2021) in Radish. Singh, *et al.* (1995) also reported that increasing concentrations of Nitrogen significantly increased the leaf length and size in Radish. Rawat and Singh (1981) reported improved yield attribute and growth parameters with recommended dose of nitrogen in comparison with control in Radish. Nitrogen is an important ingredient of plant proteins generally present to the extent of 15 to 17 percent. Nitrogen improve the absorption of nutrient and respiration process in plant and activates vegetation. Nitrogen is the main component of protein and chlorophyll, as the amount of chlorophyll regulate the synthesis of carbohydrates, increase in the chlorophyll content naturally, it increases in the production of carbohydrates (Fawad *etal.* 2021). The highest dose of Boron in present investigation (10 Kg) received maximum yield in combination with Nitrogen (60 Kg). Boron have significant effect on physiological activities of radish, which help in improvement in yield parameter. Identical

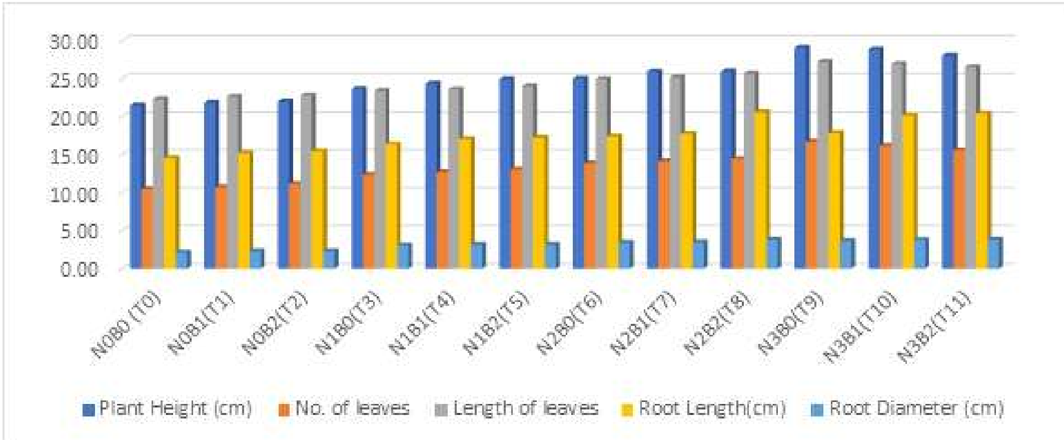

Fig.-1 : Effect of different levels of nitrogen and boron on growth parameter of Radish.

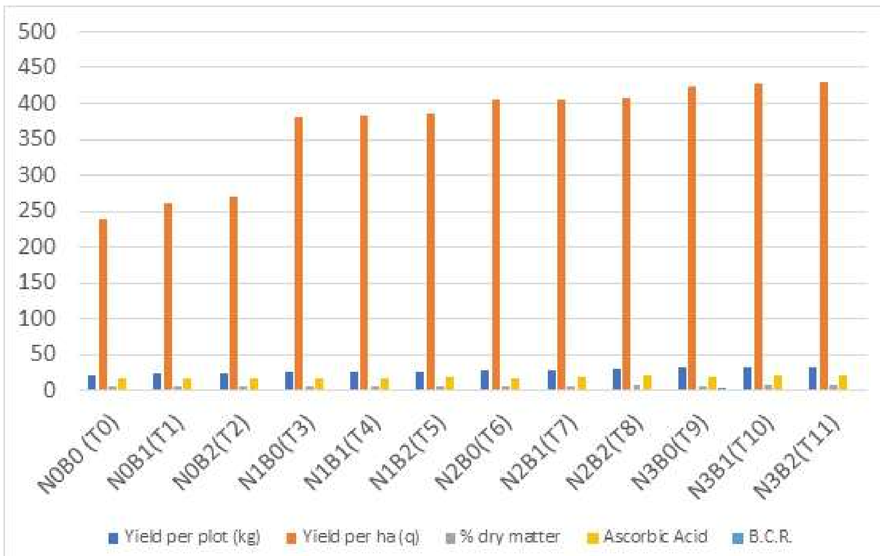

Fig.-2 : Effect of different levels of nitrogen and boron on yield and quality parameter of Radish.

results were reported by KR Maurya and Bineeta Devi (2016), and Rampal, *et al.* (2019) in Radish. Maha m. Othman S.A. El- Moursey (2020) in Sugarbeet.As the results obtained in present investigation indicate that Boron have positive response on qualitative characters of radish *viz.* Percent dry matter and Ascorbic acid content. Highest percent dry matter (8.26) was determined with T_{11} (60 Kg N + 10 Kg B), with significant difference then other treatments, Minimum percent dry matter (6.10) was founded in treatment T_0 (Control). Highest Ascorbic acid content (21.67 mg) was determined with treatment T_{11} (60 Kg N + 10 Kg B). with significant difference then other treatments, Minimum ascorbic acid (16.53 mg) was found in treatment T_0 (Control) Urea and Borex and their combination T_{11} (60 Kg N + 10 Kg B) registered higher total percent dry matter and Ascorbic acid content then all other treatment combination. Similar findings were reported by Yadav and Yadav (2012), Deepika and Pitagi (2015), Sultana, *et al.* (2015) and Kother (1963) in Radish. In comparison of lower level of Boron, Higher rate of Boron (10Kg) responded positively as it shows in the results. Highest average weight of radish root (g) recorded with the application of 10 Kg Boron (T_{11}) along with Recommended Nitrogen. Hence the highest yield per ha also recorded with the same, However Boron have very positive impact on quality character of radish. Boron is one of the essential nutrients for the optimum growth, development, yield and quality of crops. Boron is mainly involved in cell wall synthesis and structural integration. Boron starvation dramatically inhibits root elongation due to impaired cell division in the Meristem region, whereas adequate Boron supply promotes advantageous root development.

Conclusions

On the basis of above finding it can be concluded that best treatment was $T_{9,}$ with comparatively low input and high yield favours the use of treatment, followed by $T_{11,}$ which is high performer in all aspect of growth and yield but more costly on comparison with second best T_9.

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An Economic Analysis of Cost and Returns in Fenugreek Cultivation in Bikaner District of Rajasthan

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Abstract

India has been one of the major producers of fenugreek and the main producing state is Rajasthan in which area under fenugreek was 52661 hectare and production was 74670 tonnes (2019-20). The present study was conducted to determine the cost and returns in cultivation of fenugreek in Bikaner district of Rajasthan. Study based on primary data collected through different questionnaire. Various cost structures and income measures were used to calculate the return from fenugreek cultivation. The per hectare cost of cultivation in Fenugreek varied from ₹ 27317.91 on small farms to ₹ 32715.50 on large farms with an overall average of ₹ 29855.18. The various cost worked out i.e. cost A_1, cost A_2, cost B_1, cost B_2, cost C_1, cost C_2 and cost C_3 to be ₹ 19021.92, ₹ 19021.92, ₹ 19821.82, ₹ 25921.82, ₹ 23921.82, ₹ 29921.82 and ₹ 32914.00, respectively. Cost of production fenugreek varied between ₹ 1837.95 per quintal on large farms to ₹ 2053.97 per quintal on small farms with an overall average of ₹ 1901.62 per quintal. On an average the farm business income, family labour income and net income were ₹ 50269.74 per hectare, ₹ 43469.85 per hectare and ₹ 39369.85 per hectare, respectively.

Key words : *Fenugreek cost of cultivation, returns, family labour income, net income.*

Introduction

India is one of the leading countries in the world with respect to area, production and export of different seed spice. Fenugreek commonly known as 'methi' is cultivated throughout India and other parts of the world for leafy vegetable, medicinal purposes and for fodder also. Fenugreek is considered to be native of south east Europe and west Asia. India has been one of the major producers of fenugreek and the main producing state is Rajasthan in which area under fenugreek was 81699 hectare and production was 84186 tonnes (2014-15). In India, the major fenugreek producing states are Rajasthan, Madhya Pradesh, Tamilnadu, Punjab, Gujarat, and Utter Pradesh. Rajasthan is considered as 'fenugreek bowl'. Rajasthan contributing about 80% area and production of the country. In Rajasthan major fenugreek producing districts are Sikar, Bikaner, Jhunjhunu, Jodhpur, Nagour, Churu, Pratapgarh. Rajasthan and Gujarat are also known as Seed Spices Bowl and contributes more than 80% of total seed spices production in India. Fenugreek is being quoted at 1.59 USD per kilogram in the international market. But prices may fall when new arrivals gather pace. Fenugrrek also has medicinal properties. With above importance present study was conducted with the objective to study the cost and returns in cultivation of fenugreek in Bikaner district of Rajasthan.

Materials and Methods

Sampling Framework : Multi-stage random sampling was used for the selection of the farmers for the present study. The sampling in the first three stages was purposively while; the selection of farmers was randomly. The fenugreek crop was selected purposively for the present study. Bikaner district having first place in area under selected crop hence Bikaner district was selected purposively.

The Bikaner tehsil was purposively selected on the basis of highest average area (2875 hectares) and production (2364 tonnes). There are 125 total villages in Bikaner tahsils but 18 villages were identified as the major fenugreek producing villages and two villages Kolasar and Lalamdesar with highest area under fenugreek crop were purposively selected for the study. For the collection of primary data a sample of 50 farmers (small-24, medium-16and large-10) were selected with probability proportion to number of farmers available in different land size groups.

Analytical techniques : The cost of production was worked out by using following formula :

$$\text{Cost of Production} = \frac{\text{Cost of Cultivation / ha}}{\text{Quantity of main product / ha}}$$

Income measures : Following income measures were used to fulfill the second objective *i.e.* to work out profitability of fenugreek cultivation in study area.

Gross income : Value of output (both main and by product) workout at harvest prices in the study period.

Table-1 : Resource use pattern in fenugreek cultivation on different land size groups. (Per hectare)

S. No.	Input	Size of holdings			Overall Average
		Small	Medium	Large	
1.	Machine labour (hrs)	8.30	8.65	8.95	8.63
2.	Human labour (hrs)	184	208	256	216
	(a) Causal hired Labour (hrs)	40	96	184	106.67
	(b) Family Labour (hrs)	144	112	72	109.33
3.	Seed (kg/ha.)	21	22	25	22.67
	(a) Seed treatment (*Rhizobium* culture gm./kg seed)	5.82	6.14	7.52	6.49
4.	Fertilizers				
	(a) Urea (Kg.)	72.30	75.90	77.40	75.20
	(b) DAP (Kg.)	85.40	86.80	88.20	86.20
5.	FYM (Tonnes)	15.10	17.85	19.13	17.36
6.	Weedicide (Pendamathiline @ lit/ha.) spray	1	1.2	1.5	1.23
7.	Irrigation No. (By Tubewell)	4	4	5	4.33
8.	Plantprotectionchemical (Sulphur dust @ kg/ha.)	19	22	25	22

Table-2 : Breakup of cost of cultivation of fenugreek (₹ per hectare).

Input	Size of holdings			
	Small	Medium	Large	Overall average
Machine labour	4150 (15.19%)	4325 (14.64%)	4465 (13.65%)	4313.33 (14.44%)
Causally hired labour	1500 (5.49%)	3600 (12.19%)	6900 (21.09%)	4000 (13.40%)
Imputedvalue of family labour	5400 (19.77%)	4200 (14.22%)	2700 (8.25%)	4100 (13.73%)
Value of seed	1260 (4.61%)	1320 (4.47%)	1500 (4.58%)	1360 (4.56%)
FYM	2265 (8.29%)	2677.50 (9.07%)	2869.5 (8.77%)	2604 (8.72%)
Fertilizers (a) Urea	399.10 (1.46%)	418.97 (1.42%)	427.25 (1.31%)	415.11 (1.39%)
(b) DAP	1964.20 (7.19%)	1996.40 (6.76%)	2028.60 (6.20%)	1996.40 (6.68%)
Weedicide	450 (1.65%)	540 (1.83%)	675 (2.06%)	555 (1.86%)
Plant Protection chemicals	1425 (5.21%)	1650 (5.59%)	1875 (5.73%)	1650 (5.53%)
Irrigation charges	720 (2.64%)	720 (2.44%)	900 (2.75%)	780 (2.61%)
Depreciation	527.50 (1.93%)	667.10 (2.26%)	756.30 (2.26%)	650.30 (2.18%)
Land revenue	50 (0.18%)	50 (0.17%)	50 (0.15%)	50 (0.17%)
Interest on working capital	586 (2.15%)	643.43 (2.18%)	714.01 (2.18%)	647.81 (2.17%)
Interest on fixed capital	621.11 (2.27%)	723.74 (2.45%)	854.84 (2.61%)	733.23 (2.46%)
Rental value	6000 (21.96%)	6000 (20.32%)	6000 (18.34%)	6000 (20.10%)
Total	27317.91 (100%)	29532.14 (100%)	32715.50 (100%)	29855.18 (100%)

$$GI = Qm \times Pm + Qb \times Pb$$

Where, GI = Gross Income in Rupees Qm = Quantity of main product Pm = Price of main product Qb = Quantity of by product Pb = Price of product

1. Farm Business income: Gross income – Cost A1 (cost A2 in case of tenant operated land)

2. Family labour income: Gross income – Cost B2

3. Net income: Gross income – Cost C2

4. Return to Management = Gross income – Cost C3

5. Returns per rupee of investment

$$= \frac{\text{Gross Income (G.I.) / ha}}{\text{Total Cost (Cost C2) / ha}}$$

$$\text{Depreciation} = \frac{\text{Purchase price of assets – Junk value}}{\text{No. of Years of useful life (expected life)}}$$

Results and Discussion

Cost structure and profitability in cultivation of fenugreek : The cost of cultivation/production and the decision on returns to different factors of production helps in decision making about the selection of an enterprise and hence these measure were worked out for fenugreek.

Resource use pattern in cultivation of fenugreek : Inputs usage and the adoption of various cultural practices in the cultivation of fenugreek among the sample farms in Bikaner area had presented in the Table-1. Fenugreek is grown in the month of October- November and harvested in March-April of the year. On an average, single preparatory tillage operation (8.63 hrs) was done to prepare the fields with the help of tractor. Seed sowing was done in the last week of October to first week of November. The seed rate of 21, 22 and 25 kg/hectare was

Table-5 : Gross income from of fenugreek cultivation on different farm size groups.

Farm size groups	Yield (qtl./ha)		Price/qtl. (₹)		Income (₹)		Gross income (₹)
	Main product	By product	Main product	By product	Main product	By product	
Small	13.30	9.70	4200	250	55860	2425	58285.00
Medium	16.40	11.30	4200	250	68880	2825	71705.00
Large	17.80	12.50	4200	250	74760	3125	77885.00
Overall average	15.83	11.17	4200	250	66500	2791.67	69291.67

Table-6 : Returns from cultivation of fenugreek on sample farms (₹/ha)

Particulars	Size holdings			Overall Average
	Small	Medium	Large	
Gross income	58285.00	71705.00	77885.00	69291.67
Farm business Income	42988.30	53096.59	54724.34	50269.74
Family labour income	36367.19	46172.85	47869.50	43469.85
Net income	30967.19	41972.85	45169.5	39369.85
Returns to Mgt.	28235.41	38999.64	41897.5	36377.52

used by small, medium and large farmers respectively. The average quantity of seed used was 22.67 kg per hectare by the sample farms. The average quantity of chemical (Rhizobium culture) used for Seed treatment was 6.49 gm per kg seed. The average quantity of FYM used was 17.36 tonnes per hectare. on an overall basis, 75.20kg Urea and 86.80kg DAP was used by sample farmers in one hectare cultivation of fenugreek crop. 1.23 litter/hectare pendimethalin weedicide spray and simultaneously weeding control was also performed manually. On an average, 4.33 times irrigations were given to the fenugreek crop.

Breakup of cost of cultivation : Various costs incurred in the cultivation of fenugreek are presented in Table-2. On an average, the total cost per hectare of fenugreek cultivation was estimated ₹ 29855.18. It was ₹ 27317.91 on small, ₹ 29532.14 on medium and ₹ 32715.50 on large. Value of machine labour was the important component among variable cost of fenugreek and it was estimated as 15.19%, 14.64% and 13.65% of total cost by small, medium and large farmers. Imputed value of family labour was the second most important component of the cost in all the categories. Out of the total cost, it accounted for 13.73 per cent. It was 19.77 per cent on small farm, 14.22 per cent on medium farms and 8.25 per cent on large farms. Causally hired labour was the next most important component in all the categories. It accounted for 13.40 per cent of total cost. It was 5.49 percent on small farm, 12.19 per cent on medium farms and 21.09 per cent on large farms. Thus both causally hired labour and family labour together contributed about 27 per cent cost share among all the cost components.

The next important cost among fixed components were rental value of owned land and machine labour. The share of these two costs was about 20 and 14 per cent in total cost incurred in cultivation of fenugreek. Chemical fertilizers and farm yard manures were also played the important role in cost components about 8 per cent contribution was recorded of these two components. Seed and plant protection materials contributed about 5 per cent share in cost components.

Cost structure : Using different cost concepts, it is possible to find out different types of income measures. The comparative estimates of different costs incurred in fenugreek cultivation for different size groups were explained in table-4. The table reveals that all cost increased with the size of the holdings. cost A_1, on an overall basis, was ₹ 19021.92. It increased with the increase in size of holding because of better resource endowment and higher use of casually labour on medium and large farms. Cost A_2 was same as costs A_1 because no farmer had leased-in land. Cost B_1 and B_2 were worked out to be ₹ 19821.82 and ₹ 25921.82, respectively. The costs C_1 and C_2, on overall basis, were worked out to be ₹ 23921.82 and ₹ 29921.81, respectively. Cost C_3, which includes managerial cost, was worked out to be ₹ 32914 per hectare.

Cost of production : The cost of production per quintal on different cost concepts basis are given in Table-4**.**

It is evident from the table that the overall cost of production per quintal of fenugreek was ₹ 1901.62 on cost C_2 basis. The cost of production per quintal was highest on small farms i.e. ₹ 2053.97 followed by large and medium farmer i.e. ₹ 1837.95 and ₹ 1812.94, respectively. It was due to intensive use of resources by small farmers and good management.

Productivity and Profitability of the fenugreek cultivation

Productivity of fenugreek : The productivity of fenugreek and gross returns on sample farms are given in Table-5.

The table reveals that on an overall basis, yield of fenugreek was 15.83 quintal per hectare. The yield was highest (17.80 quintals) on large farms, followed by medium farms (16.40 quintals) and small farms (13.30 quintals) which indicated that as the size of holding increased, the yield of fenugreek also increased. The gross returns also increased with increased in the size of holding. Average income of fenugreek was found to be 2791.67 Rs/qtl.

Income measures : A comparison of incomes received by various size groups of farmers is shown in Table-6.

It is evident from the table that overall average gross income per hectare of fenugreek cultivation was ₹ 69291.67 on sample farms. It was ₹ 58285.00, ₹ 71705.00 and ₹ 77885.00 on small, medium and large farms, respectively. It increased with the increase in size of land holding mainly because of better use of inputs on medium and large farms. On an average the farm business income from fenugreek cultivation was ₹ 50269.74 it varied between from ₹ 42988.30 on small farms to ₹ 54724.34 on large farms. It increased with increase in size of holding. On an overall basis, family labour income was worked out to be ₹ 43469.85 per hectare. The family labour income per hectare too increased with the increase in size of holding. The overall net income for fenugreek cultivation was ₹ 39369.85 per hectare. It varied between ₹ 30967.19 per hectare on small farms to ₹ 45169.50 per hectare on large farms. The net income also increased with the increase in size of holding. The average returns over to management was worked ₹ 36377.52. It also increased with income the farm size.

Conclusions

Among all farmers family labour used was found highest in small farmers and casual labour for large farmers. Cost of cultivation decreased with increased area of holding (average of 29855.18 Rs per hectare). The yield was highest (17.80 quintals) on large farms, followed by medium farms (16.40 quintals) and small farms (13.30 quintals). The gross returns also increased with increased in the size of holding. Average income of fenugreek was found to be 2791.67 Rs/qtl (58285 Rs/ha for small farmers, 71705.00 Rs/ha for medium farmers and 77885.00 Rs/ha for large farmers). On an average, the returns on per rupee of investment on cost A_1, A_2, B_1, B_2, C_1, C_2 and C_3 were ₹ 3.67, ? 3.67, ₹ 3.52, ₹ 2.68, ₹ 2.89, ₹ 2.31 and ₹ 2.10, respectively. The return per rupee of investment on medium farms on cost C_3 basis was ? 2.19 followed by large farms (₹ 2.16) and small farms (₹ 1.94). Cultivation of fenugreek crop has been a profitable proportion in the study area. On an average the farm business income, family labour income and net income were ₹ 50269.74 per hectare, ₹ 43469.85 per hectare and ₹ 39369.85 per hectare, respectively.

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Soil Fertility Status in Some Soils of District Bulandshahr, Utter Pradesh, India

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Abstract

A reconnaissance soil survey of district Bulandshahr was carried out to determine the physical conditions and current status of the available nutrients. Surface soil samples of the study area were collected to characterize their chemical properties and accordingly to develop optimum land use plan to realize maximum agricultural productivity. The pH and Electrical conductivity of the soils ranged from 7.0-8.5 and 0.07-0.69 dsm^{-1} with a mean value 7.8 and 0.20 dsm^{-1} respectively. As per soil nutrient index (SNI), the soil of study area were found in medium category of organic carbon, low category of available nitrogen and medium category in available zinc, respectively, indicating that the soil of Bulandshahr are normal to slightly alkaline without any salt accumulation and well suit for cereal crop cultivation.

Introduction

Soil is one of the most important natural resources of a country. Knowledge about its characteristics is essential for developing optimum land use plan for maximize agriculture production. Soils differ greatly in their physical, chemical, mineralogical and biological characteristics. Since these characters control the response of soil to management practices, it is essential to have information about these characters of each soil. The knowledge about the essential nutrients and their distribution in the root zone is important. The essential nutrients usually applied through chemical fertilizers, nitrogen seems to have the quickest and most pronounced effect thus nitrogen is considered as an important nutrient element that should not only be converted but carefully regulated. Most of Thes nitrogen in the soil is associated with organic matter. In this form it is protected from rapid microbial release. Only 2 to 3% nitrogen is mineralized annually under normal condition. Assessment of soil quality generally consist Physico-chemical properties and their interaction with one another. Variation in nutrient supply is a natural phenomenon and some where it may be sufficient while some where deficient. Within a soil, variability may exist depending upon the hydrological properties of the soil. Therefore, some locations will require different management practices to sustain crop productivity and for this full information about the nutrients status is important. Deficiency of essential plant nutrients to different extent in soils of Muzaffarnagar had been reported by Sharma et al. (2003). Deficiencies of many plant nutrients are emerging fastly in intensively cultivated sandy alkaline soils of Haryana (Narwal, 2006). Pramod Kumar et al. (2013) also reported that the soil of Muzaffarnagar district were neutral to strongly alkaline in nature and low in nutrient status. Since the quality of produce is significantly influenced by the nutrient supplying capacity of soils coincidently with time crops and their economic product become significantly suboptimal. Therefor to sound information about the nutrient status of this area (Bulandshahr), study was undertaken.

Materials and Methods

A reconnaissance soil survey carried out in the month of September and October 2020. Soil samples were collected from ten locations (Anupshahr, Narora, Shikarpur, Khurja, Shikandrabad, Gulaothi, B.B.Nagar, Siyana, Lakhaoti and Unchagaon) of Bulandshahr district under different Cropping pattern.1250 surface (0-15 cm depth) soil samples from every location were collected with the help of spud and stored in polythene bags. Collected soil samples were air dried in shade, crushed gently with a wooden hammer and then pass through 2.0 mm sieve to obtain a uniform representative sample. Samples were properly labeled and stored in polythene bags for analysis. The processed soil samples were analyzed by standard methods for pH and electrical conductivity (1:2 soil water suspensions), organic matter (Walkley and Black, 1934, outlined by Jackson1973), available nitrogen (Subbiah and Asija, 1956) and available zinc in soil samples with extracted with a Diethylene triamine pentaacetate (DTPA) solution (0.005 M) DTPA + 0.01 M CaCl2+ 0.1 M triethanolamine, pH 7.3 as outlined by Lindsay and Norvell (1978). The concentration of micronutrients was determined by atomic absorption spectrophotometer (GBC Avanta PM). The nutrient index was calculated according to the procedure of Mosara *et. al. (*1982). The study area falls in Bulandshahr district of Western Uttar Pradesh, between two great rivers Ganga and Yamuna old and recent alluvium plain.

Table-1 : Location wise pH & Electrical Conductivity of the soil of Bulandshahr District.

S.No.	Location	pH		Electrical Conduct. (dsm^{-1})	
		Range	Mean	Range	Mean
1.	Anupshahr	7.1-7.8	7.2	0.11-0.18	0.15
2.	Narora	7.0-8.3	7.3	0.17-0.21	0.18
3.	Shikarpur	7.0-7.6	7.5	0.30-0.32	0.30
4.	Khurja	7.8-8.4	8.2	0.10-0.69	0.41
5.	Sikandrabad	8.0-8.5	8.1	0.26-0.41	0.29
6.	Gulaothi	7.4-3.3	8.2	0.02-0.33	0.18
7.	B.B.Nagar	7.3-7.6	7.4	0.11-0.17	0.13
8.	Siyana	7.2-8.2	8.2	0.07-0.22	0.13
9.	Lakhaoti	7.1-7.5	7.2	0.09-0.16	0.12
10.	Unchagaon	7.2-7.6	7.4	0.09-0.19	0.14
	All Over Location	7.0-8.5	7.8	0.07-0.69	0.20

Table-2 : Location wise nutrient status of the soil of Bulandshahr District.

Sl. No.	Location	Total no of samples	Organic carbon			Available Nitrogen			Available Zinc		
			Low %	Med. %	High %	Low %	Med. %	High %	Low %	Med. %	High %
1.	Anupshahr	125	52.00	24.00	24.00	48.00	40.00	12.00	60.00	32.00	08.00
2.	Narora	128	50.00	25.00	25.00	50.00	32.14	17.85	50.00	50.00	-
3.	Shikarpur	131	67.74	32.25	-	61.29	38.70	-	32.25	58.06	09.67
4.	Khurja	123	69.56	17.39	13.04	56.52	26.08	17.39	69.56	30.43	-
5.	Sikandrabad	113	46.15	38.46	15.38	38.46	46.15	15.38	61.53	38.46	-
6.	Gulaothi	119	78.94	21.05	-	-	52.63	47.36	10.52	31.57	57.89
7.	B.B.Nagar	122	50.00	33.33	16.66	62.50	25.00	12.50	29.16	54.16	16.66
8.	Siyana	133	12.12	39.39	48.48	48.48	21.21	30.30	-	30.30	69.69
9.	Lakhaoti	130	33.33	66.66	06.66	53.33	40.00	06.66	40.00	46.66	13.33
10.	Unchagaon	124	25.00	50.00	25.00	50.00	50.00	-	-	50.00	50.00
	All Over Location	1250	50.53	31.95	17.42	46.85	37.22	15.94	35.30	42.16	22.52

Results and Discussion

Location wise present distribution, nutrient index value and fertility status of the soil of district Bulandshahr are presented in table No.-One, Two and Three, with rang and mean value of the pH and Electrical conductivity. The pH and Electrical conductivity in the overall location ranged 7.0 - 8.5 and 0.07 - 0.69 dsm^{-1} with a mean value 7.8 and 0.20 dsm^{-1}. Similar result was also reported by Sharma et.al. (2008).

The table No.-3 shows that the nutrient index value of the organic carbon in overall location was calculated to 1.73 which fall under medium category of the fertility status. About 50.53%, 31.75% and 17.42% soil samples of overall location of Bulandshahr were found in low, medium and high category respectively, in organic carbon content and thus the soil of this district required judicious nitrogen fertilizer for sustainability of cereal crops.

The available nitrogen nutrient index ranged from 1.47-1.81 with a mean value 1.58 in the whole areas, indicating the low fertility status. The percentage distribution about 46.85%, 37.22% and 15.94%, soil samples were found in low, medium and high category respectively. Thus, the soil of this areas are deficient in available nitrogen content and also required judicious application in the farmer's field.

The soil of Bulandshahr district, were mostly medium in available zinc. The table-2 and 3 shows the nutrient index value of the available zinc in overall location were calculated 1.68 which falls under medium category of the fertility status. About 35.30%, 42.16% and 22.52% soil samples of overall area were found in low, medium and high category respectively.

Conclusions

The chemical composition of the soil of Bulandshahr did not follow a particular pattern with increasing distance from location-to-location, which may be due to variation in management practices, cropping sequence and their yield potential. Study area was dominated by sugarcane, rice, wheat and fodder crops. About sixty to eighty percent area is under sugar cane. Physico-chemical characteristics and nutrient status of soil in Bulandshahr district of U.P. as

Table No.-3 : Nutrient Index value and fertility status of the soil of Bulandshahr District.

S. No.	Location	Organic carbon		Available Nitrogen		Available Zinc	
		Nutrient Index	Fertility Status	Nutrient Index	Fertility Status	Nutrient Index	Fertility Status
1.	Anupshahr	1.48	Low	1.64	Low	1.48	Low
2.	Narora	1.58	Low	1.67	Medium	1.00	Low
3.	Shikarpur	1.32	Low	1.38	Low	2.09	Medium
4.	Khurja	1.43	Low	1.60	Low	1.30	Low
5.	Sikandrabad	1.69	Medium	1.76	Medium	1.38	Low
6.	Gulaothi	1.21	Low	1.47	Low	2.47	High
7.	B.B.Nagar	1.66	Low	1.50	Low	1.87	Medium
8.	Siyana	2.36	High	1.81	Medium	2.00	Medium
9.	Lakhaoti	2.66	High	1.53	Low	1.73	Medium
10.	Unchagaon	2.00	Medium	1.50	Low	1.50	Low

discussed previously indicates that soil of study area was neutral to slightly alkaline in reaction without any major problem, low to medium in available nitrogen and medium in available zinc, therefore these important nutrient needs for sustaining productivity of cereal crops in this soil.

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Suitable management strategies for Sooty mold measurement of citrus decline to the tolerable extent

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Abstract

The common use of the name *Capnodium citri* to represent several species of sooty mold fungi is reviewed. Analysis of sooty mold specimens found from *Citrus* in Chhindwara District of Madhya Pradesh. It is recommended that use of the name *Capnodium citri* for sooty mold on *Citrus* and horticulture plants is to be avoided because of its use for a number of species and on nomenclatural grounds. Under *in-vivo* conditions, among the fungicides *viz.* Copper Oxychloride, Carbendazim, Mancozeb, Carbendazim + Mancozeb and Chlorothalonil were found significant effect on reducing the sooty mold incidence but Carbendazim was recorded minimum diseases incidence and maximum orange yield.

Key words : *Citrus, Incidence, Capnodium citri, Management strategies, tolerable extent.*

Introduction

Sooty mold is a fungal disease that grows on plants and other surfaces covered by honeydew, a sticky substance created by certain insects. Sooty mold's name comes from the dark threadlike growth (mycelium) of the fungi resembling a layer of soot. Sooty mold doesn't infect plants but grows on plant parts and other surfaces where honeydew deposits accumulate Ashok Kumar Meena *et.al* (2018).

Although sooty mold doesn't infect plants, the mold can indirectly damage the plant by coating the leaves to the point that sunlight can't reach the leaf surface. Biswas K.K *et. al* (2016) Without adequate sunlight, the plant's ability to carry on photosynthesis is reduced, which can stunt plant growth. Coated leaves also might prematurely age and die, causing premature leaf drop. Fruits or vegetables that become covered with sooty mold are still edible. Wash off the mold with mild soap and warm water.

Fungi that most commonly cause sooty mold on Nagpur Mandarin plants are in the genera *Capnodium* Citri Chomnunti *et al.* 2012**.** The species of sooty mold-causing fungi present are determined by a combination of the environment, host, and insect species present. Some sooty mold species are specific to particular plants or insects, while other mold species might colonize many types of surfaces and use honeydew produced by several kinds of insects.

Timmer, LW and SE Zitiko (1992) Honeydew is a sweet, sticky liquid that plant-sucking insects excrete while they feed on sap from a plant. Because the insect can't completely digest all the nutrients they take in from this large volume of fluid, it assimilates what it needs and excretes the rest as waste (honeydew). Wherever honeydew lands—leaves twigs, fruit, yard furniture, concrete, sidewalks, parking lots, cars—sooty mold can grow.

Materials and Methods

Infected plant materials were initially examined visually using stereomicroscope for mycelia appearance and development. Fungal structures were mounted in 50% lactic acid and examined using a BH_2 Olympus light microscope equipped with a Sony digital Camera (DSCHX1). Measurements were taken in lactic acid (50%) mounts, based on at least 25-30 conidiophores, conidia, etc. Morphological characters of fungal structures including hyphal type, conidia and conidiomata, ascoma, asci and ascospores, when and if present were studied Reynolds and Gilbert (2005, 2006).

Fungicide solutions were prepared separately by taking requisite amount of fungicides for each dose. The fungicides were sprayed at 30 days interval by sprayer. The sprays with test fungicides at given concentration were taken with the help of sprayer. The spray pump wash flushed thoroughly with clean water every time before spraying next fungicide. Utmost care was taken to avoid spray drift from one treatment to another.

Assessment of disease incidence and severity was calculated using the following formula described in experiment

Percent disease reduction (PDR) was calculated using the formula of Rai and Mamatha (2005) as :

$$\% \text{ disease reduction (PDR)} = \frac{\text{PCI in control - PDI in treatment}}{\text{PDI in control}} \quad 100$$

Table-1 : Effect of fungicidal sprays on the sooty mold incidence of Nagpur Mandarin Season I 2019-20 & Season II 2020-21.

	Treatments	Conc. (%)	Percent Disease Index (PDI)							
			Pre-spray observations		10 days after 1st Spray		10 days after 2nd Spray		10 days after 3rd Spray	
			Season I 2019-20	Season II 2020-21	Season I 2019-20	Season II 2020-21	Season I 2019-20	Season II 2020-21	Season I 2019-20	Season II 2020-21
T_1	Carbendazim	0.25	4.20 (11.78)	4.81 (12.63)	8.02 (16.45)	7.16 (15.5)	10.62 (18.96)	10.25 (18.64)	13.58 (21.59)	12.35 (20.54)
T_2	Mancozeb	0.10	3.83 (11.24)	4.20 (11.78)	4.20 (11.81)	5.68 (13.79)	6.42 (14.61)	7.78 (16.19)	10.37 (18.76)	9.75 (18.19)
T_3	Copper oxychloride	0.25	4.07 (11.61)	4.32 (11.91)	3.46 (10.69)	5.06 (12.95)	4.94 (12.83)	6.79 (15.06)	8.15 (16.56)	7.90 (16.27)
T_4	Carbendazim+Mancozeb	0.20	3.83 (11.2)	3.95 (11.37)	8.77 (17.21)	7.90 (16.32)	10.74 (19.03)	11.36 (19.65)	14.94 (22.72)	13.95 (21.92)
T_5	Chlorothalonil	0.20	3.21 (10.29)	3.70 (11.04)	6.42 (14.67)	6.17 (14.33)	7.53 (15.83)	8.89 (17.34)	11.73 (20.02)	11.23 (19.58)
T_6	Metalaxyl + Mancozeb	0.20	3.95 (11.46)	4.57 (12.31)	7.41 (15.77)	6.91 (15.21)	9.88 (18.32)	9.63 (18.05)	12.10 (20.32)	12.22 (20.43)
T_7	Control	-	3.58 (10.89)	4.44 (12.16)	13.83 (21.81)	12.96 (21.09)	22.22 (28.12)	20.25 (26.73)	37.28 (37.62)	27.16 (31.4)
SEm±			(0.54)		(0.53)		(0.93)		(0.85)	
CD at 5%			(NS)		1.63		2.85		2.61	

Figures in the parentheses represent arcsine transformed values; PDI: Percent disease index

Observation will be recorded at 15 days interval starting from 15 days and Number of leaves with sooty mould growth will be recorded.

Results and Discussion

Six fungicides were evaluated *in-vivo* condition through two foliar applications at 10 days interval in field condition. The data on the incidence of sooty mold after fungicides sprays indicated that (Table 01) all the treatments showed reduction in sooty mold incidence over control and indicate that, the per cent sooty mold control over the control. Ghosh, D.K *et. al* (2003).

Yesmin K. *et al*. (2017) Management of sooty mold fungi with fungicides *in-vivo* condition in year 2019-20 First observation the treatment T_3, Copper oxychloride has the lowest mean of sooty mold incidence of (3.46 %) followed by the treatment T_2, Mancozeb of (4.20 %). The sooty mold incidence ranged from 3.46 to 8.77 percent inrespect of other treatments. The percentage of sooty mold control in treatment $T_3$and T_2 was found to be 74.98 and 69.63 per cent respectively. The per cent of sooty mold control ranged from 36.58 to 74.98 percent in respect of other treatments. And year 2020-21 The treatment T_3, Copper oxychloride has the lowest mean of sooty mold incidence of (5.06%) followed by the treatment T_2, Mancozeb of (5.68 %). The sooty mold incidence ranged from 5.06 to 7.16 percent inrespect of other treatments. The percentage of sooty mold control in treatment $T_3$and T_2 was found to be 60.95 and 56.17 per cent respectively. The per cent of sooty mold control ranged from 39.04 to 60.95 percent in respect of other treatments.

2[nd] observation in year 2019-20 The treatment T_3, Copper oxychloride has the lowest mean of sooty mold incidence of (4.94 %) followed by the treatment T_2, Mancozeb of (6.42 %). The sooty mold incidence ranged from 4.94 to 10.74 percent inrespect of other treatments. The percentage of sooty mold control in treatment $T_3$and T_2 was found to be 77.76 and 71.10 per cent respectively. The per cent of sooty mold control ranged from 51.66 to 77.76 percent in respect of other treatments. In year 2020-21 the treatment T_3, Copper oxychloride has the lowest mean of sooty mold incidence of (6.79 %) followed by the treatment T_2, Mancozeb of (7.78 %). The sooty mold incidence ranged from 6.79 to 11.36 percent inrespect of other treatments. The percentage of sooty mold control in treatment $T_3$and T_2 was found to be 66.46 and 61.58 per cent respectively. The per cent ofsooty mold control ranged from 43.90 to 56.09 percent in respect of other treatments.

3[rd] observation in year 2019-20 the treatment T_3, Copper oxychloride has the lowest mean of sooty mold incidence of (8.15 %) followed by the treatment T_2, Mancozeb of (10.37 %). The sooty mold incidence ranged from 8.15 to 14.94 percent inrespect of other treatments. The percentage of sooty mold control in treatment $T_3$and T_2 was found to be 78.13 and 72.18 per cent respectively. The per cent ofsooty mold control ranged from 59.92 to 78.13 percent in respect of other treatments. In year 2020-21 the treatment T_3, Copper oxychloride has the lowest mean of sooty moldincidence of (7.90 %) followed by the treatment T_2, Mancozeb of (9.75 %). The sooty mold incidence ranged from 7.90 to 13.95 percent inrespect of other treatments. The percentage of sooty mold control in treatment $T_3$and T_2 was found to be 70.91 and 64.10 per cent respectively. The per cent of sooty mold control ranged from 48.63 to 70.91 percent in respect of other treatments.

Conclusions

Nagpur mandarin (*Citrus reticulate* Blanco) is an important fruit crop grown commercially in different agro-climatic conditions for Its diversified use in Madhya Pradesh. it occupies an important place in the horticulture wealth an economy of the State it is the most common among citrus fruit grown in Chhindwara district, Madhya Pradesh and Is occupying premier position among Indian mandarins. It is susceptible to a number of fungal. Bacterial, viral and nematode pathogens. Insect causing decline and fruit drop losses to the crop In the present Investigation Capnodium citri declined citrus trees were recorded.

Under *in-vivo* conditions, among the fungicides *viz.* Copper Oxychloride, Carbendazim, Mancozeb, Carbendazim + Mancozeb and Chlorothalonil were found significant effect on reducing the sooty mold incidence but Carbendazim was recorded minimum diseases incidence and maximum orange yield.

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Evaluation for Biodiversity Conservation of Climate Smart Table Purpose Traditional Mango Varieties (*Mangifera indica*) of South Kerala

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Abstract

Mango the most important fruit of our nation is highly vulnerable to climatic changes. Studies on changes in climatic conditions have got great relevance now a day. Such studies are useful for knowing the flowering of mango under various climatic conditions. Many introduced varieties and hybrids are susceptible to change in climatic condition but some traditional are performing well and give good yield even under changed climatic situations. A study was conducted at the Farming Systems Research Station, Sadanandapuram, Kerala Agricultural University with an aim of finding out and evaluating ,climate smart table purpose traditional mango varieties from Southern parts of Kerala. Twenty eight table purpose traditional mangoes were identified during the study. Fruit weight of the selected mangoes varied from 150 g to 457 g, fruit length varied from 7.5 cm to 12.13 cm, fruit width varied from 6.0 cm to 9.5 cm), fruit diameter 33.00 was highest in KLM-17and TVM-2, fruit volume varied from 158 cc to 440.00 cc.), pulp peel ratio was highest 11.33 in TVM-5 and lowest 4.61 in TVM-2. Pulp stone ratio was highest in TVM -5 (10.03) and lowest in TVM -7 (3.70). Fruit weight was highest (457.0 g) in KLM-27, number of fruits per tree varies from 198.0 (KLM-23) to 810.0 (TVM-1), yield per tree varies was highest (319.0 kg) in PTA-3. Highest TSS value of 24.0^0 Brix was reported from TVM-4 and acidity varied from 0.317 % (KLM-19 and ALA-6) to 2.080 % (TVM-6). Carotenoid content was highest in TVM-2 (6.78 mg 100 g^{-1}) (KLM-25), ascorbic acid varied from 9.27 mg 100 g^{-1} (KLM-17 and ALA-12) to 24.0 mg 100 g^{-1} (KLM-18), total sugar content was highest (14.01 %) in (TVM-7).

Key Words : *Climate smart, traditional mango, biodiversity conservation , table purpose mangoes.*

Introduction

Climate change is becoming an observed reality, very likely due to the increase of anthropogenic greenhouse gas concentration. Climate change is therefore a great concern for agriculture. Mango is one of the most widely cultivated and popular fruits in these regions for its economic and nutritional values. It is the fifth most cultivated fruit in the world. It is consequently justified to wonder about the impact of climate change on the mango tree and about the consequences on mango production and cultivation [2]. Although mango tree is adapted to dry environments experiencing water stress andhigh evaporative demand, the expected increase of drought and vapour pressure deficit (VPD) would have a negative effect on photosynthesis because of the rapid stomatal closure of the mango tree when the climatic demand increases. Flooding is expected to increase in regions with more intense and frequent rainfalls, and to decrease in regions becoming drier. In both cases, the effect on mango photosynthesis will probably be negative. Mango is moderately flood-tolerant and flooding leads to a rapid decrease of transpiration, stomatal conductance and maximal photosynthetic assimilation[4].

Increasing temperatures would have a negative effect on floral induction. But in regions with particularly cool temperature during flowering, increasing temperatures would have a positive effect on pollen viability and fruit set [7]. Temperature also has a negative effect on inflorescence size and on the number of flowers per inflorescence [1]. Floral induction also requires the exposure of mature leaves to light, and higher levels of light intensity could have a positive effect on mango flowering. Drought and higher VPD would have a negative effect on fruit set and retention [6]. Drought could also have an indirect positive effect on floral induction by promoting early growth cessation and vegetative rest required for floral induction.

Mango is one of the most popular fruit crop of Kerala. Mango's flowering and fruit set are highly dependent on climatic conditions prevailing in that area. Recently climate hange studies have become increasingly important for understanding the flowering of mango under different climatic conditions [3]. Air temperature and rainfall influence vegetative and penological phases in mango and are two of the most important factors determining suitability of an area's climate for mango production. Varietal responses to the environment within and between mango cultivars account for their relative performance at different locations [5]. In conclusion, this overview of the effects of climatic factors on key processes of mango production illustrates the difficulty to draw from the current knowledge clear conclusions on the future effects of climate change on mango production and

Table-1 : Fruit characters of Table purpose traditional mangoes.

Acc no.	Fruit Weight (g)	Fruit Length (cm)	Fruit width (cm)	Fruit diameter (cm)	Fruit volume (cc)	Pulp weight (g)	Peel weight (g)
KLM 16	420.00	11.00	8.90	29.60	412.00	318.00	30.67
KLM 17	340.00	9.00	8.00	33.00	345.00	242.00	51.00
KLM 18	380.00	11.00	9.17	26.30	385.33	291.67	46.00
KLM 19	429.00	11.00	9.40	25.33	416.00	355.00	33.00
KLM 20	400.00	9.80	9.00	27.50	386.00	353.07	31.00
KLM 21	372.00	11.00	8.50	28.00	258.00	298.00	49.00
KLM 22	150.00	7.50	6.00	27.00	158.00	82.00	15.00
KLM 23	361.00	12.13	9.07	25.63	351.00	271.00	44.00
KLM 25	338.00	11.00	8.20	20.10	350.00	240.00	59.00
KLM 27	457.00	11.50	12.00	28.00	440.00	314.00	40.00
KLM 28	400.67	11.50	9.50	28.10	420.00	289.00	51.00
KLM 29	253.33	9.53	10.00	25.00	250.00	186.00	30.00
KLM 30	295.00	11.20	9.00	24.00	309.00	223.00	36.00
PTA 3	202.00	9.50	8.00	20.67	233.33	125.00	30.00
ALA 6	271.00	9.20	8.00	24.00	260.000	205.00	35.00
ALA 7	218.00	10.00	7.80	22.00	230.00	180.00	30.00
ALA 8	219.00	9.00	9.10	21.00	225.00	168.00	31.00
ALA 9	231.33	10.00	9.00	21.00	234.00	165.00	37.00
ALA10	251.00	9.20	9.50	20.67	249.00	139.00	21.00
ALA 11	173.00	7.50	8.40	19.00	170.00	130.00	25.00
ALA 12	184.00	8.50	9.00	22.67	186.00	126.00	30.00
TVM 1	420.00	11.00	8.90	29.60	412.00	318.00	30.67
TVM 2	340.00	9.00	8.00	33.00	345.00	242.00	51.00
TVM 3	380.00	11.00	9.17	26.30	385.33	291.67	46.00
TVM 4	429.00	11.00	9.40	25.33	416.00	355.00	33.00
TVM 5	400.00	9.80	9.00	27.50	386.00	353.07	31.00
TVM 6	372.00	11.00	8.50	28.00	258.00	298.00	49.00
TVM 7	150.33	7.50	6.00	27.00	159.00	85.00	18.00
CD (0.05)	32.67	1.58	1.09	2.47	24.38	28.64	1.95

Table-2 : Fruit Pulp Characteristics of Table Purpose Mango.

Acc no.	Pulp thickness (cm)	Peel thickness (cm)	Pulp/peel ratio	Pulp/stone ratio
KLM 16	1.60	0.19	8.00	8..33
KLM 17	1.33	0.35	4.90	4.97
KLM 18	2.00	0.64	8.64	7.26
KLM 19	1.90	1.45	7.09	7.01
KLM 20	1.56	0.95	9.00	6.00
KLM 21	2.00	0.84	8.86	7.30
KLM 22	1.74	0.40	5.58	4.83
KLM 23	2.35	1.52	8.03	7.47
KLM 25	3.01	1.37	7.06	6.47
KLM 27	1.50	0.38	7.84	8.49
KLM 28	2.10	1.04	9.02	7.00
KLM 29	1.96	1.03	7.53	7.46
KLM 30	1.85	1.05	7.85	9.03
PTA 3	1.40	0.43	5.99	8.05
6ALA 6	2.10	0.18	8.05	8.22
ALA 7	1.67	0.77	5.93	5.72
TVM1	3.00	1.00	9.31	8.53
TVM 2	2.80	1.12	4.61	7.03
TVM 3	2.50	1.50	6.37	5.84
TVM 4	2.20	1.00	10.71	7.82
TVM 5	2.30	1.00	11.33	10.03
TVM 6	2.80	1.10	6.22	9.30
TVM 7	1.80	2.01	5.42	3.70
CD (0.05)	0.08	0.09	1.01	0.07

Table-3 : Yield characters of table purpose traditional mangoes.

Acc no.	Fruit Weight (g)	Number of fruits	Yield per tree (Kg)	Organoleptic evaluation (Overall acceptability)
KLM 16	420.00	350	151.55	8
KLM 17	340.00	250	107.50	8
KLM 18	380.00	300	95.19	8
KLM 19	429.00	350	168.00	8
KLM 20	400.00	550	166.65	7
KLM 21	372.00	800	307.20	7
KLM 22	150.33	750	275.25	8
KLM 23	361.00	198	68.40	8
KLM 25	338.00	250	122.00	8
KLM 27	457.00	200	98.00	9
KLM 28	400.67	600	247.80	7
KLM 29	253.33	450	166.50	9
KLM 30	295.00	400	161.20	7
PTA 3	202.00	500	319.00	7
ALA 6	271.00	250	105.00	6
ALA 7	218.00	500	170.00	8
ALA 8	219.00	550	209.00	8
ALA 9	231.33	350	150.15	8
ALA10	251.00	400	160.00	8
ALA 11	173.00	620	230.64	7
ALA 12	184.00	300	45.09	7
TVM 1	295.00	810	236.00	9
TVM 2	420.00	750	315.00	7
TVM 3	340.00	200	68.00	6
TVM 4	380.00	250	95.00	8
TVM 5	429.00	200	85.80	8
TVM 6	400.00	600	240.00	8
TVM 7	372.00	450	167.40	8
CD (0.05)	34.25	28.89	34.27	0.01

Table-4 : Fruit quality analysis of table purpose traditional mangoes.

Acc no.	TSS	Acidity	Carotenoid	Ascorbic Acid	Total Sugar	Reducing Sugar	Non Reducing Sugar
KLM 16	21.00	0.600	3.13	21.77	11.32	3.31	7.77
KLM 17	15.00	0.593	3.40	9.27	13.15	3.03	9.77
KLM 18	22.00	0.320	2.33	24.00	10.41	3.34	7.12
KLM 19	20.00	0.317	5.25	20.00	14.00	4.16	10.81
KLM 20	14.00	0.640	6.72	12.00	10.51	2.77	7.88
KLM 21	20.00	0.633	3.00	15.00	7.22	2.40	4.70
KLM 22	19.00	0.960	4.00	20.33	13.12	2.60	10.37
KLM 23	15.00	0.937	5.20	20.00	11.90	2.61	9.17
KLM 25	16.00	0.923	6.78	14.93	10.40	2.50	7.60
KLM 27	16.00	0.320	5.57	14.33	13.92	3.85	9.84
KLM 28	18.00	0.630	4.48	18.00	13.12	2.93	10.05
KLM 29	19.00	0.937	5.20	20.00	11.90	2.61	9.17
KLM 30	18.00	0.923	6.78	14.93	10.40	2.50	7.60
PTA 3	14.00	0.623	3.00	23.33	7.27	1.78	6.21
ALA 6	11.00	0.317	5.25	20.00	14.00	4.16	10.81
ALA 7	15.00	0.640	6.72	12.00	10.51	2.77	7.88
ALA 8	16.00	0.317	5.25	20.00	14.00	4.26	10.81
ALA 9	21.00	0.640	6.72	12.00	10.51	2.77	7.88
ALA10	18.00	0.633	3.00	15.00	7.20	2.40	4.70
ALA 11	16.00	0.600	3.13	21.77	11.32	3.31	7.77
ALA 12	15.00	0.593	3.40	9.27	13.15	3.03	9.77
TVM 1	16.00	0.320	3.00	12.00	10.40	3.60	6.93
TVM 2	15.00	0.640	2.32	20.00	12.50	1.92	10.54
TVM 3	19.00	0.320	4.49	17.23	8.90	3.27	5.31
TVM 4	24.00	0.953	3.38	13.33	13.31	4.20	9.20
TVM 5	17.06	0.640	2.35	12.00	9.42	2.91	6.32
TVM 6	16.00	2.080	3.10	20.43	10.59	2.15	8.31
TVM 7	17.00	0.320	3.03	10.44	14.01	2.77	11.01
CD (0.05)	2.18	0.015	0.04	1.05	1.24	0.07	0.11

cultivation. Single factors can have positive or negative effects on a process, but we also have to take into account interactions between factors. However a few varieties are still existing in some homesteads are found resistant to abiotic stresses. Hence the present study is conducted with an objective of identifying, evaluation and biodiversity conservation of climate resilient mango varieties from Southern Kerala.

Materials and Methods

Detailed survey has been conducted to identify the traditional mango varieties of South Kerala (Alapuzha Thiruvananthapuram, Pathanamthitta and Kollam, districts). Field visits of farmers having indigenous mango varieties with fairly high yield even under changed climatic situations were selected for detailed study. For the study descriptive characters of leaf, inflorescence, fruit and stone were recorded as per IPGRI descriptor. Quantitative characters like petiole length, leaf length, leaf width, inflorescence length, inflorescence width, fruit length, fruit width, fruit weight, fruit volume were studied. Fruit quality characters like total soluble solids, acidity, ascorbic acid content, total carotenoids, total sugar and reducing sugar and crude fibre content were studied. Climate smart indigenous mango trees which were superior with respect to important economic characters like yield, fruit size, organoleptic qualities, regularity in bearing, offseason bearing, pest and disease resistance even under changed climatic scenario of Kerala were selected. Effect of changed climate on performance of traditional mango varieties of South Kerala was noted during the study.

Physiological changes during different phenophases of mango were conducted. Abiotic stress tolerant studies were also undertaken. The selected table purpose traditional mango varieties were characterized based on morphological markers

Results and Discussion

Based on the study it was seen that (Table-1) the fruit weight ranges from 150 g (KLM-22) to 457 g(KLM-27), fruit length varied from 7.5 cm (KLM-22, ALA-1 and TVM-7) to 12.13 cm (KLM-23), fruit width varied from 6.0 cm (KLM-22 and TVM-7) to 9.5 cm cm (ALA-10), fruit diameter varied from 20.10 cm (KLM-22) to 33.00 cm (KLM-17, TVM-2), fruit volume varied from 158 cc (KLM-22) to 440.00 cc (KLM-27), pulp weight varied from 82.0 g (KLM-22) to 355.00g (KLM-19, TVM-4), peel weight varied from 15.00 g (KLM-22) to 59.00 g (KLM-25).

Results of the experiment showed that (Table-2) fruit pulp thickness from different accessions of climate resilient traditional mango varieties varies from 1.4 cm (PTA-3) to 3.01 cm (KLM-25), peel thickness of fruits varies from 0.19 cm (KLM-16) to 2.0cm (TVM-7), pulp peel ratio was highest 11.33 in TVM-5 and lowest 4.61 in TVM-2. Pulp stone ratio was highest in TVM -5 (10.03) and lowest in TVM-7 (3.70).

Based on the results of the experiment (Table.3), it was seen that fruit weight from different accessions of climate resilient traditional mango varieties varies from 150.33 g (KLM-22) to 457.0 g (KLM-27), number of fruits per tree varies from 198.0 (KLM-23) to 810.0 (TVM-1), yield per tree varies from 68.0 Kg (TVM-3) to 319.0 kg (PTA-3). Overall acceptability of these table purpose traditional mangoes based of organoleptic analysis, varies from lowest score of 6.0 (TVM-3) to highest score of 9.0 (KLM-29) and (TVM-1).

The study of fruit quality characters showed significant difference among different accessions (Table-4). TSS value varied from 11 ^{0}Brix (ALA-6) to (TVM-4) 24.0^0 Brix, acidity varied from 0.317 % (KLM-19 and ALA-6) to 2.080 % (TVM-6). Carotenoid content varied from 2.32 mg 100 g^{-1} (TVM-2) to 6.78 mg 100 g^{-1} (KLM-25), ascorbic acid varied from 9.27 mg 100 g^{-1} (KLM-17 and ALA-12) to 24.0 mg 100 g^{-1} (KLM-18), total sugar content varied from 7.20 % (ALA-10) to 14.01 % (TVM-7), reducing sugar content varied from 1.92 % (TVM-2) to 4.26 % (ALA-8), non reducing sugar content varied from 4.70 % (KLM-21 and ALA-10) to 11.01% (TVM-7).

Conclusions

Mango is highly vulnerable to changes in climatic conditions. Now the focus is given for the identification of climate smart fruit crops .From the detailed study on climate smart table purpose traditional mangoes it was observed that fruit weight of the selected mangoes varied from 150 g to 457 g, fruit length varied from 7.5 cm to 12.13 cm, fruit width varied from 6.0 cm to 9.5 cm), fruit diameter 33.00 was highest in KLM-17and TVM-2 , fruit volume varied from 158 cc to 440.00 cc.), pulp peel ratio was highest 11.33 in TVM-5 and lowest 4.61 in TVM-2. Pulp stone ratio was highest in TVM -5 (10.03) and lowest in TVM -7 (3.70). Fruit weight was highest (457.0 g) in KLM-27, number of fruits per tree varies from 198.0 (KLM-23) to 810.0 (TVM-1), yield per tree varies was highest (319.0 kg) in PTA-3. Highest TSS value of 24.0^0 Brix was reported from TVM-4 and acidity varied from 0.317 % (KLM-19 and ALA-6) to 2.080 % (TVM-6). Carotenoid content was highest in TVM-2 (6.78 mg 100 g^{-1}) (KLM-25), ascorbic acid varied from 9.27 mg 100 g^{-1} (KLM-17 and ALA-12) to 24.0 mg 100 g^{-1} (KLM-18), total sugar content was highest (14.01 %) in (TVM-7),

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Integrated Crop Management : A Vital Tool to Maximize Crop Production and Protection Aspects in Pigeonpea

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Abstract

The technical gap between existing and proposed pigeonpea crop technologies was evaluated in the years 2020-21 and 2021-22. Ten demonstrations were carried out in farmer's fields. The results indicated that improved technology yielded a mean output of 41.4 t/ha, which was 3.4 percent higher than farmers' average production (38.4 t/ha) whereas the average extension gap was 3.0 t/ha, the average technology gap was 21.3 t/ha, and the average technology index was 51.4 percent. An additional investment combined with the introduction of new high yielding, disease resistant cultivars with suggested nutrition, water management, plant protection measures, scientific monitoring, and non-monetary elements resulted in increased mean returns of Rs.43580/ha. Improved yields resulted in a higher mean net revenue of Rs. 204295/ha and a BC ratio of 11.65 in comparison to farmers' practices (Rs. 160715/ha). The use of enhanced technologies greatly raised the income and also the net returns to the farmers, according to the ICM demonstrations done on pigeonpea at the farmers' field.

Key words : *Extension, ICM, pigeonpea, production, technology,*

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is a perennial shrub with a limited life span that is usually grown as an annual crop in underdeveloped nations. Currently, India is the major producer of pigeon peas, accounting for over 70% of total global production (Anon., 2017).

Pigeonpea production is concentrated in 22 countries (823.82 lakh ha, with 818.00 lakh tonnes produced and a productivity of 993 kg/ha), largely in Asia and Africa. However, India alone contributes 294.47 lakh ha, with a production of 231.31 lakh tonnes and a productivity of 786 kg/ha. Karnataka alone contributes 25.74 lakh square kilometres. Pigeonpea crop suffers from both biotic and abiotic stresses. Among the biotic factors diseases caused by fungi, bacteria, viruses and nematodes are the major constraints for the production and productivity. The soil borne diseases caused by the fungal pathogens such as *Fusarium*, *Phytophthora* and *Rhizoctonia* are of greater economic significance.

As a result, management approaches must be standardised to account for varying agroclimatic conditions. To tackle the wilt disease in pigeonpea, pest management strategies and biocontrol measures have been launched by employing antagonistic micro-organisms. Second, it is thought that developing resistant cultivars and combining the use of bio-agents and fungicides is more feasible.

The amount to which new agricultural technology are adopted is a critical factor in the innovation diffusion process, and it is the most essential factor for increasing agricultural productivity at a faster rate. A large number of agricultural technologies have been developed but have yet to be recognized and utilized. The gap between scientists' advice and farmers' actual implementation is common. Agricultural extension education center (AEEC) Lingsugur has done large-scale demonstrations of integrated crop management (ICM) approaches in response to the crisis.

Materials and Methods

During 2020-21 and 2021-22, ICM demonstrations were held in farmers' fields at AEEC, Lingasugur in the Raichur district of Karnataka, with the goal of popularizing improved technology for pigeon pea productivity enhancement through demonstrations. In a farmer's field, ten ICM demonstrations were held. On-campus and off-campus trainings were held to disseminate pigeon pea productivity boosting technology. The following technologies were then used to illustrate improved practices.

Sl. No.	ICM Technology implemented
1.	Improved variety-GRG 811, GRG152, BSMR-736 (Plate 1)
2.	Application of biofertilizers (PSB)
3.	Biopesticides (*Trichoderma, Pseudomonas fluorescence, Bacillus subtilis*)
4.	Timely spray of pesticides, Pheramone traps

Table-1 : pigeon pea yield, technology gap, extension gap and technology index as influenced by ICM practices.

Year	Potential yield t/ha)		% increase in yield in ICM over FP	Technology gap (t/ha)	Extension gap (kg/ha)	Technology index (%)
	ICM	FP				
2020-21	42.62	39.26	8.5	25.7	3.4	60.3
2021-22	39.66	37.6	5.4	17.6	2.06	44.4
Average	41.4	38.4	6.95	21.3	3.0	51.4

Table-2 : Economic analysis of pigeonpea demonstration.

Sl. No	Net returns (Rs/ha)		Additional returns (Rs./ha)	B:C	
	ICM	FP		ICM	FP
2020-21	234874	167590	67284	12.4	8.65
2021-22	173716	153840	19876	10.9	7.80
Average	204295	160715	43580	11.65	8.22

Plate-1 : Field visit to GRG-811 pigeonpea.

Samui percent was used to determine the technology gap, extension gap, and technology index for the study (2000).

Technology gap = Potential yield – Demonstration yield

Technology index (%) = (Potential yield - Demonstration yield /Potential yield) * 100

Results and Discussion

The data were analysed, the technology gap, extension gap, and technology index were determined using the formula, and an economic analysis was performed using the technique, and the results are shown in tables-1 and 2.

The average pod output of pigeon pea was 41.4 tonnes per hectare, compared to 38.4 tonnes in farmers' fields. The enhanced production of pigeon pea in the demonstration plot was mostly due to the use of better technology. The use of bio-inputs allowed for the mobilization of nutrients from natural soil nutrients, the use of pulse magic (micronutrient) during 50% blooming, and the use of Trichoderma in conjunction with pheromone traps to assist monitor the crop and resist disease. The demonstration yield exceeded the potential yield of farmers due to a technological gap (Balai *et al*., 2012). Farmers will ultimately abandon old technology in favour of new technology as a result of the new technologies. The technology index indicates the practicality of evolving technology in farmer's fields; the lower the value of the technology index, the greater the viability of the technology. In this demonstration, 51.4 percent of the technologies index was observed, indicating proper adoption of enhanced technologies. Keshavareddy *et al*. (2018) found similar results in mango, Shalini *et al*. (2016) in tomato, Renbomo Ngullie and Pijush (2016) in chilli, Vikram *et al*. (2018) and Rupesh (2015) in sunflower, and Berjesha *et al*. (2013) in Brassica.

The input and output prices of commodities were utilized throughout the research demonstrations to compute the gross return, cost of cultivation, net return, and benefit cost ratio (Table 2). Pigeonpea cultivation with superior technology resulted in a higher net return of Rs 204295 per hectare than farmer methods (Rs 160715 per hectare), which resulted in an extra return of Rs 43580 per hectare. In ICM, pigeon pea had a benefit-to-cost ratio of 11.65. This is due to higher yields gained through modern technology vs farmer plots used as a local control.

Conclusions

According to the study, ICM demonstration programme was found to be beneficial in increasing farmers' awareness and acceptance of several aspects of pigeonpea production technology. ICM practices raised awareness and encouraged other farmers to embrace more efficient production methods. The high yielding and resistant pigeon pea types has to be grown, which will extend throughout the taluk, including the surrounding area. The use of critical input and a participatory approach to designing and executing the demonstration will undoubtedly aid in technology transfer to farmers.

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Effect of Dates of Transplanting on the Incidence of Cabbage Aphid, *Brevicoryne brassicae* L. of Cabbage, *Brassica oleracea* var. capitata (L.) in Arid Ecosystem

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Abstract

This study describes the population variance of *Brevicoryne brassicae* on cabbage crop (Golden Acr) sown at weekly interval starting from 24th October to 21st November at Collage of Agriculture Bikaner, Rajasthan during the years *viz*., *rabi,* 2015-16 and 2016-17. All five transplanted dates were attacked by cabbage aphid, *Brevicoryne brassicae* Linnaeus. The aphid population reached to peak in the first week of February (5th SMW) during both the year at peak population ranged from 102.38 to 172.30 and 115.85 to 171.80 aphids per plant 2015-16 and 2016-17 respectively. A significant positive correlation was observed between transplanting dates and aphid population with variance explained of 91 per cent. The transplanting dates and yield revealed a significant negative correlation with variance explained of 25 per cent. A highly significant negative between aphid incidence and yield with variance explained of 17 Per cent. All the data indicate that with the delay in transplanting dates, the infestation of cabbage aphid, increased resulting in increased damage and decreased yield as well.

Key words : *Cabbage, transplant dates, arid ecosystem, Brevicoryne brassicae.*

Introduction

Cabbage, *Brassica oleracea* var. *capitata* Linn. is an important cole crop and commercially grown as leafy vegetable in India. It occupies an area of about thousand 399 hectares with an annual production of 9095 thousand million tonnes (Anonymous 2018-19). The productivity level of cabbage is much lower than its potential attributing to many causes and among them insect pests are major constraints. The cabbage crop is attacked by a major insect pests viz: *Lipaphis erysimi* (Kalt.), diamondback moth, *Plutella xylostella* Linnaeus; and tobacco caterpillar, *Spodoptera litura* Fabricius. (Sachan and Srivastava, 1972, Sharma, 2004 and Shukla and Kumar, 2004) are reported as major pests causing significant losses.

The manipulation in transplantation dates is one of the important cultural practices to avoid most vulnerable stage of the crop with the peak population buildup of pests without any additional cost. The meagre information on this aspect is available in different regions of the country on cabbage crop (Ojha *et al*., 2004 and Salman *et al*., 2007). Hence, the investigation was conducted to know the impact of different transplanting dates on the incidence of aphid of cabbage in arid region of Rajasthan where cabbage is grown as early, timely and late season crop from August to March.

Materials and Methods

The experiment was laid out in simple randomized block design (RBD) with five treatments (transplanting dates) and four replications. The plot size was 2.25 x 2.25 m^2 with row to row and plant distance of 45 x 45 cm, respectively. There were five different dates of transplanting of cabbage crop during both the years *viz*., *rabi,* 2015-16 and 2016-17 at weekly interval starting from 24^{th} October to 21^{st} November. Observations of cabbage aphid were recorded soon after their appearance at weekly interval till the harvesting of the crop. The data on aphid, were transformed into $\sqrt{x \quad 0.5}$ subjected to analysis of variance.

Results and Discussion

Value (Gomez and Gomez, 1976) and wereDuring 2015-16, at peak infestation of aphid population (102.38 aphids/plant) was recorded in the crop transplanted on 24^{th} October followed by 31^{rd} October (124.45 aphids/plant) and 7^{th} November (141.80 aphids/plant) transplanted crop, these population differed significantly to each other. The maximum aphid population (172.30 aphids/plant) during peak was noticed in the crop transplanted on 21^{th} November followed by 14^{th} November (163.05 aphids/plant) and both were at par to each other. The minimum mean aphid population (44.96 aphids/plant) of all the observations was also recorded in the crop transplanted on 24^{th} October followed by crop transplanted on 31^{th} October and 7^{th} November which exhibited 50.51 and 54.22 aphids per plant respectively.

A perfect positive correlation (r = 0.983) was found between transplanting dates and aphid population with variance explained of 86 per cent. In between the transplanting dates and yield a significant negative correlation (r = -0.853) was recorded with variance

Table-1 : Effect of dates of transplanting on the incidence of *L. erysimi* on cabbage during Rabi, 2015-16.

No. Transplanting	50#	51	52	1	2	3	4	5**	6	7	8	9	Mean
1. 24th October	0.70	1.90	5.90	11.55	28.80	61.90	74.45	102.38	101.70	98.45	46.70	5.10	44.96
	(1.07)	(1.53)	(2.51)	(3.47)	(5.40)	(7.89)	(8.65)	(10.14)	(10.10)	(9.93)	(6.86)	(2.36)	
2. 31rd October	0.95	2.25	6.95	14.45	33.00	67.15	78.85	124.45	110.75	101.25	56.20	9.85	50.51
	(1.17)	(1.65)	(2.71)	(3.82)	(5.75)	(8.22)	(8.90)	(11.18)	(10.54)	(10.08)	(7.48)	(3.21)	
3. 7th November	1.05	1.80	5.90	10.55	33.95	70.70	77.10	141.80	127.50	105.25	63.55	11.50	54.22
	1.24	(1.51)	(2.51)	(3.32)	(5.86)	(8.43)	(8.79)	(11.92)	(11.29)	(10.25)	(7.97)	(3.45)	
4. 14th November	0.35	1.25	7.45	21.85	41.10	80.85	89.80	163.05	160.30	132.20	78.45	20.70	66.43
	0.92	(1.31)	(2.81)	(4.72)	(6.44)	(9.00)	(9.50)	(12.77)	(12.68)	(11.51)	(8.87)	(4.59)	
5. 21st November	0.00	0.90	7.90	20.25	44.65	82..15	100	172.30	161.90	151.25	81.55	30.20	71.09
	0.71	(1.17)	(2.89)	(4.53)	(6.71)	(9.08)	(10.02)	(13.14)	(12.74)	(12.31)	(9.05)	(5.52)	
S.Em ±	-	0.11	0.15	0.20	0.23	0.21	0.26	0.21	0.30	0.31	0.31	0.17	
C.D. (5%)	-	0.35	0.47	0.63	.69	0.65	0.80	0.63	0.93	0.97	97	0.53	

Figures in the parentheses $\sqrt{x\quad 0.5}$ are values. **Peak aphid population # Standard meteorological week.

Table-2 : Effect of dates of transplanting on the incidence of *L. erysimi* on cabbage during Rabi 2016-17.

Transplanting	50#	51	52	1	2	3	4**	5	6	7	8	9	Mean
1. 24th October	1.35	2.65	11.15	40.45	80.80	112.30	115.85	112.45	95.65	69.95	28.80	8.75	56.61
	(1.35)	(1.76)	(3.40)	(6.39)	(9.01)	(10.60)	(10.78)	(10.62)	(9.81)	(8.39)	(5.31)	(3.03)	
2. 31rd October	1.05	3.10	11.60	42.95	84.65	131.95	133.40	115.55	102.05	72.10	33.15	9.90	61.79
	(1.24)	(1.88)	(3.47)	(6.58)	(9.22)	(11.50)	(11.57)	(10.77)	(10.12)	(8.49)	(5.77)	(3.12)	
3. 7th November	0.95	3.25	15.85	61.80	101.20	156.00	159.80	131.55	124.75	115.20	64.55	22.40	79.78
	(1.20)	(1.92)	(4.03)	(7.86)	(10.08)	(12.50)	(12.66)	(11.46)	(11.18)	(10.75)	(8.03)	(4.77)	
4. 14th November	1.20	2.35	17.75	77.15	110.90	160.15	162.00	157.45	154.30	132.20	77.15	34.20	90.57
	(1.29)	(1.68)	(4.26)	(8.79)	(10.53)	(12.65)	(12.74)	(12.56)	(12.44)	(11.51)	(8.80)	(5.87)	
5. 21st November	00	1.85	18.40	81.30	116.75	169.80	171.80	168.45	168.70	151.10	79.25	39.55	97.25
	(0.71)	(1.52)	(4.32)	(9.02)	(10.76)	(13.05)	(13.12)	(12.99)	(13.00)	(12.30)	(8.92)	(6.31)	
S.Em±	-	0.12	0.21	0.31	0.32	0.28	0.21	0.30	0.25	0.26	0.30	0.32	
C.D. (5%)	-	0.38	0.65	0.96	0.98	0.87	0.65	0.93	0.78	0.80	0.94	1.0	

Figures in the parentheses $\sqrt{x\quad 0.5}$ are values.** Peak aphid population # Standard meteorological week.

Table-3 : Effect of dates of transplanting on the incidence of *L. erysimi* on cabbage (Pooled).

No. Transplanting	50#	51	52	1	2	3	4	5**	6	7	8	9	Mean
1. 24th October	1.03	2.28	8.53	26.00	54.80	86.96	95.15	114.45	100.05	84.20	37.35	6.93	50.78
	(1.21)	(1.65)	(2.95)	(4.93)	(7.20)	(9.25)	(9.72)	(10.72)	(10.01)	(9.16)	(6.08)	(2.70)	
2. 31st October	1.00	2.68	9.28	28.70	58.83	99.55	106.13	118.18	106.40	86.68	44.68	9.88	56.15
	(1.21)	(1.77)	(3.09)	(5.20)	(7.49)	(9.86)	(10.23)	(10.89)	(10.33)	(9.28)	(6.63)	(3.16)	
3. 7th November	1.00	2.53	10.88	36.18	67.58	113.4	118.45	136.68	126.13	107.70	62.30	16.10	66.57
	(1.22)	(1.72)	(3.27)	(5.59)	(7.97)	(10.47)	(10.72)	(11.69)	(11.24)	(10.38)	(7.90)	(4.03)	
4. 14th November	0.78	1.80	12.60	49.50	76.00	120.40	125.90	160.25	157.30	132.20	77.80	27.45	78.50
	(1.10)	(1.49)	(3.54)	(6.76)	(8.49)	(10.83)	(11.12)	(12.67)	(12.56)	(11.51)	(8.83)	(5.23)	
5. 21st November	00	1.38	13.15	50.78	80.70	125.98	135.90	170.38	165.30	151.18	80.40	34.88	84.17
	(0.71)	(1.35)	(3.60)	(6.78)	(8.73)	(11.07)	(11.57)	(13.07)	(12.87)	(12.31)	(8.99)	(5.91)	
S.Em±	0.06	0.08	0.13	0.19	0.20	0.18	0.17	0.22	0.20	0.22	0.22	0.18	
C.D. (5%)	0.19	0.24	0.38	0.54	0.57	0.51	0.49	0.63	0.58	0.63	0.64	0.53	

Figures in the parentheses $\sqrt{x\quad 0.5}$ are values.** Peak aphid population # Standard meteorological week.

explained of 24 per cent. A significant negative correlation (r = -0.880) was also recorded between aphid incidence and yield with variance explained of 29 per cent**.**

During 2016-17, the minimum population of aphid (115.85 aphids/plant) at peak aphid infestation on crop was noticed in the early-transplanted crop *i.e.* 24th October followed by 31st October (133.40 aphids/plant) and these were statistically differed significantly. The maximum aphid population of aphids per plant was

Table-4 : Correlation coefficient, (*r* = value) regression equation and coefficient of determination between date of transplanting of cabbage and incidence of aphid and yield of cabbage.

S. No.	Particulars	Correlation coefficient (r)	
		2015-16	2016-17
1.	Transplanting dates v/s Aphid incidence	0.977*	0.979*
2.	Aphid incidence v/s Yield	-0.898	-0.906
3.	Transplanting dates v/s Yield	-0.853	-0.856

Significant at 5%

S. No.	Regression equation Y = a + byxX		Coefficient of determination (%) (Variance explained)	
	2015-16	2016-17	2015-16	2016-17
1.	$Y= -39.65 - 0.260\ X_1$	$Y = 40.32 - 0.259\ X_1$	24	25
2.	$Y= 112.31 - 0.578\ X_2$	$Y = -0.97 - 0.344\ X_2$	29	17
3.	$Y1 = -17.34 + 0.514\ X_1$	$Y_1 = -23.85 + 0.590\ X_1$	86	91

Y = Yield (dependent) X_1 = Date of transplanting
Y_1 = Aphid population X_2 = Aphid population

Table-5 : Effect of dates of transplanting on the yield of cabbage.

Dates of transplanting	Yield of cabbage heads (q/ha)		
	2015-16	2016-17	Pooled
24th October	202.96	193.09	198.02
31st October	223.21	214.82	219.01
7th November	198.76	188.64	194.07
14th November	179.75	165.43	172.59
21st November	155.16	145.43	150.30
S.Em±	7.96	8.94	7.58
C.D. (5%)	24.59	27.53	22.31

recorded in the late-transplanted crop *i.e.* 21st November (171.80 aphids/plant) followed by 14th November (160.15 aphids/plant) and 7th November (159.80 aphids/plant) transplanted crop these were statistically at par to each other.

The mean aphid population of all the observations recorded during the crop season indicated that the minimum mean population of 56.61 aphids per plant was also found on the crop transplanted on 24th October (early transplanted) followed by 61.79 aphids per plant in the crop transplanted on 31st October and both were statistically differed with each other.

The maximum mean aphid population 97.25 aphids per plant was found in the late- transplanted crop *i.e.* 21st November followed by the crop transplanted on 14th November (90.57 aphids/plants) and 7th November (79.78 aphids/plants) respectively, and all these were statistically differed with each other.

A perfect significant positive correlation (r = 0.979) was found between transplanting dates and aphid population with variance explained of 91 per cent which showed that the aphid incidence increased with the delay in transplanting. Relationship in between the transplanting dates and yield revealed a significant negative correlation (r = -0.856) with variance explained of 25 per cent. A highly significant negative correlation (r= -0.906) was also recorded between aphid incidence and yield with variance explained of 17 Per cent.

The pooled data of both the years show that the minimum aphid population 114.45 aphids per plant during peak infestation was recorded from the crop transplanted on 24th October followed by crop transplanted on 31rd October and 7h November which exhibited 118.18 and 136.68 aphids per plant. The population on the crop transplanted on 24th October at par with the population on the crop transplanted on 31th October, however, the later statistically differed with the population on the 7th November. The maximum aphid population (170.38 aphids/plant) was recorded on the late- transplanted crop *i.e.* 21th November followed by 14th November (160.25 aphids/plant) and both were also at par.

The pooled mean aphid population of all the observations recorded during crop the season also indicate that minimum aphid population of 50.78 aphids per plant was found on the crop transplanted on 24th October followed by the crop transplanted on 31rd October and 7th November (56.15 and 66.57 aphids/plant respectively).

The maximum mean aphid population of 84.17 aphids per plant was recorded in the crop transplanted on

21th November and it was differed with the crop transplanted on 14th November (78.50 aphids/plant).

Yield of cabbage heads : The maximum yields of cabbage heads (223.81 and 214.82 q ha^{-1}) during *Rabi* 2015- 16 and 2016-17 were obtained from the crop transplanted on 31st October which were statistically at par with 24th October (209.96 and 193.09 q ha^{-1}) but differed with 7th November (198.76 and 188.64 q ha^{-1}) transplanted crop respectively. However later were at par with crop transplanted on 14th November (179.75 and 165.43 q ha^{-1}). The minimum yields of cabbage heads (155.16 and 154.43 q ha^{-1}) were obtained from the crop transplanted on 21st November (late-transplanted), which were statistically at par with crop transplanted on 14th November.

The pooled data of both the years showed that the maximum yield of cabbage heads (219.01 q ha^{-1}) was obtained from the crop transplanted on 31th October and which were at par with crop transplanted on 24th October (198.02 q ha^{-1}). The minimum yield of cabbage heads (150.30 q ha^{-1}) was obtained from crop transplanted on 21st November (late-transplanted) which at par with 14th November (172.59 q ha^{-1}) but differed from the crop transplanted on 7th November (194.07q ha^{-1}).

The data on the effect of variation in the transplanting time on the incidence of insect pests of cabbage indicated that there was a definite pattern of incidence of pests in relation to the different transplanting dates pooled data of two years revealed that the minimum incidence of aphid (114.45 and 50.78 aphids/plant) during peak and mean was recorded from the crop transplanted on 24th October (early transplanted) followed by the crop transplanted on 31th October (118.18 and 56.15 aphid/ plant) and 7th November (136.68 and 66.57 aphids/plant).

However, maximum infestation (170.38 and 84.17 aphids/plant) was recorded in late transplanted crop *i.e.* 21st November followed by the crop transplanted on 14th November (160.25 and 78.50 aphids/plant). It was concluded that the aphid population increased with the delay in transplanting time. The present findings are in conformity with that of Chavan *et al*. (2004) who reported that no aphid incidence was observed in the crop transplanted in October, however, incidence of aphid was started from the last week in December on crop transplanted in November. The present findings are also in accordance with Salman *et al*. (2007) who reported that infestation of aphid increase by delaying the sowing dates. The crop transplanted in 1st and 15th October exhibited lowest rate of infestation.

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Genetically Modified Crops : A Promising Innovation for Enhancing Food Security and Role of Extension in Diffusing GM Technology

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Abstract

With the increase in the population, there is an increase in the food demand. The issue is to be addressed by innovative modern technology and as such genetically modified crops paved the way. The use of genetic engineering to transfer the desirable genes into crops creates genetically modified crops. The benefits include increased tolerance to biotic and abiotic stress, herbicides, and enhanced nutritional values. Based on the review of some literature, it is proved that the adoption of GM crops increases the farmer's income and reduces the chemical use thus protecting the soil health. Instead of many benefits, there are some myths like allergies and gene flow, which are against the adoption and commercialization of GM crops. This concern requires a lot of attention by extension to provide motivation and awareness to people. The paper discusses the importance of GM crops to meet food security and the role of extension in the transfer of technology.

Key words : *GM crops, food security, extension strategies*

Introduction

Food and Agriculture Organization (FAO) defined food security as when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Food security means not just increasing the food grain production, but also making the food available and accessible to all sections of the people. India being an agricultural country, still faces the problem to meet the food requirements of the growing population. According to the global hunger index 2021, India is ranking at 101 positions with about 189.2 million undernourished people, 33 lakh malnourished children and 15% of the population sleeps hungry every night. Accordingly, an article from economic times reported that the population is estimated to reach 9.2 billion by 2050 and there comes a need to uplift food grain production to 333 million tonnes by 2050. On the other hand, the percentage of agricultural workers is likely to drop to 25.7 percent by 2050 from the earlier 58.2 percent in 2001 and the average landholdings have decreased from 1.41 hectares in 1995-96 to 1.08 hectares in 2015-16. Fig 1 and 2 shows the growth of food production and population in India respectively over years.

Evolution of Indian Agriculture

Eradicating hunger was always one of the main goals of the United Nations millennium development goals. In the process of eradicating hunger, there have been continuous changes in the Indian agriculture to meet all the challenges of overpopulation, climate change, labors migration, and a decrease in cultivable land. The changes varied from :

Beginning of 19^{th} century – using traditional methods.

Beginning of 20^{th} century - shifting to the green revolution by using pesticides, insecticides to meet food sufficiency.

Beginning of 21^{st} century - shifting to organic farming due to observation of damage to the environment by the farmers but with organic farming, the food security can only be met in long term practice.

Present – need for an innovative approach to address the food security of the growing population

Need for GM Crops : Biotechnology is one such innovation, wherewith the help of genetic engineering, plants are inserted with desirable traits and transgenic crops are developed. "Genetically modified crops are crops derived from organisms whose genetic material (DNA) has been modified in a way that does not occur naturally e.g. through the introduction of a gene from a different organism". BT cotton is modified by the insertion of genes from a soil bacterium, Bacillus thuringiensis to kill caterpillar pests. Food security can't be achieved only by GM crops, but the blending of traditional technologies with biotechnologies can help to solve the problem. Many studies have proved the role of GM crops in providing food safety and security but it is still a controversial topic to the public.

Pros of GM crops

➢Nutritional enhancement: Higher vitamin content; more healthful fatty acid profiles

Stress tolerance: Tolerance to high and low temperatures, salinity, and drought

Disease resistance: For example, orange trees resistant to citrus greening disease or American chestnut trees resistant to fungal blight.

Post-harvest traits: More storage period, slow ripening

Biofuels: Plants with altered composition for more efficient conversion to ethanol

Phytoremediation: Plants that extract and concentrate contaminants like heavy metals from polluted sites.

Edible vaccines: Vaccines produced in food crops can be directly consumed and effectively elicit an immune response to a particular pathogen.

Cons of GMOs : Besides many benefits, some scientists do not approve GM crops and even a few articles were distributed on outcomes of GM crops, however, all were wrong. There is no demonstrated learn about the cons of GM crops, these are focuses raised by Anti-GMO just to prevent the entry of GM into India. The focuses are :

Allergenicity

Gene transfer

Outcrossing

Superweeds and super pests

Status of GM crops at national and international level : GM crops were first introduced in the USA in 1994 with the Flavr Savr tomato variety, which has desirable characteristics like slow ripening process, delaying softening, and rotting. With the benefits of GM crops, the area under GM crops has increased from 1.7mha in 1996 to 190.4mha in 2019 (ISAAA). Due to the increased adoption of GM crops, it is considered as fastest adopted crop technology. Besides its fast adoption, there are still protests going against this technology. Only some countries like the USA, Canada, and Japan had commercialized both food and non-food crops.

As indicated by the International Service of Acquisition of Agri-biotech Application (ISAAA), India has been positioned as the fifth biggest country as far as a region under biotech crops as shown in fig3. The Genetic Engineering Appraisal Committee (GEAC) is the peak body that takes into consideration for approval of GM crops and the only crop approved in India is GM cotton. The GEAC in 2007, suggested the approval of BT brinjal, yet the drive was impeded in 2010. BT brinjal, tomato, bhindi, rice, soya bean - under assessment and trial and error stage. BT cotton was at first supported in India on March 26th, 2002 for commercial development in six states. In addition to reducing production costs and increasing profit, it has lowered farming risk and improved farmers' viewpoint. It changed the scenario, as cotton productivity nearly multiplied in six years. India's portion in the worldwide production of cotton expanded from 12% in 2002 to 25% by 2014(ISAAA). From a net importer of cotton, India turned into the second-biggest exporter of cotton. At present over 95% of the nation's cotton region has gone under BT cotton and the yield has additionally expanded from 191 kg/ha to 436 kg/ha (pib.gov.in). fig 4 shows the most adopted GM crops all over the world.

Following endorsement for GM cotton, a few organizations also supported GM crops, expecting comparable ground breaking changes in Indian farming. BT brinjal was one such innovation suggested for commercialization in October 2009, after it finished administrative assessment in seven years, and is as yet under the ban. In the meantime, this innovation has been embraced in Bangladesh. A review by Ahmed et al (2013) on the effect of BT brinjal showed a 51% decrease in the quantity of pesticide application, 42% increment in the yields and there is no record of damage to human wellbeing. Whenever All India Composed Vegetable Improvement Task (AICVIP) directed field trails with BT brinjal crossbreeds in 2007, the paths were led in 2004 and 2005, the outcomes were is there was a normal decrease of 41.8% in the utilization of bug spray and 133.6% increment in the natural product yield. It is demonstrated that the development of BT brinjal has such countless advantages however dissenters are still against the choice.

Table-1 : Area, Production and Yield of BT cotton crop in India.

Year	Area (lakh ha)	Percent change in area (%)	Production (lakh bales)	Yield (kg/ha)	Percent change in yield (%)
2002-03	0.29	-	86.21	191	-
2003-04	0.92	68.47	137.28	307	37.78
2004-05	4.85	81.03	164.29	318	3.459
-2005-06	12.34	60.69	184.99	362	12.15
2006-07	33.54	63.20	226.32	421	14.01
2007-08	54.72	38.70	258.84	467	9.85
2008-09	66.69	17.94	222.76	403	-15.88
2009-10	85.52	22.01	240.72	403	0
2010-11	96.32	11.21	330.00	499	19.23
2011-12	107.58	10.46	352.00	491	-1.62
2012-13	105.43	-2.03	342.20	486	-1.02
2013-14	110.35	4.45	359.62	510	4.70
2014-15	119.40	7.57	348.05	462	-10.28
2015-16	106.83	-11.76	300.05	415	-11.32
2016-17	89.43	-19.45	325.77	511	18.78
2017-18	110.76	19.25	328.05	477	-7.12
2018-19	117.81	5.98	287.08	386	-23.57
2019-20	117.47	-0.28	322.67	436	11.46

(Source : Directorate of Economics and statistics, www.pib.gov.in)

Table-1 concludes that there is no regular trend in area and yield increase every year. The government of India after recognizing the importance of GM crops, has started conducting field trials in 8 different states by obtaining a nonobjection form from the state government. The states and crop trails are Punjab- mustard, maize; Haryana-maize, cotton; Delhi-mustard; Rajasthan- cotton; Gujarat-cotton, maize; Maharashtra-brinjal, rice, maize, cotton; Andhra Pradesh-chickpea, cotton; Karnataka-cotton. Brinjal, mustard, and potato are some of the crops which are awaiting permission for large-scale field trials and seed production. The varieties of some GM crops are :

Bt-cotton : MECH 12 Bt, RCH 2 Bt, Ncs-207, MRC-6322 Bt

Bt brinjal : mhb-4 Bt, mhb 9 Bt, mhb 80 Bt, Jaya and BSS-793

GM mustard: Dhara Mustard Hybrid 11 (DMH11)

GM potato: new leaf variety, innate potato, amflora

Gm soybean: roundup ready soybean

GM crops safety issue : One of the main concerns for least adoption of GM crops is their safety, many farmers and consumers believe that GM crops are not safe to consume due to their side effects like allergenicity and harm to the environment. Besides these controversies many national and international institutions like the world health organization (WHO), food and drug administration (FDA), U.S Department of Agriculture (USDA), Environmental Protection Agency (EDA), American Association for the Advancement of Science (AAAS), American Society of Plant Biologists (ASPB) and French Academy of Medicine have studied and supported that GM crops are as safe as conventionally grow crops. NAS stated that “To date, no adverse health effects attributed to genetic engineering have been documented in the human population”. Along with the institutions scientists like Norman Borlaug, have stated that “It is better to die eating GM food instead of dying of hunger”. M.S. Swaminathan also stated that “GM foods have the potential to solve many of the world’s hunger and malnutrition problems, and to help protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides”. European commission prepared a report by concluding more than 130 research projects for 25 years which involves more than 500 independent research groups stated that genetically modified organisms are no more risky than conventional plant growth technologies.

Why choose GM crops over other crops? : Many scientists consider that other farming practices like organic farming are also efficient in solving food insecurity, but the following are the reasons why we have to choose GM crops over others :

Increased crop yields

Reduce need for crop protection

One of the main benefits of GM crops is to produce plants with desirable characteristics like increasing yield and reducing the need for crop protection by genetic engineering process. The GM crops can provide resistance to biotic and abiotic stress and insects and pests, hence there will be increased yield due to less damage. Crop protection can be increased by inserting genes into the plant directly to act against insects, pests, and viruses, thus helping in reducing the use of insecticide and pesticides and reducing the cost of cultivation. The reduced spraying of chemicals also makes GM crops safe to consume.

A study by Subramanian (2009) resulted in that usage of BT cotton has increased the yield up to 30-40% with reduced use of insecticide by 50%, resulting in a net profit of US$156 per hectare. Another study by Sadashivappa and Quim (2009) resulted in the adoption of BT cotton showed a 43% rise in yield, a 21% decline in several sprays, and a 70 %increase in net profit margin. A meta-analysis by Klumper and Qaim (2014) on the impacts of Genetically Modified Crops resulted in the adoption of GM technology has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68%.

Enhanced nutrient composition and food quality : The transfer of genes also helps to nutritionally enhance the quality of foods with desirable characteristics. Nutritionally enhanced GM crops under development include varieties of wheat free of gluten, a major cause of food allergy; vegetables with higher vitamin E content to help fight heart disease; and “golden rice” genetically engineered to contain vitamin A and iron to prevent common nutritional deficiencies in developing countries.

Reduce costs of food or drug production : With the increased use of GM crops, food production increases and increased supply reduces the prices of food. Certain GM crops are under development especially to produce vaccines, which is important to protect people’s health in developing nations during epidemics. GM insulin is being used by humans since 1970, but there was no single report indicating the hazard. Recently developed vaccines Covishield and Covaxin against COVID-19 are also a product of modern biotechnology.

Greater food security : A study by Qaim and Kouser on genetically modified crops and food security in four different states like Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu has revealed that the adoption of GM crops has reduced the food insecurity problem by

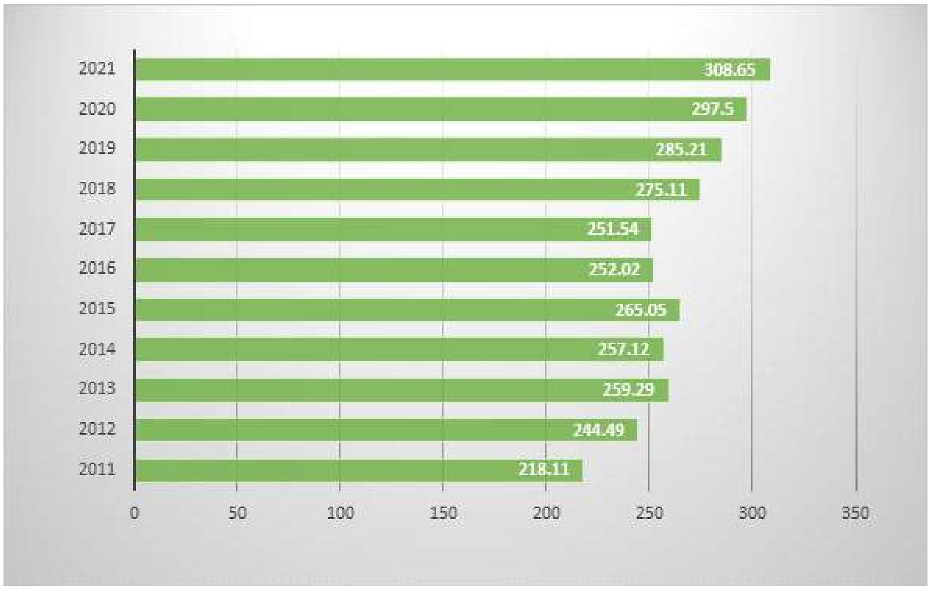

Fig-1 : Food grain production in India (statista.com).

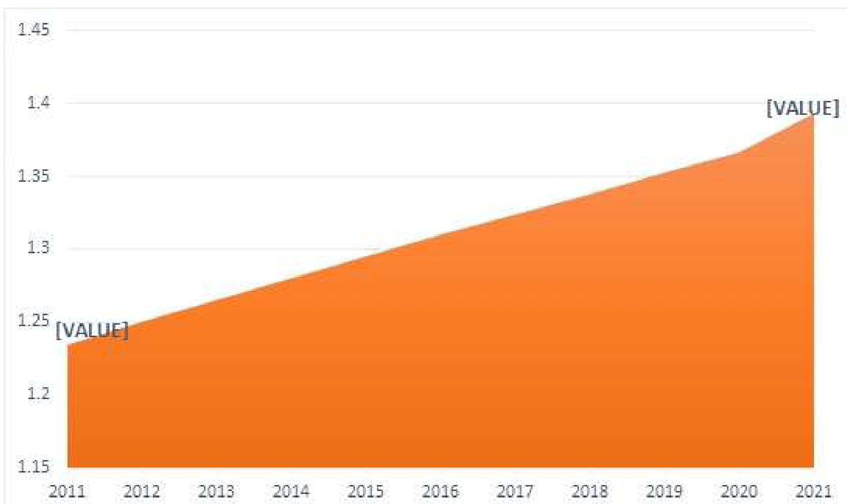

Fig.-2 : Increasing trend of population in India (macrotrends.net)

15-20% and total calorie consumption has increased by 74kcal per AE and day per ha of BT cotton. ISAAA in a report mentioned that the continuous adoption of biotech crops for 24 years can be a solution to poverty, malnutrition, food insecurity, crop disease, and climate change problems.

Regulatory process of GM crops in India : Like a coin has two sides, every technological innovation has its own set of benefits and risks. The government of India has developed a model for regulation of safety of GM crops, the process follows the steps-the applicant i.e. seed companies or plant breeders, it develops a new transgenic crop, and the first step is to apply for approval with all the details about the crop and characteristics developed to Institutional Biosafety Committee (IBSC). Fig.-5 shows the flowchart for regulation of GM crops in India.

The application is screened and on approval forwarded to the review committee on genetic manipulation (RCGM) with information on experimental designs. The RCGM conducts biosafety research level I (BRL-I) trails if approved biosafety research level-II (BRL-II) trails are conducted. Based on the plant species/ gene combination, several locations for BRL-II are decided. If approved by GEAC, the crop is allowed for commercialization, if not it is considered again. The role of the Central compliance committee (CCC) is to monitor the field trials of RCGM and GEAC. There should be approval of RCGM and GEAC for a person to establish confined field trails.

Role of extension in transfer of GM crops : Any improved technology should diffuse through the value chain for the successful transfer of technology and it is the

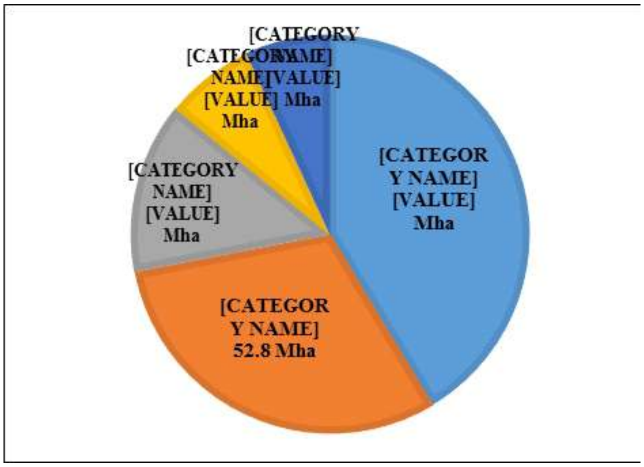

Fig-.3 : Top countries cultivating biotech crops (ISAAA).

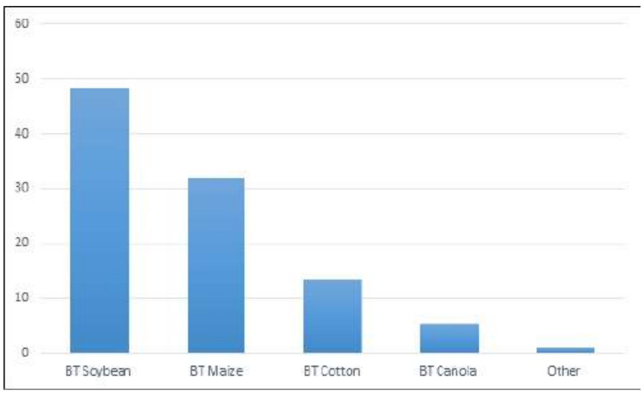

Fig.-4 : Most adopted BT crops (ISAAA).

role of extension personnel to diffuse the technology, there is always a gap in extension, where the technology is transferred to the only farmer and the remaining stakeholders like input dealers and consumers are not know about the technology, thus new technology should be diffused to all stakeholders related to the technology. It is known that the adoption of GM crops has always been inconsistent, due to the wrong perception of farmers and consumers about them. The major stakeholders involved related to GM crops are input dealers, farmers, service providers, and consumers.

Input dealers : Even if farmers want to adopt new technology, the accessibility and availability of the technology are lacking, hence many times there is a failure in the adoption of new technology. It was found that the information received by farmers from progressive farmers and input dealers was adopted more (Babu *et al.,* 2012). However, most Agri-input dealers have insufficient knowledge about GM crops so extension personnel has to provide neat scientific information and understanding about GM crops with knowledge about location-specific

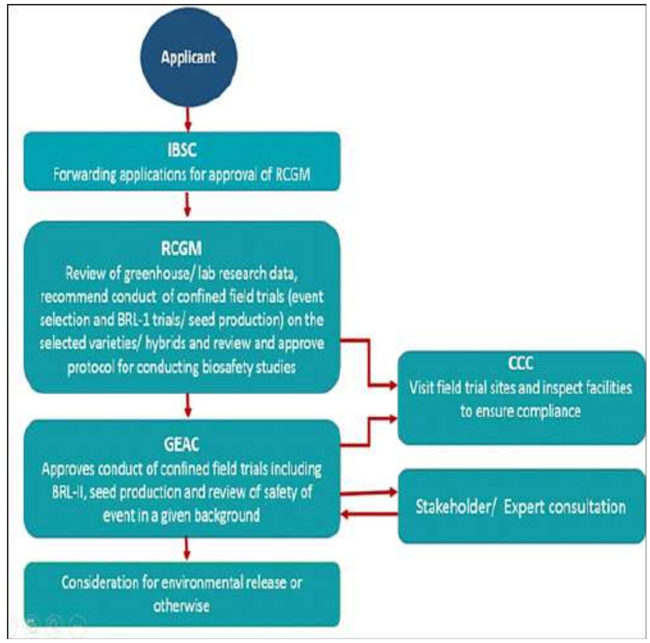

Fig.-5 : Regulation flow chart of GM crops (www.geacindia.com)

crops and varieties. As BT cotton was adopted by a large number of farmers, there was monotony in seed companies and prices were raised, the government to make seeds available to all marginal and small farmers, there were regulations in the prices of seeds, hence there is a need to provide input dealers about laws about the regulation of GM crops. After the popularization of BT cotton seeds many duplicate seeds were available in markets and farmers faced a problem, so the dealers should also know the proper source of obtaining GM seeds.

Farmers : Farmers are the most important stakeholders whose adoption affects the success of GM crops. The lack of knowledge about new technologies causes a major barrier to their acceptance (Cardello *et al.,* 2007). The extension personnel initially had to provide awareness about the GM crops and then explain to them the scope and importance of GM crops in providing food security and increasing the income of farmers. Then training about how to cultivate GM crops should be provided, Motivating farmers to adopt GM crops by explaining the results of field trials, lack of financial sources is considered as one of the main reasons why the small and marginal farmers have not adopted the technology so financial support and subsidies to a farmer for growing GM crops.

Service providers : Any improved technology without proper marketing is a loss. So the people in the middle of farmers and consumers should also be provided training about knowledge and preference of GM crops by farmers and consumers, explaining the different marketing channels for distribution of the products, and conducting exhibitions to provide the latest information about GM crops. It is also important to provide knowledge about the importance and value of GM crops in other countries so that the middlemen can export the products and gain profit.

Consumer : These are the second main stakeholders who are important in the success of an innovation, a technology after successful production and when there is no demand for the product then it is waste, so the consumers should also be provided knowledge about GM crops. The biggest concern of consumers is risk. Public perception and acceptance are dependent on trust and whether the products or processes benefit them as citizens and consumers. The extension personnel should hold meetings and educate the importance and advantages of GM crops and explain the regulatory process followed by the government to assure the safety of GM crops for consumption purposes. The extension personnel should gain trust and help them overcome their prejudice.

Conclusions

The utilization of genetically modified organisms is significant to fulfill expanding needs and further develop existing circumstances common in our current circumstances. We are at a restless crossroads where, on one hand, we are confronted with remarkable dangers to human wellbeing and climate, while then again we have chances to change the status quo done. Guidelines concerning the utilization of GMOs need a more extensive reason for the choice. By considering the facts about GM crops as solutions to problems and believing in safety, the adoption and introduction of transgenic crops should be increased in India. Endeavors should be advanced for appropriate preparation of farmers about GM innovation for legitimate reception and increment of income and food handling.

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Acceptability and Marketability of Diversified Products Developed from Chokla Wool

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Abstract

The present study was conducted with a prime objective of finding acceptability and marketability of diversified products developed from Chokla wool. Diversified products using Chokla wool were developed at Maharana Pratap University of Agriculture and Technology, Udaipur and after development of all the products they were evaluated for their acceptability and market potential. Preference for to be developed diversified products was taken from twenty old age persons suffering from multiple arthritis. By scoring and ranking method top six most preferred products were developed at College of Home Science, Udaipur by researcher viz. Chest warmer pad, Upper back supporter, Lower waist belt, Wrist belt, Knee pad and Ear muff. These products were developed using Chokla wool in pure and blended form. Each product was duplicated into three. For first product Chokla wool was used in pure form, for second product seventy per cent Chokla and thirty per cent nylon was used, whereas for third product fifty per cent Chokla and fifty per cent nylon was used. Further these products were given to twelve respondents suffering from multiple arthritis. Each product was given for a wear trial for three days, and responses were collected on suitability scale using five point rating scale.

Introduction

Fibre has been of great importance to man and rank second only to food in their usefulness. India is among the highest livestock holding countries in the world. Rajasthan accounts for more than fifty per cent of the total sheep population. Rajasthan is the biggest wool-producing area in India. The sheep-wool from Rajasthan is considered best for carpet making industry in the world. Chokla (Chapper, Shekhawati) found in Churu, Jhunhunu, Sikar & border areas of Bikaner, Jaipur and Nagaur districts of Rajasthan. This sheep is light to medium-sized, Face is generally devoid of wool and is reddish-brown/dark brown in colour; Skin is pink, Ears are small to medium in length and tubular, Coat is dense, both sexes are polled. Its wool is extremely white and lustrous. Bikaneri Chokla wool deemed to be the best carpet wool in the world. The characteristic of Bikaneri Chokla wool suits to the requirement of ideal carpet in terms of micron, length, strength and resilience. The wool produced by Chokla animals is heterogeneous in quality and generally mixed with coarser fleece of other sheep for their utilization as carpet wool (Prajapati *et al.* 2012).

Physical properties of Chokla wool fibre are as follows :

Staple length (cm) 4.70 ± 0.07 (655)

Average fibre diameter ( ) 28.22 ± 0.20 (720)

Medullation (%) 24.01 ± 0.62 (656)

Fibre density (cm2) 1 008.7 ± 46.5 (24) (Kumar *et al.* 2012).

Chokla wool is coarser in nature which delimits its uses in textile sector. At present Chokla wool is only used in the field of carpet and rug making. It is well known that apparels cannot be made using Chokla wool, this is why Chokla wool is only used for carpet and rug making. Efforts have been made to diversify uses of Chokla wool, with keeping in mind that developed products should have enough market potential. In this study quilting technique was used for the development of diversified products, because by using this technique wool does not come in direct contact with the skin of the wearer. For development of diversified products Chokla wool was used in both pure and blended form.

Materials and Methods

(A) Locale of the study : The study was conducted at Bikaner because Researcher belongs to Bikaner and is well conversant with the local language. Diversified products have been developed at College of Home Science. Udaipur.

(B) Selection of the sample

(i) Sample for wear trial of developed diversified products : For this purpose 12 respondents were selected who were willing to take wear trial of the developed diversified products.

(ii) Sample to evaluate marketability of the developed diversified product:

(a) Those respondents who were selected for the wear trial

(b) Ten market personnel dealing with sale of these

Table-1 : Preference scores for developed diversified products and their relative ranking. N=12

S. No.	Criteria of evaluation	Lower waist belt	Upper back supporter	Wrist belt	Ear muffs	Knee pad	Chest warmer pad
1.	Grip	54	52	51	45	52	43
2.	Thickness	57	53	45	46	55	50
3.	Warmth	58	59	55	57	54	57
4.	Shape and size	53	51	50	52	46	43
5.	Comfortability	56	54	53	51	49	47
6.	Support the muscle	58	55	49	44	46	45
7.	Protect the affected area	58	54	49	50	52	48
8.	Do not hinder the movement	54	50	49	48	29	44
9.	Easy to put on	56	53	54	51	50	51
10.	Easy to put off	57	53	52	59	51	48
11.	Easy to maintain	56	52	50	50	48	50
12.	Fastener used is comfortable	58	55	54	52	50	40
13.	Suitability of the design	57	57	51	53	48	47
14.	Utility of product	59	54	53	55	51	50
15.	Overall appearance	58	56	55	51	53	50
Total (900)		849	808	770	764	734	713
Percentage		94.34%	89.78%	85.56%	84.89%	81.55%	79.23%
Rank		1	2	3	4	5	5

Table-2 : Estimation of production cost of the developed diversified product. N=22

S. No.	Criteria of cost estimation	Chest warmer pad	Earmuffs	Knee pad	Wrist belt	Lower waist belt	Upper back supporter
1.	Cost of fabric (Rs.)	40	6.5	24	16.5	50	55
2.	Raw material cost (Rs.)	12.5	1.5	8	1.5	32	40
3.	Velcro (Rs.)	1.5	0	15	3	15	15
4.	Wire (Rs.)	0	3	0	0	0	0
5.	Labour cost (Rs.)	37	10	28	10	75	75
6.	Total (Rs.)	91	21	75	31	172	185

types of products judged the products for its market acceptability.

(c) Development of tool : Keeping in mind the objectives of the study two structured interview schedule and two preference rating scales were developed.

Suitability assessment rating scale : A five point consumer preference rating scale was developed to identify sutability regarding the use of diversified products developed from Chokla wool. It consists of following parameters for consumer assessment : Grip, Thickness, Warmth, Shape and size, Comfort, Support the muscle, Protect the affected area, Do not hinder the movement, Easy to put on, Easy to put off, Easy to maintain etc.

Rating criteria was as follows :

Most preferred - 5

More preferred - 4

preferred - 3

Less preferred - 2

Least preferred - 1

Evaluation for market potential : To assess the market potential of developed diversified products researcher estimated cost of the products. After this a rating scale was developed consisting of statements related to market potential of developed products by 22 respondents including ten market persons and twelve old age persons suffering from multiple arthritis. Following parameters were used by the researcher to find out cost of the developed products.

Cost of fabric

Cost of raw material and accessories

Labour cost

Profit

(d) Procedure of data collection

Development of diversified products : On the basis of preference of the respondents most preferred six products were developed namely: chest warmer pad, ear muff, knee pad, wrist belt, knee pad, lower waist belt and upper back supporter using quilting technique. Each product was duplicated in three viz. 100 per cent Chokla wool, in

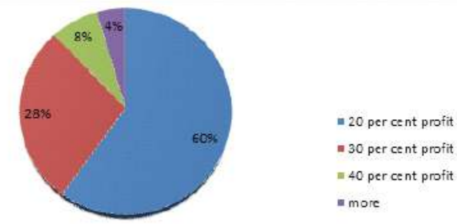

Fig. -1 : Profit gained by developed diversified products

second 70 per cent Chokla and 30 per cent nylon was used and in third product 50 per cent Chokla and 50 per cent nylon was used. There by making a total of 18 products. Skin colour spun fabric was used to prepare products.

Assessment of suitability of developed diversified products : Each of the product were independently rated using five point rating scale (consumer preference rating scale) by all the twelve respondents who also participated in wear trial of developed diversified products.

Assessment of market potential : In order to assess the market potential of the developed diversified product market potential rating scale was used. For this researcher selected ten market personals dealing with sale of these type of products and twelve old age persons who were selected for trial of developed products.

Then the profit percentage was added to the net rate in three categories i.e. 20 percent, 30 percent and 40 percent profit. These rates were shown to respondents and most acceptable rate was decided.

(e) Analysis of data : After collection of data the same was coded and analyzed:

1. Frequency : Data obtained from structured interview schedule was expressed in frequency.

2. Percentage : The data obtained from structured interview schedule tabulated according to the scores/ frequency and converted into percentage.

3. N : Sample size

Results and Discussion

This section of the study set worth clearly and precisely the findings and interpretation in the context of major objectives of the study, thus providing a bird eye view of the complete study, which makes this section as most significant and critical part of the research work. The data have been organized and analyzed by taking into account the objectives of the study. All the pertinent information has been categorized and reported under following major sections :

The data in the table reveals rank obtained by all diversified products. It was found that lower waist belt obtained first rank followed by upper back supporter with second rank, third position was secured by wrist belt and earmuff, kneepad and chest warmer pad got forth fifth and sixth position by their relative ranking. All products scored more than 79 per cent for all parameters.

Marketability of developed diversified product : In order to access the market potential for the developed diversified products researcher estimated the cost all diversified products and rating scale was developed.

The findings of Table-2 and show that the production cost of the selected diversified products. The market price of upper back supporter found to be highest i.e. 185 rupees including cost of fabric, raw material cost, Velcro, wire and labour cost. Whereas lower waist belt, chest warmer pad, knee pad, wrist belt and earmuffs cost was estimated 172, 91, 75, 31 and 21 rupees respectively.

The labour cost was decided according to the minimum wages paid in India to a skilled worker. The cost for developed products was calculated according to time consumed in production of each product. Earmuffs and wrist belt both took 30 minutes where knee pad was developed in one and half hour and chest warmer pad took two hours at the same point both lower waist belt and upper belt supporter were large in size compared to all other developed products, and it took four hours of time to develop them. As expertise to develop the product increased, time consumed for the development of the product can be reduced. Production cost of each developed product can also be reduced by developing more number of articles.

After cost calculation, the products were shown to total 22 respondents,12 respondents who took trial of developed diversified products and 10 market personnel's to access the market potential. Findings of table 4.35 reveals that 59.84 per cent respondents gave preference to 20 per cent profit whereas 28.03 per cent respondents were ready to give 30 per cent profit and 7.57 per cent respondents were willing foe 40 per cent profit and only 4.54 per cent were ready to give more than 40 per cent profit for the products. The result reveals that all developed products have enough market potential.

Conclusions

In this study researcher developed products like lower waist belt, upper back supporter, knee pad, ear muffs, wrist belt and chest warmer pad and assessed the suitability using five point preference rating scale. All developed products were highly appreciated for their uniqueness and usefulness. Respondents who took trial were highly satisfied with construction of products; they found them very comfortable and warm. Lower waist belt, upper waist belt and knee pad provided relief from pain and at the same time earmuff and chest warmer pad protected against cold. Further when these products were evaluated for market potential it was found that most of the respondents were ready to give 20 per cent profit all developed products and remaining respondents were even ready to give more than 20% profit. Efforts made by researcher were appreciated by all.

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Life Table of *Chrysoperla zastrowi sillemi* (Esben-Peterson) on Mustard Aphid [*Lipaphis erysimi* (Kaltenbach)]

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Abstract

Studies the life table of C. zastrowi sillemi was carried out at constant temperature of 25 ± 1°C on mustard aphid (*L. erysimi*) during the year 2020-21. The maximum duration of egg, larva, pre-pupa and pupa were observed as 4, 13, 2 and 4 days, respectively. The net reproductive rate (R0) of 66.81 was obtained with a mean length of generation (Tc) 43.85 days. The intrinsic rate of natural increase in numbers (rm) was 0.0958 females per female per day and the population was multiplied 2.0762 times per week. On reaching the stable age distribution the eggs, larvae, pre-pupae, pupae and adults contributed to the tune of 38.95, 47.93, 2.6, 3.84 and 6.64 per cent, respectively. The expectancy of further life was 13.59 days at the time of adult emergence.

Key words : *Chrysoperla zastrowi sillemi, life table, mustard aphid.*

Introduction

Lacewings or net-winged insects (Neuroptera: Chrysopidae) are soft-bodied insects, most commonly medium-size, comprising about 6,000 species in 18 families. Lacewings include mantispids (mantisflies), green lacewings, owlflies, antlions and their relatives. Order Neuroptera consist three suborders: Hemerobiiformia, Myrmeleontiformia and Nevrorthiformia. Suborder Hemerobiiformia comprises 11 families and Chrysopidae are one of them. Worldwide, it consist 1200 species (Devetak and Kral, 2016). In India, 65 species of chrysopids belonging to 21 genera have been recorded from various crop ecosystems. Some species are distributed widely and are important natural enemies for aphids (Yadav et al., 1998). Life table studies are useful in determining the stage in the life cycle of the pest, which contributes to the trend of population. It also determines the reproductive ability and biotic potential, in addition to development of statistics to explain population increase (Birch, 1948 and Howe, 1953).

Materials and Methods

For constructing the life table, the culture of C. zastrowi sillemi was maintained at constant temperature of 25 ± 1°C using B.O.D. incubator at AICRP on Biological control of Crop Pests, AAU, Anand during the year 2020-21. Freshly laid 100 eggs were collected from the cage with the help of wet camel hair brush and placed in 10 Petri dishes in batches of 10 each. The eggs were put on the slides in one row to facilitate observations on hatching. Fresh food was provided daily in the morning to the newly hatched larvae. All the larva after hatching was reared individually on mustard aphids. Observations on hatching, total larval development, formation of pupae, emergence of adults and fecundity of females was recorded daily. Age specific mortality in different developmental stages such as eggs, larvae, pre-pupae, pupae and adults were recorded. With a view to determine the age specific fecundity, total number of adults emerged on the same day were kept separately in oviposition wooden cage for oviposition. Number of eggs laid on subsequent days were recorded. The observations on fecundity were continued till all the females died. The female birth was calculated according to the sex ratio. Life tables were constructed according to the methods of Atwal and Bains (1974). Stable age distribution was worked out by observing the population schedule of birth rate and death rate (mx and lx) when grown in limited spare.

Results and Discussion

The data pertaining to work out the number of individuals survived during development on mustard aphid (L. erysimi) are presented in Table-1. The number that survived from 100 eggs to adult emergence was 64 individuals. The maximum duration of egg, larva, pre-pupa and pupa were recorded as 4, 13, 2 and 4 days, respectively. Life fecundity table was constructed to determine the survival of female (lx) and age specific fecundity (mx). Data from Table-2 indicated that pre-oviposition period was between 23rd and 29th days of pivotal age. Female started laying eggs after 30th day and it continued till death of the female adult, after 30th day the lx values being 0.64 and it was decreased at the end of life. The females contributed the highest number of progeny (mx= 8.61) on 47th day of pivotal age, which

Table-1 : Survival of different life stages of *C. zastrowi sillemi* reared on mustard aphid, *L. erysimi*.

Sr. No.	No. of eggs	Number of individual survived at different stages			
		Egg (0-3 days)	Larva (4-16 days)	Pre-pupa (17-18 days)	Pupa (19-22 days)
1	10	10	8	8	8
2	10	10	6	6	6
3	10	10	7	7	7
4	10	10	8	6	6
5	10	10	10	8	8
6	10	10	7	7	7
7	10	10	9	8	7
8	10	10	7	6	6
9	10	10	7	7	7
10	10	10	7	6	6
Total	100	100	76	69	68

Table-2 : Life table and age specific fecundity of *C. zastrowi sillemi* reared on mustard aphid, *L. erysimi* (for female).

Pivotal age in days (x)	Survival of female at different age interval (l_x)	Age schedule for female births (m_x)	l_xm_x	xl_xm_x
0-22		**Immature stages**		
23-29		**Pre-oviposition period**		
30	0.64	0.77	0.49	14.78
31	0.64	1.27	0.81	25.20
32	0.64	1.85	1.18	37.89
33	0.63	2.55	1.61	53.01
34	0.63	3.50	2.21	74.97
35	0.63	3.97	2.50	87.54
36	0.63	4.17	2.63	94.58
37	0.62	4.51	2.80	103.46
38	0.62	5.30	3.29	124.87
39	0.62	5.97	3.70	144.35
40	0.58	6.17	3.58	143.14
41	0.53	6.46	3.42	140.38
42	0.47	6.97	3.28	137.59
43	0.37	7.32	2.71	116.46
44	0.37	7.42	2.75	120.80
45	0.37	8.03	2.97	133.70
46	0.36	8.23	2.96	136.29
47	0.36	8.61	3.10	145.68
48	0.36	7.67	2.76	132.54
49	0.35	7.34	2.57	125.88
50	0.35	6.92	2.42	121.10
51	0.35	6.54	2.29	116.74
52	0.35	5.54	1.94	100.83
53	0.35	4.97	1.74	92.19
54	0.34	4.11	1.40	75.46
55	0.34	3.66	1.24	68.44
56	0.33	2.88	0.95	53.22
57	0.32	2.69	0.86	49.07
58	0.31	2.22	0.69	39.92
59	0.31	1.89	0.59	34.57
60	0.30	1.36	0.41	24.48
61	0.30	1.32	0.40	24.16
62	0.29	1.16	0.34	20.86
63	0.23	0.77	0.18	11.16
64	0.14	0.47	0.07	4.21
65	0.04	0.12	0.0048	0.31
	Total		66.81	2929.81

Table-3 : Mean length of generation, innate capacity for increase in numbers and finite rate of increase in numbers of *C. zastrowi sillemi* reared on mustard aphid, *L. erysimi*

Sr. No.	Growth statistics	Formula	Calculated values
1.	Net reproductive rate	R_0 = lxmx	66.81
2.	Mean length of generation (days)	$T_c = \frac{\text{lxmx}}{\text{Ro}}$	43.85
3.	Innate capacity for increase in numbers (Females/female/day)	$\text{rm} = \frac{\log e^{\text{Ro}}}{\text{Tc}}$	0.0958
4.	Arbitrary 'r_m' (rc) = 0.10 and 0.11	-	-
5.	Corrected 'r_m' (Females/female/day)	e^7 rmx.lxmx	0.1016
6.	Corrected generation time (days)	$T = \frac{\log e^{\text{Ro}}}{\text{rm}}$	41.36
7.	Finite rate of increase in numbers (Females/female/day)	antiloge$^{\text{rm}}$	1.1069
8.	Weekly multiplication of population (times/week)	$(\ )^7$	2.0762
9.	Hypothetical F_2 females	$(R_0)^2$	4464.03

Table-4 : Age specific distribution of *C. zastrowi sillemi* reared on mustard aphid, *L. erysimi* (r_m=0.0958).

Host	Percentage contribution of various stages				
	Eggs	Larvae	Pre-pupae	Pupae	Adults
Mustard aphid	38.95	47.93	2.63	3.84	6.64

Table-5 : Life table for computing life expectancy of *C. zastrowi sillemi* reared on mustard aphid, *L. erysimi.*

Pivotal age (Days)	Number surviving to the beginning of age interval	Number dying during '*x*'	Mortality rate per hundred alive at beginning of age interval (*dx**100/lx)	Alive between age '*x*' and '*x* + 1' $\frac{l_x \quad l_{(x \quad 1)}}{2}$	No. of the individual's life days beyond '*x*'	Expectation of further life $\frac{Tx}{l_x}$ 2
(x)	(lx)	(dx)	(100 qx)	(Lx)	(Tx)	(ex)
0-5	100.00	12.00	12.00	100.50	810.00	16.20
5-10	88.00	6.00	6.82	88.50	709.50	16.13
10-15	82.00	6.00	7.32	82.50	621.00	15.15
15-20	76.00	8.00	10.53	76.50	538.50	14.17
20-25	68.00	4.00	5.88	68.50	462.00	13.59
25-30	64.00	0.00	0.00	64.50	393.50	12.30
30-35	64.00	1.00	1.56	64.50	329.00	10.28
35-40	63.00	5.00	7.94	63.50	264.50	8.40
40-45	58.00	21.00	36.21	58.50	201.00	6.93
45-50	37.00	2.00	5.41	37.50	142.50	7.70
50-55	35.00	1.00	2.86	35.50	105.00	6.00
55-60	34.00	4.00	11.76	34.50	69.50	4.09
60-65	30.00	26.00	86.67	30.50	35.00	2.33
65-70	4.00	4.00	100.00	4.50	4.50	2.25

decreased day by day.The net reproductive rate (R0) (Table-3) was 66.81 with a mean length of generation (Tc) 43.85 days. The corrected generation time (T) and intrinsic rate of natural increase in numbers (rm) was 41.36 days and 0.0958 females per female per day. Similar trend was found by Gade (2010). The weekly population would be able to multiply 2.0762 times per week. The hypothetical F2 females were worked out as 4464.03. Developmental stage and the stable age distribution were calculated in Table 4. The data showed that adults contributed only 6.64 per cent to the population of stable age and that of eggs, larvae, pre-pupa and pupae were 38.95, 47.93, 2.63 and 3.84 per cent, respectively. The life expectancy data (Table-5) clearly indicated that life expectancy of C. zastrowi sillemi declined gradually with the advancement of development. The life expectancy of newly deposited eggs was 16.20 days. The expectancy of further life was 13.59 days at the time of adult emergence.

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Predatory Efficiency of *Chrysoperla zastrowi sillemi* (Esben-Peterson) on Different Hosts

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Abstract

Studies on predatory efficiency of *C. zastrowi sillemi* was carried out at constant temperature of 25 ± 1°C on different host viz., mustard aphid (*L. erysimi*), maize aphid (R. maidis), cotton aphid (*A. gossypii*), cabbage aphid, (*B. brassicae*), coriander aphid (H. coriandri) and cotton mealy bug (P. solenopsis) during the year 2020-21. Among the different hosts first instar larva of C. zastrowi sillemi fed maximum on cotton mealy bug (151.12 ± 1.60), whereas mustard aphid (18.56 ± 2.43) fed minimum. Second instar larva consumed highest number of cotton mealy bug, while among the different aphid species maize aphid (140.04 ± 1.49) fed maximum followed by cotton aphid (134.48 ± 8.06). The consumption capacity of predator increased with the advancement of its larval stage. Thus, third instar larva fed maximum numbers of individuals. Larva of predator fed maximum on cotton mealy bug (328.36 ± 6.41), followed by maize aphid, cotton aphid, cabbage aphid and coriander aphid, whereas lowest fed in mustard aphid (81.36 ± 1.83).

Key words : *Chrysoperla zastrowi sillemi, Predatory efficiency.*

Introduction

Natural enemies play an important role in agro ecosystems, offering a valid alternative or integration with other control methods (Salerno *et al*., 2002). The predators are scattered and distributed in about 167 families belonging to 14 orders of class insecta (Sathe and Bhosale, 2001). Lacewings or net-winged insects (Neuroptera: Chrysopidae) are soft-bodied insects, most commonly medium-size, comprising about 6,000 species in 18 families. Lacewings include mantispids (mantisflies), green lacewings, owlflies, antlions and their relatives. Order Neuroptera consist three suborders: Hemerobiiformia, Myrmeleontiformia and Nevrorthiformia. Suborder Hemerobiiformia comprises 11 families and Chrysopidae are one of them. Worldwide, it consist 1200 species (Devetak and Kral, 2016). In India, 65 species of chrysopids belonging to 21 genera have been recorded from various crop ecosystems (Yadav *et al.,* 1998). Sucking pests cause enormous qualitative and quantitative losses to the various economically grown crops (Metcalf, 1994). These losses reduce income drastically and farmers resort to using insecticides, which not only increases the cost of production but also pollute the environment. Biocontrol agents have great potential and it also helps in the development of non-chemical pest management strategies as there is great need for the development of a successful Integrated Pest Management programme (IPM) all over the world. Among the different biocontrol agents *C. zastrowi sillemi* is one of the most beneficial and prolific predator. It is found in different agricultural habitats with high relative frequency of occurrence (Awadallah, *et al.,* 1975). *C. zastrowi sillemi* is an active polyphagous predator against sucking pests.

Materials and Methods

To determine predatory efficiency, the culture of *C. zastrowi sillemi* was maintained at constant temperature of 25 ± 1°C using B.O.D. incubator at AICRP on Biological control of Crop Pests, AAU, Anand during the year 2020-21. Predatory efficiency of any predator must be known to study the comparative efficiency of a predator over other predators. In order to know the predatory efficiency, a laboratory study was carried out. For this, total 25 larvae of *C. zastrowi sillemi* were reared individually on different hosts *viz.,* mustard aphid **(***L. erysimi*), maize aphid (*R. maidis*), cotton aphid (*A. gossypii*), cabbage aphid, (*B. brassicae*), coriander aphid (*H. coriandri*) and cotton mealy bug (*P. solenopsis*) in plastic vials (4.0 × 3.0 cm) right from first day of hatching from eggs to the formation of pupae. Initially few individuals were provided as food but with the gradual development of larvae, the number of hosts was increased proportionally. The number of host insects consumed by individual larva was record daily. The predatory efficiency of the host was worked out separately. Numbers of individuals consumed by green lacewing at different stages of larva were recorded daily.

Results and Discussion

Data on feeding potential of *C. zastrowi sillemi* on different hosts are presented in Table-1 and fig.-1. The data indicated that significantly highest (150.12 ± 1.60) numbers of cotton mealy bug individuals were fed by first instar larvae of *C. zastrowi sillemi*. Among the different

Table-1 : Predatory efficiency of *C. zastrowi sillemi* on different hosts.

Hosts	Mean no. of individuals consumed by respective instars (Mean ± SD)			
	I instar	II instar	III instar	Total consumption
Mustard aphid (*L. erysimi*)	18.56 ± 2.43	57.20 ± 2.59	81.36 ± 1.83	157.12 ± 5.44
Maize aphid (*R. maidis*)	48.08 ± 1.51	140.04 ± 1.49	195.12 ± 3.07	383.24 ± 3.51
Cotton aphid (*A. gossypii*)	76.48 ± 5.35	134.48 ± 8.06	189.80 ± 12.77	499.76 ± 25.34
Cabbage aphid (*B. brassicae*)	51.76 ± 2.75	86.84 ± 3.98	150.12 ± 4.07	288.72 ± 10.59
Coriander aphid (*H. coriandri*)	41.68 ±3.08	93.60 ± 11.40	126.04 ± 7.25	261.32 ± 20.42
Cotton mealy bug (*P. solenopsis*)	150.12 ± 1.60	312.44 ± 11.19	328.36 ± 6.41	790.92 ± 15.51
S. Em ±	1.37	3.39	3.08	7.04
C.D. at 0.05%	4.00	9.89	9.01	20.55
C.V. (%)	4.76	5.52	3.87	4.14

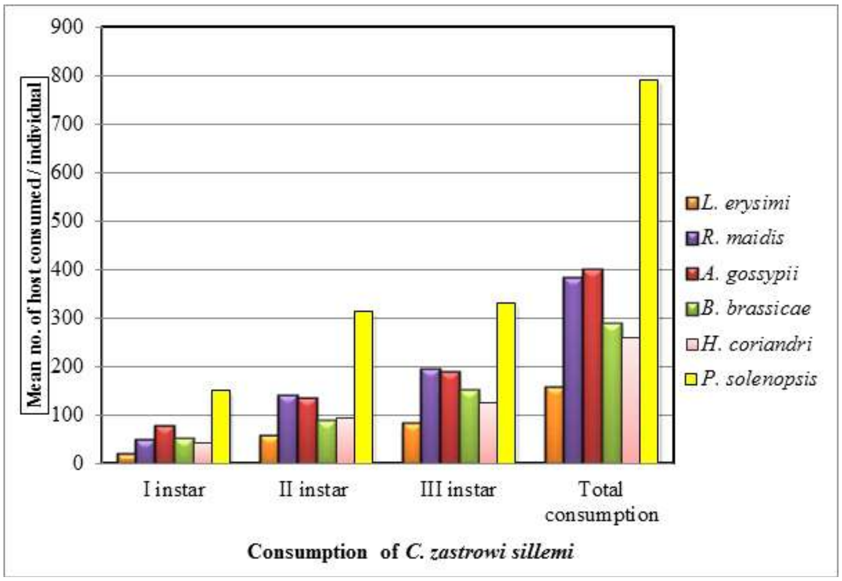

Fig.-1 : Predatory efficiency of *C. zastrowi sillemi* on six different hosts.

species of aphids, first instar larvae of *C. zastrowi sillemi* consumed maximum (76.48 ± 5.35) numbers of cotton aphid. The larvae also ate in large numbers (51.76 ± 2.75) on cabbage aphid, which is statistically comparable to maize aphid (48.08 ± 1.51). The first instar larvae fed an average of 41.68 ± 3.08 and 18.56 ± 2.43 coriander and mustard aphids, respectively. In case of second instar larva, maximum number of individuals fed on cotton mealy bug (312.44 ± 11.19). Among the various aphid species, maize aphid the highest number of individuals devoured (140.04 ± 1.49) and is statistically at par with cotton aphid (134.48 ± 8.06). The consumption of cabbage aphid and coriander aphid by predatory second instar larvae was 86.84 ± 3.98 and 93.6 ± 11.40, respectively, and both were comparable, but significantly minimum consumption was found in mustard aphid (57.2 ± 2.59). Cotton mealy bug consumption was highest in third instar larvae of *C. zastrowi sillemi* (328.36 ± 6.41). Both treatments for maize aphid (195.12 ± 3.07) and cotton aphid (189.8 ± 12.77) are statistically at par. Cabbage aphid and coriander aphid fed by *C. zastrowi sillemi* third instar larvae were 150.12 ± 4.07 and 126.04 ± 7.25, respectively. The mustard aphid had the least number of predation (81.36 ± 1.83). The third instar larvae consumed more number of individuals as compared to the first and second instar larvae. Total number of hosts fed during the entire larval period was varied from 157.12 to 790.92. It is evident from Table 4.36, the maximum (790.92 ± 15.51) numbers of cotton mealy bugs were fed by the larva of *C. zastrowi sillemi* followed by cotton aphid (499.76 ± 25.34), maize aphid (383.24 ± 3.51), cabbage aphid (288.72 ± 10.59), coriander aphid (261.32 ± 20.42) and mustard aphid (157.12 ± 5.44). The *C. zastrowi sillemi* consumed significantly more number of individuals of cotton mealy bug, while cotton aphid and maize aphid were statistically at par with each other. Cabbage aphids were found to be somewhat favourable host. Both the coriander and mustard aphids proved to be least favourite hosts. The findings of the current research matched those of Xian and Chen (2001) and Chakraborty and Korat (2010) on *L. erysimi* for the predatory efficiency of *C. zastrowi sillemi*. Similarly, Vivek *et al.* (2013) reported on *A. gossypii* and *R. maidis*. According to Aggarwal and Neetan (2014) and Bhojani *et al.* (2017) the first, second and third instar larvae of *C. zastrowi sillemi* consumed maximum on *P. solenopsis*, which is more or less similar to present findings. Similar data recorded by Panth *et al.* (2017) when fed on cabbage aphid (*B. brassicae*). Farhan *et al.* (2019) found that the third instar larvae of *C. zastrowi sillemi* was very voracious feeder and fed large number of aphids. Dikshakumari *et al.* (2020) assessed predatory efficiency of *C. zastrowi sillemi* on *A. gossypii*, which is closely related with above results. From above observations it is evident that among the six different hosts evaluated, cotton mealy bug was found to be favourable host for *C. zastrowi sillemi* which is close conformity with the results of Zahi *et al.* (2017). Yadav and Pathak (2010) also reported that the mustard aphid was least preferred host for the predator in laboratory conditions, which is in agreement with the present findings.

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Growth, Development and Flower Productivity of China Aster [*Callistephus chinensis* (L). Ness] as Influenced by Age of Seedling, Time of Planting and Plant Spacing

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Abstract

A study was conducted to know the effect of age of seedling, time of planting and plant spacing on growth and flower productivity of China aster during 2019-2020 and 2020-2021 at Krishi Vigyan Kendra, Pithoragarh. The experiment was laid out in a split plot design, by allocating the combinations of age of seedlings (A) and time of planting (T) in the main plots, and plant spacing (S) in the sub-plots with three replications. The results revealed that there were significant role of age of seedling, time of planting and plant spacing in comprising the agro-techniques for flower crop of China aster. For a productive and profitable crop of China aster used five weeks old seedling for transplanting and it should be sown early, i.e. near about June, 1st (1st week of June). On the basis of grading of marketable floral heads the wider plant spacing 40cm x 40cm is best for obtain the higher net profit in quintal per hectare.

Introduction

China aster (*Callistephus chinensis* L. Ness] is one of the most valuable garden flowers. It is excellent for use in loose flower, cut flower and also landscaping. Therefore, there is a strong need to boost the production of this flower crop. The increased productivity of flower crop can appreciably be achieved through adoption of improved cultural practices. It has been established that age of seedlings, time of planting and plant spacing play an important part in overall improvement of growth, yield and flower quality in many flower crops. Age of seedlings is one of the most important factors which affect the performance of any ornamental crop under cultivation. It is highly responsible for difference in yield, earliness, size and growth characters (Work and Carew, 1955) as well as a definite time of planting for exhibited its best performance in respect to growth, development and the best blooms of high shelf-life of cut flowers is one of the factors. Plant density not only influences the growth and development but also play an important role in production and quality of flowers. This also varies according to cultivar, place and time of planting which enables the plants to express their capabilities in terms of quality, quantity and vase-life of flower. In the light of it, therefore, felt desirable to extent the work on China aster to study the effect of age of seedling, time of planting and plant spacing in all possible combinations on growth, development and flower productivity of China aster.

Materials and Methods

Experiments were carried out at the Farm of Krishi Vigyan Kendra, Pithoragarh during 2019-2020 and 2020-2021. The three treatments of age of seedlings, four treatments of time of planting and three treatments of plant spacing, included hereby, formed thirty-six combinations, which were compared in split plot design, by allocating the combination of age of seedlings and time of planting (A x T) in the main plots, and that of plant spacing (S) in the sub-plots with three replications.

The seedlings of China aster after attaining the age of 4, 5 and 6 weeks in nursery were transplanted at 20cm x 20cm, 30cm x 30cm, and 40cm x 40cm apart on June 1st, June 8th, June 15th and June 22th, respectively in 2019-2020 and 2020-2021.

After thorough preparation of soil in the experimental plot, viz; A-7 in both the year of investigation, FYM was added as basal dressing at the rate of 3 Kg/m^2 of land. Urea, single super phosphate (SSP) and muriate of potash (MOP) were used to supply the N, P and K respectively, according to the recommended doses of N, P and K. The full amount of SSP and MOP fertilizers was applied along with half amount of urea prior to transplanting as basal dressing. The remaining amount of urea was applied as top-dressing 45 days after transplanting (DAT). Observations pertaining to different parameter of growth and flower productivity were recorded time to time and data were analyzed statistically.

Results and Discussion

Plant growth and development of any crop depend on climatic conditions, photoperiod, temperature, sunshine hours and growth reproductive phase in their own way depending upon the plant species Patil *et al. (*2005).

Age of seedling : The growth, development and flower productivity were significantly affected by the age of seedlings. This was because of seedlings of various ages

Table-1 : Growth and development of China aster [*Callistephus chinensis* (L). Ness] as influenced by age of seedling, time of planting and plant spacing.

Treat ments	Plant height (cm)		Diameter of main Stem (cm)		Number of leaves per plant		Plant spread (cm)		No. of laterals per plant		Length of the longest leaf (cm)		Width of the longest leaf (cm)		Duration (days) required for the visibility of first flower bud		Duration (days) required for colour break		Duration (days) required for commencement of full blooming		Duration (days) required for the harvest of floral heads	
	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
A_1	39.81	26.69	0.81	0.69	73.97	77.82	32.80	28.48	11.43	07.87	9.00	7.77	3.23	3.34	69.61	69.25	76.09	74.25	83.59	84.77	85.42	87.47
A_2	47.03	37.93	1.15	1.28	81.86	88.14	45.63	39.77	14.32	11.76	10.31	10.53	4.01	4.59	79.89	77.51	88.85	84.35	96.82	96.75	101.48	101.11
A_3	44.81	32.17	0.97	0.96	77.22	83.22	37.45	31.98	12.46	10.50	9.65	8.87	3.67	3.99	74.29	73.24	82.00	78.74	90.65	90.17	93.37	93.70
SEm±	0.004	0.012	0.001	0.001	0.006	0.027	0.008	0.113	0.005	0.003	0.004	0.003	0.002	0.002	0.019	0.013	0.008	0.025	0.390	0.015	0.108	0.072
CD at 5%	0.014	0.038	0.005	0.006	0.018	0.081	0.024	0.332	0.017	0.010	0.012	0.009	0.007	0.006	0.058	0.039	0.024	0.075	1.146	0.047	0.317	0.213
T_1	45.07	34.61	1.04	1.08	79.25	84.80	40.92	35.78	13.26	10.54	9.89	9.51	3.77	4.21	76.81	74.99	84.65	80.84	93.11	92.92	96.01	96.82
T_2	44.18	32.87	1.01	1.01	78.17	83.69	39.30	34.15	12.96	10.15	9.73	9.28	3.68	4.05	75.46	73.74	83.23	79.64	91.55	91.35	94.32	94.74
T_3	43.24	31.59	0.95	0.94	77.10	82.47	37.69	32.58	12.62	09.86	9.58	9.02	3.59	3.89	73.90	72.80	81.76	78.47	90.04	89.61	92.68	93.05
T_4	42.78	30.04	0.91	0.86	76.21	81.29	36.59	31.12	12.11	09.58	9.41	8.41	3.50	3.74	72.22	71.81	79.62	77.45	87.70	88.37	90.64	91.76
SEm±	0.005	0.149	0.002	0.002	0.006	0.031	0.008	0.113	0.005	0.003	0.004	0.003	0.002	0.002	0.023	0.015	0.009	0.029	0.451	0.015	0.124	0.072
CD at 5%	0.016	0.044	0.006	0.007	0.018	0.081	0.024	0.332	0.017	0.010	0.014	0.010	0.009	0.007	0.067	0.045	0.027	0.086	1.324	0.047	0.366	0.213
S_1	45.20	32.82	0.74	0.96	70.04	74.50	27.98	25.27	9.12	5.09	8.39	8.99	3.02	3.93	66.70	64.69	71.61	71.25	78.47	80.55	81.17	84.17
S2	44.56	32.25	1.08	0.98	81.21	86.99	43.41	37.04	14.47	12.41	10.24	9.05	3.92	3.97	78.01	77.30	87.21	82.65	95.50	95.08	99.24	98.51
S_3	41.69	31.73	1.12	1.00	81.80	87.69	44.49	37.92	14.63	12.64	10.33	9.13	3.98	4.01	79.07	78.01	88.13	82.60	97.09	96.07	99.87	99.60
SEm±	0.004	0.014	0.001	0.001	0.007	0.023	0.009	0.111	0.006	0.003	0.005	0.002	0.003	0.002	0.020	0.012	0.010	0.021	0.393	0.015	0.107	0.061
CD at 5%	0.013	0.039	0.005	0.005	0.021	0.065	0.025	0.309	0.017	0.010	0.015	0.006	0.008	0.008	0.056	0.034	0.029	0.059	1.090	0.044	0.297	0.172

Table-2 : Flower productivity of China aster [*Callistephus chinensis* (L). Ness] as influenced by age of seedling, time of planting and plant spacing.

Treatments	Fresh weight of floral head (gm)		Length of floral head (cm)		Width of floral head (cm)		Length of floral head Stalk (cm)		Diameter of floral stalk (cm)		No. of marketa-ble floral head per plant		Fresh weight of marketable floral head (gm) / plant		Number of unmarke-table floral head (gm) / plant		Fresh weight of unmarke-table floral head (gm) per plant		No. of marketable floral head per ha		No. of unmarke-table floral head per ha		Fresh weight of unmarke-table floral head (gm) per plant	
	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
A1	6.74	6.77	6.74	6.79	6.73	6.77	9.62	10.33	0.25	0.29	22.13	20.22	79.33	72.31	6.32	4.84	6.81	5.18	3039130	2903031	9333658.8	751181.7	9.04	7.29
A2	7.44	7.57	7.43	7.59	7.43	7.59	10.71	11.65	0.34	0.36	32.27	28.55	151.24	129.94	5.41	3.30	9.32	4.91	3977214	3792868	1258761.0	502982.1	11.07	6.46
A3	7.03	7.06	7.03	7.06	7.02	7.06	10.10	10.90	0.28	0.33	24.64	23.05	98.91	91.04	5.84	4.02	8.20	5.07	3291561	3301408	853313.6	617270.5	10.22	6.94
SEm±	0.003	0.015	0.003	0.001	0.003	0.004	0.004	0.010	0.002	0.002	0.009	0.165	0.021	0.295	0.005	0.005	0.007	0.007	38.446	38.446	56.823	34.941	0.006	0.007
CD at 5%	0.010	0.045	0.009	0.006	0.009	0.014	0.012	0.032	0.007	0.006	0.028	0.486	0.062	0.867	0.017	0.016	0.022	0.021	112.764	194.472	166.688	102.484	0.019	0.023
T1	7.21	7.31	7.20	7.35	7.20	7.35	10.36	11.22	0.31	0.34	28.26	26.02	124.99	111.25	6.04	4.34	9.07	5.75	3615509	3519558	887078.0	670664.7	11.24	7.90
T2	7.11	7.20	7.12	7.19	7.11	7.17	10.21	11.05	0.30	0.33	26.94	24.60	113.79	101.81	5.91	4.14	8.35	5.19	3490368	3408991	1499008.0	637292.1	10.39	7.20
T3	7.04	7.07	7.02	7.09	7.02	7.09	10.08	10.88	0.28	0.32	25.62	23.42	104.17	93.23	5.80	3.96	7.82	4.90	3372751	3281285	846666.6	608349.1	9.68	6.47
T4	6.93	6.95	6.92	6.96	6.92	6.96	9.93	10.69	0.27	0.31	24.56	21.73	96.36	84.78	5.68	3.79	7.20	4.37	3265245	3119909	828225.5	578939.7	9.12	6.02
SEm±	0.004	0.017	0.003	0.002	0.003	0.005	0.004	0.012	0.002	0.002	0.011	0.191	0.024	0.341	0.006	0.006	0.009	0.008	44.393	44.393	68.614	40.346	0.007	0.009
CD at 5%	0.012	0.051	0.011	0.006	0.011	0.017	0.014	0.037	0.008	0.007	0.032	0.562	0.072	1.001	0.020	0.019	0.027	0.024	130.208	224.557	192.451	118.338	0.022	0.027
S1	6.52	6.33	6.54	6.53	6.53	6.53	9.34	9.77	0.22	0.26	21.29	19.17	71.44	64.33	6.26	4.74	5.45	4.26	5320483	5166921	1564449	1183272.0	13.61	10.56
S2	7.31	7.40	7.29	7.41	7.29	7.41	10.50	11.39	0.32	0.35	28.36	25.93	125.27	111.58	6.19	4.65	10.10	6.74	3150941	3065228	1161673	515642.7	11.26	7.48
S3	7.39	7.48	7.37	7.50	7.37	7.49	10.60	11.52	0.33	0.36	29.39	26.73	132.77	117.39	5.11	2.78	8.79	4.15	1836480	1765158	319611.4	172519.2	5.46	2.65
SEm±	0.003	0.030	0.002	0.002	0.003	0.005	0.003	0.009	0.001	0.002	0.012	0.157	0.023	0.278	0.004	0.005	0.004	0.006	42.217	42.217	56.386	47.393	0.008	0.012
CD at 5%	0.010	0.046	0.007	0.006	0.009	0.016	0.010	0.227	0.004	0.006	0.034	0.436	0.066	0.773	0.012	0.015	0.014	0.017	117.019	191.443	156.295	121.366	0.024	0.034

which were transplanted on different date, necessitating there by the sowing of seeds in the nursery on different dates. Table-1 shows that the plant height was recorded highest with 5 weeks old transplants and the number of leaves per plant were also recorded maximum with A_2 (5 weeks old seedling). This age group of seedlings had out-standing superiority of about 4 per cent over A_1 (4 weeks old seedling) and A_3 (6 weeks old ones) respectively in respect of their height. Similarly in case of plant spread, the excellence of A_2 over A_1 and A_3 was to the tune of 39.2% and 21.83% (average of both years).

The number of laterals per plant increased significantly with 5 weeks old transplant. A_2, therefore, superseded the A_1 and A_3 in this context also (Table-1). The stages of visibility of flower bud, colour break and full blooming were affected significantly by the age of seedlings (Table-1). The A_2 (5 weeks old transplant) had delayed these development studies invariably. The magnitude of delayed was advanced with the increasing age of crop plants. The harvest of floral head also delayed with the advancement of age of seedlings invariably. The magnitude of delay was almost parallel as noted with other development studies with age of crop plants. The harvest of floral heads delayed maximum with A_2 which was more than that of A_3 and A_1 respectively, significantly reduction in these findings which were in close agreement with the findings as reported by Jauhari et al. (1972).

The number and fresh weight of marketable floral heads per plant increased significantly with 5 weeks old transplanting and the same treatment was also found increasing effective floral heads per hectare. The number and fresh weight of unmarketable floral heads per plant as well as per hectare were minimum with 5 weeks old transplant over 4 weeks old (A_1) and 6 weeks old (A_3) transplant (Table-2).

Time of planting : Time of planting caused many advantageous manifestations in this investigation. The significant effects of time of planting on growth parameters have been praiseworthy. The plant height (cm), plant spread (cm) and the number of leaves and laterals per plant improved appreciably by the time of planting treatments and more so when the early planting was done, i.e. on June 1st in both the years of experiment. The contribution of early planting (T_1) on growth attributes as compared to that of each delay in planting to that of T_2, T_3 and T_4 significantly and respectively, Likewise in case of plant height, diameter of main stem, number of leaves per plant, spread of plant and number of laterals per plant, the early planting (T_1) exhibited significantly more improvement than that of T_2, T_3 and T_4 respectively. These results clearly exhibit the growth promoting effects on each delay in time of planting treatments as compared to early planting (T_1). Similarly, Kaushal *et al.* (2014) has also observed corresponding increase in plant height and flower yield in china aster.

The development studies on the other hand such as duration (days) required for visibility of flower bud, colour break and full blooming were delayed due to delay in planting of aster seedlings (Table-1). The delay in aforesaid development characters caused by early planting (T_1) was significantly more pronounced than that of each delay in transplanting T_1 to T_2, T_2 to T_3 and T_3 to T_4 respectively.

The maturity of flower crop expressed as cropping span or harvest of floral head (days) also exhibited similar response on each delay in time of planting treatments (Table-2). The flower yield (q/ha) was stepped-up considerably by the each delay in transplanting. Based on average flower production of 2019-2020 and 2020-2021, it has been computed that early transplanting (T_1) increased the flower yield than that of each delay in transplanting.

The number and fresh weight of marketable floral heads per plant increased significantly with early transplanting done on June 1^{st} (T_1) and the same treatment was also increasingly effective in promoting the number of floral heads per hectare (Table-2). Similar results have also been observed by Chanda and Roychoudhary (1991) and Dhemre *et al.* (1997).

The number and fresh weight of unmarketable floral heads per plant as well as per hectare were minimum with early transplanting (T_1) done on June 1 as compared to each delay in transplanting of seedling i.e. T_1 to T_2, T_2 to T_3 and T_3 to T_4 respectively (Table-2).

The plant spacing brought about vividly changes in the performance of flower crop of aster and this practice eventually proved economically profitable (Table-1). The vegetative growth characters such as number of leaves, plant spread and number of laterals per plant consequent upon wider plant spacing showed significant improvement accept the plant height which was highest with closed plant spacing i.e. 20 cm x 20cm (S_1). Janakiram and Rao (1995) observed significant increase in plant height, number of branches and plant spread in marigold due to wider spacing. This shows that more vegetative growth was obtained at wider spacing due to more availability of nutrients, sun light and soil moisture.

The visibility of flower bud, colour break and full blooming were, however, delayed due to time of planting, but the magnitude of delay was relatively more pronounced in full blooming then in visibility of flower bud and than in colour break (Table-1). The duration (days) require for the harvest of floral head was also delay with wider plant spacing (S_1) as compared to S_2 and S_3 respectively.

The number and fresh weight of marketable floral heads per plant were significantly increased with S_3 (Table-2). As a result, the production of flower on hectare basis was magnificently decreased due to wider plant spacing. Similarly in case of number and fresh weight of unmarketable floral heads per plant, the excellence of S_3 over S_2 and S_1 and on per hectare basis the excellence of S_1 over S_2 and S_3.

The flowering and yield characters were also significantly influenced by the spacing (Table-2). Among the different spacing, S_1 (20 x 20cm) recorded maximum number of marketable floral heads per plant and per hectare, while S_3 (40 x 40cm) recorded the highest value in fresh weight of marketable floral heads per plant and per hectare. This shows that at wider spacing, more vegetative growth had accrued due to late flowering enrich is turn resulted in bigger size, minimum number of flower were and more weight of marketable floral heads per plant and per hectare, Hence, the wide spacing S_3 (40 x 40cm) was found to be the best with number and fresh weight of marketable floral heads per plant and per hectare. This was in line with findings of Samantaray *et al*. (1999).

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Assessment the Impact of Contingent Plan on Resilience to Climate Change Towards Prominent Crops of District Morena

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Abstract

Rain fed agriculture occupies a prominent place in Indian economy and rural livelihoods. At present, about 60% of total net sown area is rain fed, contributing 40% of the total food production.Often due to the late onset of the monsoon, prolonged dry spells of the monsoon, total failure of monsoon leads to failure of crops. The management of the drought primarily involves development of crop management strategies for minimizing the severity of the impact caused by the weather aberrations.The study was based on the data collected from the metrological station Morena. The contingent plan was executed according to the need of hour.Yield under P_2– application of contingent intervention (2069.56 kg/ha) was recorded significantly superior over the farmers practice P_1– farmers practice (1844 kg/ha). The maximum grain yield was recorded in C_2–pearl millet (2122.17 kg/ha) which was significantly superior yield received under C_1- Cluster bean (1929.17 kg/ha) and C_3 (1818.00 kg/ha).

Introduction

It supports 40% of human and 60% of livestock population. Coarse cereals (87.5%), pulses (87.5%), oilseeds (77%), rice (48%) and cotton (65.7%) are predominantly grown under rain fed farming (Ready et al. 2008). Dry land agriculture is largely rainfall-dependent, especially in India where the quantity and distribution of monsoon rain decides the crop production (Venkateswarlu, 2010). Agriculture in rain fed areas continues to be a gamble and rain fed farmers face several uncertainties like aberrant weather, lack of timely inputs and credit leading to low and unstable productivity and profitability. Climate variability is a predominant feature of Indian agriculture and more so in rainfed farming and, therefore, crop production is greatly conditioned by climatic risks (Venkateswarlu, 2010). Often due to the late onset of the monsoon, prolonged dry spells of the monsoon, total failure of monsoon leads to failure of crops. The management of the drought primarily involves development of crop management strategies for minimizing the severity of the impact caused by the weather aberrations.

Contingency plan can be defined as a plan aimed and executed for an outcome other than in the usual or expected plan. In other words, it is frequently used for risk management when an exceptional risk in future. In general, the change in sowing or planting time of crops, change in seed rate, change in schedule of fertilizer use, use of short duration varieties, improved crop genotypes form the core component of contingency crop planning.

At the same time provision of conservation agriculture practices might be helpful in successful establishment of crops. The moisture conservation practices like mulching and Ridge and furrow sowing etc. would be instrumental in saving considerable amount of moisture under such situation.

Research Methodology

A study was conducted on farmer’s field in Morena district under NICRA Project during 2016-17 to 2019-20. The different technologies for reduce the climate risk or mitigate the climatic abbreviation during crop period were demonstrated. The measures according to metrological data were performed to reduce the impact of weather abbreviation. The impact was analysed according to application of the contingent planning or activity. The major weather calamity is long dry spell during the kharif season. The average 358.3mm, 581.00mm and 628.00 mm rainfall received during the year 2017-18, 2018-19 and 2019-20 respectively.Rainfall pattern was analysed and identified the dry spell during the crop growth period. After the identified dry spell contingent intervention was identified for mitigate the effect of dry spell (table - 1).

The yield of crops were recorded and analysed statistically with complete RBD design. The location or farmer was taken as replication and the combination of crops C_1- Cluster bean, C_2- Pearl millet and C_3- pigeon pea with cropping method *i.e.* farmers practice (P_1) and contingent planning (P_2) was used as treatments. The economics of various crops were calculated on prevailing market prices.

Results and Discussion

The study was based on the data collected from the metrological station Morena. The contingent plan was executed according to the need of hour. The average yield and yield attributes were recorded and analysed statistically and presented in table-2.

Table-1 : Contingent Crop Planning Used during the various years from 2017-18 to 2019-20.

S. No.	Dry Spell (no. of days)	Duration	Crop	Crop stage Affected	Intervention applied
Year 2017-18					
1.	8 days	19-27 June 2017	Cluster bean	Sowing/Germination	Delayed sowing time or adjustment in sowing dates
			Pearl millet	Sowing/Germination	Delayed sowing time or adjustment in sowing dates
2.	15 days	10-24 August 2017	Cluster Bean	Flowering and pod formation	Life Saving Irrigation
			Pearl millet	Flowering and pod formation	Life Saving Irrigation
3.	10 days	01-12 September 2017	Pigeon pea	Flowering and pod formation	Life Saving Irrigation
Year 2018-19					
1.	15 days	11 to 25 June 2018	Cluster Bean	Sowing/Germination	Delayed sowing time or adjustment in sowing dates
			Pigeon pea	Sowing/Germination	Delayed sowing time or adjustment in sowing dates
2.	11 dyas	30 June to 10 July 2018	Pigeon pea	Vegetative and growth stage	Light irrigation
			Cluster Bean	Vegetative and growth stage	Light irrigation
			Pearl millet	Vegetative and growth stage	Light irrigation
3.	15 days	7 to 21 September 2018	Pigeon pea	Pod filling stage	Lifesaving Irrigation
			Cluster Bean	Pod filling stage	Lifesaving Irrigation
			Pearl millet	Pod filling stage	Lifesaving Irrigation
Year 2019-20					
1.	20 June to 5 July		Pigeon pea	Sowing/Germination	Delayed sowing time or adjustment in sowing dates
			Cluster Bean	Sowing/Germination	Delayed sowing time or adjustment in sowing dates
			Pearl millet	Sowing/Germination	Delayed sowing time or adjustment in sowing dates

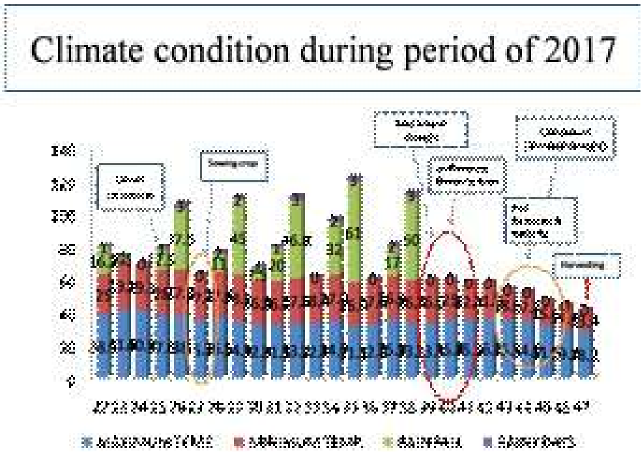
Table-2 : Yield (kg/ha), Rain Water use efficiency (kg/ha/mm) and economics of various prominent crops with farmers practices and contingent planning during 2017-19 to 2019-20.

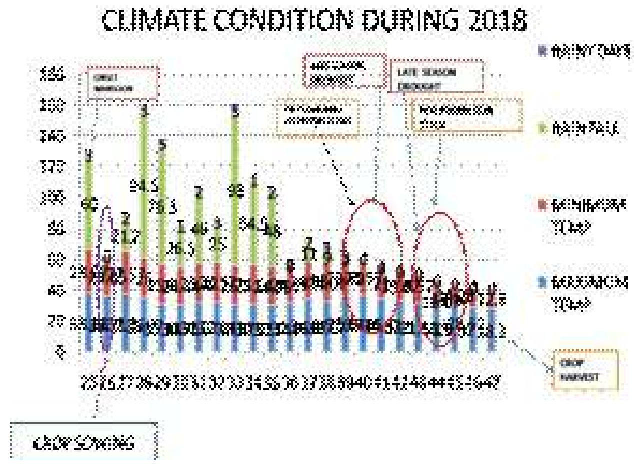
Treatment	Yield (kg/ha)	Rain Water use Efficiency (RWUE) kg/ha/mm	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net Return (Rs/ha)	B:C Ratio
P_1	1844.00	3.53	26900	74464	47564	2.77
P2	2069.56	3.96	27900	68381	40482	2.45
Sem	42.13	-	-	-	-	-
CD @ 5%	126.317	-	-	-	-	-
C_1	1929.17	3.69	23500	46620	23120	1.98
C_2	2122.17	4.06	27900	51439	23539	1.84
C_3	1819.00	3.48	31500	117001	85501	3.71
Sem	42.13	-	-	-	-	-
CD @ 5%	126.317	-	-	-	-	-
P*C	NS	-	-	-	-	-

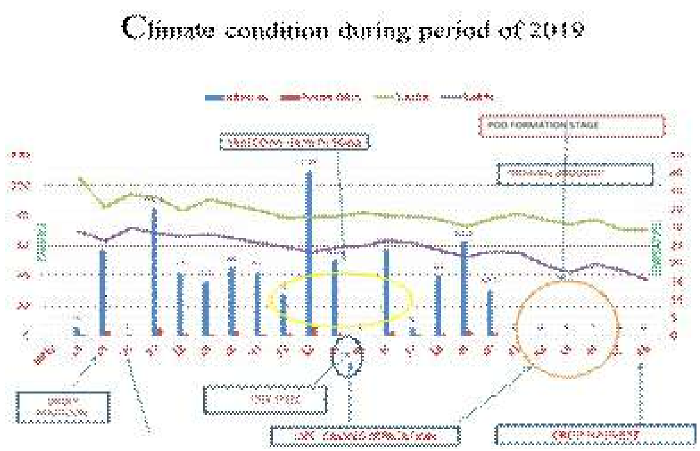
Yield (kg/ha) : The results indicated that the performance of all prominent crops of district *i.e.* pigeon pea, pearl millet and cluster bean were improved with the contingent plan to mitigate or reduce the effect of dry spell during the crop growth period.

Yield under P_2 (2069.56 kg/ha) was recorded significantly superior over the farmers practice P_1 (1844 kg/ha). Supplemental irrigation, the combination of rainfed farming and limited irrigation, are ideal choice for improving crop yield in the moisture-stressed situation (Deng et al., 2006).The maximum grain yield was recorded in C_2 (2122.17 kg/ha) which was significantly superior yield received under C_1 (1929.17 kg/ha) and C_3 (1818.00 kg/ha). It is may be due to the genetic behaviour of different crops. Dry spell given at terminal stage reduced the yield and yield attributes to the great extent as compared to other stages of dry spell (Kumar et al. 2006).

Economics : The economics of different prominent crop were significantly affected through contingent interventions. Maximum net return Rs.47564/ha was recorded under contingent planning interventions.







However, the maximum net return Rs. 85501/ha was recorded under the pigeon pea crop it was more than cluster bean (Rs. 23120/ha) and pearl millet (Rs. 23539/ha). The maximum B;C ratio was also recorded in pigeon pea 3.71 and application of contingent intervention (2.77) during crop growth period.

Conclusions

The experiment was concluded as the application of life saving irrigation to mitigate the adverse effect of dry spell on various prominent crops growing in rainfed areas of Morena district.

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Assessment of Genetic Parameters for Important Horticultural Traits in Cauliflower (*Brassica oleracea* var. *botrytis* L.)

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Abstract

Among all cool season vegetables, cauliflower (*Brassica oleracea* var. *botrytis* L.) is grown for its immature inflorescence called curd and is rich in dietary mineral nutrients and antioxidants. A field experiment was conducted during the year 2020-2021 at Experimental Research Farm, Department of Vegetable Science, College of Horticulture and Forestry, Neri, Hamirpur (H.P). It was laid in Randomized Complete Block Design with three replications. Twenty seven genotypes including check variety Palam Uphar were evaluated for various yield and yield contributed traits to study the genetic variability, heritability and intertrait association Analysis of variance indicated significant difference among the genotypes for all the characters. The genotype UHF-CAU-M-15 (6.70 kg) was recorded superior over the check Palam Uphar (6.32kg) in terms of the trait yield per plot followed by UHF-CAU-M- 14 (6.23kg). The coefficient of variation results revealed that values of PCV were greater than that of GCV for all the traits studied, although the difference was less which indicated that the influence of environment for variability in these characters is very less. High heritability along with high genetic advance was observed for days to curd maturity, number of leaves per plant, days to curd initiation, stalk length, curd size index, gross plant weight, marketable curd weight per plant. Heritability reflects the genetic bond between the parent and offspring. High heritability coupled with genetic advance provides scope for trait improvement through effective selection based on phenotypic performance. The highest estimate of genetic advance as percent of mean was seen for the characters viz., curd size index (29.68%), gross plant weight(26.58%), number of leaves(26.39%), stalk length(25.20%) and marketable curd weight per plant(24.79%) The traits showing high value of genetic advance indicated that they are operated by additive genes.

Key words : *Genotypes, cauliflower, genetic advance, heritability, variability and yield.*

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L., 2n=2x=18) is one of the important vegetables among the cole crops cultivated worldwide in different climatic conditions. The crop is reported to be native of Southern Europe in the Mediterranean region. It is edible vegetable grown due to its tender 'curd' which is pre-floral fleshy apical meristem. Cauliflower is emerged from wild cabbage "cole wart" through mutation, human selection and adaptation. It has branched tap roots with thick and small stem accommodating whorl of leaves. Cauliflower is popular for its savour, flavor and alimental value. It is well supplied with proteins, carbohydrates, vitamins and minerals. Cauliflower is high in glucosinolates and isothiocyanates, which slow down the growth of cancer cells. China leads the world in production of cauliflower followed by India. The area under cauliflower cultivation in India is 4,58,000 ha with a production of 88,40,000 MT (NHB, 2019).

The nature and amount of genetic variability in the germplasm indicate the scope of improvement in character through selection whereas; the heritability provides measures of transmissibility of the variation and response to selection. An estimation of variability parameters viz., genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance are the important traits that suggests strategy for its utilization in breeding programmes. Therefore, the present experiment was laid to assess the variability parameters for further improvement in cauliflower.

Materials and Methods

The present investigation was carried out during the year 2020-2021 in the Experimental Farm of the Department of Vegetable Science, College of Horticulture and Forestry, Neri Hamirpur, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Himachal Pradesh, India. The experimental materials for this investigation comprised twenty-seven genotypes of cauliflower also includes the check variety. The experiment was conducted in the Complete Randomized Block Design (RBD) with three replications at spacing of 60 x 45 cm. Observations were recorded on five plants of each treatment/genotype from every replication for different characters, such length of leaf (cm), plant height(cm), number of leaves per plant, days to curd initiation, stalk length(cm), curd diameter(cm), curd depth(cm), curd size index(cm^2),

Table-1 : Mean performance of yield its contributing traits in cauliflower.

Genotypes	Curd diameter (cm)	Curd depth (cm)	Curd size index (cm^2)	Gross plant weight (g)	Marketable curd weight per plant (g)	Yield per plot (kg)
VRCF-22	10.22	7.35	75.14	1090.30	550.99	4.99
VRCF-34	9.66	7.13	68.88	725.39	479.07	4.31
VRCF-51	9.91	6.82	67.59	917.66	499.21	4.51
VRCF-75	10.06	7.62	76.06	947.00	515.45	4.64
VRCF-101	12.09	8.51	102.85	1222.41	676.62	6.09
VRCF-102	11.86	8.44	100.07	1201.78	650.11	5.85
VRCF-103	10.87	7.62	81.87	1145.00	580.66	5.23
VRCF-105	11.80	7.96	93.93	1193.10	635.00	5.72
VRCF-112	11.62	8.14	94.71	1189.24	643.88	5.79
VRCF-113	10.28	7.83	80.65	1096.15	539.02	4.85
VRCF-114	10.73	7.63	82.82	1122.08	581.00	5.18
VRCF-202	9.92	7.28	72.21	938.33	506.27	4.56
VRCF-75-2	10.93	7.64	83.53	1154.39	622.30	5.60
UHF-CAUM-11	10.67	7.56	80.47	1134.52	598.15	5.38
UHF-CAUM-12	10.20	7.41	75.60	1053.67	542.53	4.86
UHF-CAUM-13	10.42	8.36	87.09	1107.85	523.00	4.71
UHF-CAUM-14	12.35	8.40	103.75	1244.63	692.33	6.23
UHF-CAUM-15	13.24	8.72	115.44	1302.33	741.92	6.70
UHF-CAUM-16	12.45	8.40	104.60	1242.09	687.30	6.19
UHF-CAUM-17	9.76	6.94	67.74	739.47	490.05	4.41
HF-CAUM-18	11.83	7.79	92.20	1212.07	631.38	5.68
UHF-CAUM-19	11.07	7.73	85.51	1160.38	617.00	5.55
UHF-CAUM-20	11.37	7.80	88.63	1180.68	609.15	5.48
UHF-CAUM-21	11.43	7.81	89.25	1172.31	599.28	5.39
UHF-CAUM-22	10.32	7.37	76.65	1101.11	527.00	4.74
Pusa Himjyoti	12.01	8.13	97.61	1226.84	673.11	6.06
Palam Uphar (check)	12.65	8.43	106.74	1253.60	701.03	6.32
Mean	11.10	7.81	87.10	1113.87	596.77	5.37
SE (m)±	0.11	009	1.74	10.62	7.10	0.07
CD0.05	0.30	0.26	4.96	30.21	20.07	0.21
CV (%)	1.67	2.01	3.47	1.65	2.06	2.33

Table-2 : Estimates of different genetic parameters for various traits in cauliflower (*Brassica oleracea* var. *botrytis* L.).

Sr. No.	Characters	Mean	Range	Coefficient of variation (%)		Heritability (%)	Genetic Advance	Genetic Advance as % mean
				Phenotypic	Genotypic			
1.	Leaf length (cm)	39.48	33.43-47.17	8.87	7.80	77.33	5.58	14.12
2.	Plant height (cm)	49.59	43.53-56.73	7.26	6.68	84.70	6.28	12.66
3.	Number of leaves per plant	17.08	12.48-21.11	14.28	13.53	89.69	4.51	26.39
4.	Days to curd initiation	70.04	57.20-86.00	11.47	11.31	97.30	16.10	22.98
5.	Stalk length (cm)	4.62	3.39-5.80	12.58	12.41	97.23	1.16	25.20
6.	Curd diameter (cm)	11.10	9.66-13.24	9.06	8.91	96.63	2.00	18.04
7.	Curd depth (cm)	7.81	6.82-8.72	6.87	6.21	81.74	0.90	11.57
8.	Curd size index (cm^2)	87.10	67.59-115.31	15.20	14.80	94.80	25.85	29.68
9.	Gross plant weight (g)	1113.87	725.39-1302.33	13.11	13.01	98.42	296.05	26.58
10.	Marketable curd weight per plant (g)	596.77	479.07-741.92	12.37	12.20	97.24	147.92	24.79
11.	Days to marketable curd maturity	89.21	75.07-105.80	9.95	9.87	98.29	17.98	20.15
12.	Total soluble solid (°B)	6.11	5.16-6.86	8.13	8.06	98.14	1.01	16.44
13.	Dry matter content (%)	8.67	7.67-8.67	8.64	7.05	66.67	1.03	11.86

gross plant weight(g), marketable curd weight per plant(g), days to curd maturity, total soluble solids(^{o}B), dry matter content (%).

The data recorded on various parameters were appropriately computed, tabulated and analyzed by using MS-Excel and OPSTAT. The results were interpreted on the basis of 'F' test value and critical difference (CD) was calculated at 5% level of significance.

Results and Discussion

A broad series of variation was observed among twenty-seven genotypes of cauliflower, evaluated for different qualitative and quantitative traits (Table-1). The performance of the genotypes revealed a wide range of variation for traits such as leaf length (33.43-47.17cm), plant height (43.53-56.73cm), number of leaves per plant (12.48-21.11), days to curd initiation (57.20-86.00), stalk length (3.39-5.80cm), curd diameter (9.66-13.24cm), curd depth (6.82-8.72cm), curd size index (67.59-115.31cm^2), gross plant weight (725.39-1302.33g), marketable curd weight per plant (479.07-741.92g), days to curd maturity (75.07-105.80), harvesting index (47.21-66.27%), Total soluble solids (5.16-6.86 ^{0}B), incidence of disorder: riceyness (4.05-32.52%) and leafiness (1.23-3.10%), dry matter content (7.67-8.67%) and yield per plot (4.31-6.32 kg) thereby indicating the presence of sufficient genetic variability among the genotypes for these traits. These were in accordance with the findings of Singh *et al.* (2013), Yadav *et al.* (2013), Santhosha *et al*. (2014), Chittora and Singh (2015) and Kumar *et al*. (2017).

Mean performance of yield contributing traits

Curd diameter (cm) : Curd diameter is also an important yield contributing character as it determines the size of the curd which has a direct relationship with the total curd yield. Curd diameter ranged from 9.66 cm in VRCF-34 to 13.24 cm in UHF-CAU-M-15 with the average curd diameter of population was 11.10cm (Table-1). UHF-CAU-M-15 had larger curd diameter and significantly superior than the check variety, Palam Uphar (12.65cm). Two genotypes namely, UHF-CAU-M-16 (12.45cm) and UHF-CAU-M-14(12.35cm) were at par with the check. Rest of the genotypes recorded lesser curd diameter in comparison to check variety. The genotype VRCF-34 (9.66cm) had recorded minimum curd diameter which was at par with UHF-CAU-M-17(9.76cm), VRCF-51(9.91cm), VRCF-202 (9.92cm). Sufficient range of variability for the curd diameter was recorded by Singh *et al.* (2013), Kumar *et al.* (2017) and Gariya *et al*. (2019) in their respective genotypes.

Curd depth (cm) : Analysis of variance revealed significant differences for curd depth which ranged from 6.82 cm in VRCF-51 to 8.72 cm in UHF-CAU-M-15 with an average curd depth of the population was 7.81cm (Table-1). The genotypes namely, Pusa Himjyoti (8.13cm),VRCF-112(8.14cm),UHF-CAU-M-13(8.36cm),UHF-CAU-M-14(8.40cm),UHF-CAU-M-16(8.40cm), VRCF-102 (8.44cm), VRCF-101(8.51cm), UHF-CAU- M-15 (8.72) had comparable curd depth with the check variety, Palam Uphar(8.48cm) while, rest of the genotypes exhibited significantly lesser curd depth than the check variety. The genotypes viz., UHF-CAU-M-17(6.94cm) and VRCF-34(7.13cm) were at par with VRCF-51 having minimum curd depth among all the genotypes. Significant difference for this trait was also observed by Chittora and Singh (2015) and Sharma *et al*. (2018) in the performance of their respective genotypes.

Curd size index (cm^2) : Curd size index is a horticultural trait which decides shape and weight and also shows positive correlation with the yield. Significant variation for curd size index was observed among the genotypes under study (Table-1). The difference between the genotypes for this character ranged from 67.59 cm^2 in VRCF-51 to 115.44cm^2 in UHF-CAU-M-15 with an overall mean of 87.10 cm^2. Statistical analysis of the data indicated that the genotype UHF-CAU-M-15(115.44 cm^2) had maximum curd size index and found significantly superior than the check variety, Palam Uphar(106.74 cm^2) while, genotypes namely, UHF-CAU-M-14(103.75 cm^2) and UHF-CAU-M-16(104.60 cm^2) were at par with the check variety. The genotypes UHF-CAU-M-17 (67.74 cm^2), VRCF-34(68.88 cm^2), VRCF-22(75.14 cm^2) and VRCF-202(72.22 cm^2) were at par with VRCF-51(67.59) which was found to have minimum curd size index among all the genotypes. Significant difference for this trait was also observed by Sahu (2017), Kumar *et al*. (2017) and Sharma *et al*. (2018).

Gross plant weight (g) : A significant variation was recorded for gross plant weight among all the genotypes under study (Table-1). The difference between the genotypes for this character ranged from 725.39g in VRCF-34 to 1302.33g in UHF-CAU-M-15 with an overall mean of 1113.87g. Genotype UHF-CAU-M-15(1302.33g) was recorded significantly superior than check variety, Palam Uphar (1253.60g). Genotypes namely, Pusa Himjyoti (1226.84g), UHF-CAU-M-16(1242.09g), UHF-CAU-M-14(1244.63g) were at par with the check while, genotype VRCF-34(725.39g) had recorded minimum gross weight which was at the par with only one genotype UHF-CAU-M-17(739.47g). Widegenetic variation with respect to this character was also reported by range of variability was also reported by Singh *et al.* (2013) Santhosha *et al*. (2014), Kumar *et al.* (2017) and Chatterjee *et al.* (2018)

Marketable curd weight per plant (g) : Productivity of cauliflower largely depends on weight and size of the curd. Marketable curd weight per plant is an important trait which shows direct association with the yield. Analysis of variance revealed significant differences for marketable curd weight per plant which ranged from 479.07g in VRCF-34 to 741.92g in UHF-CAU-M-15 with an overall mean of 596.77g (Table-2). Statistical analysis of the data indicated that the genotype UHF-CAU-M-15(741.92g) was found significantly superior than the check variety, Palam Uphar(701.03g) while, genotypes UHF-CAU-M-16(687.30g) and UHF-CAU-M-14(692.33g) were at par with the check variety. Whereas, genotype VRCF-34(479.07g) had recorded minimum marketable curd weight per plant which was at the par with genotypes UHF-CAU-M-17(490.05g) and VRCF-51(499.21g). Result of the studied were in accordance with the findings of Singh *et al.* (2013), Chittora and Singh (2015), Kumar *et al.* (2017) and Chatterjee *et al.* (2018).

Yield per plot (kg) : Yield is an important horticultural character which determines the potential of any variety. The ultimate objective of cultivation is to have more yield and good returns. Highly significant variations were observed for yield per plot among the genotypes It was ranged from 4.31kg in VRCF-34 to 6.70kg in UHF-CAU-M-15 with an overall mean of 5.37kg. Statistical analysis of the data indicated that the genotype UHF-CAU-M-15(6.70kg) was found significantly superior than the check variety, Palam Uphar(6.32 kg) while, two genotypes UHF-CAU-M-16(6.19kg) and UHF-CAU- M-14 (6.23kg) were at par with the check variety. However genotypes namely, UHF-CAU-M-17 (4.41kg) and VRCF-51 (4.51kg) were found to be at par with VRCF-34 (4.31kg) which was found to have minimum value for yield per plot. Similar result have also been obtained by Manaware *et al*. (2017), Kindo *et al.* (2017) and Gariya *et al.* (2019).

Phenotypic and genotypic coefficient of variability : Since, phenotypic variation is the sum of genotypic variation and environmental variation therefore, it is not completely responsible for effective selection. Hence it is useful to study the genotypic and phenotypic coefficients of variation that can give the idea about the available variability present in the genetic population. The values of PCV were greater than that of GCV for all the traits studied, although the difference was less which indicated that the influence of environment for variability in these characters is very less. Earlier workers namely (Singh *et al.*, 2006; Kumar *et al.*, 2011) also recorded higher estimates of PCV than respective GCV. Moderate genotypic and phenotypic coefficients of variation were seen (table 2) in traits like days to curd initiation (11.31% and 11.47%), number of leaves (13.53% and 14.28%), stalk length (12.41% and 12.58%), curd size index (14.80% and 15.20%), gross plant weight (13.01% and 13.11%), marketable curd weight (12.20% and 12.37%). The traits had shown low genotypic and phenotypic coefficients of variation are leaf length (7.80% and 8.87%), plant height (6.68% and 7.26%), curd diameter (8.91% and 9.06%), curd depth (6.21% and 6.87%), days to curd maturity (9.87%), TSS (8.06%), dry matter content (7.05%). Similar information was also given by (Singh *et al.*, 2013; Chittora and Singh, 2015; Kumar *et al.*, 2017).

Heritability : Heritability is essential to compute the degree of genetic variability that can be transmitted from one generation to next generation. Heritability coupled with genetic advance provides scope for trait improvement through effective selection based on phenotypic performance. It reflects the genetic bond between the parent and offspring. High heritability allows the breeder to make direct selection on an individual plant in order to expand a specific trait of interest. If the heritability is on lower side, instead of making selection on the basis of desirable progeny, breeder must focus on the progeny testing. Heritability helps in the selection of elite types from the mixed parental populations or segregating populations.

A broad sense heritability estimate provides information on relative magnitude of genetic and environmental variation in germplasm pool. The heritability estimate varied from 66.67 per cent in dry matter content (%) to 98.42 per cent in gross plant weight (Table-4). The heritability for the characters under study are categorized as high (>80%), moderate (50-80%) and low (< 50%) as previously done by Warshamana, 2005.

High heritability was observed for the characters viz., gross plant weight (98.42%), days to curd maturity (98.29%), total soluble solids (98.14%), days to curd initiation (97.30%), marketable curd weight per plant (97.24%), stalk length (97.23%), curd diameter (96.63%), curd size index (94.80%), Number of leaves (89.69%), plant height (84.70%) and curd depth (81.74%). Alike observations were recorded by (Dubey *et al.,* 2003) for gross plant weight, (Kumar and Thakur, 2004) for plant height and days to curd maturity, (Sharma *et al.,* 2006) for stalk length and marketable weight, (Singh *et al*., 2006) for stalk length, (Singh *et al.,* 2010) for days to curd maturity and plant height, (Kumar *et al*., 2011) for marketable curd weight per plant, (Chittora and Singh, 2015) for gross plant weight.

Moderate heritability was recorded for leaf length (77.33%) followed dry matter content (66.67%). Almost same findings were reported by (Chittora and Singh, 2015) for leaf length.

Genetic advance and genetic gain : Genetic advance is defined as a gain in performance of a particular trait achieved through selection while, Genetic gain is the percentage of population mean. Heritability alone is not sufficient but genetic advance along with heritability is more useful in predicting the gain under selection. The traits showing high value of genetic advance indicated that they are operated by additive genes. The moderate value of genetic advance for the traits indicated that they are governed by both additive and non-additive genes while the traits expressing low genetic advance revealed significance of non-additive gene effects. In the present study, it was categorized as high(>20%), moderate (10-20%), low (0-10%) and presented in table 2.

The range of genetic advance as per cent mean varied from 11.57 to 29.68%. The highest estimate of genetic advance as percent of mean was seen for the characters viz., curd size index (29.68%), gross plant weight (26.58%), number of leaves (26.39%), stalk length (25.20%), marketable curd weight per plant (24.79%), days to curd initiation(22.98%) and days to curd maturity(20.15%). Chittora and Singh (2015) reported high genetic advance as percent mean for gross plant weight and marketable curd weight per plant, Manaware *et al.* (2017) for number of leaves, days to curd initiation, marketable curd weight per plant, gross plant weight and days to curd maturity, Vanlalneihi *et al.* (2017) for number of leaves and marketable curd weight, Chatterjee *et al.* (2018) for all the above traits except days to curd initiation, Gariya *et al*. (2019) for all the above recorded traits except curd size index, Kumari *et al.* (2020) for number of leaves, marketable curd weight per plant, gross plant weight. The moderate genetic advance as percent mean was recorded for traits viz., curd diameter(18.04%), total soluble solids(16.44%), leaf length(14.12%), plant height(12.66%), dry matter content(11.86%) and curd depth(11.57%). Manaware *et al*. (2017) recorded for stalk length, Sharma *et al.* (2018) for curd depth, curd diameter, total soluble solids, dry matter content and Kumari *et al.* (2020) for leaf length.

Conclusions

A broad range of diversity was observed among twenty-seven genotypes of cauliflower, evaluated for various characters. From the present investigation, it can be concluded that the genotype UHF-CAU-M-15 was recorded superior over the check Palam Uphar in terms of yield per plot. The difference between the estimates of genotypic and phenotypic coefficients of variation were minute for all the traits under study revealing less influence of environmental factors on these traits. High heritability coupled with high genetic advance was observed in traits like days to curd maturity, number of leaves per plant, days to curd initiation, stalk length, curd size index, gross plant weight, marketable curd weight per plant which showed that the selection for these traits will be highly effective.

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Prediction of Rainfall and Transmission of Prediction Information for Better Crop Management

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Abstract

Half of the population of India depends directly upon agriculture. Many economists have said that innovation in agriculture is the key to the growth of GDP. Government has done many efforts to improve the agriculture sector by helping farmers financially from giving them short loans for cultivation to buying their crops at a good price. Rainfall is also a major aspect of cultivation especially in areas where other means of irrigation is not possible. In this work, Rainfall prediction model is used to predict rainfall and a web portal is proposed to transmit the prediction information for helping farmers in decision making process.

Key words : *Data mining, artificial neural network, bagging, ensembles method, rainfall prediction, machine learning.*

Introduction

India is a developing country with 3.5 trillion dollar economy. India's growth rate is expected to be around 7% to 8% during the financial year 2022-2023 [1]. Agriculture's contribution in the GDP was calculated around 17% in 2019-2020 but due to the COVID-19 pandemic, almost all the industrial sector shout down and many workers working there moved to their native places and joined agriculture. All this leads to an increase in agriculture share from 17% to 19.9% in 2020-21. [2]

The target of 5 trillion dollar economy can be achieved with advancement in the agriculture by aggregating new technological advances in this sector. [3] In many ways, COVID-19 pandemic highlighted the importance of agriculture which is being neglected in the 21st century. To make advancement in agriculture, we have to make the system intelligence system and making learning. [4]

Rainfall contributes largely in the decision making process of selection of suitable crop. Farmers roughly estimate about the rainfall and cultivate a crop accordingly. Sometime due to variation in the normal amount of rainfall, farmers has to been the cost of additional water supply or compromise in the yield of the crop. Both the things results in less income of farmer and ultimately reduction in the big number i.e. GDP.

By using machine leaning techniques, some trends in the rainfall prediction can be studied and its relation with the other parameters of environment can be explored. This can help in efficient and accurate prediction of rainfall which is helpful in suitable crop selection. [5]

In this work a rainfall prediction model is proposed using bagging ensemble method with artificial neural network. This prediction model analyse the historical trends by historical weather data and predict the rainfall. It is also important to highlight that to observe a significant contribution, the prediction information must reach to farmers through a user friendly system. [6] Novel rainfall prediction model and a service oriented architecture are for prediction and transmitting the prediction information respectively. This work is fully dedicated toward society and information will be supplied to farmers so that they can easily utilize that information in order to make right decision for selection of crop. This prediction portal also contains information about various crop and their needs for cultivation.

Data set overview : Data set taken for this study contains around 9000 instances. Daily weather data has been analyzed for 11 parameters given in table-1. Near around 7000 instances are used to train the model and around 2000 are used for the testing purpose as shown in figure 1.

Proposed Model : In this work, a rainfall prediction model and a service oriented architecture is proposed for helping farmers in better decision making in cultivation. This service oriented architecture (SOA) is basically a web portal which is used for transmission of prediction information to the famers to help them in selection of a suitable crop as per rainfall assessment of that season. [7]

This web portal contains information regarding the amount of rainfall (in mm) during any month and details about the cultivation of crops such as process of cultivation and water requirement. [8] Information given on the service oriented architecture will be directly beneficial for the farmers by helping them in better plaining, water management and rainfall assessment.

Table-1 : Attributes description of Data set.

S. No.	Attribute Name	Data Type
1.	Station code (STN)	Integer
2.	Date (DATE)	Integer
3.	Temperature (TEMP)	Numeric
4.	Dew point (DEWP)	Numeric
5.	Sea level pressure (SLP)	Numeric
6.	Visibility (VISIB)	Real
7.	Wind speed (WDSP)	Numeric
8.	Maximum sustained wind speed (MXSPD)	Numeric
9.	Maximum Temperature (MAXT)	Numeric
10.	Minimum Temperature (MINT)	Numeric
11.	Precipitation Amount (PRCP)	Real

Table-2 : Performance of N-RPM.

S. No.	Performance Parameters	Proposed N-RPM
1.	Accuracy	89.14%
2.	Precision	79.87%
3.	Recall	71.08%
4.	F-measure	75.21%
5.	Specificity	0.964
6.	RMSE	0.284

A Novel Rainfall prediction model is used to predict the rainfall on the basis of historical weather data. Ten atmospheric parameters are studied with respect to rainfall which are given in table 1. [9] N-RPM is based on bagging ensembles method with artificial neural network as base prediction method. In N-RPM, a total of 20 ANN's are used to make the prediction more accurate.

Random sampling is used to train the artificial neural networks which helps in further enhancement of the model's performance.[10] Random sampling also helps in class imbalance problem. The N-RPM is shown in figure 2. Every neural network is trained using a dedicated data set formed from original data set by random selection of instances. In this way the model becomes more robust and accurate. The number of training cycles used for ANN is 500 with having learning rate of 0.3 and momentum of 0.2. [11]

Novel rainfall prediction model is implemented using rapid miner 8.1 shown in figure 3. In this work weather data of district Hissar of Haryana is used. Before using the dataset preprocessing is done in which redundant attributes are removed from the data set. [12]

This service oriented architecture as web portal is implemented by using HTML-5 and CSS. The homepage of web portal is shown in figure 4. [13]This service oriented architecture contains six submodules as shown in figure in which two important submodules are rainfall prediction and crop advisor. In rainfall prediction submodule monthly rainfall will be provided in mm as

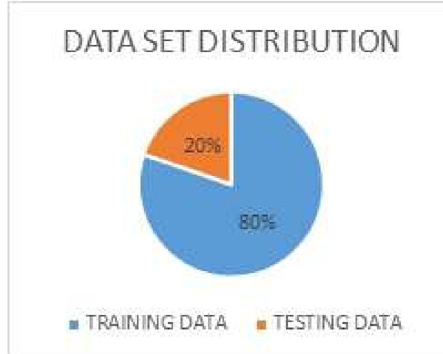

Fig.-1 : Data Set Distribution.

shown in figure 5. This portal is very easy to use and easily access able by anyone having an internet enabled device such as mobile phone. [14]

In crop advisor submodule the details about various crops such as process of cultivation, water requirements, best time to sow etc. are given. [15] All these information will be helpful for the less experienced youth who wants to join agriculture as a profession. Also it encourages the new entries from non-agriculture families to this noble profession. The crop advisor model is shown in figure 6 and 7.

Results and Discussion

In this work a novel rainfall prediction model is proposed which is discussed in previous section of this paper. Also a service oriented architecture (SOA) as a web portal is proposed and implemented. The Novel rainfall prediction model is being compared with the other existing prediction methods on the basis of 6 parameters namely Accuracy, precision, recall, RMSE, F-measure etc.

Conclusion and Future scope : In this work, the practicality and applicability of a research work is justified. A Novel Rainfall prediction model (NRPM) is proposed using Bagging ensembles method. The prediction information i.e. amount of rainfall is transmitted to the general public for actual use of it.

This works highlights the importance of not only doing research is the field of agriculture but to actually transfer the outcome of that research to general public for giving practical purpose to research work. The accuracy of prediction is very significant and effective but can be further improved by including parameters that deals with climate changes due to various human initiated development.

The pollution levels and Co2 emissions are also increasing day by day affecting the climatology of earth at various levels. The depletion of ozone (O3) layer and rise in the levels of greenhouse gases should be consider for further study.

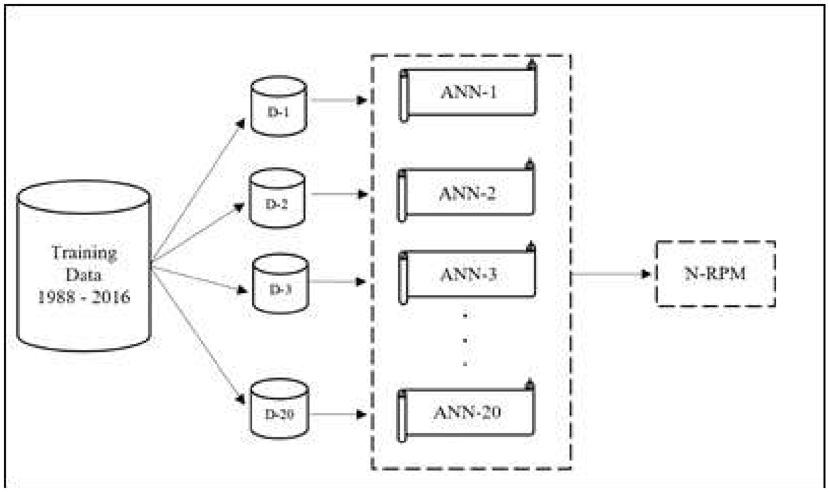

Fig.-2 : Novel-Rainfall prediction model (N-RPM).

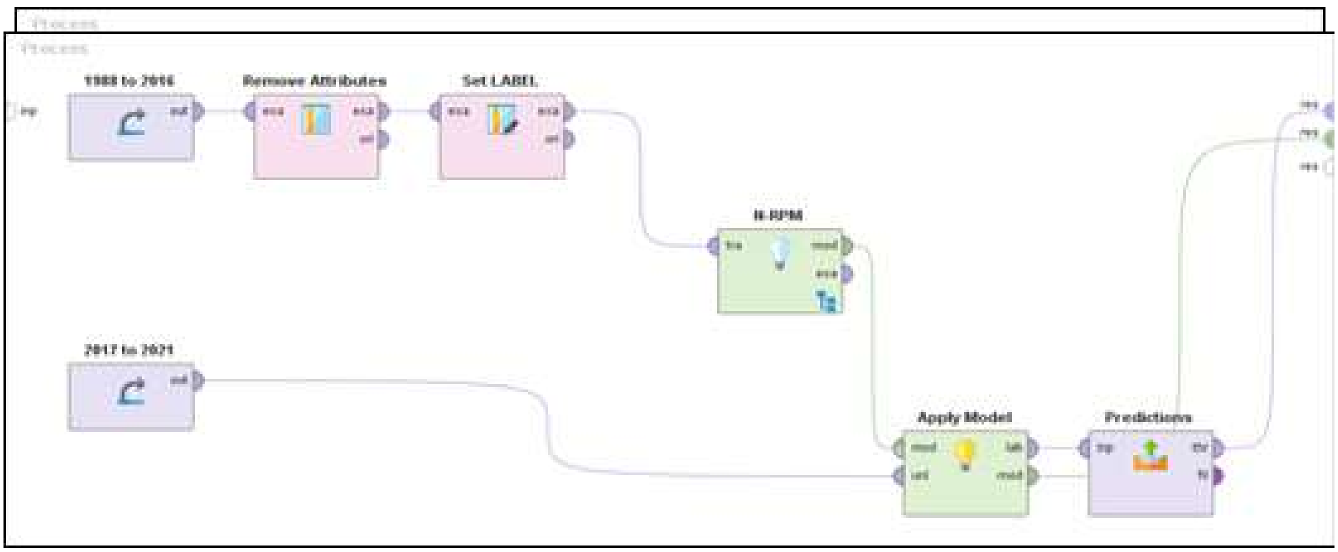

Fig. 3 : Novel-Rainfall prediction model (N-RPM).

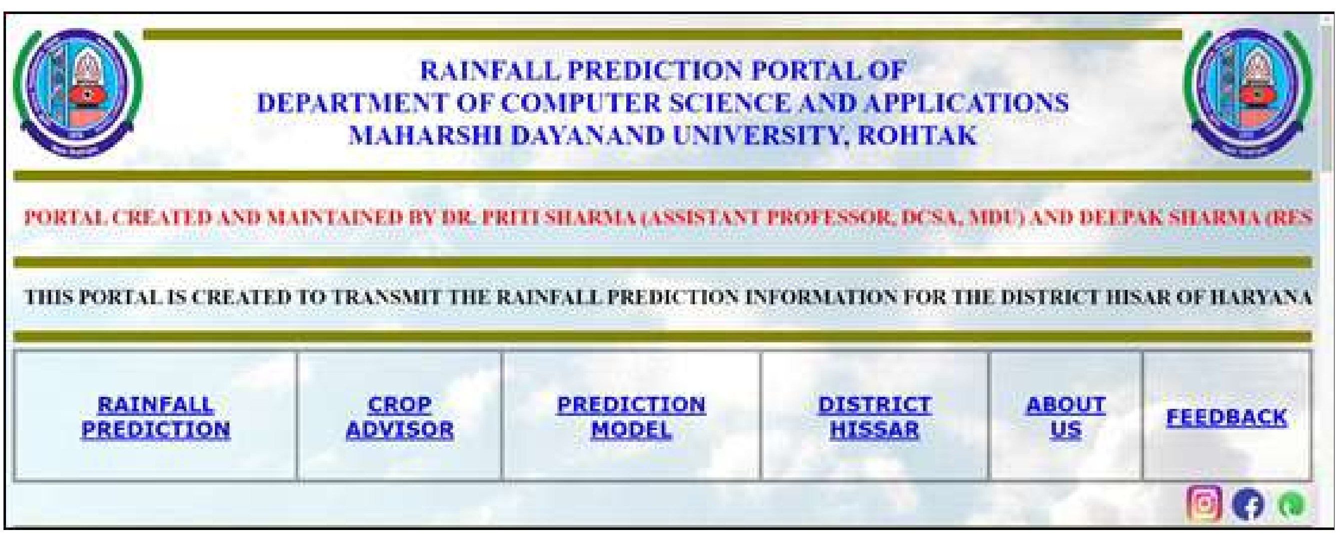

Fig.-4 : Main page of Rainfall prediction portal (SOA).

Fig.-5 : Rainfall prediction module (SOA).

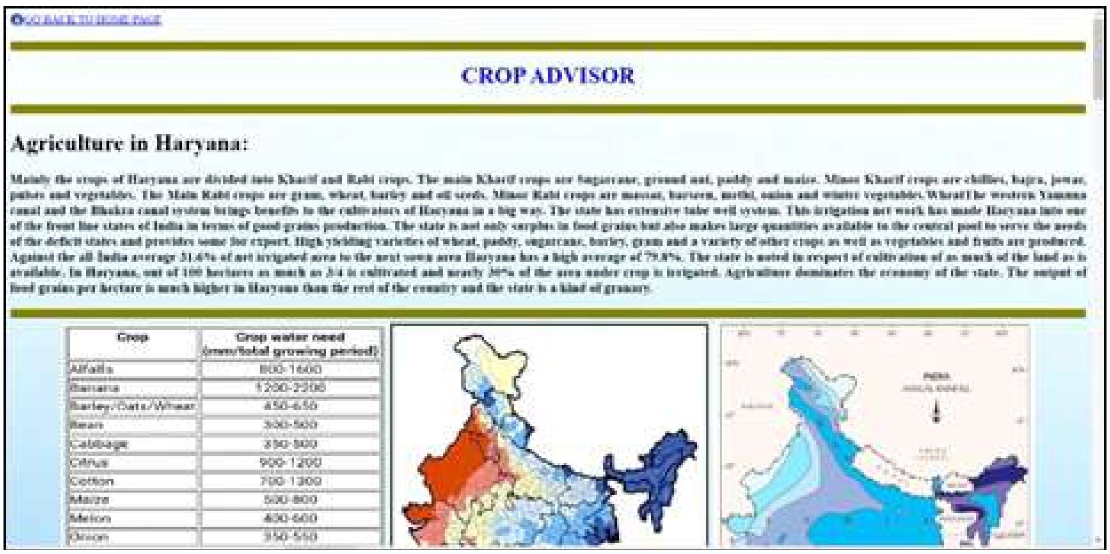

Fig-6 : Crop advisor module (SOA).

Fig.-7 : Crop advisor module of Rainfall prediction portal (SOA).

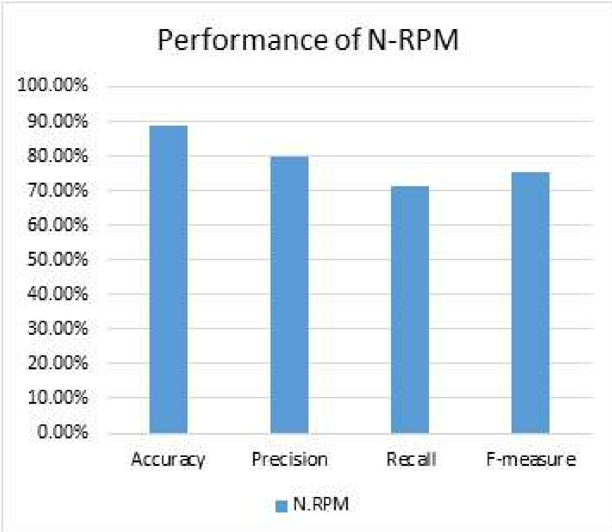

Fig.-8 : Performance of N-RPM.

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Effect of Inorganic and Bio-Fertilizer on Growth of Onion (*Allium cepa* L.) cv. Pusa Red

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Abstract

The present investigation entitled entitled "Effect of Inorganic and Bio-fertilizer on Growth and Development of Onion (*Allium cepa* L.) cv. Pusa red" was carried out at Vegetable Research Farm, Department of Horticulture,, Mahatma Jyoti Rao Phule University, Jaipur (Rajasthan). During winter season 2016-2017 and the experiment was out in the Randomised Block Design (RBD) consisting of 13 treatment. Among in various treatment of onion, it was observed that the plant height was significantly increased growth stage (30,60,90 DAT). The Plant heigth of treatment T_8 (75 % RDF+ Azotobacter + PSB), was found significantly superior at 30 DAT (33.10 cm), 60 DAT(55.21 cm), 90 DAT (60.67 cm) while Treatment T_0 (control) performed poorly. Regarding the number of leaves per plant in various growth as treatment T_8 again found significantly superior due to heavy vegetative growth stage as compared to T_6 and T_7. However, lowest number of leaves per plant found were noticed in T_0 (control). The maximum leaf diameter was found under the treatment T_8 (75 % RDF + Azotobacter + PSB), was found significantly superior at leaf diameter (2.60 cm) whereas the minimum leaf diameter was found in the treatment T_0(control). Which was statically at par with T_6, T_7, T_{10} and T_{12}. Whereas the minimum leaf diameter (1.57 cm) was found in the treatment T_0. This experiment overall treatment T_8 is found superior in all stage.

***Key words** : Azotobacter, growth , inorganic, onion, PSB.*

Introduction

Onion (*Allium cepa* L.) is one of the most important commercial vegetable Crops belongs to family Amaryllidaceae and it is one of the most important monocotyledonous, cross-pollinated and cool season vegetable crops. It is a semi perishable in nature and can be transported to a long distance without much injury. Most of the botanists believed that it has been origin in area including Iran, Pakistan and the mountainous countries in the North. According to Vavilov (1951), the primary centre of origin lies in Central Asia and the Near East and the Mediterranean are the secondary centre of origin. India ranks first in area covering 1225 thousand hectare (Anonymous, 2015-16) & second in production in the world next to China with production of 209.94 lakh tonnes (Anonymous, 2015-16). In India, onion is produced during two seasons' i.e kharif and rabi. The major onion producing states are Maharashtra, Gujarat, Karnataka, Andhra Pradesh, Orissa, Tamil Nadu, Uttar Pradesh, Madhya Pradesh and Rajasthan, which together account for 95 per cent of total area and production in the country. Maharashtra is the largest producer of the onion with production 5864.00('000MT) followed by Madhya Pradesh 2826.00('000MT). In Rajasthan, onion is grown extensively in the districts of Alwar, Ajmer, Jodhpur, Sikar, Nagaur, Jhunjhunu and Bikaner. The total production in the state during the year 2015-16 was 1435.112 M.T from an area of 86.306 ('000ha) (Anonymous, 2015-16). The rabi crop of onion is grown at a very large scale in comparison to kharif crop in the state because of adverse climatic conditions like high temperature at the time of kharif seedling raising. Onion accounts for 70 per cent of our total foreign exchange earnings from the export of fresh vegetables. Government of India has declared onion as an essential commodity. imilarly, phosphorus is indispensible constituent of nucleic acid, phospholipids and several enzymes. It is also needed for the transfer of energy within the plant system and is involved in various metabolic activities. Phosphorus has its beneficial effect on early root development, plant growth, yield and quality of crop produce.

Biofertilizers are products containing living cells of different types of microorganism, which have an ability to convert nutritionally important elements to available form through biological processes. In recent years, biofertilizers have emerged as an important component of the integrated nutrient supply system and hold a great promise to improve crop yield through environmentally better nutrient supplies.

The biofertilizers are alternative sources to meet the nutrient requirement of crops and to bridge the future gaps. Further, knowing the deleterious effect of using only chemical fertilizers on soil health, use of chemical fertilizers supplemented with organic waste and biofertilizers will be environmentally benign.

Table-1 : Treatment and their combination.

Treatment	Concentration (kg/ha)	Notation
Control	-	T_0
50% RDF	75:80:25 kg NPK	T_1
50% RDF + *Azotobacter*	75:80:25 kg NPK + 2kg *Azotobacter*	T_2
50% RDF + PSB	75:80:25 kg NPK + 2kg PSB	T_3
50% RDF + *Azotobacter* + PSB	75:80:25 kg NPK + 2kg *Azotobacter* + 2kg PSB	T_4
75% RDF	100:60:37.5 kg NPK	T_5
75% RDF + *Azotobacter*	100:60:37.5 kg NPK + 2kg *Azotobacter*	T_6
75% RDF + PSB	100:60:37.5 kg NPK + 2kg PSB	T_7
75% RDF + *Azotobacter* + PSB	100:60:37.5 kg NPK + 2kg *Azotobacter* + 2kg PSB	T_8
100% RDF	150:80:50 kg NPK	T_9
100% RDF + *Azotobacter*	150:80:50 kg NPK + 2kg *Azotobacter*	T_{10}
100% RDF + PSB	150:80:50 kg NPK + 2kg PSB	T_{11}
100% RDF + *Azotobacter* + PSB	150:80:50 kg NPK + 2kg *Azotobacter* + 2kg PSB	T_{12}

Table-2 : Effect of various inorganic and biofertilizers on plant height at 30 DAT, 60 DAT and at harvest of onion.

Treatment	Plant Height (cm)		
	30 DAT	60 DAT	90 DAT
T_0 (Control)	22.57	43.11	48.21
T_1 (50% RDF)	25.02	45.67	53.56
T_2 (50% RDF + *Azotobacter*)	25.20	46.04	54.11
T_3 (50% RDF + PSB)	25.67	46.56	54.67
T_4 (50% RDF + *Azotobacter* + PSB)	27.10	47.81	55.03
T_5 (75% RDF)	26.01	46.10	54.47
T_6 (75% RDF + *Azotobacter*)	31.67	52.17	58.07
T_7 (75% RDF + PSB)	32.33	53.47	59.51
T_8 (75% RDF + *Azotobacter* + PSB)	33.10	55.21	60.67
T_9 (100% RDF)	26.47	48.01	55.89
T_{10} (100% RDF + *Azotobacter*)	27.87	49.10	56.40
T_{11} (100% RDF + PSB)	28.48	49.33	56.87
T_{12} (100% RDF + *Azotobacter* + PSB)	29.10	49.56	57.42
S. Em+	1.36	2.14	2.07
C.D.(5%)	3.97	6.24	6.04

Table-3 : Effects of various inorganic and biofertilizers on leaf diameter and number of leaves after 30 DAT of onion.

Treatment	Number of leaves 30 DAT	Leaf Diameter (cm)
T_0 (Control)	2.67	1.57
T_1 (50 % RDF)	3.00	1.81
T_2 (50 % RDF + *Azotobacter*)	3.10	1.97
T_3 (50 % RDF+ PSB)	3.20	2.09
T_4 (50 % RDF + *Azotobacter* + PSB)	3.30	2.15
T_5 (75 % RDF)	3.50	2.30
T_6 (75 % RDF + *Azotobacter*)	3.87	2.51
T_7 (75 % RDF + PSB)	4.01	2.55
T_8 (75 % RDF + *Azotobacter* + PSB)	4.33	2.60
T_9 (100 % RDF)	3.40	2.27
T_{10} (100 % RDF + *Azotobacter*)	3.50	2.35
T_{11} (100 % RDF + PSB)	3.61	2.37
T_{12} (100 % RDF + *Azotobacter* + PSB)	3.75	2.41
S. Em+	0.13	0.06
C.D.(5%)	0.37	0.16

Materials and Methods

The investigation was carried out during *Rabi* season at Vegetable Research Farm, Department of Horticulture, Mahatma Jyoti Rao Phule, Jaipur (Rajasthan).The region falls under Agro-Climatic Zone III- A (Semi-Arid Eastern Plain). Achrol is situated at 26.5º North latitude, 75.47º East longitude and an altitude of 427 meters above Mean Sea Level in Jaipur district of Rajasthan. The experiment was laid out with three replication and 13 Treatment. The plant to plant and row to row distance were taken 15 x 10 cm.

The climate in semi-arid characterized by extremes of temperature both in summer and winter, with low rainfall and moderate relative humidity. The average annual rainfall is approximately 500 mm which is mostly received during July to early September; sporadic showers in winters are also not uncommon. The maximum temperature ranges from 28 to 45ºC during May and June, while in December and January, it falls below 3ºC, evaporation ranges from 1.3-17.5 mm/day. The meteorological data during the period of experimentation recorded. The seeds of onion cv. Pusa Red were sown in well prepared nursery beds. Before sowing, the seeds were treated with fungicide Thiram @ 2.5 gm per kg of seed. The seeds of onion cv. Pusa Red were sown in well prepared nursery beds. Before sowing, the seeds were treated with fungicide Thiram @ 2.5 gm per kg of seed. The seedling were transplanting in winter month December of 2016. Transplanting of seedlings was done in evening hours in each experimental bed at the spacing of 1510 cm, according to experimental design. After transplanting, a light irrigation was given for the proper establishment of the seedlings. The following observations with regards to the growth and development parameters were recorded.

All the intercultural operations like weeding watering, gap filling etc. were carried out during the research experiment.

Results and Discussion

The above investigation entitled “Effect of Inorganic and Bio-fertilizer on Growth and Development of Onion (*Allium cepa* L.) cv. Pusa red” was conducted at experiment field of Vegetable Research Farm, Department of Horticulture, Mahatma Jyoti Rao Phule, Jaipur (Rajasthan). The result obtained form this investigation, according to different parameter has been presented and explained blow.

Growth Parameter : The growth parameters like plant height, number of leaves at 30, 60, 90 day and leaf diameter after transplanting and it is shown in table-2 and fig.-1.

Plant height : The plant height increased significantly with the different treatments of organic manures, inorganic fertilizers and bio-fertilizer upto harvesting. The significantly maximum plant height was recorded in treatment T_8 (75 % RDF + Azotobacter + PSB) at 30, 60 , 90 DAT and at harvest. While, the lowest plant height was recorded in treatment T_0 (Control). The result revealed that plant height was numerically maximum (33.10 cm) in treatment T_8 (75 % RDF + *Azotobacter* + PSB), which was statically at par with T_7 and T_6. The lowest plant height (22.57 cm) was found in treatment T_0. Plant height at 60 DAT was presented in showed significantly increase and maximum plant height (55.21 cm) was recorded in T_8 (75 % RDF + *Azotobacter* + PSB), which was statically at par with T_7, T_6, T_{10} , T_{11} and T_{12}. While minimum plant height (43.11 cm) was found in control (T_0). Plant height at 90 DAT was recorded significantly highest (60.67 cm) in T_8 (75 % RDF + *Azotobacter* + PSB), which was statically at par with T_4, T_6, T_7, T_9, T_{10} , T_{11} and T_{12} T_7, while minimum plant height (48.21cm) was measured in absolute control (T_0).

This may be due to application of integrated nutrient management, increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin contents in the plants which ultimately improving the plant height.

The increase in plant height may be due to inoculation of biofertilizers and PSB might have increased the amount of available phosphorus in the root zone for the growth and development of plants. In addition to phosphate solubilization these microbes can mineralize organic phosphorus into a soluble form. These reactions take place in the rhizosphere and the microorganism render more phosphorus into soil solubilization required for their smooth growth and metabolism. The surplus is available for plants to be absorbed. It also produce fungistatic and growth promoting substances, like auxins, gibberlines, cytokines etc. which influence the plant growth parameters by enhancing cell division, cell elongation and thus increasing the metabolic activity Jayathilake *et al.* (2002), Jayathilake *et al.* (2003), Reddy and Reddy (2005), Singh (2002),Yadav (2005)

Number of leaves per plant : The data clearly indicated that the number of leaves per plant of onion responded significantly to various treatments of inorganic fertilizers and biofertilizer under study. The significantly maximum number of leaves per plant was recorded in the treatments T_8 (75 % RDF + Azotobacter + PSB) at 30 DAT and at harvest. However, the minimum number of leaves per plant was recorded under treatment T_0 (control) at 30 DAT and at harvest. Probable reasons for enhanced more number of leaves, may be due to promotive effects of

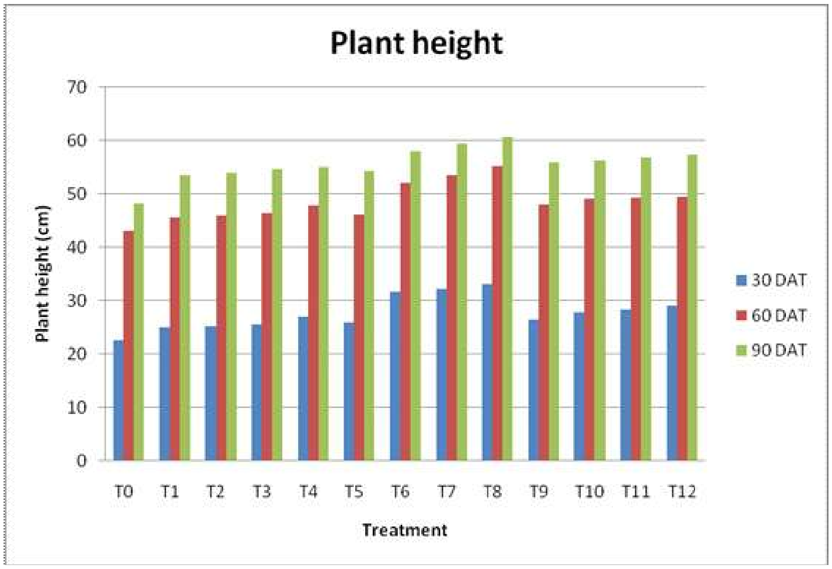

Fig.-1 : Effects of various inorganic and biofertilizer on plant height after 30 DAT, 60 DAT and 90 DAT at harvest of onion.

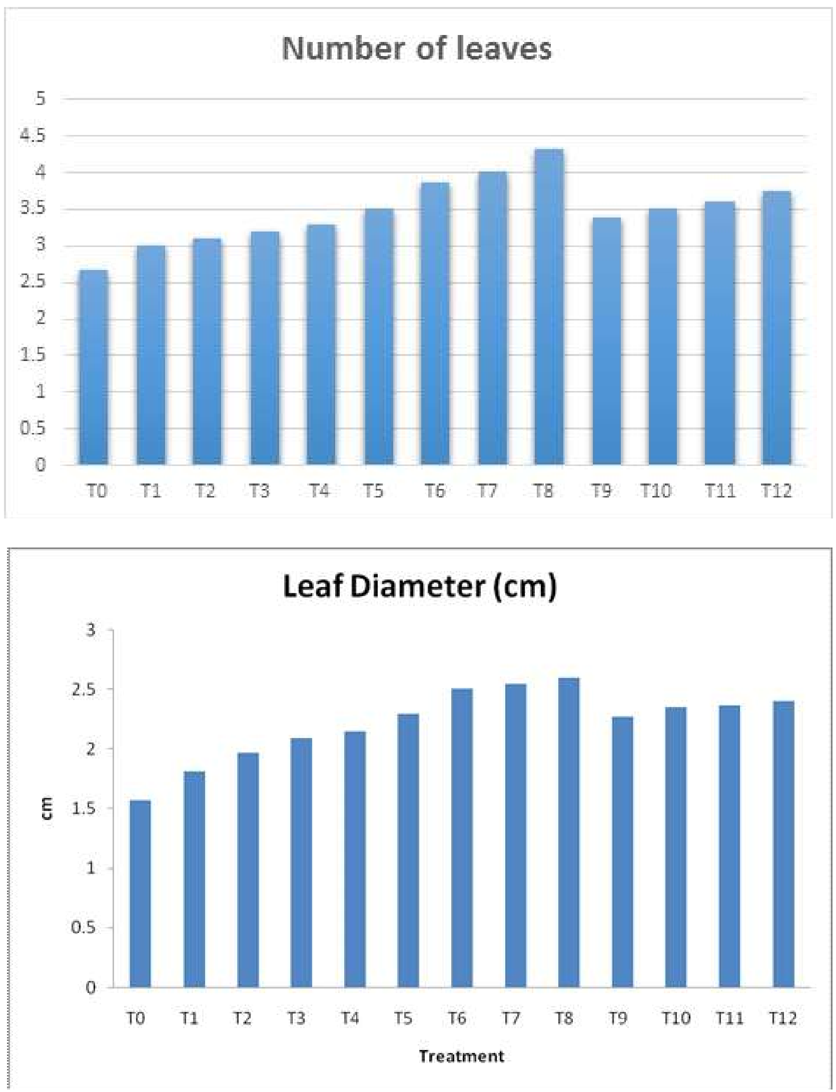

Fig.-2 : Effects of various inorganic and biofertilizer on leaf diameter and Number of leaves after 30 DAT of onion.

integrated nutrient management on vegetative growth which ultimately lead to more photosynthetic activities. The Number of leaves per plant of onion differed by different treatments of inorganic and biofertilizers is given in depicted graphically in number of leaves per plant was recorded at various growth stages viz. 30 days after planting and at harvest. A critical examination of the data revealed that number of leaves per plant was comparatively lower at the initial stage (30 DAT) and their after increased upto harvest.

It is apparent that the experimental results and data presented in showed significant differences among all the treatments for the number of leaves per plant after 30 DAT. The maximum number of leaves (4.33) was found in treatment T_8 (75 % RDF+ *Azotobacter*+ PSB), which was statically at par T_6 and $T_{7.}$ The treatment T_0 (control) showed the minimum number of leaves (2.67) per plant after 30 DAT

Possible reason for increased number of leaves per plant may be due to the improvement in growth related attributes because of certain growth promoting substances secreted by biofertilizers, better uptake of water, nutrients and their transportation. Similar studies were also conducted by Jayathilake *et al.* (2002), Jayathilake *et al.* (2003), Reddy and Reddy (2005), Kumar *et al.* (2010), Singh (2004).

Leaf diameter : The leaf diameter increased significantly with the different treatments of inorganic fertilizers and bio-fertilizer up to harvesting. The maximum leaf diameter was found under the treatment T_8 (75 % RDF + Azotobacter + PSB), whereas the minimum leaf diameter was found in the treatment T_0(control). A perusal of experimental results and data presented in Table-3 and Fig.-3 showed significant differences among all the treatments for leaf diameter. The maximum leaf diameter (2.60 cm) was found under the treatment T_8 (75 % RDF + *Azotobacter* + PSB), which was statically at par with $T_{6,}$ $T_{7,}$ T_{10} and $T_{12.}$ Whereas the minimum leaf diameter (1.57 cm) was found in the treatment $T_{0.}$ These results are in accordance with those of Brinjh *et al.* (2014).

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Yield and Gap Analysis of Groundnut (*Arachis hypogaea* L.) Productivity through Cluster Front Line Demonstration in Giridih District of Jharkhand

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Abstract

The Cluster Front Line Demonstration (CFLD) on groundnut was carried out by 207 farmers on an area of 80 ha over the period of five years (2016-17 to 2020-21). The individual plots selected were of the size of 0.5 to 1.5 acre per farmer. The technology demonstrated was variety 'Kadri - 6' with full package of practice including recommended dose of fertiliser (40:30:20 NPK, Kg/ha) with plant protection as per requirement. The average yield during five years was 5.06 q/ha which was 47.5 % more than farmers check yield. The average value of technology gap, extension gap and technology index were 2.4 q/ha, 1.6 q/ha and 32.5 % respectively. Average net return and benefit cost ratio were Rs.21,480/ha and 2.54 respectively over the period of five years which were far better than farmers practice net return of Rs.11,560/ha and benefit cost ratio of 1.9. This could be due to good management of demonstration plots with introduction of new variety and adopting improved package of practices.

Key words : *Yield, technology gap, extension gap, technology index, CFLD and economics.*

Introduction

Consuming groundnut is very beneficial for our health especially in winters. Peanuts contain vitamin E, magnesium, foliate, copper and arginine. Studies reveal that peanuts can even be useful for weight loss and reduce the risk of cardiovascular disease. The crop is of great importance due to high edible oil content and nutritious value of kernel as human food. It is very important source of oil (40-45%), protein(26%), carbohydrate (25%), minerals(Phosphorus, Calcium & Irons) and vitamins. It is number one oilseed crop in India with an area 4.91 million ha with a production of 9.95 million tons and productivity 20.63 q/ha. As far as Jharkhand is concern it is far behind the national average area, production and productivity. The sandy loam upland soil is very much suitable for its cultivation in Jharkhand with especially in Giridih district with an area of 300-350 ha and production of 300 – 320 tons with a productivity 10-11 q/ha. The poor productivity of groundnut in giridih district may be due to non adoption of improved production technology by the farmers and lack of awareness about the new varieties of high potential yield. Keeping in view the above facts KVK, Giridih conducted a CFLD sponsored by Ministry of Agriculture (GOI) through ICAR, ATARI, Patna (Zone IV). The main objective of the programme was to establish the impact of the groundnut production technology and increase the productivity and profitability of groundnut on farmers field. Similar programme had also been taken up by Anonymous 2017-18, Dupare *et al* 2012 and Rajmal *et al* 2020.

The district has greater potential of groundnut production due to favourable climate and soil condition. In this district the recommended production technology has not yet been adopted by the farmers due to various reasons including suitable extended methodology. The other reason may also include socio economic conditions of the resource poor farmers. Hence it needs and efficient technology transfer system on the basis of learning by doing and seeing in believing principle. Recently farmers have attracted towards groundnut cultivation due to marketing of value added products of groundnut coming from neighbouring and other state of the countries. Since marketing of groundnut is not a being challenge for farmers so they can be convinced for large scale production with full package of practices and high yielding of varieties. Groundnut kernel is consumed in various raw and cooked form apart from extraction of oil. In recent years groundnut have become an essential food item in almost every house of Jharkhand particularly in urban and semi-urban areas. The state of Jharkhand has taken a various steps to popularize groundnut cultivation through agencies like ATMA and NGOs. The well drained sandy loam soils of entire Jharkhand especially district like Giridih is very much conducive for groundnut cultivation. Presently the low yield of groundnut in the state in general and Giridih a particular is due to poor agronomic practices such as highest seed rate, unbalanced fertilizer application and faulty plant protection measures.

Materials and Methods

The study was carried out during kharif season from

2017-18 to 2020-21 (four years) by KVK Giridih of Jharkhand. The demonstration were conducted in farmer's field of 10 different villages of Giridih District in agroclimatic zone -IV of Jharkhand. During these four years of study a total numbers of 35, 27, 30 and 30 beneficiaries were selected in 2017-18, 2018-19, 2019-20 and 2020-21 respectively for this project. Farmers were trained to follow the package and practices for groundnut cultivation as recommended by the Birsa Agricultural University and need based inputs were provided to the beneficiaries (Table-1). The farmers followed the full package of practices like soil testing, seed treatment with fungicide and bio-fertilizer, recommended fertilizer application, weed management, Integrated pest management (IPM) practices etc. In case of local check, the traditional practices were followed by using existing varieties. An area of 40 hectare was covered under cluster front line demonstration with active participation of 122 farmers. Before conducting CFLDs, a list of farmer was prepared from group meeting and specific skill training was imparted to the selected farmers.

In general, the soil of the Demonstration plot sites were sandy loams in texture, acidic in reaction (pH 5.0 – 5.3) , low to medium in organic carbon (0.4 – 0.6 %) and low in available nitrogen (185.4 – 211.5 kg N /ha), low in available phosphorus (7.6 – 9.6 kg P_2O_5 kg /ha) and low in available potassium (85.7 – 111kg K_2O /ha) shown in Table-1.

In demonstration plots, use of quality seeds of improved varieties (K-6), line sowing and timely weeding, need based pesticide as well as balanced fertilizer were emphasized and comparison has been made with the existing practices shown in Table-2. Visit of farmers and the extension functionaries was organized at demonstration plots to disseminate the message at large scale. The beneficiaries under the programme were facilitated by KVK Scientists in performing field operations like sowing, spraying, weeding, harvesting etc. during the course of training and visits. The traditional practices were maintained in case of local checks. The data were collected from both CFLD plot as well as control plots by random crop cutting method and analysed by using simple statistical tools. The technology gap and technological index (Yadav *et al*., 2004) along with the benefit cost ratio (Samui *et al*., 2000) were calculated by using following formula as given below.

Technology Gap = Potential yield - Demonstration yield

Extension Gap = Demonstration yield - Farmer's Practice yield

Technology Index

$$= \frac{\text{Potential yield - Demonstration yield}}{\text{Potential Yield}} \quad 100$$

Additional Return = Demonstration Return - Farmer's Practice Return

Percentage increase in yield

$$= \frac{\text{Demonstration yield - Farmers Practice yield}}{\text{Famer's Practice Yield}} \quad 100$$

Table-1 : Soil nutrient status of the demonstration plot.

Soil test report	Demonstration plot
PH	5.0 – 5.3
Ec (dS m^{-1})	1.10 – 1.17
Available N (Kg ha^{-1})	185.4 – 211.5
Available P_2O_5 (Kg ha^{-1})	7.8 – 9.6
Available K_2O (Kg ha^{-1})	85.7 – 111
Organic Carbon (%)	0.4 – 0.6

Results and Discussion

The four year data in respect of CFLD on groundnut conducted in Giridih district of Jharkhand have been presented in Table-1 and Table-2. The data on existing or farmers practice and recommended technology of groundnut clearly shows that there was a gap between recommended technology and farmers technology in regard to variety, seed treatment, fertilizer application and plant protection measures. The gap varied substantially in respect of fertilizer management and partially in weed management. Farmers use to practice traditional method of all cultural activities and old varieties available in the locality.

Groundnut Yield : Average groundnut yield under CFLD was observed as 1620 kg/ha which was higher by 33.9% over the prevailing farmers practice 1210 kg/ha. This superiority of yield could be due to adoption of recommended package of practices and high yielding variety (K-6). The package of practices of groundnut included new agriculture technology right from seed treatment to harvesting of groundnut similar result were also reported by Solanki and Nagor, 2020 Singh et al 2014 , Sharma et al 2016 and Solanki et al 2020. The low level of yield of farmers plot was due to low yielding local variety, unbalanced fertilizer application and poor management of plant protection activities. The higher yield of demonstration plot was also due to timely sowing of groundnut as well as earthing up of groundnut with timely plant protection measures.

Technology Gap : The data in respect of technology gap for groundnut have been presented in Table-3, which revealed that maximum technology found in the year 2017-18(340 kg/ha) and lowest in the year 2020-21(230 kg/ha). The average technology gap over the period of four years was 290 kg/ha. The data also reveals that technology gap went on reducing over the succeeding years of CFLD (2017-18 to 2020-21). This may be due to difference in agricultural practices, soil fertility status timeliness of availability of inputs and timely agriculture

Table-2 : Difference between technological intervention and farmer's practices under CFLD on Sesame.

Particulars	Technological Intervention in CFLD	Farmers Practices	Gap
Variety	Kadri-6	Local/own seed	Full gap
Seed rate	5 kg/ha	8-10 kg/ha	High Seed rate
Sowing method/spacing	Line sowing : Spacing Row to Row – 30 cm Plant to Plant – 15 cm	Broadcasting uneven plant population	Partial gap
Time of sowing	12-18 July	25-30 July	Partial gap
Seed treatment	Seed treatment was done with 2.5 gm of Carbendazim	No seed treatment	Full gap
Fertilizer	Balanced fertilizer application as per soil test values, 52 kg/ha urea 88 kg/ha DAP and 35 kg/ha MOP.	Imbalanced use of fertilizer 50 kg urea as top dressing and 50 kg of DAP as basal dose /ha	Full gap
Weed management	Application of oxadiazone @ 1.25 lit. ha-1 as pre – emergence + 1 HW	Mannual weeding at 35 – 40 DAS	Full gap
Plant Protection	Spray of insecticide as per nature of insects at 75 % flowering and pod filling stage	Injudicious use of insecticides and fungicides based on advice of input dealers	Partial gap with high cost

Table-3 : Grain Yield and Gap analysis of cluster frontline demonstration on Groundnut.

Year	Sample Area (ha)	Sample No. of Farmers	Average Yield (q/ha)			% increase over FP	Technology Gap (q/ha)	Extension gap (q/ha)	Technology Index (%) CFLD
			Potential	CFLD	FP				
2017-18	5.0	15	18-20	15.6	11.2	39.2	3.4	4.4	17.8
2018-19	30.0	110	18-20	16.0	12.8	25.0	3.0	3.2	15.7
2019-20	10.0	29	18-20	16.2	13.4	20.9	2.8	2.8	14.7
2020-21	30.0	77	18-20	16.7	11.1	50.4	2.3	5.7	12.1
Tot./Average	75.0	231	19.0	16.2	12.1	33.9	2.9	4.0	15.1

Table-4 : Economic analysis of the cluster frontline demonstration on Groundnut.

Year	Total return (Rs. per ha)		Input Cost (Rs. Per ha)		Net Return (Rs. per ha)		Addition al return (Rs per ha) CFLD	B : C ratio	
	Recommended Practice (RP)	Farmer's Practice (FP)	Recommended Practice (RP)	Farmer's Practice (FP)	Recommended Practice (RP)	Farmer's Practice (FP)		Recommended Practice (RP)	Farmer's Practice (FP)
2017-18	93600	67200	40695	42000	52905	25200	27705	2.3	1.6
2018-19	96000	68000	36930	42500	59070	34300	24770	2.6	1.8
2019-20	97200	80400	38880	42300	58320	38100	20220	2.5	1.8
2020-21	100200	66600	47700	43180	52500	23420	29080	2.1	1.54
Average	96750	72450	41051	42745	55699	30255	25444	2.4	1.7

Note : Price of groundnut seed@ Rs. 60/kg

operation perform by the farmers as per suggestion of the scientist. Therefore location specific recommendation and suitable variety as per climatic condition appears to the necessary to minimize the technology gap in different farming situation. These location specific recommendation appear to be necessary to bridge the gap. Solanki et al 2013 and Singh et al 2014 and Kumar *et al* (2018) reported similar results.

Extension Gap : The data on the extension gap (q/ha) for the period of 2017-18 to 2020-21 have been presented in Table-3. It varied from 2.8 q/ha to 5.6 q/ha over the period of four years in respect of groundnut. The variation in extension gap over the different years may be attributed to difference in soil moisture status, soil fertility status and non uniform timeliness of agricultural activities.

With an average of 4.0 q/ha this higher value of difference in extension gap clearly indicates that there is a need to trained the farmer through various methods of extension technique like focused group discussion, audio visual tools, Krishak gosti and farmers scientist interaction. The similar results were reported by Singh et al 2014, Mahadik and Palathi 2016, Mishra and Sarangi 2018 and Singh *et al* (2019).

Since the extension gap is the difference or gap between the yield of demonstration plot and farmers practice plot the observed extension gap may be assigned to adoption of improved transfer of technology in demonstration plots resulting in higher seed yield than traditional farmers practices. The gap can be minimized by educating the farmers in the respect of new technologies and varieties of groundnut.

Technology Index : The technology index of CFLD on groundnut have been presented in Table-3. From the data as in Table it is evident that technology index gradually decreased from 17.8% to 12.1% over the period of four years (2017-18 to 2020-21) with an average value of 15.1%. The highest value of technology index was observed in 2017-18 and lowest value in 2020-21. The Technology index indicates the feasibility of evolved technology at the farmers field. The lower the value of T.I. more is the feasibility of technology. From the data observed during the different years it can be advocated that awareness and adoption of improved variety with recommended scientific package and practices have increased during the consequent years of demons. The result is in conformity with Sharma et al 2016, Solanki and Nagar 2020, Kumar *et al* (2013), Prasad et al (2017), Gangwar et al 2019 and Mitnala et al 2018 and Prasad and Singh (2021).

Economics Analysis : The data on economics analysis of CFLD on groundnut have been presented in Table-4. The data clearly indicates higher gross return under demonstrated plot (Rs. 96750/ha) than the farmers practice (Rs 72450/ha) which is due to higher average yield under demonstrated plot than the farmers practice plot. It is also evidence from the table that average cost of cultivation in demonstrated plot and farmers practice plot were (Rs 42,745/ha and Rs 41,051/ha respectively). The net return in demonstration plot was Rs 55,699/ha whereas in farmers practice plot was Rs 30,255/ha with an additional return of Rs. 25,444/ha. This additional return was 84% higher than farmers practice plot. The additional return (Rs/ha) varied from Rs 20,220/ha to Rs 29,080/ha over the period of four years. The maximum benefit cost ratio (2.6) was during the year 2018-19 whereas it was minimum (2.1) during the year 2020-21 with an average value of four years. Solanki et al 2020, Prasad et al (2017) and Sharma et al 2016 also reported similar results.

Conclusions

Thus it may be concluded from the above results that the yield and net return in groundnut crop increased significantly with the improved production technologies and improved varieties. It can also be concluded that with the adoption of scientific package & practices and the technology gap and extension gap can be managed to desirable levels and substantial profit enhancement. In nut shell it can be advocated that suitable technologies and suitable extension methodology can substantially increase the output and outcome of groundnut in the Giridih district of Jharkhand. The result also indicated that CFLD has very good impact on the farming community of the district.

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Impact of Cluster Frontline Demonstration of Horsegram Var. Birsa Kulthi-1 on Yield and Technological Gap in Giridih District of Jharkhand

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Abstract

The demonstration carried under Cluster Front Line Demonstration (CFLD) programme under NFSM during 2017-18 to 2020-21 by Krishi Vigyan Kendra, Giridih to minimize the yield gap, technology gap, extension gap and maximize the economic return through improved package of practices. The outcome of the study revealed that yield of the horse gram under Cluster Front Line Demonstration varied from 7.9 q/ha to 9.0 q/ha during five years which was 49.99 % higher than the yield under farmers practice. The average technology gap and extension gap was 0.9 q/ha and 2.8 q/ha respectively. The technology index over the four years varied from 5.2 % to 16.8 %, net return of demonstrated plot was between Rs. 18410/ha to Rs. 25435/ha during different years. The Benefit Cost ratio of demonstrated plot varied from 1.9 to 2.3 whereas it varied from 1.5 to 1.8 for farmers practice plot.

Key words : *Technology gap, extension gap, technology index, CFLD, yield and economics.*

Introduction

Horse gram is an important crop of South India. Its grain is used for human consumption as 'dal' as well as in preparation of so called 'rasam' and also as a concentrated feed for cattle. It may also be used as green manure. Horse gram (*Macrotyloma uniflorum* Lam. (Verdc.)) is an underutilized (Aiyer 1990) and unexplored (Reddy *et al.* 2008) food legume. It is considered as a good source of protein, carbohydrates, energy (Bravo *et al.* 1998). It is tolerant to drought (Bhardwaj and Yadav 2012), salinity (Reddy *et al.* 1998) and heavy metal stresses (Reddy *et al.* 2005). Horse gram mainly grown in India, Africa, Australia , Burma, Malaysia and West Indies under low soil fertility status with few inputs (Witcombe *et al* 2008). In India , it is generally sown late in rainy season by resource-poor farmers in marginal and drought prone condition.

Horse gram is a short day and day neutral plant, matures in 120-180 days after planting, (Cook et al. 2005). The land of Jharkhand is predominantly upland and medium land suitable for pulse production and horse gram is one of the important important kharif pulse crops in Jharkhand in general and in Giridih district in particular. Due to lack of awareness and knowledge about the recent varieties and improved technologies farmers are still using old varieties and traditional cultivation practices resulting in poor productivity (430 kg/ha) of horse gram. This is far below the average national productivity (750 kg/ha) and state average of 588 kg/ha. It is, therefore, necessary to find out the technology gap in horse gram production and also to know the problems and constraints in adopting modern horse gram production technologies, Islam *et al,* (2011). The Krishi Vigyan Kendra made an effort to reduce the time lag between generations of technology at the research institution and its transfer to the farmers for increasing productivity and income from the agriculture and allied sectors on sustained basis. Krishi Vigyan Kendra is grass root level organisation meant for application of technology through assessment, refinement and demonstration of proven technologies under different micro farming situations in a district. Krishi Vigyan Kendra, Giridih took this opportunity of CFLD programme under NFSM to analyse the constraints and gaps in technology transfer and to overcome it through farmers deep involvement by means of training, gosthi, group discussion and field days. Frequent farmer scientist interaction and scientists visit to farmers field right from sowing to harvesting could generate enthusiasm in famers for successful conduction of demonstration. Considering the above discussed issue a project implementation was under taken by the KVK , Giridih with the main objective of studying the effect of Cluster Frontline Demonstration on Horsegram var. Birsa Kulthi-1 in Giridih District of Jharkhand to boost the production and productivity of pulses through CFLDs with latest and specific technologies.

Materials and Methods

The study was carried out during kharif season from 2017-18 to 2020-21 (4 consecutive years) by KVK, Giridih, Jharkhand. The demonstrations were conducted in farmer's field of 10 different villages of Giridih District in agro climatic zone-IV of Jharkhand. During these five years of study a total numbers of 48,27,31 and 39 beneficiaries were selected in 2017-18, 2018-19, 2019-20 and 2020-21 respectively for the project. Farmers were trained to follow the package and practices for Horse gram cultivation as recommended by the Birsa Agricultural University and need based inputs were provided to the beneficiaries (Table-2). The farmers followed the full package of practices like soil testing seed treatment with bio-fertilizer, fertilizer application, weed management, Integrated pest management (IPM) practices etc shown in Table-1. In case of local check, the traditional practices were followed by using existing varieties. An area of 70 hectare was covered under cluster front line demonstration with active participation of 187 farmers. Before conducting CFLDs, a list of farmer was prepared from group meeting and specific skill training was imparted to the selected farmers.

In general, the soil of the Demonstration plot sites were sandy loams in texture , acidic in reaction (pH 5.0 – 5.4) , low to medium in organic carbon (0.4 – 0.6 %) and low in available nitrogen (186.6 – 210.8 kg N /ha), low in available phosphorus (7.7 – 9.8 kg P2O5 kg /ha) and low in available potassium (86.4 – 110 kg K_2O /ha) shown in Table-1.

In demonstration plots, use of quality seeds of improved varieties (Birsa Kulthi-1), line sowing and timely weeding, need based pesticide as well as balanced fertilizer were emphasized and comparison has been made with the existing practices. Visit of farmers and the extension functionaries was organized at demonstration plots to disseminate the message at large scale. The beneficiaries under the programme were facilitated by KVK Scientists in performing field operations like sowing, spraying, weeding , harvesting etc during the course of training and visits. The traditional practices were maintained in case of local checks. The data were collected from both CFLD plot as well as control plots by random crop cutting method and analysed by using simple statistical tools. The technology gap and technological index (Yadav *et al.*, 2004) along with the benefit cost ratio (Samui *et al.*, 2000) were calculated by using following formula as given below.

$$\text{Technology Gap} = \text{Potential yield} - \text{Demonstration yield}$$

$$\text{Extension Gap} = \text{Demonstration yield} - \text{Farmer's Practice yield}$$

$$\text{Technology Index} = \frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential Yield}} \quad 100$$

$$\text{Additional Return} = \text{Demonstration Return} - \text{Farmer's Practice Return}$$

Percentage increase in yield

$$= \frac{\text{Demonstration yield} - \text{Farmers Practice yield}}{\text{Famer's Practice Yield}} \quad 100$$

Table-1 : Soil nutrient status of the demonstration plot.

Soil test report	Demonstration plot
PH	5.0 – 5.4
Ec (dS m^{-1})	1.10 – 1.19
Available N (Kg ha^{-1})	186.6 – 210.8
Available P_2O_5 (Kg ha^{-1})	7.7 – 9.8
Available K_2O (Kg ha^{-1})	86.4 – 110
Organic Carbon (%)	0.4 – 0.6

Results and Discussion

Cluster Front Line Demonstration (CFLD) conducted during 2017-18 to 2020-21 in different locations of Giridih district indicated that the components of package and practices like improved variety, spacing, balance dose of fertiliser and weed/pest management had significant effect on different yield and economic parameters of Horse gram gram. The data in respect of yield performance of demonstrated plot of Horsegram gram was much higher than the local check/farmer's practices. The average per cent increase in yield comparing to local variety/farmers practice was highest in 2019-20 (58.0%) and lowest in 2017-18 (44.2%). The average demonstrated yield during five years was 8.6 q/ha as compared to farmers yield of 5.7 q/ha. On an average, the yield of demonstrated plot of horse gram was 49.99 % superior to the farmers plot during five years. The difference in yield or yield gap between demonstrated crop and farmers practice plot was clearly due to adoption of improved variety of horse gram (Birsa Kulthi-1) as well as due to improved package of practices including sowing methods, seed rate, seed treatment, balance fertilizer application and proper plant protection measures. The non-uniform yield pattern in different years as shown in the Table 3 may be due to variation in climatic condition over the years. The yield superiority of demonstrated plot is in conformity with Saikia *et al.*,(2018). Similar result was also observed by Dubey *et al.*, (2010) and Hiremath and Nagaraju. (2007).

Technology Gap : The observed technology gap has been presented in Table-3. The data of demonstrated yield and potential yield shows that technology gap during the different years varies from 0.5 q/ha to 1.6 q/ha. On an average the technology gap for the demonstrated horse gram was 0.9 q/ha which may be due to less difference between potential yield and demonstrated yield . Variation in climatic conditions over the different years resulted in variation in yield attributing characters and impacting the yield and economic parameters of demonstrated plot as well as of farmers practice plot. This reflected in variation in technology gap over the years marginally. Similar findings were also recorded by Katare *et al*. (2011) and Sharma and Sharma (2004).

Extension Gap (Q/ha) : The data in respect of extension

Table-2 : Difference between technological intervention and farmer's practices under CFLD on Horsegram.

Particulars	Technological Intervention in CFLD	Farmers Practices	Gap
Variety	Birsa Kulthi-1	Local/own seed	Full gap
Seed rate	20 kg/ha	40 kg/ha	High Seed rate
Sowing method/ spacing	Line sowing , Row to row- 30 cm Plant to plant – 15 cm	Broadcasting uneven plant population	Partial gap
Time of sowing	1-10 September	15-30 September	Partial gap
Seed treatment	Seed treatment was done with 2.0 gm of Carbendazim per kg seed, and with Rhizobium culture + PSB @ 2 packet each for 10 kg seed. 5ml imidachlorprid per kg seed for sucking pests.	No seed treatment	Full gap
Fertilizer	Balanced fertilizer application as per soil test values, 112 kg DAP, 12 kg Urea and 40 kg/ha MOP.	Imbalanced use of fertilizer 50 kg urea as top dressing and 50 kg of DAP as basal dose /ha	Full gap
Weed management	Application of Fluchloralin 1.25 lit. ha-1 as pre – emergence + 1 hand weeding at 30 DAS	Mannual weeding at 35 – 40 DAS	Full gap
Plant Protection	Dichlorovas 1.0 lt/ha spray of insecticide to control pod borer at 75 % flowering and pod filling stage	Injudicious use of insecticides and fungicides based on advice of input dealers	Partial gap with high cost

Table-3 : Grain Yield and Gap analysis of cluster frontline demonstration on Horsegram.

Year	Sample Area (ha)	Sample No. of Farmers	Average Yield (q/ha)			% increase over FP	Technology Gap (q/ha)	Extension gap (q/ha)	Technology Index (%) CFLD
			Potential	CFLD	FP				
2017-18	10.0	35	9-10	8.8	6.1	44.2	0.7	2.7	7.3
2018-19	10.0	27	9-10	8.7	5.9	47.4	0.8	2.8	8.4
2019-20	10.0	30	9-10	7.9	5.0	58.0	1.6	2.9	16.8
2020-21	10.0	30	9-10	9.0	6.0	50.0	0.5	3.0	5.2
Average	40.0 (total)	122 (total)	8.5	8.6	5.7	49.99	0.9	2.8	11.5

Table-4 : Economic analysis of the cluster frontline demonstration on Horsegram.

Year	Total return (Rs. per ha)		Input Cost (Rs. Per ha)		Net Return (Rs. per ha)		Additional return (Rs per ha) CFLD	B : C ratio	
	Recommended Practice (RP)	Farmer's Practice (FP)	Recommended Practice (RP)	Farmer's Practice (FP)	Recommended Practice (RP)	Farmer's Practice (FP)		Recommended Practice (RP)	Farmer's Practice (FP)
2017-18	44000	30500	20952	17940	23048	12560	10488	2.1	1.7
2018-19	43500	29500	19772	16400	23728	13100	10628	2.2	1.8
2019-20	39500	25000	20790	15625	18710	9375	9335	1.9	1.6
2020-21	45000	30000	19565	20000	25435	15435	15435	2.3	1.5
Average	43000	28750	20270	17491	22730	11472	11472	2.12	1.65

Note : Price of Horse gram Rs. 50/kg.

gap during different years as given in Table No.3. During the demonstration period of 2016-17 to 2020-21 the extension gap varied from 2.7 q/ha to 3.0 q/ha between demonstrated and farmers practice plots. The low value of extension gap clearly indicates farmer support and involvement in carrying out these demonstrations. The support and involvement of farmers in demonstration of horse gram was due to training and frequent visit of scientist to farmers field along with field day organised by Krishi Vigyan Kendra The result is in conformity with Bairwa *et al* ., (2013).

Technology Index : The calculated data of technology index is clearly on lower side and varied from 5.2 % to 16.8 % during the demonstration period of five years (2016-17 to 2020-21). It has been depicted in Table 3. This indicates the increased feasibility of the technology on location specific farming situation. Since technology index is influenced by technology gap and potential yield so lower value of technology gap resulted in lower value of index indicating more feasibility of the provided technology on farmers field. Similar results is also found by Dhaka *et al* ., (2015) and Tomar *et al* ., (2003)

Economics of CFLD : Based on local inputs and labour cost, significantly higher additional return of demonstrated plot over farmers practice was achieved which varied from Rs. 9335/ha to Rs. 15435/ha. On an average the total return and net return was Rs. 43000/ha and Rs. 22730/ha respectively, during five years which was much higher than farmers practice of Rs. 28750 and Rs.11472 respectively for the same period. On an average benefit cost ratio for demonstrated plot and farmers practice plot was 2.12 and 1.65 respectively. The gross return of horse gram was calculated on local market rate of horse gram lifted by merchants from farmers field, which varied from Rs. 48/kg to Rs. 52/kg over the different years. Here the quality of horse gram grains under CFLD has been assumed at par with farmers practice produce plots. The result is similar to Meena *et al*., (2012), Prasad *et al*., (2017) , Jha *et al*., (2020) and Prasad and Singh (2021).

Conclusions

The above finding of CFLD on horse gram may be concluded in the way that technology gap can be minimised to a considerable extent by adopting improved variety and scientific package of practices along with proper training of farmers. The productivity and profitability can be enhanced by bringing down extension gap through full involvement of farmers in the demonstration process in form of training, group discussion etc. It may be concluded that cluster demonstration in a scientific way plays a vital role in convincing farmers to adopt the improved technology. The demonstration enhances the knowledge of farmers in regard to improved variety, improved package of practices and timely agricultural operations in the crop. All the indicators like yield of horse gram, technology gap, extension gap and technology index evaluated in this demonstration clearly indicates the enhanced productivity and profitability of horse gram in the district and contributing to great extent in overall pulse production of the district.

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Evaluation of Chrysanthemum (*Dendranthema grandiflora* Tzvelev) Varieties for Vegetative and Floral Attributes

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Abstract

An experiment was conducted to evaluate the ten varieties of chrysanthemum Thai Chen Queen, Winter Queen, Pusa Adtiya, Bidhan Mallika, Pusa Shwet, Pusa Guldasta, Garden Beauty, Pusa Arunodaya, Ravi Kiran and New Tata Century under polyhouse condition at Floriculture and Landscaping Block, College of Horticulture, VCSG, Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand in the month of September to December, 2021. The experiment was laid out in completely block design with three replications. The results revealed that among the different varieties tried, tallest plant (40.60 cm), maximum plant spread (25.82 cm), numbers of branches per plant (17.73), number of leaves per plant (144.40), earliness in 1st flower bud appearance (52.86 days), maximum duration of flowering (24.13 days), stem length (30.60 cm), number of flowers per plant (23.44) and number of flowers per m^2 (211.81) were recorded in Pusa Adtiya. However, the variety New Tata Century recorded maximum flower diameter (9.87 cm) and found statistically at par with Garden Beauty (9.41 cm). The variety Garden Beauty recorded maximum vase life (21.76 days). Thus, from the present study it can be concluded that Pusa Aditya performed well in terms of earliness and flower yield. However, in case of flower quality and vase life Garden Beauty was found good.

Key words : *Asteraceae, chrysanthemum, evaluation, floral attributes and varieties.*

Introduction

Chrysanthemum (*Dendranthema grandiflora* Tzvelev) popularly known as Queen of East, autumn queen, mums and *guldaudi*. It belongs to the family Asteraceae and native to Northern Hemisphere, chiefly Europe and Asia. It is one of the most important commercial flower crops which have huge demands in international and domestic markets. The long stemmed flowers are used for making flower arrangements, bouquets and vase decoration. The loose flowers are used for making garlands and religious purpose. The compact and dwarf plants are suitable for pot and bedding purpose. The different shape, size, colour and extended vase life of flowers make it most preferential as well as profitable crop among growers.

The performance of any crop or variety largely depends on interaction between genotype and prevailing climatic conditions. Munikrishnappa *et al.* (2013) stated that plants have to be exposed to proper climatic conditions in order to get optimum and economic flower yield. For providing favourable climatic conditions to crop, protected cultivation is one of the best options. Pleog and Heuvelink (2006) reported that variations among chrysanthemum varieties were found large in response to environment particularly temperature. The interaction between temperature and cultivar occur for every developmental trait. The polyhouse planting of chrysanthemum recorded significantly better growth and yield 35–40% more to open planting (Gaikwad and Dumbre, 2001). The main advantage of growing the crop under cover or protected conditions is exploitation of genetic potential of the genotypes (Akhtar *et al.,* 2020).Evaluation of varieties for desirable traits is one of the most important steps in crop improvement programme. It helps in identification of variety(s) for specific traits suitable for particular purpose (Kem *et al.,* 2003). In view of the importance and potentiality of the crop, a study on evaluation of chrysanthemum varieties on the basis of vegetative and floral attributes was conducted.

Materials and Methods

The investigation was carried out under polyhouse condition at Floriculture and Landscaping block, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand, India from September to December, 2021. The experimental site was located at the high hills of Himalaya at an altitude of 1900 meters above MSL, 29° 20'-29° 75' N Latitude and 78° 10'-78° 80'E Longitude. A total of 10 varieties of chrysanthemum collected from Model Floriculture Center, GBPUAT, Pantnagar, were used for divergence study. Ten varieties of chrysanthemum *viz.,* Thai Chen Queen, Winter Queen, Pusa Adtiya, Bidhan Mallika, Pusa Shwet, Pusa Guldasta, Garden Beauty, Pusa Arunodaya, Ravi Kiran and New

Tata Century were procured from GBPUAT, Pantnagar used for the study. The uniform size cuttings were planted at a spacing of 30 cm x 30 cm. The experiment was laid out in Completely Randomized Design (CRD) with three replications. Standard cultivation techniques were followed during entire period of investigation. The data on various vegetative and floral attributes were recorded and statistically analyzed (Gomez and Gomez, 1984).

Results and Discussion

Out of ten varieties of chrysanthemum evaluated for their vegetative and floral attributes the data revealed in Table 1 showed significant difference in terms of plant height. The tallest plant (40.60 cm) was recorded in Pusa Adtiya. However, shortest plant (23.16) was observed in Thai Chen Queen and found statistically at par with Pusa Arunodaya (24.52 cm). The variation in plant height might be due to differential characters of individual varieties that expressed their genetic characters. Uddin *et al.* (2015) stated that varietal characters are responsible by a gene. A similar variation in plant height among chrysanthemum varieties was also observed by Singh *et al* (2017), Rao and Kumar (2014) in chrysanthemum. The maximum number of branches per plant and plant spread (17.73 and 25.82 cm, respectively) were recorded in Pusa Adtiya and found statistically at par with Winter Queen (15.33 and 23.56 cm, respectively), Pusa Shwet (16.43 and 24.24 cm, respectively). However, minimum number of branches per plant and plant spread (7.21 and 15.72 cm, respectively) were recorded in Thai Chen Queen and found statistically at par with Pusa Arunodaya (9.70 and 17.31 cm, respectively), Ravi Kiran (9.93 and 19.46 cm, respectively) and New Tata Century (8.53 and 16.95 cm, respectively). The number of branches per plant and plant spread are the hereditary traits and governed by genetic makeup of plants. The results are in close conformity with the findings Prakash *et al.* (2018), Thakur *et al.* (2018) and Negi *et al.* (2020) in chrysanthemum.

The number of leaves per plant was ranged from 36.10 to 144.40, maximum in Pusa Aditya and minimum in Thai Chen Queen. The variation in leaf production could be attributed due to genetic characters of the varieties. Similar findings have been reported by Sathian *et al.* (2015) and Suvija *et al.* (2016) in chrysanthemum. Winter Queen had maximum leaf area per plant (12.46 cm^2) and found statistically at par with New Tata Century (11.90 cm^2). The minimum leaf area per plant (4.50 cm^2) was observed in Garden Beauty and found statistically at par with Pusa Shwet (6.39 cm^2). Variation in leaf area indicates additive gene effects as showed by Nair and Shiva (2003) in gerbera. The variation might be due to the inherent character of varieties under similar environmental condition. The results obtained on this aspect are in agreement with Jamaluddin *et al.* (2015) and Kumar *et al.* (2015) in chrysanthemum.

The earliness in days taken for first flower bud appearance (52.86 days) were recorded in Pusa Aditiya and found statistically at par with Bidhan Mallika (53.40 days). The delay in days taken for first flower bud appearance (72.59 days) were observed in Pusa Guldasta and found statistically at par with Ravi Kiran (71.46 days), Thai Chen Queen (69.58 days) and New Tata Century (68.33 days). Behera *et al.* (2002) stated that variation for late or early flowering seems to be genetically controlled characters in the varieties. The difference in time of blooming time might be due to inherent characters of the individual variety as well as presence of additive genes present in the individual variety. This is in line with the findings of Srilatha *et al.* (2015) and Suvija *et al.* (2016) in chrysanthemum.

Among 10 varieties tried, duration of flowering varies from 13.76 to 24.13 days, minimum in Thai Chen Queen and maximum in Pusa Aditiya. The maximum flower diameter (9.87 cm) was recorded in New Tata Century, whereas, minimum in Bidhan Mallika (4.59 cm). The variations in duration of flowering and flower diameter could be attributed due to the genetic makeup of the varieties and their interaction with prevailing genotype and environment. The result agrees with the findings of Kumar (2014), Rao and Kumar (2014), Srilatha *et al.* (2015) and Suvija *et al.* (2016) in chrysanthemum. The stem length is a genetic factor and therefore, it is expected to vary among the varieties. The maximum stem length (30.60 cm) was recorded in Pusa Adtiya. Whereas, the minimum stem length (13.16 cm) was recorded in Thai Chen Queen. These differences in stem length may be due to the presence of additive genes present in the individual varieties. This could be attributed due to fact that the same variety recorded tallest plant height which leads to maximum stem length. These findings are in corroboration with the works of Vetrivel and Jawaharlal (2014) and Kireeti *et al.* (2017) in chrysanthemum.

The maximum numbers of flowers per plant and per square meter (23.44 and 211.81, respectively) were recorded in Pusa Aditiya. However, minimum number of flowers per plant and per square meter (8.10 and 70.18, respectively) were observed in Thai Chen Queen and found statistically at par with Ravi Kiran (9.09 and 72.90). Maximum number of flowers per plant in Pusa Aditiya could be attributed due to favourable environment condition under protected conditions which resulted vigorous vegetative growth i.e. more plant spread and number of leaves which enable the plant for transformation of accumulated stock of photosynthesis to reproductive sinks. This is confirmed by the findings of

Table-1 : Evaluation of chrysanthemum varieties for vegetative and floral attributes under polyhouse condition.

Varieties	Plant height (cm)	No. of branches per plant	Plant spread (cm)	No. of leaves per plant	Leaf area (cm^2)	Days taken to first flower bud appearance	Duration of flowering (days)	Flower diameter (cm)	Stem length (cm)	No. of flowers per plant	Number of flowers per m^2	Vase life (days)
V_1	23.16	7.21	15.72	36.10	9.82	69.58	13.76	8.97	13.16	8.10	70.18	17.75
V_2	32.76	15.33	23.56	138.40	12.46	67.46	18.26	8.76	22.76	16.03	144.48	19.25
V_3	40.60	17.73	25.82	144.40	8.92	52.86	24.13	6.73	30.60	23.44	211.81	17.15
V_4	35.33	13.83	20.69	71.13	7.04	53.40	16.46	4.59	25.33	15.06	135.95	15.00
V_5	31.40	16.43	24.24	140.16	6.39	61.40	22.13	9.07	21.40	18.06	161.89	18.00
V_6	28.09	11.26	20.37	68.80	10.10	72.59	16.26	5.04	18.09	11.23	102.76	15.68
V_7	34.18	14.26	21.13	95.33	4.50	57.73	17.00	9.41	24.18	15.66	135.18	21.76
V_8	24.52	9.70	17.31	56.83	8.22	67.33	14.63	8.60	14.52	8.72	78.63	18.33
V_9	33.84	9.93	19.46	58.86	8.24	71.46	15.26	9.19	23.84	9.09	72.90	20.39
V_{10}	28.35	8.53	16.95	39.86	11.90	68.33	14.06	9.87	18.35	8.32	74.60	19.72
SE (d)	2.28	2.20	1.42	0.60	1.50	2.28	1.42	0.60	2.10	1.44	3.39	1.33
C.D.	4.80	4.62	2.98	1.26	3.15	4.80	2.98	1.26	4.42	3.03	7.12	2.78

V_1 (Thai Chen Queen), V_2 (Winter Queen), V_3 (Pusa Adtiya), V_4 (Bidhan Mallika), V_5 (Pusa Shwet), V_6 (Pusa Guldasta), V_7 (Garden Beauty), V_8 (Pusa Arunodaya), V_9 (Ravi Kiran) and V_{10} (NewTata Century)

Rao and Kumar (2014) and Suvija *et al.* (2016) in chrysanthemum. The vase life was ranged from 15.00 to 21.76 days, maximum in Garden Beauty and minimum in Bidhan Mallika. The variations in vase life may be due to the different accumulation of carbohydrates due to varied leaf production and sensitivity of cultivars to ethylene and also might be due to genetical makeup of genotypes as reported by Jamaluddin *et al.* (2015) in chrysanthemum and Deka and Talukdar (2015) in gerbera.

Conclusions

Thus, from the present study, it can be concluded that Pusa Aditya performed well in terms of plant height, plant spread, earliness in flowering, duration of flowering and flower yield. For the quality attributes like flower diameter and vase life, varieties Garden Beauty, Winter Queen and New Tata Century were found better.

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Effect of Sowing Times and Nitrogen Levels on Growth and Yield of Proso Millet (*Panicum miliaceum* L.) under Southern Agro-Climatic Conditions

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Abstract

A study was undertaken on sandy loam soils of dryland farm at S.V. Agricultural College, Tirupati campus of Acharya N.G. Ranga Agricultural University during *kharif*, 2019. The experiment was laid out in split-plot design with three replications having four times of sowing [II FN of June (S_1), I FN of July (S_2), II FN of July (S_3), and I FN of August (S_4)] as main plots and four nitrogen levels [0 kg N ha^{-1} (N_1), 20 kg N ha^{-1} (N_2), 40 kg N ha^{-1} (N_3) and 60 kg N ha^{-1} (N_4)] as sub plots. Among the sowing times tried, II FN of June (S_1) sown crop resulted in the higher growth parameters (plant height, leaf area index, dry matter production and numbers of tillers m^{-2}), grain yield and straw yield. While their lowest were with the crop sown during I FN of August (S_4). Application of 60 kg N ha^{-1} (N_4) increased the growth parameters, grain yield and straw yield. Reduced growth parameters, grain and strawyieldswere observed with no nitrogen application (N_1).

Key words : *Growth parameters, nitrogen levels, proso millet, times of sowing and yield.*

Introduction

The term "millet" is used for several small seeded annual grasses that are of minor importance in the western world but a staple food in the diets of African and Asiatic people. Millets can be cultivated in the wide range of soils and climates and are of special importance in semiarid regions because of their short growing seasons (Schery, 1963).

Panicum miliaceum, also known as proso millet, cheena, common millet, hog millet, broom corn, yellow hog, Hershey or white millet, is planted in some African countries as a food crop. Proso millet planted after wheat in a wheat-proso-fallow rotation is an excellent way to control or atleast reduce infestation of annual weeds (Nelson and Daigger, 1975). In India, proso millet is grown mostly in Southern India although it is cultivated in scattered localities in Central and hilly tract of North India. It is a short duration crop sometimes used as contingency or insurance crop against a crop failure, due to unfavourable weather conditions or natural calamities. It also possesses special characters for adoption under adverse conditions such as drought, high temperature, low soil fertility and infestation of disease and pests.Time of sowing is considered as one of the most important non-monetary inputs which plays a key role in increasing yield especially in Southern Agro-climatic region. Nitrogen is a major plant nutrient which helps in higher biomass accumulation and yield of the crop. Very little research has been conducted with millets, especially proso millet, compared with other cereal grains in terms of optimum time of sowing and nitrogen dose.In this article, the growth and yield of proso millet due to varied sowing time and nitrogen levels are discussed.

Materials and Methods

A field experiment was carried out during *kharif*, 2019, at S.V. Agricultural College Farm, Tirupati campus of Acharya N.G. Ranga Agricultural University. Theexperimental soil was sandy loam in texture, neutral in soil reaction (7.3), low in organic content (0.46%) and available nitrogen (197.20 kg ha^{-1}), medium in available phosphorus (38.10 kg ha^{-1}) and available potassium (274.40 kg ha^{-1}). The experiment was laid out in a split-plot design with sixteen treatment combinations and replicated thrice. The treatments include four sowing times allotted to main plots *viz.,* II FN of June (S_1), I FN of July (S_2), II FN of July (S_3) and I FN of August (S_4) and four nitrogen levels allotted to sub plots *viz.,* 0 kg N ha^{-1}(N_1), 20 kg N ha^{-1} (N_2), 40 kg N ha^{-1} (N_3) and 60 kg N ha^{-1} (N_4). The test variety of proso millet used was DHPM-2769 and the spacing adopted was 25 cm $\times$10 cm. Nitrogen was applied through urea as per the subplot treatments where 50 per cent was applied as basal and the remaining half was top dressed at 20 DAS. Phosphorus was applied @ 20 kg ha^{-1} common to all the plots as basal.

Five plants were selected at random from net plot area and labeled with tags for recording growth parameters *viz.,* plant height, leaf area index, dry matter production and numbers of tillers m^{-2} at 20 DAS, 40 DAS, 60 DAS and at harvest. The grain and straw obtained from the net plot area including the sampled plants were thoroughly sun dried, weighed and expressed in kg ha^{-1}. The data obtained was statistically analysed by following the analysis of variation for split-plot design with factorial concept as suggested by Panse and Sukhatme (1985).

Table-1 : Growth parameters of proso millet as influenced by times of sowing and nitrogen levels.

Treatments	Plant height (cm)	Leaf area index	Dry matter production (kg ha^{-1})	Number of tillers m^{-2}
Times of Sowing (S)				
S_1 - II FN of June	92.0	1.05	4577	248
S_2 - I FN of July	86.0	0.97	4203	226
S_3 - II FN of July	77.0	0.90	3757	210
S_4 - I FN of August	66.0	0.83	3222	159
SEm±	1.21	0.014	73.4	3.6
CD (P=0.05)	4.1	0.05	259	13
Nitrogen levels (N)				
N_1 - Control	68.0	0.77	2923	183
N_2 - 20 kg ha^{-1}	76.0	0.93	3744	199
N_3 - 40 kg ha^{-1}	86.0	1.00	4255	218
N_4 - 60 kg ha^{-1}	91.0	1.06	4840	243
SEm±	1.02	0.017	99.9	3.7
CD (P=0.05)	3.0	0.05	293	11
Times of sowing (S) x Nitrogen levels (N)				
N at S				
SEm±	2.42	0.027	146.8	7.2
CD (P=0.05)	NS	NS	NS	NS
S at N				
SEm±	2.17	0.032	187.9	7.4
CD (P=0.05)	NS	NS	NS	NS

Table-2 : Grain and straw yield of proso millet as influenced by times of sowing and nitrogen levels.

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha-1)
Times of Sowing (S)		
S_1 - II FN of June	1239	2909
S_2 - I FN of July	1145	2688
S_3 - II FN of July	1052	2428
S_4 - I FN of August	745	2131
SEm±	25.4	52.6
CD (P=0.05)	90	185
Nitrogen levels (N)		
N_1 - Control	796	2058
N_2 - 20 kg ha^{-1}	954	2448
N_3 - 40 kg ha^{-1}	1127	2672
N_4 - 60 kg ha^{-1}	1304	2977
SEm±	36.3	71.9
CD (P=0.05)	107	211
Times of sowing (S) × Nitrogen levels (N)		
N at S		
SEm±	50.9	105.2
CD (P=0.05)	NS	NS
S at N		
SEm±	67.9	135.3
CD (P=0.05)	NS	NS

Statistical significance was tested by F test at five per cent level of probability. Critical difference for the significant source of variation was calculated at five percent level of significance. Treatmental differences that were not significant were denoted by NS. Growth parameters recorded at 20 DAS, 40 DAS, 60 DAS and at harvest, grain and straw yields obtained were presented.

Results and Discussion

Growth parameters : Sowing time and nitrogen levels exerted significant influence on growth parameters of proso millet while their interaction was found to be non significant (Table-1). Plant height, leaf area index, dry matter production and numbers of tillers m^{-2} increased significantly when the crop was sown during II FN of June (S_1) than that of I FN of July (S_2). Significantly lesser growth parameters were with the crop sown during I FN of August (S_4) compared to the crop sown during II FN of July (S_3). The favourable weather conditions existed during the growth period of early sown crop might have increased the photosynthetic rate which resulted in taller plants, higher leaf area index and increased dry matter production. The increased moisture available with the crop sown during II FN of June (S_1) might have increased the tiller buds which resulted in higher numbers of tillers m^{-2}. Similar findings were observed with Deshmukh *et al.* (2013). Application of 60 kg N ha^{-1} (N_4) revealed significantly higher plant height, leaf area index, dry matter production and numbers of tillers m^{-2} compared to that with 40 kg N ha^{-1} (N_3) while their lowest were obtained with 0 kg N ha^{-1} (N_1). The increased auxin levels with higher dosage of nitrogen might have enhanced cell multiplication and cell elongation which increased plant height, leaf area index and thus dry matter production. Higher numbers of tillers m^{-2} with 60 kg N ha^{-1} (N_4) might be due to increased cytokinin synthesis, which promoted the growth and development of tiller buds at each node of the shoot.The results were closely related with the findings of Singh and Maurya (2013) and Arshewar *et al*. (2018).

Grain and straw yield : Times of sowing and nitrogen levels significantly influenced the grain and straw yield. However their interaction effect was not statistically traceable (Table 2). The higher grain and straw yield was realized with II FN of June (S_1) sown crop which was significantly higher than that of I FN of July (S_2). Whereas the crop sown during I FN of August (S_4) resulted in lower yield. Increased grain and straw yield with early sown crop might be due to favourable weather conditions experienced by the crop with prolonged photoperiod due to which efficient translocation of assimilates was observed thereby increasing the yield. These results were inline with the findings of Mubeena *et al*. (2019) and Nandini and Sridhara (2019). Crop that received 60 kg N ha^{-1} (N_4) resulted in significantly higher grain and straw yield than with other lower nitrogen levels tried. Lowest grain and straw yield were recorded with control (N_1). Higher rate of nitrogen metabolism with 60 kg N ha^{-1} (N_4) might have resulted in production of more carbon accumulationand thus increasing grain and straw yield. Similar results were obtained by Jyothi *et al.* (2016) and Arshewar *et al*. (2018).

Conclusions

From the present experiment it can be inferred that proso millet sown during II FN of June (S_1) resulted in significantly higher growth parameters, grain yield and straw yield. With respect to nitrogen levels, crop supplied with 60 kg N ha^{-1} (N_4) resulted in superior growth parameters, grain yield and straw yield. Hence, it is concluded that the optimum time of sowing for proso millet is II fortnight of June with 60 kg N ha^{-1}.

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Evaluation of Plant Extracts against Chrysanthemum Aphid, *Macrosiphoneilla sanborni* (Gillette) in Field Conditions

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Abstract

A study was conducted to evaluate the insecticidal bioefficacy of plant extracts against Chrysanthemum aphid, *Macrosiphoneilla sanborni* (Gillette) in open field conditions at College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal. The experiment consists of eleven treatments i.e. Control, Neem leaf extract @4%, Artemisia leaf @5%, Onion bulb @5%, Ginger rhizome extract 4%, Turmeric rhizome @4%, Papaya leaf @5%, Marigold leaf @5%, Nettle grass @5%, Garlic bulb @4%, Chilli fruit @5%. The spray of plant extracts was done for two times at 20 days intervals when incidence of chrysanthemum aphid population was above ETL. The experiment was laid out in Randomized Complete Block Design with three replications. After 1st and 2nd spray the highest per cent reduction in aphid population (53.98% and 42.99%) and maximum yield (53.60 q/ha) over pretreatment was recorded in Neem leaf extract @4%. The results of this study revealed that among all the extracts tried neem leaf extract was found to be the most promising as it gave the highest per cent reduction in aphid population whereas lowest per cent reduction was seen in the Nettle grass @5%. Floral farmers as well as the floral industry will be benefited with our research as they may replace the chemical pesticides with botanicals.

***Key words** : Bioefficacy, chrysanthemum, population, reduction, toxicity.*

Introduction

Chrysanthemum (*Dendranthema grandiflora* Borkh) gets its name from the Greek words Chryos – golden, anthos – flower and belongs to the family Asteraceae. Chrysanthemums were cultivated in China as early as 15th century BC. The plants were used as herbs and the roots and leaves were eaten. The plant migrated to Japan several centuries later and thrived in the temperate climates of Asia (Brahma, 2002). Presently 2000 varieties are grown around the world and in India about 1000 varieties are grown (Datta and Bhattacharjee, 2001). Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Rajasthan, Madhya Pradesh and Gujarat are the major states of India where large area is under chrysanthemum.

In India, it has been recognized as one among the five commercially important flower crops. Chrysanthemums are grown for cut flowers, loose flowers, as potted plants and as border plants in the garden (Zhang *et al.,* 2020). In North India various hues of red, yellow, white and purple colored chrysanthemums are grown in abundance for decorating the landscape either in the ground or in pots. But in South India mostly the yellow colored flowers are preferred and grown as loose flowers for trade. Profitable production of chrysanthemum is constrained by several factors, the most important being damage caused by insect pests such as aphids, caterpillars, mites, whiteflies, thrips and leaf miner (Janakiram *et al.,* 2006).

The chrysanthemum aphid, *Macrosiphoniella sanborni* (Gillette) is a widespread pest on cultivated chrysanthemum throughout the world. It is an anholocyclic species with East Asian origin (Blackman and Eastop 2006). *Macrosiphoniella sanborni* is a vector of chrysanthemum viruses, vein mottle and virus B. More than 15 species are known to colonize cultivated and wild chrysanthemum (Miller and Stoetzel, 2001). The aphid causes significant damage which results in deformation and disturbance of flower development (Heie, 1995). All of these factors together cause significant economic damage to chrysanthemum by decreasing their beauty and the value of cut flowers. Infestation of *M. sanborni* on chrysanthemums result in loss of vigour, yellowing, premature leaf fall and stunted growth (Pal and Sarkar, 2009). In heavy infestations, the honeydew deposits secreted by the aphids favour the development of sooty moulds, and the aphids can transmit viral diseases. Field evaluation with formulated neem extracts revealed the effect to be more of growth regulatory nature thereby showing that azadirachtin is a physiological toxin for aphid species. Neem seed extracts

Table-1 : Details of plant extacts used.

T. No.	Treatments	Plant Part Used	Concentration (%)
T_1	Control	-	-
T_2	*Azadirachta indica* (Neem)	Leaf extract	4
T_3	*Artemisia vulgaris*	Leaf extract	5
T_4	*Allium cepa* (Onion)	Bulb extract	5
T_5	*Zinziber officinalis* (Ginger)	Rhizome extract	4
T_6	*Curcuma longa* (Turmeric)	Rhizome extract	4
T_7	*Carica papaya* (Papaya)	Leaf extract	5
T_8	*Tagetes minuta* (Wild Marigold)	Leaf extract	5
T_9	*Urtica dioica* (Nettle sting grass)	Leaf extract	5
T_{10}	*Allium sativum* (Garlic)	Bulb extract	4
T_{11}	*Capsicum annuum* (Chilli fruit)	Fruit extract	5

Table-2 : Efficacy of different plant extracts against population of aphid *Macrosiphoniella sanborni* after 1st spray.

Treatments	Concentration (%)	No. of aphids/10 cm twig at indicated period							
		Before spray	1 DAS	3 DAS	5 DAS	7 DAS	Pooled mean	Per cent reduction over control	
T_1	Control		31.13	31.28	31.53	32.54	33.51	32.21	-
T_2	Neem leaf	4	28.76	23.03*	13.76*	11.86*	10.66*	14.82	53.98
T_3	Artemisia leaf	5	23.83*	21.73*	18.93*	13.40*	13.46*	16.88	47.59
T_4	Onion bulb	5	28.33	24.70*	22.00*	14.53*	13.40*	18.65	42.09
T_5	Ginger rhizome	4	22.90*	22.46*	19.63*	15.06*	12.33*	17.37	46.07
T_6	Turmeric rhizome	4	26.90	23.66*	19.73*	14.20*	11.20*	17.19	46.63
T_7	Papaya leaf	5	25.76*	24.33*	22.03*	16.20*	11.26*	18.45	42.71
T_8	Marigold leaf	5	23.73*	22.93*	22.66*	14.86*	12.93*	18.34	43.06
T_9	Nettle grass	5	27.80	26.16*	24.26*	16.26*	13.26*	19.98	37.96
T_{10}	Garlic bulb	4	23.30*	20.16*	17.90*	14.46*	12.40*	16.23	49.61
T_{11}	Chilli fruit	5	26.23*	25.20*	24.96*	15.26*	13.20*	19.65	38.99
	SE(d)		1.806	1.925	1.948	2.259	1.855		
	C.D. (0.05)		3.793	4.045	4.092	5.315	3.896		

*Significant at 5% level of significance as compared with control, DAS = Days After Spray

reduced the population of aphid on respective host plants significantly, EC50 values being 0.88 and 0.96 for *Macrosiphoneilla rosae* (L.) and *M. sanborni* respectively (Opender, 1999).

Only female chrysanthemum aphids are known. They reproduce parthenogenetically by giving birth to more females. When the winged female stage infests new plants, it usually starts feeding and producing live nymphs. Each female can produce 4-8 young aphids per day. Within about a week the new nymphs mature into wingless females which begin to bear youngones of their own. One aphid on a plant in a short time may build the population up to hundreds of individuals. As the plant becomes crowded, more and more of the offspring develop into winged females which in turn migrate to other plants to begin new infestations (Valizadeh *et al.,* 2013). Botanicals have many advantages in comparison to synthetic insecticides. For example they have low mammalian toxicity effects, human health and environmental friendly, also they are easily available and affordable (Sharma and Signhivi, 2017). Synthetic chemicals may cause risk to human health and also leads to acute or chronic poisoning, also chronic diseases like cancer, respiratory problems and fertility problems (Mustafa *et al.,* 2017).

Materials and Methods

An area of 9.4×3.2m^2 was ploughed thoroughly with the power tiller followed by two cross tilling and it was leveled with the help of a leveler. After the field was ploughed it was divided into 33 plots (each plot 90cm × 90cm) having proper irrigation channels, path and space so that the different replications and plots could be marked.

Collection of different plants was done from the nearby places. Extract was prepared by crushing the leaves, bulbs, rhizomes and fruits separately. The crushed material was separated through muslin cloth and was filtered by filter paper. Five plants out of nine were selected randomly and the spray application was given on the appearance of the pest as well as natural enemy and

Table-3 : Efficacy of different plant extracts against population of aphid Macrosiphoniella sanborni after 2nd spray.

Treatments	Concentration (%)	No. of aphids/10 cm twig at indicated period							
		Before spray	1 DAS	3 DAS	5 DAS	7 DAS	Pooled mean	Per cent reduction over control	
T_1	Control	-	30.43	30.56	30.66	31.71	31.64	31.14	-
T_2	Neem leaf	4	27.03*	22.30*	21.10*	14.65*	12.98*	17.75	42.99
T_3	Artemisia leaf	5	26.83*	22.83*	21.60*	18.91*	16.97*	21.42	31.21
T_4	Onion bulb	5	21.80*	26.70*	24.40*	22.43*	18.55*	23.02	26.07
T_5	Ginger rhizome	4	22.70*	23.33*	22.60*	20.43*	17.50*	20.96	32.69
T_6	Turmeric rhizome	4	26.73*	23.00*	22.16*	19.22*	17.30*	20.42	34.42
T_7	Papaya leaf	5	23.03*	26.10*	23.93*	21.32*	18.31*	22.41	28.03
T_8	Marigold leaf	5	29.80	25.10*	23.33*	20.04*	17.69*	21.54	30.82
T_9	Nettle sting grass	5	25.80*	29.33	26.33*	23.00*	19.10*	24.44	21.51
T_{10}	Garlic bulb	4	22.80*	22.66*	21.13*	18.83*	14.74*	19.34	37.89
T_{11}	Chilli fruit	5	23.70*	26.90	26.00*	22.78*	19.07*	23.68	23.95
	SE(d)		1.496	1.757	1.382	1.423	1.554		
	C.D. (0.05)		3.142	3.691	2.903	2.989	3.264		

*Significant at 5% level of significance as compared with control, DAS = Days After Spray

Table-4 : Effect of different plant extracts on the yield of Chrysanthemum flower.

	Treatments	Yield (g/plot)	Yield (Q/ha)	Avoidable Yield losses	
				Q/ha	Per cent
T_1	Control	269.57	33.28	-	-
T_2	Neem leaf	434.18	53.60	20.32	37.91
T_3	Artemisia leaf	316.05	39.01	5.76	14.76
T_4	Onion bulb	362.60	44.76	11.48	25.64
T_5	Ginger rhizome	425.33	52.51	19.23	36.62
T_6	Turmeric rhizome	406.18	50.14	16.86	33.62
T_7	Papaya leaf	292.12	36.06	2.78	7.7
T_8	Marigold leaf	340.83	42.07	8.79	20.89
T_9	Nettle sting grass	281.85	34.79	1.51	4.34
T_{10}	Garlic bulb	321.68	39.74	6.46	16.25
T_{11}	Chilli fruit	312.88	38.62	5.34	13.82
	SE(d)	5.15	0.63		
	C.D. (0.05)	10.83	1.33		

subsequently 2 sprays were given at 20 days interval using manually operated garden hand sprayer with duromist nozzle. Extracts of respective plant materials were made by grinding the sufficient quantity of leaves, bulbs, rhizomes and fruits using grinder. Aphid population was recorded on 10 cm long terminal twig from randomly selected 5 plants before and 1, 3, 5 and 7 days after first and second spray applications.

The per cent reduction of pest over control was calculated by using the following formula (Abbott, 1925).

$$\text{Per cent reduction} = \frac{C - T}{C} \quad 100$$

Where,

T = Treatment

C = Control

Avoidable loss (%) was calculated by applying formula :

$$\text{Avoidable loss (\%)} = \frac{\text{Yield in Treatment} - \text{Yield in Control}}{\text{Yield in Treatment}} \quad 100$$

Yield : The weight of entire flowers harvested from each plot were recorded for each treatment. The yield per plot was worked out and expressed as gram (g), kilogram (kg) and quintal/ha.

$$\text{Yield (q/ha)} = \frac{\text{YieldPlot}}{\text{Plot size}} \quad \frac{10{,}000}{100}$$

Results and Discussion

Effect of different plant extracts *viz.,* Neem leaf @4%, Artemisia leaf @5%, Onion bulb @5%, Ginger rhizome @4%, Papaya leaf @5%, Turmeric rhizome @4%, Marigold leaf @5%, Nettle grass @5%, Garlic bulb @4% and Chilli fruit @5% were evaluated against aphid *Macrosiphoneilla sanborni*. The results were evaluated one day before and 1, 3, 5 and 7 days after first and

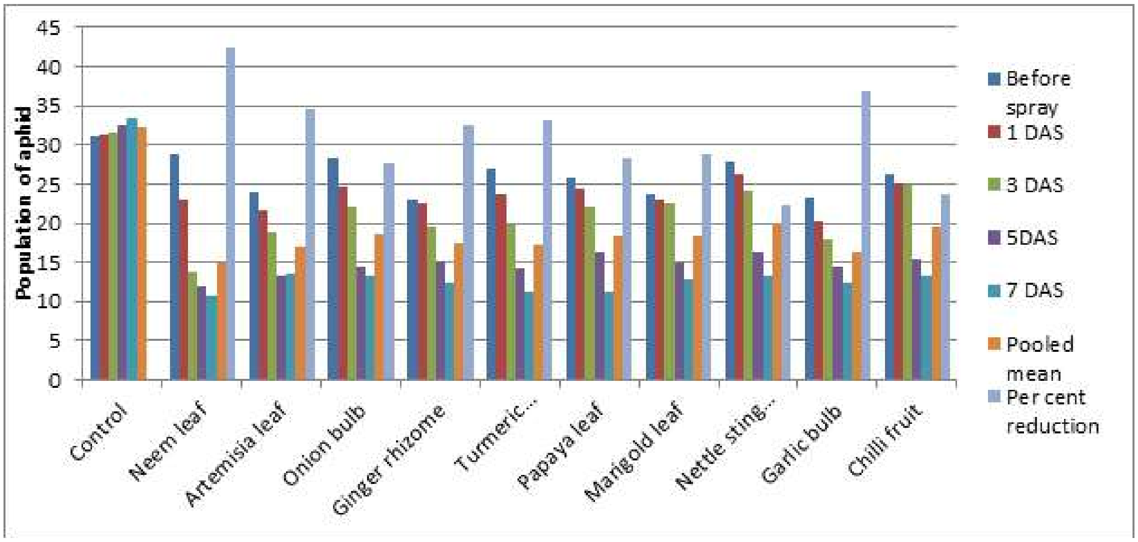

Fig-1 : Graphical representation of plant extracts efficacy against aphid.

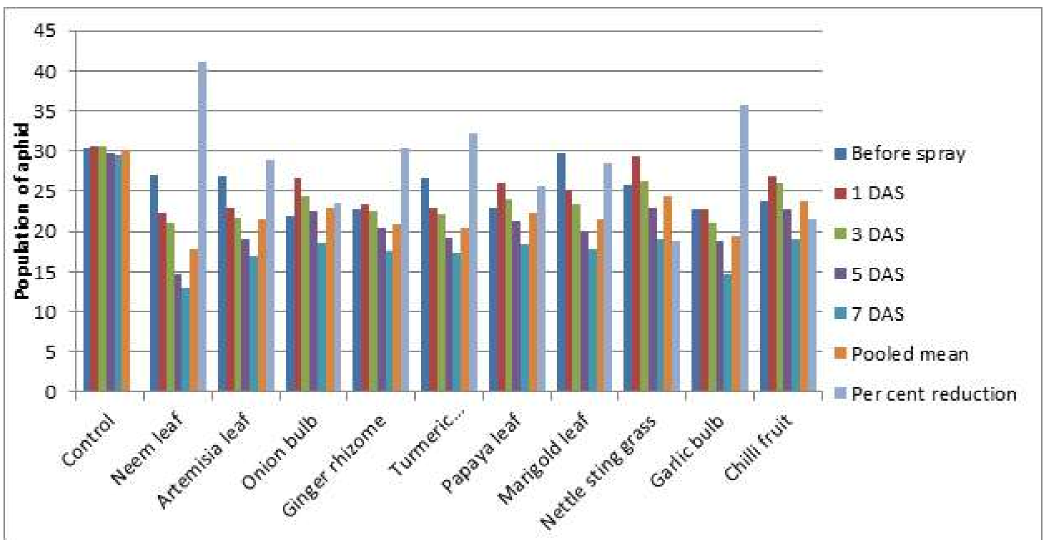

Fig-.2 : Graphical representation of plant extracts efficacy against aphid after second spray.

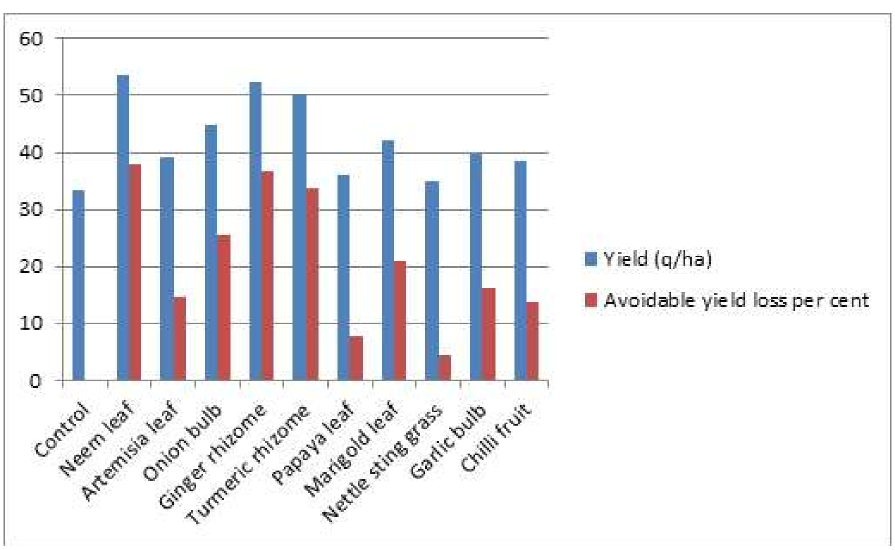

Fig.-3 : Effect of different plant extracts on the yield of Chrysanthemum flower.

second sprays as shown in Table 2. The data showed that among all the plant extracts tried most promising plant extract was found Neem leaf extract followed by Garlic bulb extract with the pooled mean of 14.82 and 16.23 aphids/twig population, respectively. Similar observations was recorded by Bahar *et al.* (2007) who applied botanicals against bean aphid. They concluded that the Neem and Garlic extract gave up to 50.90% and 37.53% reduction in aphid population. The next best treatment was found to be Artemisia and Turmeric with 16.88 and 17.20 aphids/twig, the result was found in close conformity with the research done by Mehta and Sharma (2009) who observed that the 5% concentration of Artemisia extract gave significantly minimum reduction in aphid weight after *Azadirachtin*.

The per cent reduction of aphid in Neem and Garlic extract was recorded as 53.98%, 42.99% and 49.61%, 37.89% respectively, after both the sprays (Table-2 and 3). The same is represented graphically for easy reference (Figs.-1 and 2) showing the efficacy of all the treatments against the pest. Among the different botanicals sprayed, the overall maximum mean aphid population was found in the plot treated with Nettle sting grass extract @5% followed by Chilli fruit extract @5% showed the per cent reduction of 37.96%, 21.51% and 38.99%, 23.95% after both the sprays as shown in the Table 2 and 3 but they were found to be superior over untreated control against aphid. Although, there are few researches on the insecticidal activity of Nettle grass, Bozsik (1996) in one of his experiment found a very little effect of nettle extract on *Hyalopterus pruni* (Mealy plum aphid) and found that the number of aphids kept increasing from 89.5 to 193.7 in just a week.

The yield of chrysanthemum flower under different treatments varied from 33.28 to 53.60 q/ha. The maximum yield (53.60 q/ha) was recorded from the plot treated with Neem leaf extract @4% and followed by Ginger extract and Turmeric extract (52.51 and 50.14 q/ha, respectively) as shown in the Table 4. These findings are in conformity with the research done by Gupta (2005) and Amin and Defray (2013) who reported that the Neem leaf extract was very effective against aphid population. In our study, the minimum yield was found in Nettle grass extract (34.79 q/ha) followed by Papaya leaf extract (36.064 q/ha). The maximum avoidable loss percentage was found in the treatment $T_{2,}$ Neem leaf extract (37.91%), T_5 Ginger rhizome extract (36.62%) and T_6 Turmeric extract (33.62%) while minimum avoidable loss percentage was found in Papaya leaf extract (7.7%) and Nettle grass leaf extract (4.34%). Therefore, the highest yield loss could be avoided by the application of Neem leaf extract 4% followed by Ginger rhizome extract 4% and Turmeric rhizome extract 4%. Kora and Teshome (2016) confirmed that the minimum (0) aphids were recorded from the plot they treated with Ginger extract.

On the other hand, Papaya leaf extract @5% and Nettle grass extract @5% proved to be least effective against the pest *M. sanborni*, as they recorded the lowest yield. These results are in line with the findings of Choudhary *et al.* (2017) proved that the Neem based insecticides, Nimbecidine @ 5ml/l was most effective against stem borer with avoidable loss percentage of 23.81%. Thus from the present investigation it can be concluded that among all the plant extracts, Neem leaf extract 4% and Garlic bulb extract 4% were found to be highly effective against *M. sanborni*.

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Integration of Seed Treatment and Botanicals for the Management of Thrips, *Thrips tabaci* Lindeman Infesting Cumin

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Abstract

Cumin (*Cuminum cyminum* L.) is important spices crop commonly known as *Jeera* and belongs to Apiaceae family. There are so many sucking insect pests attacking the cumin crop. Among them, thrips was a major pest of this crop in Saurashtra region as the farmers of Saurashtra regions are facing the infestation of thrips since two years. This emerging pest is attacking after 20 to 30 days of sowing of the crop and damaging the crop by sucking the cell sap continuously which leads to drying up of the leaves, branches and stem. To combat thrips, several chemical pesticides have been used as a spray application. However, problems like residues in seeds and environmental contamination are the result of injudicious use of chemical pesticides that leads to pesticide resistance, poisoning and hazards to non-target organisms etc. To overcome the insecticidal resistance problem and as this pest is attacking more within first month of sowing, seed treatment along with botanical insecticides are one of the important considerations to manage the pests in a non-chemical way. In order to study the different seed treatments along with foliar application of botanicals, the results revealed that, among the different seed treatments, thiamethoxam 30 FS have reduced thrips population to a greater extent which was followed by clothianidin 50 WDG and imidacloprid 30.5 SC. Whereas, among foliar application of botanicals, NSKE 0.25% was found better than rest of the treatments *i.e.*, azadirachtin 10000 ppm and tobacco decoction 0.25%. Moreover, the highest seed yield harvested in the plots treated with thiamethoxam 0.10% + NSKE 0.25% followed by imidacloprid 0.122% + NSKE 0.25%.

Introduction

India is the leading producer of spices in the world and popularly known as the Land of Spices. Major seed spices to be grown in India are coriander, cumin, fenugreek, fennel, dill etc. Cumin (*Cuminum cyminum* L.) is commonly known as *Jeera* that belongs to Apiaceae family. It is believed to be indigenous to northern Egypt, eastern Mediterranean region, Iran and India **(3)**. Cumin is well known for their digestive properties and for flavoring bread and other dishes during the period of ceremonial fasting. There are a large number of insects associated with the cumin. Among them, aphids and thrips are the major threat to the crop as the cause enormous damage to the crops. Since two years, the farmers of Saurashtra regions are facing the infestation of thrips and causes the considerable damage to the crop. This emerging pest is attacking after 20 to 30 days of sowing of the crop. The pest suck the cell sap continuously from the cumin plant which leads to drying up of the compound leaves followed by branches and stem and thus it hinders the vegetative growth and development of the crop.

Several chemical pesticides have been used as a spray application for combating thrips. As the pupal stage of this pest is inside the soil, a soil application of newer insecticides is to be intensified. However, problems like residues in seeds and environmental contamination are the result of injudicious use of chemical pesticides. Among the several avenues to overcome the insecticidal resistance problem and as this pest is attacking more within first month of sowing, to check the effect of seed treatment along with replacement with new molecules of insecticides is one of the important considerations. Botanical insecticides are one of the alternatives to conventional pesticides in agricultural pest management. Botanical pesticides are the naturally occurring secondary metabolites (phytochemicals) and extracted from the plant sources which can control /kill the pests and thus helping in the agricultural pest management. So, use of botanicals is considered as one of the important consideration to manage the pest population in non-chemical way.

Material and Methods

Details of experiment : In order to study the efficacy of different botanicals *viz.*, NSKE 5 per cent @ 0.25%, azadirachtin 1 EC @10000 ppm, tobacco decoction 5% @ 0.25 per cent were used. The experiment was laid out in a Split Plot Design during *Rabi*, 2019 at Department of Plant Pathology, Junagadh Agricultural University, Junagadh. Cumin variety GC-4 was broadcasted in November, 2019. All agronomical practices were adopted as per the recommendation in the vogue. Details of the experiment are given in Table-1.

Table-1 : Details of botanicals used as seed treatment and foliar applications for their efficacy against cumin thrips, *T. tabaci.*

Sr. No.	Technical name	Concentration (%)	Dose	Trade name	Manufacture name
1	2	3	4	5	6
S : Seed Treatment (g or ml /kg seed)					
–S_1	Imidacloprid 30.5 SC	0.122%	4 ml	Imida Gold +	United Phosphorus Ltd.
S_2	Clothianidin 50 WDG	0.25%	4 g	Dantotsu	Sumitomo Chemical India Pvt. Ltd.
S_3	Thiamethoxam 30 FS	0.12%	4 ml	Actara	Syngenta India Ltd.
B : Foliar Spray (g or ml /10 lit. water)					
B_1	NSKE 5%	0.25%	500 ml	-	-
B_2	Azadirachtin 1 EC	10000 ppm	20 ml	-	-
B_3	Tobacco decoction 5%	0.25%	500 ml	-	-

Table-2 : Effect of seed treatments along with foliar application of botanicals against thrips after first spray.

Treatments	3 DAS	5 DAS	7 DAS	10 DAS
1	2	3	4	5
Seed treatments (S)				
S_1 Imidacloprid 30.5 SC @ 0.122%	11.91 (141.84) [14.71]	9.56 (91.39) [19.14]	11.38 (129.50) [11.93]	13.90 (193.21) [10.03]
S_2 Clothianidin 50 WDG @ 0.25%	12.18 (148.35) [10.82]	9.85 (97.02) [14.23]	11.50 (132.25) [10.05]	14.33 (205.34) [4.44]
S_3 Thiamethoxam 30 FS @ 0.12%	11.56 (133.63) [19.72]	8.84 (78.41) [30.95]	10.48 (109.83) [25.28]	13.62 (185.50) [13.63]
S.Em.±	0.21	0.11	0.19	0.19
C.D. @ 5%	0.57	0.30	0.52	0.54
Botanicals (B)				
B_1 NSKE 5% @ 0.25%	12.35 (152.52) [6.53]	7.95 (63.20) [44.09]	10.16 (103.22) [29.83]	12.85 (165.12) [23.11]
B_2 Azadirachtin 1 EC @ 10000 ppm	12.64 (159.76) [4.00]	10.25 (104.04) [8.02]	11.41 (130.18) [11.57]	14.39 (207.07) [3.64]
B_3 Tobacco decoction 5% @ 0.25%	10.54 (111.09) [33.20]	10.10 (102.01) [9.84]	11.80 (139.24) [5.29]	14.61 (213.45) [0.68]
S.Em.±	0.19	0.14	0.19	0.16
C.D. @ 5%	0.41	0.30	0.33	0.35
S X B	NS	NS	NS	NS
C.V. %	10.02	9.36	8.77	7.36
Control				
Control (No Spray)	12.89 (166.37)	10.63 (113.09)	12.13 (147.12)	14.66 (214.80)

Notes :
1. NS : Non-significant
2. Figures in parentheses ( ) are retransformed values; those outside are $\sqrt{x}$ transformed value those in [ ] are per cent reduction over control values.

Application of botanicals : The seed treatment of three different insecticide s *viz.,* imidacloprid 30.5 SC @ 0.122%, clothianidin 50 WDG @ 0.25% and thiamethoxam 30 FS @ 0.12% were applied few hours before sowing. Sowing of treated seeds will be done in split plot design. According to the treatments, spraying of the three different botanicals *viz.,* NSKE 5 per cent @ 0.25%, azadirachtin 1 EC @ 10000 ppm, tobacco decoction 5% @ 0.25 per cent were applied with the help of knapsack sprayer. As the population of thrips was heavy after 45 days of germination, the spray was carried out to check the population. To combat the pest, second spray was carried out at 15 days after the first spray. Thereafter the pest population was in controlled condition.

Method of recording thrips, *T. tabaci* population on cumin : The observations on thrips were recorded visually from five randomly selected and tagged plants (by tapering the plant on white paper). Observations on thrips population were recorded at 3, 5, 7 and 10 days after each spray.

Yield : With a view to evaluate the effect of different botanicals on the cumin yield, crop was harvested from each net plot. The harvested yield was weighted and converted on hectare basis.

Results and Discussion

Bio-efficacy of different botanicals against cumin thrips, *T. tabaci* : To determine the efficacy of different

Table-3 : Effect of seed treatments along with foliar application of botanicals against thrips after second spray.

Treatments		3 DAS	7 DAS	7 DAS	10 DAS
1		2	3	4	5
Seed treatments (S)					
S_1	Imidacloprid 30.5 SC @ 0.122%	13.88 (192.65) [13.73]	10.43 (108.78) [26.78]	10.95 (119.90) [14.62]	13.25 (175.56) [11.21]
S_2	Clothianidin 50 WDG @ 0.25%	13.45 (180.90) [18.97]	10.90 (118.81) [20.00]	10.99 (120.78) [14.03]	13.64 (186.04) [5.94]
S_3	Thiamethoxam 30 FS @ 0.12%	13.44 (180.63) [3.77]	10.10 (102.01) [31.29]	11.03 (121.66) [13.36]	12.87 (165.63) [16.20]
S.Em.±		0.13	0.17	0.18	0.21
C.D. @ 5%		NS	NS	NS	NS
Botanicals (B)					
B_1	NSKE 5% @ 0.25%	14.66 (214.91) [43.00]	9.20 (84.64) [43.00]	9.69 (93.89) [33.05]	12.12 (146.89) [25.75]
B_2	Azadirachtin 1 EC @ 10000 ppm	14.85 (220.52) [15.91]	11.18 (124.99) [15.91]	11.66 (135.95) [3.23]	13.71 (187.96) [4.97]
B_3	Tobacco decoction 5% @ 0.25%	11.26 (126.78) [17.78]	11.05 (122.10) [17.78]	11.61 (134.79) [3.96]	13.94 (194.32) [1.78]
S.Em.±		0.25	0.25	0.16	0.17
C.D. @ 5%		0.45	0.43	0.36	0.37
S X B		NS	NS	NS	NS
C.V. %		9.58	11.94	9.54	8.11
Control					
Control (No spray)		14.95 (222.36)	12.19 (148.52)	11.85 (140.38)	14.06 (197.76)

Notes :
1. NS : Non-significant
2. Figures in parentheses ( ) are retransformed values; those outside are $\sqrt{x}$ transformed value those in [ ] are per cent reduction over control values.

Table-4 : Effect of seed treatments along with foliar application of botanicals against thrips (pooled over sprays).

Treatments		3 DAS	5 DAS	7 DAS	10 DAS
1		2	3	4	5
Seed treatments (S)					
S_1	Imidacloprid 30.5 SC @ 0.122%	12.89 (25.15) [87.02]	9.99 (99.90) [23.26]	11.16 (124.66) [13.28]	13.57 (184.31) [13.88]
S_2	Clothianidin 50 WDG @ 0.25%	12.81 (23.16) [88.04]	10.37 (107.58) [17.36]	11.24 (126.435) [12.05]	13.98 (195.51) [8.65]
S_3	Thiamethoxam 30 FS @ 0.12%	12.49 (20.24) [89.55]	9.46 (89.66) [31.12]	10.75 (115.70) [19.51]	13.24 (175.48) [18.01]
S.Em.±		0.09	0.21	0.122	0.17
C.D. @ 5%		NS	NS	NS	NS
Botanicals (B)					
B_1	NSKE 5% @ 0.25%	13.56 (184.01) [5.03]	8.57 (73.54) [43.50]	9.92 (98.55) [31.44]	12.48 (155.85) [27.18]
B_2	Azadirachtin 1 EC @ 10000 ppm	13.74 (188.78) [2.57]	10.68 (114.20) [12.27]	11.53 (132.85) [7.58]	14.04 (197.33) [7.80]
B_3	Tobacco decoction 5% @ 0.25%	10.90 (118.84) [90.27]	10.57 (111.80) [14.11]	11.70 (137.07) [4.65]	14.27(203.74) [4.80]
S.Em.±		0.13	0.122	0.122	0.16
C.D. @ 5%		0.29	0.26	0.28	0.35
S X B		NS	NS	NS	NS
C.V. %		6.90	7.89	7.41	7.72
Control					
Control (No spray)		13.92 (193.76)	11.41 (130.18)	11.99 (143.76)	14.63 (214.03)

Notes :
1. NS : Non-significant
2. Figures in parentheses ( ) are retransformed values; those outside are $\sqrt{x}$ transformed value those in [ ] are per cent reduction over control values.

Table-5 : Effectiveness of various botanicals on cumin seed yield due to thrips.

Treatments	Seed yield (kg /ha)
1	2
S_1B_1	2109
S_1B_2	1607
S_1B_3	1175
S_2B_1	2024
S_2B_2	1085
S_2B_3	1474
S_3B_1	2279
S_3B_2	1426
S_3B_3	1915
Control (No Spray)	950
Mean	1604.4
ANOVA	
S. Em. +	238.43
C. D. @ 5%	715
C. V.%	24.60

Notes :
1. Treatment mean with letter(s) in common are not significant at 5% level of significance within a column
2. Seed treatments: Imidacloprid 0.122% (S_1), Clothianidin 0.25% (S_2) & Thiamethoxam 0.12% (S_3)
3. Foliar application: NSKE 0.25% (B_1), Azadirachtin 10000 ppm (B_2) & Tobacco decoction 0.25% (B_3)

seed treatments and botanicals against cumin thrips, three seed treatments *viz.,* S_1: imidacloprid @ 0.122%, S_2: clothianidin @ 0.25% and S_3: thiamethoxam @ 0.12% and three botanical aerial spraying *viz.*, B_1: NSKE 0.25%, B_2: azadirachtin @10000 ppm & B_3: tobacco decoction 0.25 %, was tested. The combination of seed treatments and foliar application *viz.,* S_1B_1, S_1B_2, S_1B_3, S_2B_1, S_2B_2, S_2B_3, S_3B_1, S_3B_2 & S_3B_3 were made in such manner that overall effect can be worked out. During the experiment, seed treatments were given prior to the sowing of the crop while foliar applications were given twice with respective botanicals. The first spray was made when pest reached considerable thrips population and second was carried out at 15 days after first spray. The results on thrips population are presented here under.

Effect of different botanicals against thrips, *T. tabaci* during first spray : In cumin, thrips population reached to considerable level after 6^{th} week of sowing. The periodical data showing effect of seed treatments and botanical spray on infestation to cumin due to thrips on three, five, seven and ten days after spray (DAS). The bio-efficacy of various botanicals has been adjudged based on individual as well as pooled over period data.

Seed treatments : The data on mean thrips count after first application of insecticides presented in Table-2 revealed that, on third, fifth, seventh and tenth DAS results were found non-significant, which means the effectiveness of the seed treatments were same as they are at par with each other. To know its effectiveness, a considerable amount of reduction of thrips population over control was worked out. In the interaction of seed treatment and foliar application of botanicals, per cent reduction over control data showed some sort of reduction at different days after spray *i.e.,* three, five, seventh and tenth. Among the different seed treatments, thiamethoxam 30 FS have reduced thrips population to the extent of 19.72, 30.95, 25.28 and 13.63 per cent at three, five, seventh and tenth days after first spray, respectively. While, imidacloprid 30.5 SC (14.71, 19.14, 11.93 and 10.03 per cent, respectively) and clothianidin 50 WDG (10.82, 14.23, 10.05 and 4.44 per cent, respectively) have reduced considerable thrips population at three, five, seventh and tenth days after first spray, respectively. In a nutshell, any of the tested seed treatments, which were given at time of sowing, can be applied for the management of thrips infesting cumin.

Botanical spray : The data on mean thrips population after first application of botanicals presented in Table-2 revealed that among sprayed botanicals, tobacco decoction 0.25% (111.09 mean thrips/plant) was found most effective as lowest thrips population was observed. The next best treatments were NSKE 0.25% (152.52) and azadirachtin 10000 ppm (159.76) which was on par with each other at 3 DAS. On fifth day after spraying NSKE 0.25% (63.20) was found to the best botanical treatment with lowest thrips population. The next effective treatments were tobacco decoction 0.25% (102.01) and azadirachtin 10000 ppm (104.04) which was on par with each other. NSKE 0.25% (103.22) was found significantly superior to other treatments as it recorded lowest thrips population. The next best treatment was azadirachtin 10000 ppm (130.18) followed by tobacco decoction 0.25% (139.24) on seven days after spraying. Similar pattern was observed on the tenth day after spraying *i.e.,* NSKE 0.25% (165.12) was considered as effective botanical treatment followed by azadirachtin 10000 ppm (207.07) and tobacco decoction 0.25% (213.45).

Effect of different botanicals against thrips, *T. tabaci* during second spray : After fifteen days of first spray, the second spray was carried out. The periodical data showing effect of seed treatments and botanical spray on infestation to cumin due to thrips on three, five, seven and ten days after spray (DAS). The bio-efficacy of various insecticides has been adjudged based on period data.

Seed treatments : The data on mean thrips count after second application of insecticides presented in Table-3 revealed that, on third, fifth, seventh and tenth DAS results were found non-significant, which means the effectiveness of the seed treatments were same as they are at par with each other. To know its effectiveness, a considerable amount of reduction of thrips population over control was worked out. In the interaction of seed treatment and foliar application of botanicals, per cent reduction over control data showed some sort of reduction at different days after spray *i.e.,* three, five, seventh and tenth. Among the different seed treatments, thiamethoxam 30 FS have reduced thrips population to the extent of 3.77, 31.29, 13.36 and 16.20 per cent at three, five, seventh and tenth days after second spray, respectively. While, imidacloprid 30.5 SC (13.73, 26.78, 14.62 and 11.21 per cent, respectively) and clothianidin 50 WDG (18.97, 20.00, 14.03 and 5.94 per cent, respectively) have reduced considerable thrips population at three, five, seventh and tenth days after second spray, respectively. In a nutshell, any of the tested seed treatments, which were given at time of sowing, can be applied for the management of thrips infesting cumin.

Botanical spray : The data on mean thrips population after second application of botanicals presented in Table-3 revealed that among sprayed botanicals, tobacco decoction 0.25% (126.78 mean thrips /plant) was found most effective as lowest thrips population was observed. The next best treatments were NSKE 0.25% (214.91) and azadirachtin 10000 ppm (220.52) which was on par with each other at 3 DAS. After fifth days of spraying, NSKE 0.25% (84.64) was found to be effective botanical treatment as it was significantly superior to the other treatments. The next best treatment was tobacco decoction 0.25% (122.10) and azadirachtin 10000 ppm (124.99) and which was on par with each other. On seven days after spraying, NSKE 0.25% (93.89 mean thrips /plant) was the best treatment when compared to other botanical treatments. While, tobacco decoction 0.25% (134.79) and azadirachtin 10000 ppm (135.95) was found to be at par with each other. Among all sprayed botanicals, NSKE 0.25% (146.89) recorded lowest thrips population and was considered effective as compared to other treatments followed by azadirachtin 10000 ppm (187.96) and tobacco decoction 0.25% (194.32) on tenth day after spray.

Effect of different botanicals against thrips, *T. tabaci* (pooled over sprays) : The data on mean thrips count after seed treatments and two applications of botanicals pooled over spray presented in Table-4. The periodical data showing effect of seed treatments and botanical spray on infestation to cumin due to thrips on three, five, seven and ten days after spray (DAS). The bio-efficacy of various botanicals has been adjudged based on pooled over spray.

Seed treatments : The data on mean thrips count of pooled over spray presented in table 4 revealed that, on third, fifth, seventh and tenth DAS results were found non-significant, which means the effectiveness of the seed treatments were same as they are at par with each other. To know its effectiveness, a considerable amount of reduction of thrips population over control was worked out. In the interaction of seed treatment and foliar application of botanicals, per cent reduction over control data showed some sort of reduction at different days after spray *i.e.,* three, five, seventh and tenth. Among the different seed treatments, thiamethoxam 30 FS have reduced thrips population to the extent of 89.55, 31.12, 19.51 and 18.01 per cent at three, five, seventh and tenth days after pooled over sprays, respectively. While, imidacloprid 30.5 SC (87.02, 23.26, 13.28 and 13.88 per cent, respectively) and clothianidin 50 WDG (88.04, 17.36, 12.05 and 8.65 per cent, respectively) have reduced considerable thrips population at three, five, seventh and tenth days after pooled over sprays, respectively. In a nutshell, any of the tested seed treatments, which were given at time of sowing, can be applied for the management of thrips infesting cumin.

Botanical spray : The data on mean thrips population after pooled over spray application of botanicals presented in table-4 revealed that among sprayed botanicals, tobacco decoction 0.25% (118.84 mean thrips/plant) was found most effective treatment for the control of thrips. The next best treatments were NSKE 0.25% (184.01) and azadirachtin 10000 ppm (188.78) which was on par with each other at 3 DAS. On 5 DAS, NSKE 0.25% (73.54 mean thrips /plant) was found to the best with lowest thrips population followed by tobacco decoction 0.25% (111.80) and azadirachtin 10000 ppm (114.20) and which was on par with each other. On seventh day after spraying, NSKE 0.25% (98.55) was found significantly superior to other treatments as it recorded lowest thrips population followed by azadirachtin 10000 ppm (132.85) and tobacco decoction 0.25% (137.07). Similar pattern was observed on the tenth day after spraying *i.e.,* NSKE 0.25% (155.85) was considered as effective botanical treatment followed by azadirachtin 10000 ppm (197.33) and tobacco decoction 0.25% (213.45). In nutshell, *T. tabaci* can be effectively managed by seed treatments of thiamethoxam as percentage reduction over control was higher. Whereas, among the foliar spray, NSKE 0.25% and azadirachtin 10000 ppm exhibited satisfactory protection against thrips throughout the infestation.

The obtained results are in close conformity with the earlier workers as azadirachtin 0.15% EC @ 15 ml/lit at 7 days interval proved effective against garlic thrips (4). Similarly, all neem-based bio-pesticides are most promising treatment against thrips in onion (1). In onion, azadirachtin 0.03% and NSKE are found to be effective for the control of thrips in fennel. (2).

Impact of different botanicals on cumin seed yield

Yield : The data on seed yield harvested from the different treatments are summarized in table-5 revealed that all botanicals formulations recorded significantly higher seed yield than control. The highest (2279 kg /ha) seed yield harvested in the plots treated with S_3B_1 (thiamethoxam 0.10% **+** NSKE 0.25%) but it was at par with S_1B_1 (imidacloprid 0.12% **+** NSKE 0.25%) (2109 kg /ha), S_2B_1 (clothianidin 0.20% **+** NSKE 0.25%) (2024 kg /ha) and S_3B_3 (thiamethoxam 0.10% **+** tobacco decoction 0.25%) (1915 kg /ha). Further, S_1B_2 (imidacloprid 0.12% **+** azadirachtin 10000 ppm) (1607 kg /ha) was found at par with S_2B_3 (clothianidin 0.20% **+** tobacco decoction 0.25%) (1474 kg /ha) and S_3B_2 (thiamethoxam 0.10% **+** azadirachtin 10000 ppm (1426 kg /ha). The next treatment was S_1B_3 (imidacloprid 0.12% **+** tobacco decoction 0.25%) (1175.58) which was at par with S_2B_2 (clothianidin 0.20% + azadirachtin 10000 ppm). Whereas, S_2B_2 comparatively yielded lower (1085 kg /ha).

Conclusions

In the trial on bio-efficacy of different botanicals against thrips infesting cumin, the results were found non-significant on third, fifth, seventh and tenth days after spray (DAS), which means the effectiveness of the seed treatments were same as they are at par with each other. Among the different seed treatments, thiamethoxam 30 FS have reduced thrips population to a greater extent which is followed by imidacloprid 30.5 SC and clothianidin 50 WDG. In a nutshell, any of the tested seed treatments, which were given at time of sowing, can be applied for the management of thrips infesting cumin. While, among the different botanicals, based on both the sprays, *Thrips tabaci* can be effectively managed by foliar sprays of NSKE 0.25% followed by azadirachtin 10000 ppm and tobacco decoction 0.25%. The highest (2279 kg /ha) seed yield harvested in the plots treated with S_3B_1 (thiamethoxam 0.10% **+** NSKE 0.25%) but it was at par with S_1B_1 (imidacloprid 0.12% **+** NSKE 0.25%) (2109 kg /ha), S_2B_1 (clothianidin 0.20% **+** NSKE 0.25%) (2024 kg /ha) and S_3B_3 (thiamethoxam 0.10% **+** tobacco decoction 0.25%) (1915 kg /ha). Whereas, S_2B_2 (clothianidin 0.20% + azadirachtin 10000 ppm) was found comparatively lower yielder among different botanical treatments (1085 kg /ha).

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Eco-Friendly Management Strategy for Shoot Fly and Stem Borer Infesting Pearl Millet Crop

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Abstract

A field experiment was conducted for the management of shoot fly and stem borer in pearl millet during *kharif* 2017-18 to 2021-22at Pearl Millet Research station, Junagadh Agriculture University, Jamnagar. Results showed that the seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + spray of imidacloprid 17.8 SL 0.009% at 35 DAG or seed treatment of imidacloprid 600 FS @ 8.75 ml/kg followed by two sprays at 20 and 40 DAG either *B. bassiana* @ 1 × 10^8cfu/g or Panchgavya 3 % for the effective and economical management of shoot fly and stem borer. The highest net return (Rs. 21841/-) and ICBR (1:11.11) was recorded in seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + spray of imidacloprid 17.8 SL 0.009% at 35 DAG,followed by seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + two spray of Panchgavya 3% at 20 and 40 DAG(Rs. 19586/-) with ICBR (1:8.36) and seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + two spray of *B. bassiana* 1 × 10^8 cfu/g @ 0.007% at 20 and 40 DAG (Rs. 19335/-) with ICBR (1:10.39).

Key words : *Shoot fly, stem borer, panchagvaya, B. bassiana, pearl millet.*

Introduction

Pearl millet is the most widely grown staple food of majority of poor and small land holders in Asia and Africa. It is also consumed as feed and fodder for livestock. It occupies an area of 6.93 million ha with an average production of 8.61 million tonnes and productivity of 1243 kg/ha [1]. The major pearl millet growing states are Rajasthan, Maharashtra, Uttar Pradesh, Gujarat and Haryana contributing 90% of total national production. It is critically important for food and nutritional security as it possess several advantages such as early maturing, drought tolerance, require minimal purchase inputs and mostly free from biotic and abiotic stresses. Due to the excellent nutritional properties and resilience to climate change, pearl millet along with other millets is renamed as nutricereals for production, consumption, trade and was included in Public Distribution System. To bring millets into mainstream for exploiting the nutritional rich properties and promoting their cultivation, Govt. of India has declared Year 2018 as the "Year of Millets" and the Year 2023 was declared as "International Year of Millets" by FAO Committee on Agriculture forum.

Twenty six insects and two non-insect pests were found feeding on pearl millet [2]. Out of these, shoot fly, *Atherigona approximate* Malloch, stem borer, *Chilopartellus* Swinhoe and ear head worm, *Helicoverpaarmigera* are comparatively more serious pests attacking the crop. Shoot fly causes 23.3 to 36.5 % grain losses and 37.5 % fodder losses. Stem borer causes between 20-60 % losses [8]. Use of insecticides is not the right choice to control these pests due to its cryptic behavior of feeding inside the stem. Chemical insecticides are the most effective control measure against insect pests on pearl millet. However, some insecticides are expensive, toxic and when used extensively, may be harmful to human health and the environment. Thus, there is a need to design alternate pest management options that have limited adverse effects on the environment and are effective against target insect pests. One such option is the use of seed treatment or soil application of insecticides, which is an easy, economic and feasible method to manage insect pests during early stage of the crop growth without causing any harmful effect on natural enemies. Objective of the study was to determine the effectiveness of the seed dressing chemicals and soil application of insecticides with foliar application of bio pesticides to reduce load of the chemical pesticides pearl millet agro ecosystem. Hence the present research work for the management of these pests was under taken.

Materials and Methods

The experiment was conducted in Randomized Block Design with eleven treatments including control in three replications at Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar during *Kharif* 2018 to 2021. The pearl millet variety GHB-558 was sown at 60 × 10 cm spacing for this purpose. The gross plot size was 5.0 × 3.6 m and net plot size was 4.0 × 2.4 m. Seed treatment and furrow applications were given initially at the time of sowing. While, foliar application was given at 20 and 40 days after germination. For shoot fly, observations were recorded from randomly selected 20 plants of net plot plants by counting the dead hearts at vegetative stage. Thus, shoot fly dead heart percent incidence was worked out. For stem borer, plant showing parallel holes due to stem borer larvae in the leaves was considered as damaged plant and percent damaged plant was calculated. At ear head stage, number of ear heads showing shoot fly (deformed ear head) and stem borer (empty/white ear head) damage were recorded separately and thus percent ear head damage was worked out from ear heads of 20 plants of net plot. Grain and fodder yield was recorded from net plot area at harvest and data thus, obtained was analyzed statistically [5].

No.	Treatments
T_1	Seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + Two spray of B. bassiana1 × 108cfu/g @ 0.007% at 20 and 40 DAG
T_2	Seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + Two spray of Panchgavya3% at 20 and 40 DAG
T_3	Seed treatment of imidacloprid 600 FS @ 8.75 ml/kg + Two spray of azadirachtin 0.15% w/w @ 0.000375% at 20 and 40 DAG
T_4	Furrow application of carbofuran 3G @ 33kg/ha + Two spray of B. bassiana 1 × 108cfu/g @ 0.007% at 20 and 40 DAG
T_5	Furrow application of carbofuran 3G @ 33kg/ha + Two spray of Panchgavya 3% at 20 and 40 DAG
T_6	Furrow application of carbofuran 3G @ 33kg/ha + Two spray of azadirachtin 0.15% w/w @ 0.000375% at 20 and 40 DAG
T_7	Furrow application of cartap hydrochloride 4G @ 25kg/ha + Two spray of *B. bassiana* 1 × 108cfu/g @ 0.007% at 20 and 40 DAG
T_8	Furrow application of cartap hydrochloride 4G @ 25kg/ha + Two spray of Panchgavya3% at 20 and 40 DAG
T_9	Furrow application of cartap hydrochloride 4G @ 25kg/ha + Two spray of azadirachtin 0.15% w/w @ 0.000375% at 20 and 40 DAG
T_{10}	Seed treatment with imidacloprid 600 FS @ 8.75 ml/kg followed by spray of imidacloprid 17.8 SL 0.009% at 35 DAG
T_{11}	Control

Results and Discussion

Shoot fly incidence : Data presented in Table-1 indicated that differences of per cent incidence of shoot fly at vegetative stage were found significant during the year 2018, 2020, 2021 and pooled. During 2018, least shoot fly incidence was recorded in T_{10} (0.69%) and it was at par with T_2 (0.94%). During 2020, again least shoot fly incidence was recorded in T_{10} (3.75%) and it was at par with T_2 (4.17%), T_1 (5.42%), T_3 (5.83%), T_5 (5.83%) and T_4 (6.67%).During 2021, least shoot fly incidence was recorded in T_1 (2.77%) and it was at par with T_{10} (4.03), T_3 (4.03%) and T_2 (4.52%). Considering the pooled data, least incidence (2.82%) was recorded in T_{10} (Seed treatment with imidacloprid 600 FS @ 8.75 ml/kg followed by spray of imidacloprid 17.8 SL 0.009% at 35 DAG). However, it was statistically at par with T_2 (3.21%) and T_1 (3.53%). Whereas, it was 8.71% in control.

Data showed that differences in shoot fly infestation at ear head stage were found significant in all the years as well as in pooled. Moreover, during 2018, least shoot fly incidence was recorded in T_{10} (0.95%). However, it was at par with T_2 (1.07%), T_1 (2.51%), T_8 (2.72%) and T_6 (2.88%). During 2020, again least shoot fly incidence was recorded in T_{10} (3.67%) and it was at par with T_2 (6.00%), T_1 (6.33%) and T_4 (6.33%).During 2021, least shoot fly incidence was recorded in T_1 (1.91%). However, it was at par with T_2 (3.32%), T_{10} (3.55%) and T_3 (3.98%). So far as pooled data is concerned, least incidence (2.72%) was recorded in T_{10} (Seed treatment with imidacloprid 600 FS @ 8.75 ml/kg followed by spray of imidacloprid 17.8 SL 0.009% at 35 DAG) and it was statistically at par with T_2 (3.46%) and T_1 (3.58%). Whereas, it was 8.27 % in control.

Stem borer incidence : Data presented in Table-2 indicated that differences in stem borer incidence during 2018, 2020, 2021 and in pooled were found significant at vegetative stage. During 2018, least stem borer incidence (1.29%) was recorded in T_{10} (Seed treatment with imidacloprid 600 FS @ 8.75 ml/kg followed by spray of imidacloprid 17.8 SL 0.009% at 35 DAG). However, it was at par with T_2 (1.39%), T_5 (2.72%), T_1 (3.04%) and T_6 (3.28%). During 2020, least stem borer incidence was recorded in T_{10} (3.33%). However, it was statistically at par with T_2 (4.58%), T_1 (5.42%), T_3 (5.83%) and T_5 (6.67%). During 2021, least stem borer incidence was recorded in T_1 (1.62%). However, it was at par with T_2 (2.39%) and T_{10} (3.01%). In case of pooled data, least stem borer incidence (2.55%) was recorded in T_{10} (Seed treatment with imidacloprid 600 FS @ 8.75 ml/kg followed by spray of imidacloprid 17.8 SL 0.009% at 35 DAG) and it was at par with T_2 (2.79%) & T_1 (3.36%).

Data indicated that difference of stem borer incidence at ear head stage was found significant in all the years as well as in pooled analysis. Least stem borer incidence was recorded in T_{10} during 2018 (0.47%). However, it was statistically at par with T_1 (0.59%), T_3 (1.07%), T_2 (1.31%) and T_4 (1.79%). During 2020, T_{10} (Seed treatment with imidacloprid 600 FS @ 8.75 ml/kg followed by spray of imidacloprid 17.8 SL 0.009% at 35 DAG) recorded least stem borer incidence (3.33%). However, it was statistically at par with T_2 (5.00%), T_1 (5.67%) & T_4 (6.00%).During 2021, least least stem borer incidence was observed in T_2 (3.22%) and it was statistically at par with T_{10} (3.32%), T_3 (3.49%), T_1 (3.55%), T_7 (5.97%) and T_4 (6.07%). In case of pooled of three years, T_{10} recorded least stem borer incidence

Table-1 : Statement showing year wise and pooled shoot fly per cent incidence in pearl millet (2018, 2020 and 2021).

No.	Percent shoot fly incidence at vegetative stage				Percent shoot fly incidence at ear head stage			
	2018	2020	2021	Pooled	2018	2020	2021	Pooled
T-1	8.91^{*abc} (2.40)	13.16^{*abc} (5.42)	9.58^{*d} (2.77)	12.33^{*cd} (3.53)	9.11^{*abc} (2.51)	14.44^{*bc} (6.33)	7.95^{*d} (1.91)	12.52^{*c} (3.58)
T-2	5.56^{bc} (0.94)	11.16^{bc} (4.17)	12.27^{bcd} (4.52)	10.90^{d} (3.21)	5.93^{bc} (1.07)	14.05^{bc} (6.00)	10.50^{cd} (3.32)	11.47^{c} (3.46)
T-3	11.00^{a} (3.64)	13.85^{abc} (5.83)	11.58^{cd} (4.03)	14.59^{b} (4.50)	10.87^{ab} (3.55)	15.24^{abc} (7.00)	11.51^{bcd} (3.98)	14.95^{b} (4.85)
T-4	11.23^{a} (3.79)	14.95^{ab} (6.67)	14.43^{bc} (6.21)	16.03^{b} (5.56)	10.63^{abc} (3.40)	14.44^{bc} (6.33)	14.05^{abc} (5.89)	15.40^{b} (5.21)
T-5	9.40^{abc} (2.67)	13.76^{abc} (5.83)	13.96^{bc} (5.82)	14.46^{bc} (4.77)	10.40^{abc} (3.26)	15.60^{abc} (7.33)	15.24^{ab} (6.91)	16.06^{b} (5.83)
T-6	9.14^{abc} (2.53)	15.86^{a} (7.50)	15.39^{ab} (7.04)	15.50^{b} (5.69)	9.76^{abc} (2.88)	15.81^{ab} (7.67)	13.16^{bc} (5.19)	15.08^{b} (5.24)
T-7	9.25^{abc} (2.58)	16.19^{a} (7.92)	14.43^{bc} (6.21)	15.34^{b} (5.57)	10.83^{ab} (3.53)	15.24^{abc} (7.00)	14.30^{abc} (6.10)	15.86^{b} (5.54)
T-8	9.67^{ab} (2.82)	15.86^{a} (7.50)	14.43^{bc} (6.21)	15.47^{b} (7.50)	9.49^{abc} (2.72)	16.41^{ab} (8.00)	14.90^{abc} (6.61)	15.71^{b} (5.78)
T-9	10.23^{a} (3.15)	16.74^{a} (8.33)	13.91^{bc} (5.78)	15.90^{b} (5.76)	10.38^{abc} (3.25)	16.75^{ab} (8.33)	14.85^{abc} (6.57)	16.30^{b} (6.05)
T-10	4.77^{c} (0.69)	11.58^{c} (3.75)	11.06^{cd} (4.03)	10.07^{d} (2.82)	5.62^{c} (0.95)	10.76^{c} (3.67)	10.86^{bcd} (3.55)	10.33c (2.72)
T-11	12.84^{a} (4.94)	17.21^{a} (11.67)	18.03^{a} (9.53)	19.74^{a} (8.71)	11.57^{a} (4.02)	19.95^{a} (11.67)	17.80^{a} (9.11)	19.00^{a} (8.27)
T	1.39	1.20	1.09	0.82	1.48	1.42	1.38	0.82
	4.10	3.54	3.21	2.31	4.38	4.18	4.07	2.33
Y	-	-	-	0.427	-	-	-	0.43
	-	-	-	1.20	-	-	-	1.21
YxT	-	-	-	1.41	-	-	-	1.42
	-	-	-	NS	-	-	-	NS
	15.58	10.55	13.86	16.81	16.22	16.01	18.13	16.72

* indicates arcsine transformed values, figures in parenthesis are retransformed values.

(2.37%). However, it was statistically at par with T_2 (3.18%) & T_1 (3.27%). Whereas, it was 8.07% in control.

Seed dressing with imidacloprid 70 WS @ 10g/ 100g seeds was found to be most effective in reducing the damage caused by shoot fly (14.3%) and in enhancing the grain yield in sorghum [2]. The seed treatment with imidacloprid 70 WS @ 10g/kg seeds also recorded lowest shoot fly incidence of 8.4% dead hearts [3]. Further, even with lower dose of imidacloprid 70 WS i.e. 5g/kg seed [4] performed better in reducing shoot fly incidence in sorghum. Seed treatment with imidacloprid 600 FS @ 7 ml/kg seed was found effective in reducing shoot fly incidence [9].Foliar spray of *B. bassiana*WP @ 5 g/l recorded the least incidence of shoot fly (7.2%) and stem borer (5.36%) at earhead stage of pearl millet crop [6].The seed treatment of clothianidin WDG @7.5 g/kg seed followed by spray of *B. bassiana*@ 0.007% recorded lower infestation of shoot fly and stem borer in pearl millet crop [7].

Yield : The pooled data presented in Table-3 showed that T_{10} (Seed treatment with imidacloprid 600 FS @ 8.75 ml/kg followed by spray of imidacloprid 17.8 SL 0.009% at 35 DAG) recorded highest grain yield (3369 kg/ha). However, it was at par with T_2 (3325 kg/ha), T_1 (3250 kg/ha), T_4 (3097 kg/ha), T_3 (3064 kg/ha) and T_8 (3062kg/ha).In case of fodder yield, highest fodder yield was recorded in T_{10} (7259 kg/ha). Economics of the various treatments indicated that highest net return (Rs. 21841/-) and ICBR (1:11.11) was recorded in T_{10} followed by T_2(Rs. 19586/-) with ICBR (1:8.36) and T_1 (Rs. 19335/-with ICBR (1:10.39).

Table-2 : Statement showing year wise and pooled stem borer per cent incidence in pearl millet (2018, 2020 and 2021).

No.	Percent stem bore incidence at vegetative stage				Percent stem borer incidence at ear head stage			
	2018	**2020**	**2021**	**Pooled**	**2018**	**2020**	**2021**	**Pooled**
T-1	10.04*^{abc} (3.04)	13.33*^{bc} (5.42)	7.31*^{c} (1.62)	12.46*^{cd} (3.36)	4.40*^{bc} (0.59)	13.69*^{bc} (5.67)	10.86*^{c} (3.55)	10.63*^{dc} (3.27)
T-2	6.77^{bc} (1.39)	11.60^{bc} (4.58)	8.89^{c} (2.39)	10.59^{d} (2.79)	6.57^{abc} (1.31)	12.49^{bc} (5.00)	10.34^{c} (3.22)	11.26^{dc} (3.18)
T-3	10.63^{abc} (3.40)	13.59^{bc} (5.83)	11.06^{bcde} (3.68)	14.12^{bc} (4.31)	5.93^{bc} (1.07)	15.24^{ab} (7.00)	10.76^{c} (3.49)	11.96^{cd} (3.85)
T-4	11.05^{abc} (3.68)	15.86^{ab} (7.50)	14.35^{ab} (6.14)	16.21^{b} (5.77)	7.68^{abc} (1.79)	14.05^{abc} (6.00)	14.26^{bc} (6.07)	13.70^{bc} (4.62)
T-5	9.49^{abc} (2.72)	14.76^{bc} (6.67)	13.85^{abcd} (5.73)	14.80^{bc} (5.04)	8.35^{ab} (2.11)	15.60^{ab} (7.33)	14.58^{bc} (6.34)	14.70^{b} (5.26)
T-6	10.43^{abc} (3.28)	16.14^{ab} (7.92)	15.28^{a} (6.94)	16.27^{b} (6.05)	8.18^{abc} (2.02)	16.27^{ab} (8.00)	15.47ab (7.11)	15.12^{b} (5.71)
T-7	11.23^{ab} (3.79)	15.60^{bc} (7.50)	14.76^{ab} (6.49)	16.36^{b} (5.93)	8.45^{ab} (2.16)	15.24^{ab} (7.00)	14.15^{bc} (5.97)	14.18^{bc} (5.05)
T-8	11.00^{abc} (3.64)	15.28^{bc} (7.08)	14.43^{ab} (6.21)	16.01^{b} (5.64)	7.90^{abc} (1.89)	16.02^{ab} (7.67)	14.51^{bc} (6.28)	14.87^{b} (5.28)
T-9	10.85^{abc} (3.54)	16.19ab (7.92)	13.85^{abc} (5.73)	16.04^{b} (5.73)	8.21^{abc} (2.04)	15.66^{ab} (7.33)	14.39^{bc} (6.18)	14.58^{b} (5.18)
T-10	6.52^{c} (1.29)	10.00^{c} (3.33)	10.00^{c} (3.01)	10.29^{d} (2.55)	3.92^{c} (0.47)	10.34^{c} (3.33)	10.50^{c} (3.32)	9.12^{c} (2.37)
T-11	13.16^{a} (5.19)	21.23^{a} (13.33)	16.74^{a} (8.17)	19.97^{a} (8.90)	10.46^{a} (3.30)	18.42^{a} (10.00)	19.29^{a} (10.91)	18.38^{a} (8.07)
T	1.33	1.70	1.24	0.83	1.28	1.38	1.34	0.77
	3.93	5.02	3.66	2.35	3.77	4.08	3.97	2.18
Y	-	-	-	0.4341	-	-	-	0.4031
	-	-	-	1.2277	-	-	-	1.1400
YxT	-	-	-	1.4396	-	-	-	1.3368
	-	-	-	NS	-	-	-	NS
	13.72	19.82	16.84	16.81	18.26	16.18	17.18	17.15

* indicates arcsine transformed values, figures in parenthesis are retransformed values

Conclusions

Looking to the efficacy, yield and economics of the treatments, seed treatment with imidacloprid 600 FS @ 8.75 ml/kg followed by spray of imidacloprid 17.8 SL 0.009% at 35 DAG or seed treatment of imidacloprid 600 FS @ 8.75 ml/kg followed by two sprays at 20 and 40 DAG either *B. bassiana* @ 1 X 10^8cfu/g or Panchgavya 3 % for the effective and economical management of shoot fly and stem borer.

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Table-3 : Economics of various treatments for the management of shoot flt and stem borerinfesting pearl millet.

No.	Yield kg/ha		Yield increase over control (kg/ha)		Additional income over control (Rs./ha)	Total Expenditure (Rs./ha)	Net return (Rs./ha)	ICBR
	Grain	fodder	Grain	fodder				
T-1	3250	6884	985	2926	21395	2060	19335	1:10.39
T-2	3325	6329	1060	2371	22246	2660	19586	1:8.36
T-3	3064	4866	799	908	15889	2835	13054	1:5.60
T-4	3097	5931	832	1973	17573	4309	13264	1:4.08
T-5	2980	6295	715	2337	15743	4909	10834	1:3.21
T-6	2889	5583	624	1625	13325	5084	8241	1:2.62
T-7	2857	7154	592	3196	14296	4700	9596	1:3.04
T-8	3062	6472	797	2514	17458	5300	12158	1:3.29
T-9	2822	5764	557	1806	12250	5475	6775	1:2.24
T-10	3369	7259	1104	3301	24001	2160	21841	1:11.11
T-11	2265	3958	-	-	-	-	-	-

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Qualitative Analysis of Cow Dung Microbiota – A Metagenomic Approach

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Abstract

Cow dung contains a varied array of microorganisms that, due to their ability to produce a variety of metabolites, may be advantageous to humans. Many cow dung microbes have shown inherent potential to boost soil fertility by phosphate solubilization, in addition to producing unique phytochemicals. It has an important role in the stimulation and protection of plant growth. There is a growing interest in researching applications of cow dung microbes in finding detailed analysis of cow dung microbiota. As a result, the current study was conducted to identify the antimicrobial genomic characteristics of cow dung samples as well as their microbial diversity by culturable independepent 16s DNA method was taken up. Total community DNA was extracted from fresh dung of Desi and cross breed's cow.16Sr RNA was amplified, sequenced and deposited in gene bank. The sequenced organism was identified as Bacillus *flexus* (accession no - MW560477). The outcomes of this study indicated the significance for safe cow dung application in agricultural fields, as well as future research into the antibacterial potential of the diverse microbiota of cow dung, which has agricultural, environmental, and medical implications.

Key words : *Cow dung, metagenomics, 16s RNA, phylogenetic analysis.*

Introduction

Cow dung is the undigested remains of eaten food that is emitted by bovine animal species. It contains 24 different minerals, including nitrogen, potassium, sulphur, iron, magnesium, copper, cobalt, and manganese, as well as traces of sulphur, iron, magnesium, copper, cobalt, and manganese. Native Indian cows have higher levels of calcium, phosphorus, zinc, and copper than crossbred cows (Garg *et al*., 2007). Livestock farming is a tradition in India, and it is deeply connected to the agricultural economy. Ayurvedic formulations frequently use various byproducts derived from cows. For centuries, cow dung has been used as an organic fertilizer in Indian south East Asian farming. It improves soil nutrient status, enhances plant resistance to pests and diseases, and promotes photosynthetic activity and the further such as sulpho oxidation and phosphorous solubilization (Naskar *et al.,* 2003). Cow dung is an important biomaterial for soil amendment that is used to generate energy across the world. It's a great element has a unique since it keeps the soil alive and fosters microbial diversity.

Cow dung is the undigested residue of plant matter that's also excluded by symbiotic bacteria living in the rumen of the animal. The different mineral matter that passed through the cow's digestive system are ubiquitous in the likely to result facial matter. Carbon, nitrogen, hydrogen, oxygen, and phosphorus, among other elements, are present, along with salts, sloughed-off cells as the digest moves through the digestive tract, urea, mucus, and cellulose, lignin, and hemi - cellulose. Cow dung improves the mineral status of soil that helps plant susceptibility to pests and diseases and even drives plant growth and other beneficial activities (Bharati Sharma *et al*., 2015).

Bacillus spp., Lactobacillus spp., and Corynebacterium spp., as well as protozoa and yeast (Saccharomyces and Candida) are all found in abundance in cow dung (Neene et al., 1999).

In India, 69.9% of the population lives in rural areas, where cows (Bos indicus) are the most common bovine and produce 9-15 kg of manure per day (Werner *et al.,* 1989; Brown 2003).

Many different bacterial genera have been isolated from cow dung by Sawant *et al.* (2007), including Citrobacter koseri, Enterobacter aerogenes, Escherichia coli, Klebsiella oxytoca, Klebsiella pneumoniae, Kluyvera spp., Morgarella morganii, Pasteurella spp., Providencia alcaligenes, Providencia stuartii, and Pseudomonas.

Cow dung may thus act not only as a substitute for chemical fertilizers by supplementing organic matter, but also as a soil conditioner (Garg and Kaushik 2005; Yadav *et al.* 2013; Be'langer *et al.* 2014). Although slurry from biogas plant species is a nutrient-rich source, it cannot be used on a large scale due to drawbacks such as eutrophication and soil nutrient leaching (Garg *et al*., 2005; Wachendorf *et al*.,2005; Islam *et al*., 2010; Lu *et al*., 2012; Guo *et al.* ,2014).

Our current agricultural techniques use a wide range of agrochemicals, including inorganic fertilizers, which are washed off of fields and into water bodies by irrigation, rain, and other means, affecting the ecosystem and directly affecting human existence.

To address these issues, save our natural ecosystem, and save many farmers, we must abandon chemical fertilizers in favor of natural bio fertilizers and bioresource such as cow dung and cow urine-based agriculture, which are simple to implement and can act as cost-effective carriers of soil nutrients. To address this, we selected a bioresource sample of cow dung from various breeds and analyzed it in a laboratory environment. The metagenomic technique was used to identify strains with the most potent and effective beneficial properties at the species level.

Materials and Methods

Cow dung collection : Different breeds of cow dung and buffalo dung were collected in aseptic conditions.

Isolation and enumeration of cow urine Isolates : By using distilled water as blanks, the obtained samples were submitted to a serial dilution technique, with each sample containing 9ml of water. The tubes were labeled and placed in a test-tube stand, after which 1ml of cow urine sample was transferred to the next tube, and the same procedure was repeated for each dilution and poured over different agar plates. The plates were incubated for 24 hours at 37°C, and the colony count was measured per plate at the required dilution. Using a sterilized inoculating loop, the diverse colonies were purified by restreaking on Nutrient agar medium. The colony morphology, colour, shape, size, edges, surface, margins, and elevations of isolated microorganism colonial possessions were also examined. Microscopy and biochemical tests were used to characterize these cultures.

Powdered cow dung : To reduce moisture content, cow dung samples weighing about 1000g were shade dried for five days. 1000g of cow dung from various cow breeds was kept in the shadow for to dry.

1000g of Jersey cow dung was collected and shadow dried for 5 days. When compared to cow dung from an Indian cow, the moisture content was high. The powdered cow dung was then applied to the dried cow dung. The net weight of the powdered material was 220g.

1000g of Holstein cow dung was taken and shadow dried for 5 days. When compared to Gir cow dung, the moisture content was high. The powder form cow dung was then practiced to the dehydrated cow dung. The powdered material weighed 200g net.

1000g of buffalo dung was taken and shadow dried for 5 d. The moisture content was high when compared to cow dung from *Jersey.* The dried buffalo dung was then powdered. The powdered material had a net weight of 190g.

1000g of Gir dung was taken and shadow dried for 5 d. The dried Gir dung was then powdered. The powdered material had a net weight of 150g. Similarly with local Khillar found net weight of 130g.

Cow dung extracts preparation : Solvents such as acetone and ethanol were used to prepare the extract. In a conical flask, 100 ml of acetone and ethanol were mixed with 10g of powdered various breeds of cow dungs and incubated in a rotating shaker for three days. The extract was then filtered and stored using Whatman no1 filter paper for future use

Phytochemical screening of cow dung extracts : For phytochemical screening, filtered ethanol and acetone extracts of cow dung were utilized.

Test for flavanoids:

Test for glycosides : 0.50ml of the cow dung extract was dissolved in 1ml of water and then aqueous 10% sodium hydroxide solution was added .Formation of yellow colour indicates the presence of glycosides in a given sample.

Lead acetate test : A few drops of lead acetate solution were added to 0.5ml of the extract for the lead acetate test. The presence of flavonoids is indicated by the yellow colour of the precipitation.

Test for steroids :

Salkowski Test : To 2 ml of extract, added 2 ml of chloroform and 2 ml of concentrated H_2SO_4 and shaken well. Chloroform layer appeared red and acid layer showed greenish yellow fluorescence, in the presence of steroids.

Test for tannins : 1 ml of 10% lead acetate solution was added to 5 ml of the extract. The presence of tannins was revealed by the formation of yellow precipitate.

Test for phenols : A small quantity of the extract was dissolved in 0.5 ml of 20% Sulphuric acid solution. Followed by addition of a few drops of 2% Sodium hydroxide solution, it turned blue in the presence of phenols.

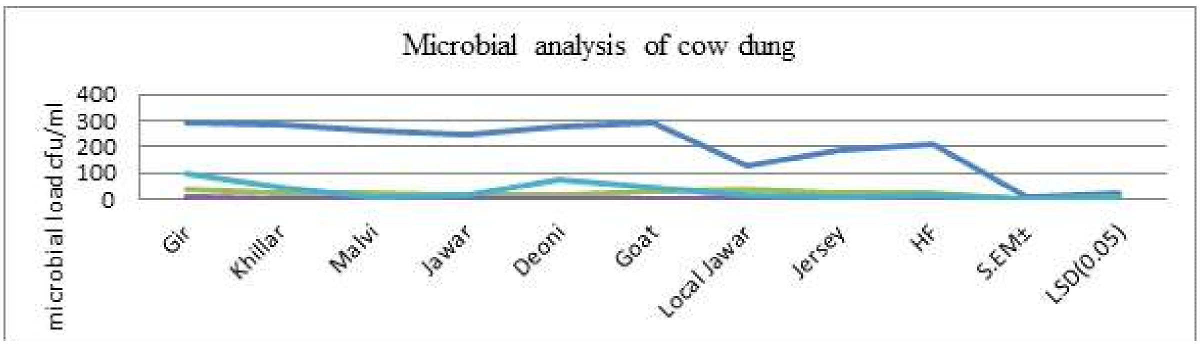
DNA sequencing and phylogenetic analysis

A single band of high-molecular weight DNA was found on a 1.0 percent agarose gel after DNA was extracted and separated from a selected culture and its quality was evaluated. 16SrRNA-F and 16SrRNA-R primers were used to amplify a fragment of the 16S rRNA gene. When resolved on an agarose gel, a single distinct PCR amplicon band of 1500 bp was seen.

To remove impurities, the PCR amplicon was

Table-1 : Microbial Analysis of Cow dung.

Treatment	Bacteria (10^5) cfu/ml	Fungi (10^2) cfu/ml	Actinomycetes (10^4) cfu/ml	PSB (10^5) cfu/ml	N fixers (10^5) cfu/ml
Gir	293.00	7.00	37.50	6.00	98.25
Khillar	281.50	2.75	20.50	2.25	42.25
Malvi	260.25	7.00	18.50	1.25	9.75
Jawar	244.75	6.00	17.75	1.50	11.00
Deoni	276.50	5.50	17.25	2.25	75.50
Goat	290.00	2.00	26.00	3.00	44.75
Local Jawar	130.00	3.50	33.50	2.50	14.50
Jersey	186.50	9.75	25.50	1.50	3.75
HF	208.75	5.75	18.75	1.70	12.00
S.EM±	7.96	0.42	3.16	0.37	2.58
LSD (0.05)	23.22	1.24	9.23	1.07	7.53



purified. On an ABI 3730xl Genetic Analyzer, forward and reverse DNA sequencing reactions of PCR amplicon were performed with 16SrRNA-F and 16SrRNA-R primers using BDT v3.1 Cycle sequencing kit. Using aligner software, a consensus sequence of the 16S rRNA gene was produced from forward and reverse sequence data.

The 16S rRNA gene sequence was utilized to perform BLAST searches against the NCBI's 'nr' database. The first ten sequences were chosen and aligned using Clustal W, a multiple alignment software programmer, based on their maximum identity score. MEGA 10 was used to create the distance matrix and phylogenetic tree.

Results and Discussion

All the isolation and analysis methods used for qualitative analysis of cow's urine were found effective against different parameters.

The present study was attempted to assess the microbial diversity of the fresh cow dung samples by culture based method as diverse microorganisms have been reported to be present in cow dung, which include bacteria and fungi in previous studies (Gupta *et al.,*2016; Gupta kk *et al.,*2016 ; Rupela *et al.,* 2003).

Microbial analysis of cow dung from various breeds was highly significant when compared to cross breeds, the Gir –Desi breed had the highest bacterial population, followed by khillar, Deoin. The highest nitrogen fixing bacteria were found in the Gir- Desi breed, followed by the Deoni.Phosphate solublizers were more abundant in Ghir.Beneficial organisms were found in very small numbers in the HF and jerssey breeds. Surprisingly, when compared to cross breeds, very remarkable observations were recorded in goat dung.

This study revealed the microbial load in cow dung was more compared to other animal like cross breeds. In this Desi cow dung was found more efficient compared to other breed. Experimental results proved the potentiality of Gir cow's dung isolates. Data shows that Desi cow's dung contained high microbial population with beneficial isolates. A countable review on enumeration of Desi cows 'dung isolates. The morphological and cultural characteristics were observed.

The highest number of microorganisms were isolated in less dilution and determined by standard methods. Among the screened isolates 9 isolates were highly potential this showed up the rapid production of gelatinase and starch production. The starch and gelatin liquefaction tests revealed that the screened isolates were positive. Only a few isolates tested quantitatively positive for Catalase. This suggests that screening isolates from cow's dung really does have a great potentiality and is bioresourceable. The more studies should be focused on enumeration and cultural studies on Desi cow's dung

Table-2 : Summerised results of biochemical and phytochemical Tests.

Sl. No.	Isolates	Starch Hydrolysis	Gelatin Hydrolysis	Casein Hydrolysis	PSB	Catalase	Flavonoids	Steroids
1.	ZBDS1	+	+	+	-	+	-	+
2.	ZBDS2	-	+	-	+	+	+	-
3.	NFBDS15	+	-	-	-	+	+	+
4.	NFBDS4	+	+	+	-	+	+	+
5.	NFBDS5	+	+	+	-	-	+	+
6.	NFBDS6	+	+	-	-	-	+	+
7.	NFBDS7	+	+	+	+	+	+	+
8.	NFBDS8	+	+	+	-	+	+	+
9.	NFBDS20	+	+	-	-	+	+	+

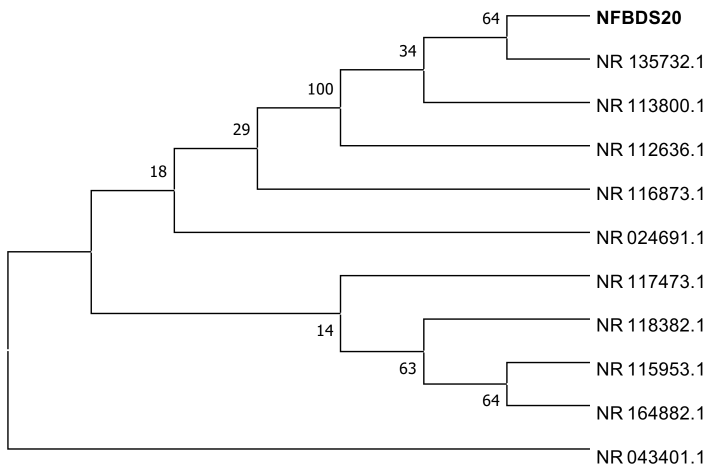


Figure-1 : Molecular Phylogenetic analysis by Maximum Likelihood method.

screening to utilize the natural substrate for sustainable agriculture.

3. Phylogenetic analysis :

The evolutionary history was deduced using the Kimura 2-parameter model as well as the Maximum Likelihood technique [Kimura., 1980]. The evolutionary history of the taxa examined is shown by the bootstrap consensus tree generated from 1000 repetitions. Branches that correspond to partitions that have been replicated in less than 50% of bootstrap replicates have been collapsed.

Next to the branches are the percentage of duplicate trees in which the related taxa clustered together in the bootstrap test (1000 replicates). The initial tree(s) for the heuristic search were automatically generated by applying the Neighbor-Join and BioNJ algorithms to a matrix of pair wise distances calculated using the Maximum Composite Likelihood technique, and then picking the topology with the best log likelihood value. Eleven nucleotide sequences were analyzed. Positions in the codon included. Eleven nucleotide sequences were analyzed. 1st+2nd+3rd+Noncoding codon locations were included. Gaps and missing data were removed from all positions. The total number of places in the final dataset was 1472 (Kumar *et al.*, 2018). MEGA7 was used to perform evolutionary analysis

The sequenced organism is *Bacillus flexus,* is rod shaped Gram variable bacteria, in laboratory conditions; it produces opaque, creamish, raised margin colonies at 30 ± 2°C when incubated at 24–72 hrs recently transferred to Priestia family known as *Priestia flexa*(Gupta *et al.,*2020). Catalase and oxidase were positive in the Bacillus flexus strain. Indole, methyl red, and Vogues Proskauer's tests all came back negative, therefore citrate was used instead. Nitrate was converted to nitrite, and the urea could not be hydrolyzed. Few moderately alkaliphilic bacteria, particularly those belonging to the genus Bacillus, can produce extracellular lipase, amylase, and proteases that are active even at alkaline pH (Martins *et al.,* 2001; Vargas *et al.,* 2004).

An earlier report reveals that Multidrug resistant strains of *Bacillus flexus* species are a part of the indigenous soil microbial communities have an advantage. To know the soil microbial diversity we worked with the metagenomic approach for the identification based on the functional and structural diversity of natural soil microorganisms. Therefore due to its important function and contribution to the environment is another motivation for sequencing genome of *Bacillus flexus.*

In Bacillus aerophilus, Bacillus cereus, Bacillus megaterium, Bacillus oceanisediminis, Bacillus safensis, Bacillus circulans, and Bacillus flexus evidence for the presence of the nifH gene and thus the ability to fix atmospheric nitrogen was discovered (Yousuf *et al.,* 2017).

From the analysis it was concluded that Desi cow's urine is highly effective and potential in controlling the plant pathogens. Ancient research and literature emphasized the antifungal activity of cow's urine and this work was concluded to be one of the best natural sources for enzymes. The hydrolysis and lipase activity proves its efficiency in agricultural and medicinal value. These may be helpful in producing commercial enzymes to correlate with decomposing the agricultural residues and wide application in industry. Apart from antifungal the isolate is beneficial to the soil as it has an amazing ability to grow on glycerol as the sole carbon and energy source. Isolating such a potential organisms from desi cow urine is a remarkable observation for us. Very countable reports are available on Metagenomics of cow urine. Further research has to do on pot study culture, to quantify the inhibitors and determine the whole gene sequence.

Conclusions

A *Bacillus* spp. are one of the most prominent culturable soil bacteria found in most soils and are well known for their ability to have a wide range of plant-friendly effects. Bacillus spp. are well-adapted to a wide range of environmental circumstances due to their genetic and metabolic diversity. Bacillus spp. are a good option for use as a biofertilizer agent because of their vast environmental adaptability and a variety of positive features.

As seen by the vast range of cry gene uses, Bacillus spp. characteristics connected with biological control are increasingly commercially exploited. Apart from the ability of Bacillus spp. to create endotoxins, other characteristics such as the generation of antimicrobial peptides should be commercialised after enough field testing. Bacillus interactions with other soil microorganisms are very well studied and have been produced in large quantities to some extent. Bacillus members have a lot of potential for agro-biotechnological applications since of their diverse functional attributes. However, more targeted development and testing for crop productivity under field circumstances is required to boost the scope of practical utility.

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Non-Timber Forest Products (NTFPs); Challenges and Strategies for Sustainable Livelihood

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Abstract

Non-timber forest products (NTFPs) constitute an important source of livelihood for millions of people from forest fringe communities across the world. In India, NTFPs are associated with the socio-economic and cultural life of forest-dependent communities inhabiting wide ecological and geo-climatic conditions throughout the country. It is estimated that 275 million poor rural people in India, depend on NTFPs for at least part of their subsistence and cash livelihoods. The NTFPs also serve as a vital livelihood safety net in times of hardship. Furthermore, the NTFP extraction has multiplier effects in the economy by generating employment and income in downstream processing and trading activities. However, depletion of NTFPs resources on account of indiscriminate exploitation, deforestation and forest degradation have a major issue of concern that may affect the NTFP based livelihood and economics. This study attempts to outline the extent, reliance and livelihood significance of NTFPs for forest dependent communities and to suggest strategies for their sustainable development and utilization. Sal leaf marketing channel in the Ghumsur North Forest Division: Channel 1: Primary Collector/Processed –Village Agents – Intermediate Agents – Big Traders – Whole Sellers – Retailers- Consumers. Channel 2 – Primary Collector – Weekly Hat (Weekly Local Market) –Consumers. Challenges and strategies of NTFP management which will be useful in sustainable development of resources vis-a-vis provide livelihood opportunities to the poorest section of society have been discussed.

Key words : *NTFPs, livelihood, marketing channel, challenges*

Introduction

Non-timber forest products (NTFPs) play an important role in the livelihood of the rural people living near the forest. Forest acts significantly in the life of landless and tribal people for income

generation and food from forest (Nayak *et. al,* 2021; Singh *et al.,* 2010; Ahenkan and Boon, 2011). NTFPs include wild edible fruit, mushroom, berry, root, tuber and green or vegetable etc. to meet the food requirements of the rural people. According to the World Resource Institute (1990), NTFPs provide livelihood to nearby 500 million people in India (MoEF, 1996). Globally, more than a billion people depend directly on forests for their livelihoods and the remaining six billion of us depend on forests for a variety of economic, social and environmental benefits such as the rainfall, biodiversity, pollinators, carbon storage and clean water they provide. Out of which NTFPs contribution is significant in providing adequate food, fuel, feed, health and fiber for growing populations. The NTFPs play important roles in the livelihoods of millions of rural and urban people across the globe (Shackleton *et al.,* 2015; Malhotra *et al.,* 2010; Pandey *et al.,* 2011). It is well established that NTFPs fulfil multiple functions in supporting human well being. The NTFPs provide the products for food, shelter, medicines, fibres, energy and cultural artefacts for many of the world's poorest people and a considerable proportion of the less poor. After agriculture, NTFP collection was the most important activity among the respondents as all of them in the area were involved in the forest activity (Nayak *et. al.,* 2017). Non-timber forest products (NTFPs) are goods of biological origin other than timber from natural, modified or managed forested landscapes. They include fruits and nuts, vegetables, medicinal plantss, gum and resins, essences, bamboo, rattans and palms; fibres and flosses, grasses, leaves, seeds, mushrooms, honey and lac etc. The NTFPs can also be referred to as all the resources or products that may be extracted from forest ecosystem and are utilized within the household or are marketed or have social, cultural or religious significance (Shackleton *et. al.,* 2004; Marshall *et.al.,* 2003). Majority of rural households in developing countries and a large proportion of urban households depend on the products to meet some part of their nutritional, health, house construction, or other needs1. The NTFPs create high economic value and large-scale employment. The NTFPs have attracted global interest due to the increasing recognition of the fact that they can provide important community needs for improved rural livelihood (FAO., 1995; World Bank, 2006).

Categories and uses of NTFPs : The NTFPs can be classified into different categories, based on the purpose of use (for example, as food, fuel, medicine, house hold utensils and farm implements); the part of plants harvested (leaf, fruit, stem and roots) and level of use (self

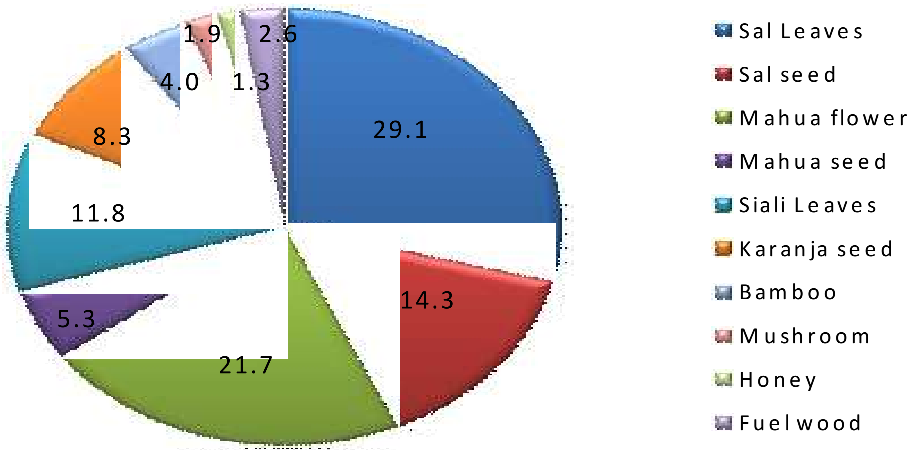

Fig.-1 : Percentage contribution of different NTFPs to Net return.

supporting and commercial). Once viewed as the products of poor unlike that of the timber for the rich, NTFPs provide a green social security to billions of people in the form of food supplements, traditional medicines, fuel and fodder, low-cost building materials and source of employment and income generation. In some cases, the revenues earned from NTFPs are the only source of cash income, which increases the dependency of people on commercially interesting NTFPs resources (Pandey, *et al.,* 2015).

Livelihood significance of NTFPs : In Indian context, NTFPs are associated with socio-economic and cultural life of forest dependent communities inhabiting in wide ecological and geo-climatic conditions in different concentrations throughout the country (Anonymous, 2009 Pandey *et al.,* 1998). Tribal livelihood systems vary considerably between different regions as also among the various ethnic groups, depending on ecological, historical and cultural factors. Collection of NTFPs by communities primarily for meeting their subsistence needs it varies from state to state ranging from 5.4-55% in the country. In Manipur alone, a North-Eastern state of India, nearly 90% of the population depends on forest products as a major source and some 250000 women are employed in collecting forest products. It is estimated that 275 million poor rural people in India i.e., 27% of the total population, depend on NTFPs for at least part of their subsistence and cash livelihoods (Pandey *et al*., 2016). This dependency is particularly intense for half of India's 89 million tribal people, the most disadvantaged section of society, who live in forest fringe areas. About 70% of the NTFP collection in India takes place in the tribal belt of the country, whereas, 55% of employment in forestry sector is attributed to NTFP sector (Mallik, R.H. 2000).

The net returns generated from the NTFPs collected by the respondents were found out from the quantity collected and the price/bundle or kilogram in the study of Ghumsur North Forest Division. The net return from NTFPs were sal leaves > siali leaves > bamboo > fuel -wood > mahua flower > honey > mushroom > karanja seed > sal seed > mahua seed (Nayak *et.al.,*2019).

Global attention on NTFPs : The past decade has witnessed a rapid growth and upsurge in global interest in NTFPs of among conservation and development organizations due to the increasing recognition that NTFPs can contribute significantly to the livelihoods of forest dependent communities, household food security and nutrition; generate additional employment and income and offer opportunities for NTFP based enterprises (Belcher *et al.,* 2005; FAO, 2006 ; Poffenberger, M., 2006). Around one billion people rely on wild harvested products for nutrition and income and the invisible trade in wild resources is estimated to generate $ 90 billion/annum. In India alone the livelihoods of around 6 million people are maintained by the harvest of forest products.

Management interventions : Importance of NTFPs has moved to the centre stage of the global development agenda (Shackleton, C.M. and Pandey, A.K., 2014). In the past two decades, a number of countries have begun to fine-tune and well-intentioned forest policies to reflect the socio-economic, ecological and cultural realities of NTFP use. This has resulted in a number of specific improvements to the ways in which these products are regulated, including re-thinking the use of costly and complex inventories and management plans for NTFPs. The Food and Agriculture Organisation (FAO) was one of the first agencies to promote NTFPs through their Programme on NTFPs. Over the past 20 years, other international agencies such as the World Bank (WB) and Canadian International Development Agency (CIDA), International Development Research Centre (IDRC), Centre for International Forestry Research (CIFOR), International Union for the Conservation of Nature (IUCN) and the Biodiversity Support Programme (BSP), among

Table-1 : Common NTFPSs observed in Ghumsur North Forest Division, Odisha, their taxonomical positions and plant parts locally used and its potential uses :

Sl. No.	Local Name	Botanical Name	Family	Parts used	Uses
1.	Arjun	*Terminalia arjun*	Combretaceae	Bark and fruits	Tannin for leather, medicinal
2.	Asan	*Terminalia tomentosa*	Combretaceae	Bark	Tassar cocoons, medicinal
3.	Amba	*Mangifera indica*	Anacardiaceae	Roots, bark, seed kernel	Fruit edible, medicinal
4.	Ambada	*Spondias pinnata*	Anacardiaceae	Roots, bark, fruits, seeds	Medicinal
5.	Aonla	*Emblica officinalis*	Phyllanthaceae	Root, bark, leaves, fruits	Fruit edible, medicinal
6.	Arakha	*Calotropis gigentea*	Apocynaceae	Whole plant	Medicinal
7.	Aswastha	*Ficus religiosa*	Moraceae	Bark, shoots, fruits, seeds	Medicinal, rope, fruits for animals
8.	Anchhu	*Morinda tinctoria*	Rubiaceae	Roots and leaves	Medicinal
9.	Bandhan	*Ougeinia oojeinensis*	Fabaceae	Bark	Medicinal
10.	Bara	*Ficus benghalensis*	Moraceae	Root, bark, leaves, buds, latex	Medicinal, rope, fruits for animals
11.	Bel	*Aegle marmelos*	Rutaceae	Roots, leaves and fruits	Medicinal, fruit edible
12.	Bhalia	*Semecarpus anacardium*	Anacardiaceae	Fruits	Medicinal
14.	Baidanka	*Mucuna pruriens*	Fabaceae	Roots, leaves, seeds and hair	Medicinal
15.	Bana haladi	*Curcuma aromatic*	Zingiberaceae	Rhizomes	Medicinal
16.	Baula	*Mimosups elengi*	Sapotaceae	Bark, flowers, fruits, seeds	Fruit edible, medicinal
17.	Begunia	*Vitex negundo*	Lamiaceae	Whole plant	Medicinal
18.	Babul	*Acacia nilotica*	Fabaceae	Bark, gum, fruits	Calico-printing, dyeing, sizing
19.	Bahada	*Terminalia bellerica*	Combretaceae	Bark and fruits	Fruit for animals, medicinal, tannin
20.	Bhuin aonla	*Phyllanthus niruri*	Phyllanthaceae	Whole plant	Medicinal
21.	Bhuin nimba	*Andrographis paniculata*	Acanthaceae	Whole plant	Medicinal
22.	Bana khajuri	*Phoenix sylvestris*	Arecaceae	Fruits	Medicinal
24.	Bhersunga	*Murraya koenigii*	Rutaceae	Roots, bark, leaves	Medicinal
25.	Bana tulasi	*Ocimum americanum*	Lamiaceae	Leaves and seeds	Medicinal
26.	Chatiana	*Alstonia scholaris*	Apocyanaceae	Barks and leaves	Medicinal
27.	Chakunda	*Casia tora*	Fabaceae	Leaves and seeds	Medicinal
28.	Champa	*Michelia champaka*	Magnoliaceae	Whole plant	Perfume, medicinal
30.	Duba ghassa	*Cynodon dactylon*	Poaceae	Whole plant	Medicinal
31.	Dimiri	*Ficus hispida*	Moraceae	Bark and fruit	Fruit is edible , medicinal
32.	Dudura	*Datura fastusa*	Solanaceae	Whole plant	Tannin for leather, Medicinal
33.	Dhanantwari	*Cymbopogon citratus*	Poaceae	Whole plant	Medicinal
34.	Dhaura	*Anogeisus latifolia*	Combretaceae	Roots, bark, leaves, seeds, gum	Medicinal, sizing paper printing
35.	Eucalyptus	*Eucalyptus indica*	Myrtaceae	Leaves	Oil, medicinal
36.	Gohira	*Acacia leucophloea*	Fabaceae	Barks	Medicinal
37.	Gayasha	*Leucas aspera*	Lamiaceae	Leaves ,flowers	Medicinal
38.	Guluchi	*Tinospora cordifolia*	Menispermaceae	Stem	Medicinal
39.	Gambhari	*Gmelina arborea*	Verbenaceae	Whole plant	Fruit for animal, medicinal
40.	Ganga siuli	*Nyctanthes arbortristis*	Oleaceae	Leaves, flowers, seeds	Medicinal
41.	Ghikuanari	*Aloe vera*	Asphodelaceae	Leaf juice	Medicinal
42.	Harida	*Terminalia chebula*	Combretaceae	Fruits	Tannin for leather, medicinal
43.	Kendu	*Dyospyros melanoxylon*	Ebenaceae	Fruits and Leaves	Fruit is edible, bidi preparation
44.	Kaincha	*Abrus pricatorius*	Fabaceae	Roots, leaves, seeds	Medicinal
45.	Kaitha	*Limonia Feronia*	Rutaceae	Bark, fruits, gums	Medicinal
46.	Lantana	*Lantana camara*	Verbenaceae	Whole plant	Medicinal
47.	Lajakuli	*Mimosa pudica*	Fabaceae	Roots, leaves	Medicina
48.	Mahula	*Madhuca indica*	Sapotaceae	Flower and fruits	Edible oil, fruits, country liquor
49.	Maha neem	*Melia composite*	Meliaceae	Whole plant	Medicinal
50.	Mai	*Lannea coromandelica*	Anacardiaceae	Bark and leaves	Medicinal
51.	Maha kala	*Trichosanthes anguina*	Cucurbitaceae	Roots and fruits	Medicinal
52.	Mundi	*Mitragyna parvifolia*	Rubiaceae	Bark, roots and leaves	Medicinal
53.	Neem	*Azadirchta indica*	Meliaceae	Leaves, bark and seeds	Oil and medicinal
54.	Sisoo	*Dalbergia sissoo*	Fabaceae	Roots, leaves, bark, heart wood	Medicinal
55.	Sunari	*Cassia fistula*	Fabaceae	Whole plant	Medicinal
56.	Satabari	*Asparagus racemosus*	Asparagaceae	Tuberous roots	Medicinal
57.	Simili	*Bombax ceiba*	Bombacaceae	Roots, gum, bark and fruits	Cotton, medicinal
58.	Salai	*Boswellia serrata*	Burseraceae	Bark ,gum and resin	Pleasant smell-burnt, medicinal
59.	Sahada	*Streblus asper*	Moraceae	Roots, bark, leaves, latex	Medicinal
60.	Siali	*Bauhinia vahili*	Caesalpiniaceae	Fibre	Binding kendu leaf, rope making

Sources : Behera, M. 2019.

others, have incorporated the concept of NTFPs into their research and development programmes. The concept of NTFPs, therefore, became an economically acceptable ecological option of development. Some of the following strategies need to be addressed for sustained livelihood through NTFPs.

(i) Sustainability : The sustainability of NTFP harvest depends on the organs that are harvested but also on the life cycle of harvested species. Good collection/harvesting practices of some important medicinal plants / NTFPs as in the Table 1 have been standardized and its uses were very effective for the health and livelihood sustenance (Behera, M., 2019).Adoption of sustainable harvesting practices at right time of harvest showed positive impact on resource conservation, socio-economic status of community, quality of produce and economic returns.

(ii) Monitoring system : Most of the collectors are not aware about the rules and regulations pertaining to harvest and management of NTFPs. The monitoring and enforcement of laws also varied considerably across central India. There is also the greatest lack of clarity as to who is responsible for monitoring and enforcing rules about harvesting and marketing of NTFPs. There is urgent need for development of effective and locally appropriate participatory monitoring mechanism. Adoptive monitoring mechanism with the active involvement of people needs to be developed. Sometimes third party monitoring can also be done. The developed harvesting practices may be modified in light of monitoring results.

(iii) Post-harvest technologies : Post harvesting practices e.g., drying, processing, storage and packaging can make a major difference to price and quality of produce.

(iv) Adding value : The majority of NTFPs sold by collectors/harvesters did not undergo only basic value-addition. The activity of value addition is largely performed by market intermediaries and manufacturers and there is little value addition at the primary collector's level. Interventions like preparing time schedule for collection of material, identification of correct plant and their parts, maintaining hygienic conditions while collection, following non destructive harvesting techniques, removal of foreign material from the collected product, sorting, drying and storage appropriately and packaging of collected material. Therefore, some value addition such as drying, chopping or cleaning at collector level will increase the value and quality of the produce.

(v) Marketing system : The NTFPs value chains are complex, with multiple stages and actors involved in the process of getting a product from forest to consumer; they are also dynamic and change over time. Therefore, information about the quantity and quality of the product, price and their market is very important. Important NTFP like Sal leaves are an important role for increasing the economic condition of the country. They depend on the Sal leaves for collection, stitching and processing of the plates which are bio-degradable and ecological substitute for thermo cool. Plates are used locally in the shops, hotel, marriage and festival. Sal leaf marketing channel in the study area: Sal leaf marketing channel in the study area :

Channel 1 : Primary Collector Village Agents Intermediate Agents Big Traders Whole Sellers Retailers Consumers

Channel 2 : Primary Collector Weekly Hat (Weekly Local Market) Consumers

(vi) Challenges in Marketing : The major challenges were no formal market, illiteracy, lack of exposure, no storage facility, lack of institutional support, lack of market information, lack of demand of the products, poor quality of the products, remoteness of the village and low shelf life in priority order. The solutions to the challenges were well established market involving primary stakeholders, development of infrastructure for cold storage to be developed, information about market and price of the produce through SMS or by different government institution, market functionaries may be proactive for timely disposal besides, value addition may be made to increase durability and marketability, Govt. institutions should arrange some exposure visit to successful market for the farmers and location and demand specific products should be chosen knowledge about demands of product should be known to dwellers.

(vii) Suggestions for market improvement : Different majors should be considered for the improvement of marketing structure and channel for NTFPs like; Infrastructure Support, Processing, Value Addition etc., involvement of Gram Sabha / Palli Sabha, provision of MSP under Price Support System ,strengthening institutional support furthering the causes for better management of NTFPs, Continuous Research and Development on Scientific Harvest and Forestry management for restore quality parameters to be fit for industries, effective marketing linkages with insurance and working capital support for entrepreneurship, forward and backward linkages for trade , Capacity Building of Primary Stakeholders , involvement of PRI on Forestry Management ,Value Chain Development, Infrastructure / Enterprises/ Marketing and Enabling policy and institutionalization.

Conclusions

It is clear that the contribution of NTFPs to income varies across ecological settings, seasons, income level, etc.

They contribute to improving nutrition either as part of the family diet or as a means to achieve household food security. It has been established that a significant number of rural, tribal and overall forest dependent communities derive a significant part of their food, nutrition, healthcare needs and income from NTFPs. They also contribute to the well-being of rural households, particularly the poor, in terms of food security, nutrition, health and subsistence. However, a number of factors, including a policy vacuum, non-destructive harvesting, destruction of natural habitats, bushfires, population growth and high demand, are hindering the use and development of NTFPs. An appropriate policy framework for a sustainable promotion of NTFPs, domestication of NTFPs, improving harvesting and processing techniques are necessary to facilitate food security, reduction of poverty and improved livelihoods, particularly for the economically-marginalized and forest-dependent communities. Many study indicated that gathering minor forest produce is the most prominent source of income and represents, "nitty-gritty? component of livelihood strategies among the forest dwellers.

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Characterization of Fortified Sweetened Milk Kefir : Physicochemical, Sensory and Textural Properties Analysis

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Abstract

Characterization of fortified sweetened milk kefir with stabilizer (WS) was done and compared with fortified sweetened milk kefir without stabilizer (WOS) and control kefir. Chemical composition of both fortified sweetened milk kefir with stabilizer (WS) and without stabilizer (WOS) showed significantly ($p<0.05$) higher total solids content. The protein and fat content of three kefirs did not differ significantly ($p>0.05$). Carbohydrate and ash contents of both fortified sweetened kefirs (WOS & WS) were significantly ($p<0.05$) higher than control kefir. The ethanol content was quantified as 0.035% in control kefir, 0.62% in kefir (WOS) and 0.30% (0.30 g/100g) in kefir (WS). Flavour score was highest for kefir (WS), followed by kefir (WOS) and control kefir. Body and texture was significantly ($p<0.05$) higher for kefir (WS). No significant ($p>0.05$) difference was observed in colour and appearance among all the three kefirs. Overall acceptability of kefir (WS) and kefir (WOS) was significantly ($p<0.05$) higher than control kefir. All textural properties like firmness, consistency, index of viscosity and stickiness of kefir (WS) was significantly ($p<0.05$) higher than kefir (WOS) and control kefir. Fortified sweetened milk kefir (WS) demonstrated significantly ($p<0.05$) higher antioxidant activity than control kefir but no significant difference was observed with kefir (WOS).

Key words *: Characterization, fortified sweetened milk kefir, proximate composition.*

Introduction

Among the many fermented dairy products, kefir gained a lot of attraction in health conscious population being good for health. In central Asia between the Caucasus Mountains and Mangolia kefir has been consumed for thousands years (Dzwolak & Ziajka, 2000) and now it is becoming outspread in other part of the world. Kefir results from mixed microbial activity that gives it a slightly acidic taste, yeasty and tangy flavour. Various attempts have been made to make the milk kefir tastier and palatable with addition of sugar, dietary fiber and stabilizer. In one such experiment (Solanki and Ghosh, 2021) we showed the optimization process of fortified sweetened milk kefir with addition of 6% sugar, 3% inulin & 0.1% pectin. Addition of sugar, inulin and pectin brings about desirable change in optimized product in terms of taste, composition, texture, sensory characteristics and shelf life. Since the kefir is complex mixture of symbiotic bacteria and yeast, it results a non-homogenous composition that also widely affected by milk type and volume that ultimately affect its physiochemical, sensory & textural properties (Altay *et al.* 2013). In addition to this, the composition of its grains and cultures and the production process also influence its properties (Otles and Cagindi 2003). In one experiments Mitra and Ghosh (2019) reported quality characteristics of kefir prepared from different kefir grain source like US, Australia and India. Wszolek et al. (2001) analysed properties of kefir made from bovine, caprine and ovine milk with different starter cultures. Kefir commonly contains 89–90% moisture, 0.2 - 3.5% fat, 3.0 - 3.3% protein, 4 - 6.0% carbohydrate, 0.7 - 0.9% ash and 0.8 - 1.0% lactic acid and 0.8 - 1.0% alcohol (Otles and Cagnidi 2003). In literature, kefir's structural and microbial composition is analysed in details (Prado et al. 2015) but there is little information available on kefir proximate composition and its physiochemical, sensory & textural properties. Specifically, in presence of sugar, inulin and pectin the said properties are relatively unknown, so current study was designed to evaluate the optimized fortified sweetened milk kefir (with stabilizer) for physiochemical, sensory, textural, antioxidant properties and compared with control and fortified sweetened milk kefir (without stabilizer).

Materials and Methods

Preparation of fortified sweetened milk kefir (ws) : Development and optimization process of fortified sweetened milk kefir (WS) has been reported by Solanki and Ghosh (2021) in detail. Briefly whole fresh milk was standardized to 3% fat and homogenisation was done. Fortified sweetened milk kefir was prepared with the addition of stabilizer i.e. pectin at 0.1% level, sugar at 6% level and 3% inulin on milk basis. Heat treatment up to 90-92°C for 10 minutes was done followed by cooling at 30°C. At this temperature, kefir grains were inoculated at 4 g/L to the milk and incubated at 30ºC for about 20-24 h in B.O.D incubator till the titratable acidity reached at 1%

lactic acid. The fermented product was thoroughly stirred and sieved through nylon sieve of 1/20-inch mesh size to retrieve the kefir grains. Finally, product was filled in polypropylene cups and kept for maturation for 24 h at refrigerated temperature (6-8°C) and stored. For comparison, control kefir was prepared in same manner as the optimized product without addition of pectin, sugar and inulin. Kefir without stabilizer (WOS) was also prepared with 6% sugar and 3% inulin on milk basis.

Proximate composition : Moisture content of kefir samples were determined as per AOAC 925.23 A (1990) given for milk. Fat was determined as per the method AOAC 989.05. (2012) given for milk. Total protein in sweetened milk kefir was determined as per the method described in AOAC 991.20 (2012) for milk. The total carbohydrate content was determined by difference. Ash content of kefir samples were determined as per the method described in AOAC 945.46. (2012) given for milk.

Physico-chemical analysis

pH : The pH of kefir samples was measured directly by inserting the electrode into the sample followed by recording of reading.

Titrable Acidity : The acidity of kefir samples was measured as per the method of AOAC947.05 (2012) for milk. Briefly Phenolphthalein indicator of 2-3 drops was added and titrated against 0.1 N NaOH till the first appearance of faint pink colour. The acidity was expressed as % lactic acid by weight.

Ethanol estimation : The ethanol content of kefir samples was determined using GC unit (M/s Agilent technologies, U.S.; Fig.4.5) equipped with Flame Ionization Detector (FID) and GC column, HP-5 5% phenylmethylsiloxane (30m L × 0.25mm ID × 320 μm film thickness). The carrier gas was Helium (column flow rate 1.2 ml/minute) in constant flow mode. The flow mode was split less. The injector and the detector were set at 180°C and 280°C, respectively. Identification of ethanol was achieved by comparing the retention times of the peaks with previously run pure ethanol in toluene standard

Antioxidant property analysis : Antioxidant activity of fortified sweetened milk kefir was checked by estimating scavenging effect of the kefir upon 1,1-Diphenyl-2-picrylhydrazyl (DPPH) Radicals. This estimation was done according to the method of Liu et al. (2005) with slight modifications. Briefly, 1ml of milk kefir (1mg milk kefir in 1 ml distilled water) is mixed with 1 ml of working methanolic solution of DPPH Radicals. The mixture was shaken vigorously and left to stand for 30 minutes in the dark, and the absorbance was then measured at 517 nm.

Sensory evaluation : Sensorial assessment of the all three milk kefir samples was carried out by an expert panel of minimum five judges to judge the kefir samples on a 9-point hedonic scale (9=like extremely; 1=dislike extremely) at room temperature. Duo-trio tests were used to determine a candidate's ability to detect differences among similar products with different ingredients for selection of Judges.

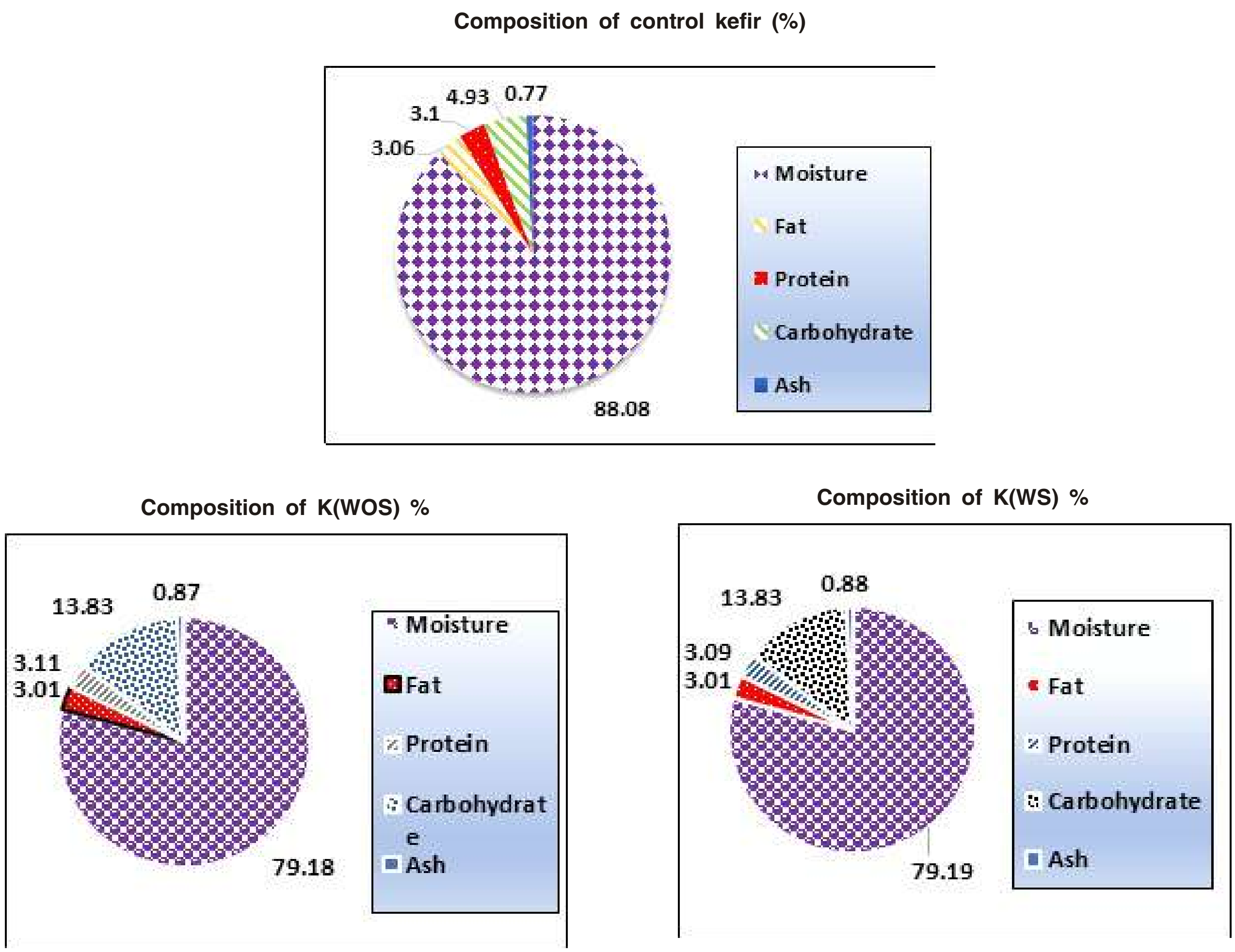
Textural analysis : Textural properties such as firmness, consistency, index of viscosity and stickiness were determined using TA-XT Plus Texture Analyser (Stable Microsystem, UK) with P/25 cylindrical probe. At 6-8°C, textural properties of kefir samples were measured using 200 ml kefir in a 250 ml beaker. The probe travelled at a speed of 1.0 mm/s up to 10 mm distance into the kefir sample from the surface and then returned to the original position generating force-time curve. The positive peak of the curve gave firmness (Newton), the negative peak gave stickiness (Newton), the area of positive peak gave consistency (Newton-second) and the area of negative peak gave index of viscosity (Newton-second).

Statistical analysis : The data were subjected to analysis of variance (ANOVA) using IBM SPSS statistics 23 software. Results of triplicate trials were used for statistical analysis.

Results and Discussion

Proximate composition : Proximate composition of control, fortified sweetened milk kefir (without stabilizer) and fortified sweetened milk kefir (with stabilizer) is depicted in Fig.1. It was observed that with the addition of inulin and sugar, moisture content of kefir decreased significantly ($p<0.05$). Chemical composition of both fortified sweetened milk kefir (with and without stabilizer) showed significantly ($p<0.05$) higher total solids content due to the addition of sugar and inulin. The fat content of these three kefirs did not differ significantly ($p>0.05$) as they were made from the same milk in which standardization of fat was done. Similarly, protein content also did not differ significantly ($p>0.05$) as all kefirs were made from the same milk. However, carbohydrate and ash contents of both fortified sweetened kefirs were significantly ($p<0.05$) higher than control kefir because of the addition of sugar and inulin. Carbohydrate content was measured by difference.

Kefir composition is non-uniform and not very much depicted (Otles and Cagindi 2003) and depends upon the type of milk and starter culture. It was observed that with the addition of inulin and sugar, moisture content of kefir decreased significantly ($p<0.05$). It is because of sugar and inulin significantly increases ($p<0.05$) the total solid content of the kefir resulting in the loss of moisture content. The fat content of these three kefirs did not differ



K(WOS) – kefir without stabilizer, K(WS) – kefir with stabilizer

Fig.-1 : Chemical composition of control and fortified sweetened milk kefirs.

significantly (p>0.05) as they were made from the same milk in which standardization of fat was done. The fat content of all the three kefirs is also in agreement with values reported by Magalhaes et al. (2011) for Brazilian kefir i.e.2.34% after 24 h of fermentation. Similarly, protein content also did not differ significantly (p>0.05) as all kefirs were made from the same milk.

However, carbohydrate and ash contents of both fortified sweetened kefirs were significantly (p<0.05) higher than control kefir because of the addition of sugar and inulin (Fructan). Carbohydrate content of control kefir is also in agreement with value reported by Wszolek et al. (2001) for bovine kefir i.e. 4.7% and slightly lower than reported by Ozer and Ozer (1999) i.e. 6%. In various studies ash content of kefir reported is 0.7% (Ozer and Ozer 1999) 0.55% to 0.66% (Kök-Tas et al. 2014), 0.7%-1.1% (Wszolek et al. 2001). Our results are also comparable with these findings.

Acidity and pH : Acidity and pH of control kefir, fortified sweetened milk kefir (without stabilizer) and fortified sweetened milk kefir (with stabilizer) is depicted in Table.1. It was observed that these three types of kefirs did not differ significantly (p>0.05) in terms of pH and acidity.

Acidity was higher and pH was lower slightly in kefir (with stabilizer) than kefir (without stabilizer), may be due to more maturation period for the former kefir. But optimized products (i.e. kefir with stabilizer) showed optimum pH and acidity.

Ethanol estimation : The exotic, refreshing flavour and unique aroma of kefir is ascribed to its ethanol content. It is one of the major products formed during fermentation along with lactic acid and CO_2 (Otles and Cagindi 2003). Thus, ethanol content was estimated in kefir using GC-FID (Gas Chromatography-Flame Ionization Detector). The retention time (RT) and peak area of ethanol and internal standard i.e. butanol in control and fortified sweetened milk kefirs obtained by GC-FID analysis is presented in Table 2. The peak area was quantified as % ethanol of the product as per the formula given in section 4.3.1.8. The ethanol content was quantified as 0.035% (0.035 g/100g)

Table-1 : Acidity and pH of control and fortified sweetened milk kefirs.

Attributes	Control kefir	K(WOS)	K(WS)
Acidity	1.03 ± 0.07[a]	1.04 ± 0.04[a]	1.09 ± 0.02[a]
pH	4.47 ± 0.02[a]	4.46 ± 0.02[a]	4.43 ± 0.01[a]

Mean ± S.D; means with different superscripts in a row differ significantly ($p<0.05$) (n=3); K(WOS) –Kefir without stabilizer, K(WS) - Kefir with stabilizer.

Table-2 : Retention time and area of chromatograms of control and fortified sweetened milk kefirs obtained by Gas Chromatography.

Compound identified	Std-reference (Butanol)		Control Kefir		Developed Fortified Sweetened Milk Kefir (WS)		Fortified Sweetened Milk Kefir (WOS)	
	RT(min)	Area	RT (min)	Area	RT (min)	Area	RT (min)	Area
Ethanol	-	-	2.658	2619373	2.696	64616261	2.657	38355538
Butanol	3.921	77634284	3.916	74550765	3.916	214366237	3.920	61567292

WS-with stabilizer, WOS-without stabilizer

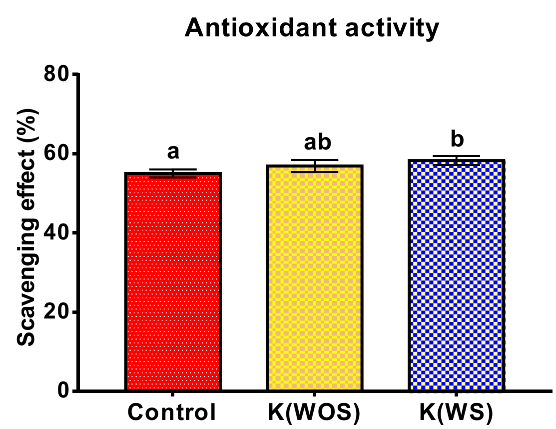
in control kefir, 0.62% (0.62 g/100g) in fortified sweetened milk kefir (without stabilizer) and 0.30% (0.30 g/100g) in fortified sweetened milk kefir (with stabilizer). It was observed that addition of sugar and inulin increased the ethanol content of kefir. Yeasts are primarily responsible for the ethanol production in kefir.

Although yeasts are commonly recognized for ethanol producing ability, but hetero fermentative lactobacillus are also capable of producing ethanol (up to 0.25%) and CO_2 (Marshall et al. 1984). Kefir has been accounted to contain 1.98 g/L of CO_2 and 0.48% alcohol (Beshkova et al. 2002), and the substance of carbon dioxide (201.7–277.0 ml/L) emphatically related with the quantity (10–100 g/L) of kefir grains (Garrote et al 1998). There are notable variations among the reported ethanol contents of kefir (0.01-1.0%) (Kurman et al. 1992). The measures of ethanol and CO_2 produced amid the maturation of kefir rely upon the production conditions (Farnworth 2005).

Antioxidant activity : Antioxidant activity of kefirs was determined by using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) assay. DPPH is a stable free radical and when dissolved in methanol it exhibits a characteristics absorption at 517 nm. Antioxidant molecules act as hydrogen donor and scavenge the free radicals by turning the colour of DPPH assay solution from dark purple to light yellow, resulting in absorbance value.

Fig.-2 depicts the DPPH radical-scavenging activity of control kefir, fortified sweetened milk kefir (without stabilizer) and fortified sweetened milk kefir (with stabilizer). Fortified sweetened milk kefir (with stabilizer) demonstrated significantly ($p<0.05$) higher DPPH radical-scavenging activity than control kefir. Highest scavenging activity (58.28%) was showed by fortified sweetened milk kefir (with stabilizer), followed by fortified sweetened milk kefir (without stabilizer) (56.90%) and control kefir (55.14%).

Higher scavenging activity of fortified sweetened milk kefir may be due to antioxidant effect of inulin fibre. Pectin present in fortified sweetened milk kefir (with stabilizer) may have shown antioxidant activity of it. Soultani et al. (2014) reported that the addition of pectin did not decrease the antioxidant properties of tea and suggested the use of pectin in new food formulations because the expected health benefits are not masked by the presence of pectin. Liu *et al.* (2005) reported the effect of milk kefir and soy milk kefir on the scavenging activity of DPPH radical displayed significant activity than milk and soy milk. They suggested that some components of antioxidant presented in the kefir grains were transferred to milk and soy milk during fermentation. The increased scavenging activity of fermented milk may also be related to milk protein peptides (Chen *et al.* 2003; Nishino *et al.* 2000; Suetsuna et al. 2000). McCue and Shetty (2005) suggested that the increasing of antioxidant activity during soy milk yogurt production using kefir culture may be due to the mobilization of phenolic compounds. Guven *et al.* (2003) analysed the antixoidative outcome of kefir and

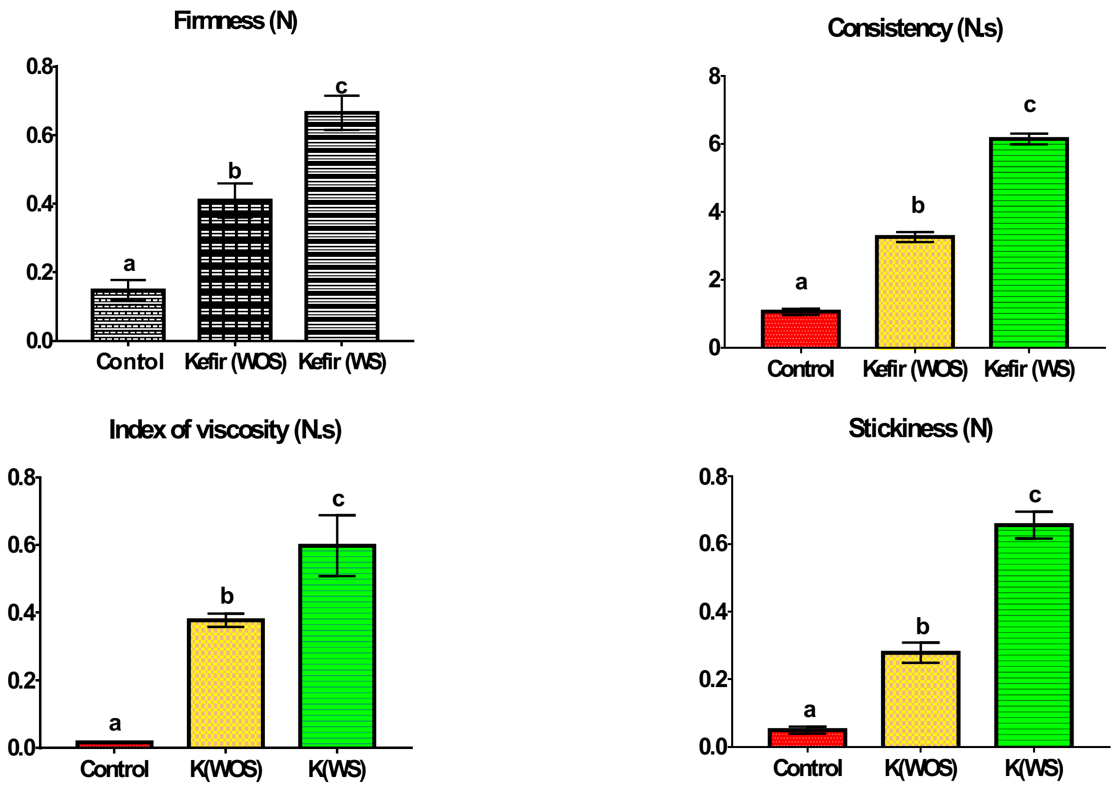


Means with different letters differ significantly, $p<0.05$); K(WOS)-kefir without stabilizer, K(WS)-kefir with stabilizer

Fig.-2 : Antioxidant activity of control and fortified sweetened milk kefirs.

(means with different letters differ significantly, $p<0.05$); WOS- without stabilizer, WS-with stabilizer)

Fig.-3 : Sensory evaluation of control and fortified sweetened milk kefirs.



(Means with different letters differ significantly, $p<0.05$); K(WOS)-kefir without stabilizer, K(WS)-kefir with stabilizer)

Fig.-4 : Textural properties of control and fortified sweetened milk kefirs.

Vitamin E against oxidative harm of CCl_4 in animal model. Results demonstrated that both Vitamin E and kefir have an ability to protect tissues against CCl_4-incited harm, and kefir offered more insurance when contrasted with Vitamin E. Sirirat and Jelena (2010) reported that the high inhibition percentage of antioxidant activity of rice-milk kefir was similar to inhibition percentage of BHA activity. BHA is known to be effective antioxidant (Madhavi et al. 1996).

Sensory evaluation : Sensory attributes of control kefir, fortified sweetened milk kefir (without stabilizer) and fortified sweetened milk kefir (with stabilizer) is depicted in Fig.3. It was observed that flavour score of these three types of kefir were significantly ($p<0.05$) different from each other and it was highest for kefir (with stabilizer), followed by kefir (without stabilizer) and control kefir, respectively. Body and texture was significantly ($p<0.05$) higher for kefir (with stabilizer). No significant ($p>0.05$)

difference was observed in colour and appearance among all the three kefirs. Overall acceptability of kefir (with stabilizer) and kefir (without stabilizer) was significantly ($p<0.05$) higher than control kefir.

Flavour, body and texture were significantly ($p<0.05$) higher for kefir with stabilizer than kefir without stabilizer, may be due to the pectin addition. Pectin is a stabilizer which shows very complex rheological behaviour that depends on its addition in the presence of sugars and acids. As pectin has thixotropic behaviour in the presence of sugars and acids, it behaves as liquid upon agitation but settling into gels at rest (Chan *et al.* 2016). Same behaviour was observed in sweetened milk kefir. During retrieving of kefir grains, the product was same as liquid but after maturation period it became set because of the again formation of gel structure by pectin. It has been reported that heat treatment of milk does not affect the ability of pectin to stabilize particles such as casein and denatured whey protein (Chan et al. 2016). In agreement to this, Towler (1984) found that very high heat treatments (95°C for 60 min.) did result in reduction in whey separation but no whey separation occurred in beverage made with 0.3% pectin.

Textural properties : Textural properties of control kefir, fortified sweetened milk kefir (without stabilizer) and fortified sweetened milk kefir (with stabilizer) is depicted in Fig.4. It was observed that firmness of kefir (with stabilizer) was significantly ($p<0.05$) higher than kefir (without stabilizer) and control kefir. Similarly, consistency was also significantly ($p<0.05$) higher for kefir (with stabilizer) than kefir (without stabilizer) and control kefir. Similar trend was observed in index of viscosity and stickiness. All textural properties were significantly ($p<0.05$) higher for kefir with stabilizer than kefir without stabilizer, may be due to pectin in kefir with stabilizer type kefir showed its functional properties during maturation period.

Optimized product was showing higher firmness may be because of higher total solids content. Paseephol *et al.* (2008) also stated that the firmness of yogurt is directly dependent on its total solids content. Exopolysaccharides (EPS) may contribute altogether to the textural properties of kefir (Chen *et al.* 2009). In kefir, Kefiran is an exopolysaccharide (Farnworth 2005), can increase viscosity, water retention and collaboration with different segments of the milk, bringing about increased rigidity of the casein framework in the end product and therefore, less syneresis in that product (Duboc and Mollet 2001).

Conclusions

An attempt was made to do characterization of fibre fortified sweetened milk kefir. It can be a potential alternative to other fermented dairy products like misti dahi and yogurt etc. Composition of developed and control kefir was similar except moisture content. Total solids content was seen higher in fortified sweetened milk kefir. pH and acidity was not much differing in all kefirs. Sensory evaluation of developed fortified sweetened milk kefir revealed that addition of sugar made its taste more palatable which was liked by Indian palate. Pectin and inulin addition improved the textural properties and water holding capacity of kefir contributing to its acceptance. Antioxidant activity was also found more in the developed product. Ethanol content was found slightly more in developed product than control kefir. Fortified sweetened milk kefir was found superior in sensorial and textural properties than normal kefir.

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A Paradigm : For Quantifying the Value of Women's Efforts in Small-Scale Fishing

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Abstract

In small-scale fisheries all around the globe, women play a significant role. Their contributions to the sector's productivity and household income made the whole fish value chain. However, this labor goes unnoticed and unappreciated, and women are still out of decision-making in fisheries management and policy formulation. This study aims to overlook how women's fish processing and trading operations contribute to the fish value chain. This approach combines the Resource-Knowledge-Based-View, which emphasizes how women's actions generate value at all levels of the value chain. Findings show that a) valuable assets arise from women's labor in small-scale fisheries and b) to make gender visible: implementation of policy is necessary. Recognizing the significance of women's work is a step toward empowering them and making an otherwise invisible workforce visible.

Key words : *Resource-Knowledge-Based-View, Women, Gender, Fish value chain*

Introduction

Women have a significant contribution to the global seafood economy. About half of the 200 million individuals involved in small-scale fishing are women [46]. Women work in the catch, selling, processing, and financial elements of fisheries [16]. Yet, in fisheries economics, women's labor inside fish value chains remains overlooked and devalued. It is because most research on fisheries has been done by natural sciences, which focuses on fish resource dynamics, harvests, and hence fishing - a male-dominated activity [44,42]. However, fishing and the sea are associated with masculinity due to cultural norms and prejudices [8]. The role of men in fisheries is too revered in folklore, culture, and literature, but not for cleaning and preparing fish for food [31]. This bias extends to scholarly writing on fisheries, where men fishers have received far more attention than fisherwomen [32]. The fisheries development policies focus overwhelmingly on fish production while ignoring the processing and distribution process [22]. Despite recent studies demonstrating women's contributions to the fisheries sector [42, 22] gendered aspects of fishing have yet to be accepted by the public in fisheries science, economics, and policy. The outcome, we suggest, is a dominating implicit theory of value in fisheries research and economics that favors production (fish harvests) while ignoring or underestimating the importance of post-harvest activities in producing value. The Use of value, social, cultural, and political worth and conceptions of human well-being are ignored from economic definitions of value (financial or exchange value) [10]. As a result, unpaid labor and other intangible contributions made by women in the business go unnoticed. Second, the goods of producers might be valued not only in terms of use and trade criteria but also in terms of who creates them [31]. Several feminist studies across disciplines, geographic and historical contexts have looked at how job and skill categories – and hence value – are gendered [34]. Women are not seen as real workers by patriarchal norms and beliefs as the labor done by women has no worth. Thus, local forms of patriarchy and gender constructs under which labor divisions are formed are at the foundation of the discounting of women's work. According to a recent worldwide estimate of marine fisheries employment (in 144 coastal countries), the global marine fisheries employ roughly 260 million (76 million) people, encompassing full- and part-time work in direct and indirect sectors, men, women, and children [16]. Surprisingly, Asia and Africa contributed the most to global fisheries employment, owing to the scarcity of jobs in sections of these two continents [43]. Although involvement varies greatly from one location to the next, combining these two figures would result in 130 million women contributing to worldwide marine fisheries in some form [2]. Women catch less fish, especially huge fish, than males. They do, however, have a disproportionately high involvement rate in invertebrate collecting, processing, and marketing, and they make up the majority of employees in seafood processing factories in several regions of the world, including Asia, Africa, and the Pacific [42]. Nonetheless, in most nations and areas, their efforts go unnoticed. Although recent research on small-scale fisheries covers most of the known data on women and fishing, quantitative data on participation and/or contribution to total catch was only available for a few countries [12]. The vast corpus of literature on the subject of women and fisheries, or gender and fisheries, demonstrates significant efforts in recent decades to enhance the prominence of women's engagement in fisheries [36]. Many of these studies highlight the absence of gender-disaggregated data in fisheries-related activities as a fundamental barrier to increasing gender equity. The different fisheries-related activities that women are participating in across the world are listed here to illustrate the worldwide scale of their engagement in fisheries [25].

Europe : Women have played a major role in the processing business in Europe since the 19th century, especially at the peak of the herring fishery [35]. Women's engagement in the fisheries industry in the European Union is estimated to be 6% and 59 % for marine fishing and processing, respectively, according to the World Fish Center, with over 65,000 women engaged in these two sectors combined [35]. Compared to their roles in support, marketing, processing, trading, and other fisheries-related activities, women in this region have a relatively modest part in capture fisheries (aside from picking shellfish). The extent to which women participate in these activities, particularly their involvement in sustaining fishing operations, fisher-families, and communities, is unknown at this time [47]. Women are still substantially excluded from fisheries management systems, such as fisheries cooperatives and policy creation, despite increased gender equality in Europe [35]. While women gained the legal right to fish in certain countries, such as France, in 1963, most of the unpaid labor they perform to maintain family fishing companies remain unnoticed. In 1986, the European Council Directive (816/613/ EEC) on "the application of the principle of equal treatment between men and women engaged in an activity, including agriculture, in a self-employed capacity, and on the protection of self-employed women during pregnancy and motherhood" [11] gave women indirectly involved in fisheries some legal recognition. This has given women who work in fisheries in administrative and support tasks (e.g., bookkeeping, repairing nets, auctioning fish, etc.) some recognition and legal status [11]. Women typically do not consider this profession because it may be done at home while juggling other domestic and child-rearing responsibilities [45]. The opportunity cost of recruiting someone else to perform this function is the economic worth of this role. This has yet to be measured, but it must be taken into account when valuing women's contributions to fisheries [15]. Summer rentals at fisher families' houses in Western Europe (e.g., Germany) are organized by fishermen's wives as a method to augment the family income, thereby giving an indirect subsidy to their husbands, allowing them to continue fishing activities that are no longer viable. Recent research on women's engagement in UK fisheries backs up the assumption that women play a significant but undervalued role in the hidden workforce, providing unpaid help to fishing businesses [47]. According to the study, while women make considerable contributions to the fishing sector, they are underappreciated, either unpaid or underpaid, and have little participation in management and policymaking [24].

Africa : The role of small-scale fishing in poverty reduction and food security in Africa has gotten a lot of attention [3]. Processing and trade, in addition to the core industry of fishing, have been recognized as bringing significant value to the economy, which was previously undervalued. In terms of gender and fisheries, current research has focused on the involvement of women in African fisheries. Women, who are typically regarded among the poorest and most disadvantaged populations in developing nations, can earn money in the fishing industry. Women account for 80–90 % of fish dealers in the Congo [3]. Women's involvement in the fish trade has been highly integrated into the culture in some parts of Mozambique, both as a way to supplement meager household incomes and because the majority of male laborers were increasingly employed in South African mines, whereas women are minimally involved in other parts of Mozambique [18]. Women have traditionally been involved in the harvesting of marine creatures at low tide in coastal villages throughout the Comoros islands. Here, women often sell half of their catch and keep the other half for family use, so directly contributing to household income and food security [17]. Women have an important role in the processing and funding of fisheries in West Africa [28]. Market women in West Africa lend money to fishermen and maintain clear client–patron ties [41]. Although women in West Africa seldom catch fish, they play an important part in distributing it, which affects the family's economic returns, as well as supporting tasks such as delivering consumables (such as ice, bait, and salt) and mending fishing gear [41]. Women in East Africa, on the other hand, harvest from the intertidal zone in Mozambique, and seaweed farming, octopus traps, and fishing tiny fish in the intertidal zone in Tanzania [7]. However, as an octopus has grown in value on the international market, males are progressively displacing women from this occupation, which formerly supplied them with both a source of revenue and a source of nutrition. Although women are vitally involved in fishing for survival and livelihood, their efforts are usually unnoticed. As a result, women are excluded from fishing groups, creditors overlook them, and no training is provided to enhance fishing tactics, opportunities, and circumstances [13]. Gender factors must be addressed as a basic component of food and income security planning in rural African communities, especially since globalization affects the local availability of primary resources such as fisheries [1].

Table-1 : Main species captured by women's near shore fishing activities[40]

Group	Species	Uses
Fish	Herbivores and grazers found on reefs and seagrasses include rabbit fishes and spinefoots (Siganidae), wrasses (Labridae including *e.g. Novaculichthys macrolepidotus), surgeonfishes* and unicornfishes (*Acanthuridae*), and parrotfishes (*Scaridae* and e.g. *Leptoscarus vaigiensis*)	Expenditure and income of households Species are available fresh or dried. Drying is a popular practice in remote places (because to transportation issues/ costs). Spine foot and wrasse species are offered grilled at the weekly market (to domestic tourists). Children and teens specialize in capturing small bodied species and young fish found in extremely shallow reef, rockpool, and seagrass ecosystems utilizing a small portable Hawaiian sling made of a rigid metal wire propelled by an elastic band.
Moray	Muraenidae (e.g., *Echidna nebulosa, Enchelynassa canina, Gymnothorax* spp.)	Moray eels are a low-value species that are mostly consumed by fisher families. They are, however, quite easy to catch because they may be found in tidal pools looking for stranded fish and invertebrates.
Shrimp	Palaemon concinnus, Metapenaeus ensis*, Psalidopus huxleyi, Metapenaeopsis spp., Metapenaeus spp.*	Most shrimp and prawn species are in high demand, and are either sold at market, used to make shrimp powder, or consumed locally to flavor recipes. Brackish species are fished annually with hand nets in river mouths or with beach seines established. Small toddlers frequently seek shallow water and tidal shrimp by overturning rocks at low tide.
Crabs	*Portunidae, Scylla serrata, Portunus armatus*	The majority of tiny reef crab species, such as blue swimmer crabs, are consumed in the home. Large crabs (*Scylla* spp., *mangrove mud crabs*) are marketed locally.
Shelled molluscs	*Sampling of mollusc*	At the household level, the meat of bivalves and gastropods is utilized for food. Only a few species, such as Asaphis violascens and Tridacna squamosa, are harvested to be sold fresh for eating. Households consume *Cypraea tigris, Cypraecassis rufa,* and *Pinctada margaritifera,* and their shells are sold. Three gastropods (*Charonia tritonis, Mauritia arabica, and Monetaria caputserpentis*) and one cephalopod (Nautilus pompilius) were not devoured, but their empty shells are sold to visitors (for example, * $25 per shell for Charonia tritonis). Turbo marmoratus (* $5-12/shell) and Tectus niloticus (*$5-12/shell) are also sought for for adornments, ornamentation, or jewelry. 84 percent of the bivalves and gastropods detected were solely for domestic consumption.
Octopus	*Octopus cyanea, Callistoctopus ornatus, Octopus spp.*	The octopus was collected by prodding and probing coral crevices with an iron rod. With a mean market price of $4.55/kg, octopus was consistently one of the most valuable of all species collected across all fisheries, with a price varying according to size. Octopus is a valuable source of cash (it is prioritized for sale) and is available sun-dried, smoked, or fresh. For social occasions, octopus is cooked in palm leaves. Small people are occasionally exploited as bait.
Squid	*Loliginidae* (e.g. *Sepioteuthis lessoniana, Sepioteuthis* spp.)	The selling of squid is prioritized. It's caught with a hand line and sold either fresh or smoked (never observed as a dried product)
Peanut worms	*Echinoidea*	Urchins are collected for eating in seagrass regions. The roe is taken out and fried (steamed), or the urchin is roasted whole over hot coals and broken open to eat.
Peanut worms	*Sipunculida*	In seagrass habitats, sipunculid worms are excavated from the sand. The rough skin is removed, and the inside meat is cooked, fried, or dried for eating.

America : In Canada and the United States, there is a paucity of literature about women in fishing. Women's roles in fishing towns in Newfoundland and Nova Scotia, however, have received a lot of attention, especially at the peak of the Atlantic cod fishery [5]. Women had a crucial role in the processing of cod for shipment to Europe and the Caribbean, two of the fishery's most significant trade partners [29]. Furthermore, while women in northern Canadian indigenous communities have played a part in fishing, they have been mostly excluded from choices that influence the resources they utilize [20]. However, their efforts go unnoticed, and they are rarely mentioned in fisheries sector statistics or socio-economic valuations [33]. To rise their profile within fishing communities and at the level of government, women are beginning to organize themselves and find a collective voice in fish worker cooperatives. Women directly participate in fishing-related activities and indirectly assist fisher families and communities in Latin America (Mexico, Central, and South America) and also beginning to contribute to debates about the link between sustainable fisheries and healthy fishing communities as a result of their involvement in workshops and conferences [16].

Asia : Several variables, including growing aquaculture output, labor mobility across nations, and changing social standing of women, have contributed to women's shifting position in Asian fisheries. Asia, being the world's largest aquaculture producer, is seeing an increase in the number of women working in the industry. Although women contribute more labor to the aquaculture industry than males, they are typically excluded from decision-making processes [4]. In China, which has a large population, Women make up 33 % of the rural aquaculture workforce in 2008 [4]. accounting for 62% of reported world aquaculture production with contributions ranging from 42% to 80% in Indonesia and Vietnam. Furthermore, when women migrate across borders to work as workers in neighboring nations or the Middle East, their traditional role in reef gleaning and coastal food collecting is being supplanted [30]. In locations like the Philippines, the role of women as regular and steady household food suppliers is shifting, and nutritional security may be jeopardized if their position is not properly recognized. The United Nations has made some efforts to develop microcredit programs in fishing villages to aid in poverty reduction and women's empowerment. In Vietnam and the Philippines [16], this microfinance method, which includes loans, savings, and insurance coverage, has proven effective. Through their job as fish sellers, women in Goa, India, have earned significant economic independence and empowerment, enhancing living conditions and expanding prospects for their families [14]. Environmental deterioration and unsustainable resource extractions in Malaysia have diminished livelihood diversification, putting gender equity in homes and communities where women formerly worked alongside men in fishing activities in jeopardy. Women's social and economic roles have shifted in Bangladesh and presumably throughout much of Asia as a result of the transition from subsistence economies to global market economies driven by commerce [19]. In Asia, innovative microcredit schemes have improved women's access to economic opportunities and employment Women's social and economic roles have shifted in Bangladesh. and presumably throughout much of Asia as a result of the transition from subsistence economies to global market economies driven by commerce [19]. In Asia, innovative microcredit schemes have improved women's access to economic opportunities and employment [6]. To understand the ramifications of these shifting roles on fisheries, women, and development, more research is needed [27].

Value and contribution :

Women's catches in marine fisheries : Though women's participation in fisheries is common over the world, we focus our quantitative analysis on the Pacific's small-island developing countries—a region long renowned for its reliance on seafood and where women are known to be significantly involved in fisheries operations. Even though fishing is a recognized hobby for women, statistics on the subject sometimes fail to reflect this contribution. The most typical occupation for women is reef gleaning, which entails collecting invertebrates as shown in table-1 (crabs, shellfish, octopus, echinoderms, and so on) and fish from the beach. This occupation is mostly carried out by women, and it provides a significant amount of the local daily diet Most officially reported fisheries to catch data do not adequately represent activities like reef gleaning, at least not to the level that firsthand observations show [38]. National statistics provided to and published by the United Nations' Food and Agriculture Organization (FAO) provide some estimates of invertebrate catches, but only for those taken and sold for export. In most situations, the subsistence component has been substantially disregarded [26]. However, certain nations, such as Fiji, have recently made significant efforts to estimate subsistence catches, realizing that this is one of the most important domestic fisheries sectors [39].Women's participation in the overall catch varies by ethnic group [23] and industry. Women dominate subsistence activities, notably in Melanesia, with over 2/3 of the population. This periodical publishes in-depth papers regularly from major academics in the field of Pacific women and fisheries, on themes ranging from fishing practices to food security and policy. Women caught 80 %of the subsistence catch in Micronesian and Polynesian societies, whereas women caught 20 to 25 % of the subsistence catch in Micronesian and Polynesian civilizations. Women in Melanesian societies contributed 20% to the commercial, artisanal catch, but women in Micronesian and Polynesian cultures contributed just 10% to the commercial catch [23].

Nutritional contribution : In many regions of the globe, fish (including invertebrates) are an important and often vital component of the diet, contributing significantly to protein demand and giving essential micronutrients to men, women, and children's diets. Fisheries and aquaculture for local consumption provide a significant contribution to family nutritional security, especially in developing countries. Immune function, childhood growth, cognitive development and function, and reproductive success are all dependent on proper nutrition [21]. While livelihoods in the fishing industry, particularly small-scale fishing, have been connected to household nutritional security [21] additional research is needed to fully comprehend the relationship between nutrition and small-scale fishing.

The economic value : The overall income (i.e., landed value) of the catch obtained by women was determined using the catch estimates from women's fishing activities as derived above, in conjunction with country-specific ex-vessel pricing data [37]. The economic effect was then evaluated along the value chain, which included direct and indirect impacts from fisheries, using country-specific output multipliers [9]. One technique to account for the economic activity produced from the different secondary links to the fishing sector is to use output multipliers [9].

Challenges for development policy : Moving from gender and fisheries research to policy creation and implementation is another important barrier. Both fisheries and development policy should take gender into account. Over the last decade, those working on gender and fisheries have nearly universally agreed on the necessity for gender-disaggregated data in fisheries. The collecting of such data might be done quickly and simply. Governments might simply gather such data as part of routinely performed national census surveys. Women may be able to collect statistics on not just the number of fisherman, but also their gender and the various fishing-related roles as fishing cooperatives become increasingly inclusive of women i.e., financing, gear maintenance, processing, marketing, etc. Apart from gaining universal acceptability in fisheries management, the next difficulty is connecting women in fisheries to global development. The link to development will be easier to make now that the importance of women in fisheries is widely understood. Women's vital and special position in health, nutrition, population, and poverty reduction necessitates an examination of their role in all aspects of society. As part of a wider effort to address gender inequities, we've focused on their significant, yet under-represented role in fisheries. Unleashing the potential of women as full political, economic, and social actors in all sectors would help to advance development, raise living standards, and improve world health.

Conclusions

Women's contributions to fisheries, both directly and indirectly, are frequently disregarded in fisheries management, economics, and policy. As a result of these studies, policy decisions are made. Women's participation in fisheries is quantified here, with an emphasis on their contribution to total catch and economic value-added. This quantitative evaluation is ongoing. Their responsibilities range from harvesting and preparing seafood to selling and financing the industry. Women contribute considerably to the regular availability of protein in their families in many countries, and/or add major economic value to fish taken and landed by men through their influence in over-processing and marketing operations. Women's empowerment, increased engagement in management and stewardship, and challenges of food security and development would all benefit from quantifying and properly acknowledging this contribution.

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Residence Time Distribution and Flow Behavior Study of Horizontal Liquid-Full Scraped Surface Heat Exchangers Using Water

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Abstract

Residence time distribution, flow pattern and friction factor of horizontal liquid full scraped surface heat exchangers (LF-SSHEs) as influenced by mass flow rate, rotor speed, number of blades, ratio of diameter of rotating cylinder to that of inner stationary cylinder and pressure of liquid were investigated using tap water as test fluid. A saturated sodium chloride solution as a tracer of residence time was injected through an injector at the inlet of LF-SSHE flowing with tap water at steady state. The samples were collected after every 15 sec at the outlet and the conductivity of collected samples were measured. Due to higher range of Re_r/Re_{rc} from 21.30 to 220.57, the flow behavior in experiments had a combined axial and Taylor vortex flow away from transitional zone of rotational flow i.e. from vortical to turbulent. For small rotor assembly (d_s/d_t as 0.16) with set of 4 blades, the friction factor varies from 0.5807 to 1.2291, however, for large rotor assembly (d_s/d_t as 0.52); it varies from 0.0661 to 0.1514. This indicated that friction factor and power consumption is lower in large rotor assembly than that in small rotor assembly. With the increase of mass flow rate, d_s/d_t , pressure of liquid and number of blades, the value of mean residence time (t_{cbar}) and variance were decreased (P= 0.01), which exhibited flow towards plug flow or uniform treatment to each molecules of feed product. With the increase of rotor speed from 2.33 to 7.00 rps, the t_{cbar} and variance were increased, resulting in decreased in Peclet number (P= 0.05) causing less uniform heating/cooling treatments to food particles during processing.

Key words : *Taylor vortex and axial flow, axial dispersion coefficients, poiseuille flow, couette flow, taylor number, peclet number.*

Inroduction

The horizontal liquid full scraped surface heat exchangers (LF-SSHEs) have been frequently used in the food and chemical industry to heat or cool high viscosity and particulate liquid products. The temperature distribution, heat transfer characteristics and power requirements of LF-SSHEs depend on residence time distribution, flow pattern and friction factor. These are further being affected by the design and geometrical configuration apart from physical and thermal properties of fluids. It is well known fact that the real system will neither behave exactly as plug flow (i.e. velocity distribution is uniform and flat across the flow passage) nor as completely mixed flow (i.e. the properties of medium are uniform inside the heat exchanger including those at outlet). The flow pattern most often deviates from these two extreme conditions and residence time distribution (RTD) of the liquid elements flowing through LF-SSHEs is not uniform.

This is caused partly by the differences in the velocity along the length of different streamlines and partly by dispersion due to vortices and pumping effect caused by the scraper blades. With the change of flow patterns and RTD, the friction factor also varies, which influences the heat transfer and power requirements. Therefore, it is of paramount importance to study these parameters for a horizontal LF-SSHE to be used for forewarming or preheating operation.

Previous studies on RTD in a LF-SSHE (Blaisdell and Zahradnik, 1959; Chen and Zahradnik, 1967; Milton and Zahradnik, 1973, Bateson, 1971 and Trommelen and Beek, 1971) have shown the influence of process conditions on the RTD. Cuevas et. al. (1980) investigated the RTD in SSHE thermal processor in ultra high temperature range of 130°C, a step input was used and tracer concentration was monitored by sampling the outlet of the system at every 15 sec and measuring the absorbance at 600 nm in a Bausch and Lamb spectronic 20 spectrophotometer. The behaviour was observed to be somewhere between ideal laminar flow and plug flow, probably closer to plug flow.

Regarding flow pattern with axial flow in SSHE (Synder, 1962; Schwarz et. al., 1964; Martin and Payne, 1972; Sorour and Coney, 1979; Takeuchi and Jankowski, 1981, Gu and Fahidy, 1985) have shown the effects of operating conditions on the onset of torroidal vortex flow and the onset of Spiral flow. The friction factors for Poiseuille flow, Couette flow and combined Taylor vortex and axial flows have been studied by Simmers and Coney (1979).

The residence time distribution study was made using stimulus response technique and results have been envisaged by modeling statistically and also graphically. The models for experimental mean residence time, variance to show the spread of RTD, Peclet number and friction factors have been developed in the investigation to be used by the design programs for horizontal LF-SSHEs.

Materials and Methods

Process variables : Following independent process paramters were considered for the RTD study of horizontal LF-SSHE : Test fluid : Tap water

Flow rate : 50, 75, 100, 150 and 200 litres/hour i.e.

: 0.01368, 0.02052, 0.0271, 0.0407 and 0.0546 kg/s

Rotor speed : 2.33, 4.00 and 7.00 rps

Number of blades : 2 and 4.

Ratio of diameter of rotating shaft to dia. of staionary cylinder (d_s/d_t): 0.16 and 0.52

Liquid pressure : 0.5 kgf/cm^2 (29.4 KPa) and 1.5 kgf/cm^2 (147.1 KPa) gauge

Experimental Procedure : The experimental set up included the feed tank, rotameter, injecting device, horizontal liquid full SSHE, sample collecting valve and return line (Fig.-1). The RTD study was carried out at zero heat flux and the steady state was maintained by adjusting the back pressure needle valve and rotameter inlet valve to achieve the desired flow rate and pressure of liquid while keeping the scraper in rotation. After achieving the steady state flow, the return line was taken out of balance tank and saturated solution of sodium chloride was injected by syringe as a tracer input at the rubber cork equipped injection point in the inlet line of LFSSHE. Each time 15 ml of tracer input was injected through the injected device and its concentration was measured at the outlet by collecting the sample in the sample bottles at time interval of 15 sec. The conductivity of the samples (C_i) was measured with the help of a digital conductivity meter with respect to sampling time t_i. Just after the experiment, the hold up volume at different operating conditions was measured by suddenly stopping the pump and collecting working fluid from bottom lowest point of liquid full SSHE. The same amount of tracer (15 ml) was mixed with hold up volume (V) and its conductivity (Cbar) was measured.

Theory/Calculation

Charcterization of Flow Pattern : There has been an increasing theoretical and experimental interest in Taylor couette flow and Taylor vortex flow combined with axial flow in horizontal and vertical LFSSHE by Di Prima and Swinney, 1981 and Park et. al., 1983, Astill, 1964. Martin and Payne (1972) developed a relationship in Ta, Re_{ax}, d_s, d_t and a point z, where the first discernible ripple occurs. Ripple was reported to occur at Ta > Ta_z for $0.5 < d_s/d_t < 0.98$ and $0.01 < L < 0.15$, in which, T_{az} and L are defined as $T_{az} = 1150\ L^{-1.175}$ and $L = 4z/\{(d_t\text{-}d_s)\ Re_{ax}\}$. In the present hydrodynamic study, the flow pattern of water in isothermal condition in horizontal LFSSHE was studied based on evaluation of critical Taylor number (Ta_z) at which first torroidal vortice was formed in combined Taylor vortex flow depending upon the work of Martin and Payne (1972).

When axial Reynolds number (Re_{ax}) is less than 1800, the axial flow is said to be laminar otherwise, the axial flow is turbulent. However, the rotational flow is vortical when Taylor number is greater than critical Taylor number, otherwise, it is laminar. But the rotational flow is turbulent when rotational Reynolds number (Re_r) is greater than 100,000.

Evaluation of Friction factor : The friction factors for poiseuille flow, Couette flow and combined Taylor vortex and axial flows were determined on the basis of following expressions (Simmers and Coney (1979):

The friction factor for laminar fully developed axial flow (f_1) is defined as :

$$f_1 = {}_{w1}/(\ u_{av}^2/2) = 8(1 - d_s/d_t)/(A_c\ .\ Re_{ax}) \qquad ...(1)$$

where, ${}_{w1} = \mu^2\ .\ Re_{ax}/\{A_c.\ \ .\ d_s\ (d_t - d_s)/2\}$

The friction factor for coquette flow (f_2), if $d_s/d_t \quad 1$ is expressed as :

$$f_2 = {}_{w2}/(\ u_r^2/2) = 2(1\text{-}\ d_s/d_t)/v\{(\ d_s/d_t).Ta)\} \qquad ...(2)$$

In case of friction factor (f3) for combined Taylor vortex and axial flow, Simmer and Coney (1989) showed experimentally that ${}_{w3}/\ {}_{w1} = (Ta/Ta_c)\ 0.735$ and friction factor is expressed as follows :

$$f_3 = \{2\ (1 - d_s/d_t\ )^2/\ A_c\ .\ d_s/d_t\}\ (Re_{ax}/\ Ta)\ (Ta/\ Ta_c)^{\ 0.735} \qquad ...(3)$$

Characterization of RTD experiment : To describe the RTD, the plug flow with axial dispersion model and tank in series models are used with analytical and graphical approaches as applied by Levenspiel (1974) and Trommelen and Beek (1971). It is assumed that plug flow with axial dispersion model existed in LFSSHE i.e. the flow is essentially a plug flow on top of which some degree of back mixing or intermixing in axial direction is superimposed, which is represented by an expression similar to Fick's law as follows :

$$c\ /\quad = D_e\ {}^2c\ /\ \ x^2 \qquad ...(4)$$

$$c\ /\quad = (D_e uL)\ {}^2c\ /\ \ z^2 \quad\ c\ /\ \ z \qquad ...(5)$$

Where, the dimensionless group (D_e/uL), the axial dispersion number characterizes the RTD behaviour of the LFSSHE. The parameter uL/D_e is called as Peclet number, z = x/L and $\quad = t_i$/tbar = tu/L. The variance in residence time is presented by Aris (1959) in the following form:

$$^{2} = \ ^{2}/(tbar)^{2} = 2\,(D_e/uL) \qquad ...(6)$$

where, the mean hold time tbar was defined as follows :

tbar = hold up volume/volumetric flow rate

C ( ) = C_i / Cbar

= t_i/tbar

Mass flow rate = Wx x0.001/3600 ...(7)

Where, W is mass flow rate in litre/hour and ñ is density in kg/m^3

To characterize the experimentally determined RTD, software was written to calculate the experimental mean residence time t_{cbar}, variance, dispersion coefficient, axial dispersion number, peclet number and ratio of dispersion coefficient over kinematic viscosity of the fluid as a non dimensional number as follows :

$$t_{cbar} \quad t_i C_i \ / \quad C_i \qquad ...(8)$$

$$^{2} = (\ t_i^2 C_i \quad C_i) - (\ t_i C_i \quad C_i)^2 \qquad ...(9)$$

actual mean velocity u = L/tbar ...(10)

axial dispersion coefficient, $D_e = \ ^{2}\,u\,L/2$ ...(11)

Peclet number $P_e = uL/D_e = 2\,(tbar)^2/ \ ^{2}$ ...(12)

Applying tank in series model, the number of ideally mixed tanks in series equivalent to actual heat exchanger for particular flow condition was calculated as :

$$n_T = (tbar)^2/ \ ^{2} \qquad ...(13)$$

Statistical Analysis : Statistical analysis was done as per the procedure of Snedechor and Cochran (1967). The least square analysis was performed with analysis of variance for two way classification without interaction using following linear model (Harvey, 1975) :

$$Y_{ijk} = \quad + a_i + b_j + e_{ijk} \qquad ...(14)$$

Where, i=1,2,…….p

J=1,2,……..q

K=1,2,……..n_{ij}

Y_{ijk} =Kth observation in jth B class and ith A class

=Overall mean

a_i=effect of the ith class

b_j=effect of the jth class

e_{ijk}=random errors

Duncan's multiple range test was used to estimate significant difference among means at the 5 % probability level (Duncan, 1955).

Results and discussion

Flow pattern in Liquid full horizontal SSHE in isothermal condition : A fortran software was developed to analyse the RTD parameters and non dimensional flow numbers. Results revealed that the Taylor number was much higher than the critical Taylor number (Ta_z) estimated from relationship of Martin and Payne (1972). Ta_z calculated at an interval of 0.10 meter from the inlet in longitudinal direction was decreasing with the increase of axial distance (z) and also with the decrease of value of axial Reynolds number (Re_{ax}) (Fig. 2.0 and 3.0). It was indicated from result that the experiment had a combined axial and Taylor vortex flow away from transitional zone of rotational flow i.e. from vortical to turbulent. It was resulted due to the fact that the Taylor number (7.5×10^7 to 4.6×10^8) observed were much higher than critical Taylor number ranging from 24184 to 125208, while the value of Re_r/Re_{rc} ranged from 21.30 to 220.57. As Harrod (1990) indicated the values of Re_r/Re_{rc} greater than 1.2 in vertical LFSSHE for representing the flow closer to plug flow, the flow in this study was not close to plug flow but closer to transition zone related to conversion of rotational flow from vortical to turbulent. Such a flow structure was highly complex and the effects of flow pattern on several engineering aspects such as axial dispersion, friction factors and residence time distribution and thereby heat induced changes in the manufactured products and energy requirements are of much significance.

Back Mixing in Liquid full horizontal SSHE in Isothermal condition : Axial dispersion coefficients measured in RTD experiment, being the measure of back mixing or intermixing, were correlated empirically in the following form for water for large rotor assembly in LF-SSHE :

$$D_e/ \ = 0.025\,(Re_r/Re_{rc})^{0.994}\,(Re_{ax})^{1.182} \qquad ...(15)$$

Where,

d_s/d_t = 0.52 and B = 4

26 Re_r/Re_{rc} 153.5

171 Re_{ax} 726

The correlation coefficient was 0.60 and t-test indicated that Re_r/Re_{rc} and Re_{ax} significantly regressed at P= 0.01 to ratio of axial dispersion coefficient and kinematic viscosity (D_e/í). However, for small rotor assembly in horizontal LF-SSHE, the empirical for back-mixing was developed as :

$$D_e/ \ = 3.78\,(Re_r/Re_{rc})^{0.574}\,(Re_{ax})^{1.46} \qquad ...(16)$$

Where,

d_s/d_t = 0.16 and B = 4

21 Re_r/Re_{rc} 100

192 Re_{ax} 657

The correlation coefficient was 0.50 and t-test indicated that Re_{ax} significantly regresses at P= 0.05 but Re_r/Re_{rc} did not significantly regressed D_e/ in small rotor. Therefore, the back mixing can be reduced or plug flow condition can be improved by increasing the mass flow rate or Re_{ax} easily in large rotor than small rotor as the coefficient is less in large rotor. The radial mixing or increase in Re_r/Re_{rc} reduces plug flow condition and increases axial dispersion more significantly in large rotor assembly. Therefore, at minimum rotor speed, the flow pattern tends to follow plug flow pattern in comparison to high rotor speed.

Friction factor in Liquid full horizontal SSHE in isothermal condition : The friction factor for flow of water in horizontal LFSSHE was correlated as follows :

$$f = 0.379\,(d_s/d_t)^{-1.671}(B)^{0.0016}(Re_r/Re_{rc})^{-0.516}(Re_{ax})^{-0.0478} \quad ...(17)$$

where, $0.16 < d_s/d_t < 0.52$

$2.10 < Re_r/Re_{rc} < 220.57$

$87.68 < Re_{ax} < 657.28$

$2 < B < 4$

The correlation coefficient was 0.998 at P = 0.01. The t-test of partial regression coefficients indicated that d_s/d_t and Re_r/Re_{rc} regressed significantly at P = 0.001 and Re_{ax} regressed significantly at P = 0.01, however, B did not significantly regressed friction factor. The values of friction factor vary from 0.05792 to 1.2291 for the range of parameters given above. For small rotor assembly (d_s/d_t as 0.16) with set of 4 blades, the friction factor varies from 0.5807 to 1.2291, however, for large rotor assembly; it varies from 0.0661 to 0.1514. This indicated that friction factor and power consumption is lower in large rotor assembly than that in small rotor assembly. This is due to fact that there is increase in annular area and back mixing effects in small rotor assembly. Higher the flow was away from laminar rotational flow zone lower was the friction factor and thereby reduction in power consumption in LFSSHE system. The exponent of d_s/d_t had negative value of -1.671 which indicated that large rotor assembly had lower friction factor than that in small rotor assembly. Another expression for friction factor was developed in the following Cobb Douglas form keeping the number of blades (B) and d_s/d_t as constant :

$$f = a\,(Re_r/Re_{rc})^{b1}\,(Re_{ax})^{b2} \quad ...(18)$$

The constant, exponents and correlation coefficients for the above model are presented in table-1 for different range of variables, blade numbers and d_s/d_t. b_1 and b_2 both are negative and significant at P = 0.01. Re_{ax} affects more in decreasing the friction factor than Re_r/Re_{rc} as per the table-1.0

Residence time distribution (RTD in Liquid full horizontal SSHE) in isothermal condition : Least square analysis was performed to see the effects of d_s/d_t, Number of blades (B), rotor sped (N) and flow rates on RTD characteristics at constant pressure of 147.1 KPa gauge (Table- 2). The effects on RTD characterizing parameters as influenced by independent variables are summarized as follows:

Effects of variables on experimental mean residence time : With the increase of flow rate from 0.01368 to 0.05472 kg/s, the value of t_{cbar} was decreased from 235 to 94 sec. (P= 0.01). Duncan multiple range test (DMRT) test indicated significant difference among all the flow rate levels at P= 0.05. It was not significantly affected by rotor speed (N). With the increase of rotor speed from 2.33 to 7.00 rps, the t_{cbar} was increased from 160 to 176.3 sec. An increase in d_s/d_t from 0.16 to 0.52 decreased the t_{cbar} from 177.6 to 147.4 sec significantly (P= 0.01). Similarly, an increase in number of blades from 2 to 4 significantly decreased the t_{cbar} from 177.3 to 147.7 sec. (P= 0.01). Table 2.0 indicated a decrease in t_{cbar} from 182 to 147 sec. with the increase of pressure from 29.42 to 147.1 KPa gauge and the effect was significant at P= 0.01. The correlation developed for experimental mean residence time (t_{cbar}) in LF-SSHE with water was :

$$t_{cbar} = -197.85 + 197.77\,d_s/d_t + 462\,B - 27.34\,N - 9162.82\,M_f - 477.5\,(d_s/d_t)^2 - 76.68\,(B)^2 + 3.10\,N^2 + 62314.6\,M_f^2 - 45\,(d_s/d_t)\,B + 41\,d_s/d_t\,N + 8.49\,d_s/d_t\,M_f - 4.0\,B.N + 467\,(B)(M_f) + 1.4\,(N)(M_f) \quad ...(19)$$

The correlation coefficient (R^2) was 0.8279. The partial regression coefficients along with t-values are given in table-3. Mass flow rate significantly decreased the mean residence time at P=0.01. The interaction effect of d_s/d_t and N increases the residence time at P= 0.05.

Effects of variables on variance in residence time : Variance in residence time (^{2}) was significantly reduced by mass flow rate and pressure (P= 0.01), however, d_s/d_t, rotor speed and blade number affect variance significantly at P= 0.05. DMRT indicated significant difference from 7.00 rps with other two levels (P = 0.05). No significant difference was indicated between 2.33 and 4.00 rps rotor speed in regards of variance but significant difference existed between 2.33 and 7.00 rps. With the increase of mass flow rate from 0.01368 to 0.05473 kg/s, the variance was decreased from 18833 to 3395 significantly (P= 0.01). DMRT indicated significant difference from 0.01368 to 0.02736 but no significant difference between two close low levels of flow rate was indicated at P = 0.05. Lee *et. al.,* 1995 also observed that an increase in rotor speed

Table-1 : Intercept and partial regression coefficients for predicting friction factor of water according to model $f = a (Re_r/Re_{rc})^{b1} (Re_{ax})^{b2}$

Sl. No.	Constant	Exponents		Range of variables				Corr. Coeff. R^2
	a	b1	b2	d_s/d_t	B	Re_r/Re_{rc}	Re_{ax}	
1.	1.513	-0.53**	-0.09**	0.52	2	31-221	87-430	0.998**
2.	1.135	-0.06**	-0.06**	0.52	4	26-154	170-726	0.997**
3.	6.738	-0.02NS	-0.02NS	0.16	2	21-104	239-604	0.990**
4.	10.999	-0.53**	-0.09**	0.16	4	21-100	192-657	0.999**

** : P = 0.01, NS : Not significant

Table-2 : Least square means of RTD characterizing parameters in horizontal LF-SSHE.
Fluid : water Pressure of liquid : 1.5 kgf/cm^2 (147.1 Kpa) gauge

Effects	Observations (LS Means ± S.E.)			
	Mean residence time, t_{cbar}	Variance, ^{2}	Peclet No. (Pe)	No. of ideally mixed tank in series (n_T)
Overall Mean (μ)	163 ± 4.74	11342 ± 1148	2.72 ± 0.21	1.42 ± 0.21
d_s/d_t	**	*	*	*
0.52	147 ± 6.70	10845 ± 1624	3.26 ± 0.43	1.64 ± 0.22
0.16	178 ± 6.70	11838 ± 1624	2.19 ± 0.43	1.20 ± 0.23
No. of Blades, (B)	**	*	*	*
2	177 ± 6.70	14082 ± 1624	2.41 ± 0.43	1.31 ± 0.22
4	148 ± 6.70	8601 ± 1624	3.04 ± 0.43	1.53 ± 0.22
Rotor speed (N), rps	NS	*	*	*
2.33	161 ± 8.21^a	9233 ± 1989^a	3.24 ± 0.53^a	1.72 ± 0.27^a
4.00	151 ± 8.21^{ab}	9387 ± 1989^a	2.79 ± 0.53^a	1.48 ± 0.27^a
7.00	176 ± 8.21^a	15405 ± 1989^b	2.14 ± 0.53^a	1.07 ± 0.27^a
Flow rate (M_f), Kg/s	**	**	NS	NS
0.0135	235 ± 10.60^a	20791 ± 2568^a	3.70 ± 0.68^a	2.11 ±0.35^a
0.0202	202 ± 10.60^b	15946 ± 2568^{ab}	2.72 ± 0.68^a	1.41 ± 0.35^a
0.0271	175 ± 10.60^c	10825 ± 2568^{bcd}	2.63 ± 0.68^a	1.31 ±0.35^a
0.0407	117 ± 10.60^d	5399 ± 2568^c	2.51 ± 0.68^a	1.25 ±0.35^a
0.0546	94 ± 10.60^e	3746 ± 2568^{cd}	2.01 ±0.68^a	1.03 ±0.35^a
Pressure of liquid	**	**	*	*
147.1 KPa (1.5 Kgf/cm^2)	147±6.31	8589±1112	3.05±0.29	1.51±0.15
29.42 KPa (0.3 Kgf/cm^2)	182±6.42	14207±1130	2.19±0.30	1.09±0.15

* : P = 0.05; ** : P = 0.01; NS : Not significant, LS means within column with same subscripts did not differ significantly at P = 0.05 for each effects.

significantly increased the variance regardless of particle concentration resulting broader distribution in C( ) vs curve. This is because of back mixing and channeling which may be taken place at increasing degree with increasing in rotor speed and decrease in flow rate beyond the optimum. The variance as influenced by d_s/d_t, rotor speed (N), blade number (B) and mass flow rate (M_f) was correlated in box Wilson model as follows :

$$^2 = -54764.28 + 16.59\, d_s/d_t - 16.88\, B + 0.584\, N - 126.81\, M_f - 19.88\, (d_s/d_t)^2 + 2.67\, (B)^2 + 0.0107\, N^2 + 950.67\, M_f^2 + 1.78\, (d_s/d_t)\, B - 1.64\, d_s/d_t\, N + 58.98\, (d_s/d_t)\, .M_f - 0.00247\, (B).(N) + 19.71\, (B)(M_f) + 10.60\, (N)\, (M_f) \quad ...(20)$$

The correlation coefficient was 0.70. The t – test of partial regression coefficients for above model is shown in table-4.

Effects of variables on Peclet number and number of ideally mixed tank in series : Table 2.0 indicated a significant increase from 2.19 to 3.26 of Peclet number when d_s/d_t increased from 0.16 to 0.52 and increase form 2.19 to 3.05 with the increase of pressure from 0.3 to 1.5 Kgf/cm^2 (P=0.01). Similarly, rotor speed significantly reduced the Peclet number from 3.24 to 2.14 (P=0.05). Peclet number and number of ideally mixed tank in series were not significantly affected by mass flow rate at P=0.05 but were significant at P= 0.25. Though the Peclet number decreased from 3.70 to 2.06 with the increase of mass flow rate but DMRT indicated no significant difference among the flow rate on plug flow condition. Selected RTD curves showing flow closer to plug flow as influenced by flow rates in the form of C(è) vs è were shown in Fig. 4.0 for large rotor assembly and Fig. 5.0 for small rotor

Table-3 : Intercept and partial regression coefficients of Box Wilson model for experimental mean residence time during RTD of water in horizontal LF-SSHE.

Coefficients	Mean residence time t_{cbar} = f (d_s/d_t, B, N, M_f)	
	Intercept and partial regression coefficients	t-value
a_0	-197.85	-
a_1	197.77	1.15^{NS}
a_2	462.09	0.06^{NS}
a_3	-27.34	1.43^{NS}
a_4	-9162.82	4.42**
a_{11}	-477.47	1.50^{NS}
a_{22}	76.68	0.06^{NS}
a_{33}	3.10	1.76^{NS}
a_{44}	62314.60	2.55*
a_{12}	-45.02	1.97^{NS}
a_{13}	40.58	3.43**
a_{14}	8.49	0.01^{NS}
a_{23}	-4.02	1.89^{NS}
a_{24}	466.66	1.67^{NS}
a_{34}	1.41	0.01^{NS}
R^2	0.83**	
No. of observations	60	

* : P = 0.05; ** : P = 0.01; NS : Not significant

Table-4 : Intercept and partial regression Coefficients of Box Wilson model for variance during RTD of water in horizontal LF-SSHE.

Coefficients	Variance, ^{2} = f (d_s/d_t, B, N, M_f)	
	Intercept and partial regression coefficients	t-value
a_0	-54764.28	-
a_1	16.59	0.20^{NS}
a_2	-16.88	0.04^{NS}
a_3	0.58	0.00^{NS}
a_4	-126.81	2.48**
a_{11}	-19.88	0.12^{NS}
a_{22}	2.67	0.04^{NS}
a_{33}	0.011	0.97^{NS}
a_{44}	950.67	1.87*
a_{12}	1.78	1.83^{NS}
a_{13}	-1.64	2.84**
a_{14}	58.98	0.59^{NS}
a_{23}	-0.00	2.37^{*}
a_{24}	19.71	1.85^{NS}
a_{34}	10.60	1.51^{NS}
R^2	0.70**	
No. of observations	60	

* : P = 0.05; ** : P = 0.01; NS : Not significant

assembly. In large rotor assembly for four blade, and liquid pressure of 147.1 KPa, the RTD curve is narrower or flow is closer to plug flow at 0.02736 (i.e. 100 lt/hr) flow rate of water for 2.33 rps and then followed by 4.00 and 7.00 rps. For flow rate lower and higher than this, the flow is more away from plug flow characteristics. In small rotor assembly for four blade, and liquid pressure of 147.1 Kpa, the RTD curve is narrower or flow is closer to plug flow at 0.02052 (i.e. 75 lt / hr) flow rate of water for 2.33 rps and then followed by 4.00 and 7.00 rps. For flow rate lower and higher than this, the flow is more away from plug flow characteristics. This indicated that there exists an optimum condition of mass flow rate beyond which, the flow tends to mixed flow condition.

Conclusions

It was indicated from the experiments that the flow pattern in horizontal liquid full SSHEs is a combined axial and Taylor vortex flow away from transitional zone of laminar to Vortical flow as the value of Re_r/Re_{rc} ranged from 21.30 to 220.57. The back mixing can be reduced or plug flow condition can be improved by increasing the mass flow rate or Re_{ax} easily in large rotor (i.e. d_s/d_t = 0.52) than small rotor as the coefficient is less in large rotor. The radial mixing or increase in Re_r/Re_{rc} reduces plug flow condition and increases axial dispersion more significantly in large rotor assembly. The results indicated the higher influence of rotor speed**,** d_s/d_t, and number of blades than mass flow rates on Peclet number. Least square means of Peclet number were slightly decreased with the increase of flow rate and had no significance at P= 0.05. At lower speed of rotor (2.33 – 4.00 rps), low flow rates of 75-100 ltrs / hr (i.e. 0.02052 – 0.0271 kg/s), blades number as four and high pressure of 1.5 kgf/cm^2 gauge, the plug flow was achieved with greater values of Peclet number for large rotor assembly (d_s/d_t =0.52) for water in horizontal LF-SSHEs. The results indicated that friction factor and power consumption is lower in large rotor assembly than that in small rotor assembly. This is due to fact that there is increase in annular area and back mixing effects in small rotor assembly. The models developed for mean residence time, variance, D_e/í and friction factor will be useful in analyzing the RTD behaviour under some operating parameters using computer softwares.

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Nomenclature

A_c=Cross sectional area of flow, m^2

B=Number of Blades in rotor

d_t=Inside diameter of static cylinder shell in LF-SSHE, m

d_s=Outside diameter of rotating shaft in Lf-SSHE, m

D_e=Axial dispersion coefficients, m^2/s

f=friction factor in Lf-SSHE

L=Effective length of LF-SSHE

M_f=Feed rate of test fluid, kg/s

n_T=Number of ideally mixed tank in series

N=Number of Blades in rotor

tbar=Mean residence time calculated from volumetric hold-up of test fluid

tcbar=Mean residence time = $t_t C_i \quad C_i$

Re_{ax}=Axial Reynolds Number, $u(d_t - d_s) \quad /$

Re_r=Rotational Reynolds number, $Nd_t^2 \quad / \quad _a$

Re_{rc}=critical rotational Reynolds Number,

$$\sqrt{\ }\{2Ta_c(d_t+d_s)d_t^4\}/\{\ ^2(d_t - d_s)^3 d_s^2\}$$

Ta=Taylor Number, $\{\ Re_r^2(d_t - d_s)^3 d_s^2]/[2(d_t+d_s)d_t^4]$

Ta_c, Ta_z = Critical Taylor Number

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Studies on Combining Ability in Rice (*Oryza sativa* L.)

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Abstract

Rice is the foremost food crop among cereals and it is the staple food crop providing high calories for the people of South and South East Asia. To maintain the same level of self-sufficiency, the rice production should be increased to sixty percent by the year 2020. (Daniel, 2000). Hence urgent need to enhance the rice production both at national and global levels. This can be achieved by maximizing yield in low and medium productivity areas or by the exploration of new methods and development of hybrids with superior adaptability and yield. Yield and its attributing characters were studied among 40 genotypes. Among the parents, IR 28 and Pusa 3A (L3) were found to be good general combiners for grain yield per plant and its related characters. The cross IR 58025 x ASD 16 exhibited higher per se performance for most of the characters studied, whereas IR 58025 x ASD 19 recorded highest mean values for panicle length and grain yield. All the ten characters revealed higher sea effects for all the crosses indicating the predominance of non- additive gene action.

Key words : *General combining ability, specific combining ability, rice.*

Introduction

Rice (*Oryza sativa* L. 2n=24) is the staple food crop providing 35-99 per cent of the total calorie intake of people in South and South-East Asia. In India rice is grown in 43.86 million ha, the production level is 104.80 million tonnes and the productivity is about 2390 kg/ha (Agricultural Statistics at a glance-2020). The area under rice crop was 30.81 million/ha in 1950-51 which has increased to 43.86 million/ha during 2020-21 which is 142 per cent higher. Increase in the genetic yield level became a quiet challenging task as the yield of high yielding varieties, have reached to a yield plateau under tropical conditions (Cassman *et al.,* 1995).

Combining ability analysis helps in the evaluation of lines in terms of their genetic value and the selection of suitable parents for hybridization. It also helps in the identification of superior cross combinations. The Line x Tester analysis (Kempthorne, 1957) provides information about general combining ability (gca) of parents and specific combining ability (sca) effects of crosses and is helpful in estimating various types of gene actions.

Materials and Methods

The present investigation was carried out at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai nagar, during the period of 2020-2021. The material consisted of 40 genotypes of rice, including three cytoplasmic male sterile/ maintainer lines.

The experiment was raised in Randomized Block Design, during September 2020-January 2021. Observations were recorded on ten randomly selected plants for each replication. Total of seventeen characters such as days to first flower, plant height, productive tillers per plant, panicle length, grains per panicle, 1000 grain weight, grain yield per plant, grain length, grain breadth, grain L/B ratio, kernel length, kernel breadth, kernel L/B ratio, milling recovery, head rice recovery, amylase content, alkali spreading value.

The mean values were compared for each genotype over two replications for each cross. The variances and the corresponding standard errors of the mean were computed from the deviations of the individual values (Panse and Sukhame, 1964). The procedure outlined by Kempthrone (1957) was followed for the Line x Tester analysis. The gea and sea effects were estimated using the following method

$Xijk = \mu + \hat{g}i + \hat{g} + \hat{s}_{ij} + \hat{e}_{ijk}$

Where,

= Population mean

$\hat{g}_i$ = gca effect of the i^{th} line

$\hat{g}$ = sca effect of the j^{th} tester

$\hat{s}_{ij}$ = sca effect of ij" hybrid combination

$\hat{e}_{ijk}$ = error associated with ijkt observation

i = number of lines

j number of testers

k = number of replications

Result and Discussion

The ANOVA showed significant differences among

Table-1 : ANOVA of combining ability variance for ten yield and grain quality characters.

Source	Days to first flower	Plant height	Productive tillers per plant	Panicle length	Number of grams per panicle	1000 grain weight	Grain yield per plant	Grain length	Grain breadth	Grain LIB ratio
GCA	1.67	0.01	0.25	0.07	4.46	-0.0005	0.41	0.00	0.0012	0.0004
SCA	59.82	-19.05	4.17	0.71	156.84	1.97	29.60	0.02	0.0178	0.0142
GCA/SCA	0.027	0.0005	0.059	0.098	0.028	0.002	0.013	0.00	0.064	0.028

Table-2 : General combining ability effects of the parents.

Parents	Days to first flowering	Plant height	No. of productive tillers/plant	Panicle length	No. of grains/ panicle	1000 grain weight	Grain Yield / plant
L1	7.22	-0.26	0.06	0.83**	9.57**	0.51**	2.77**
L2	-1.88**	-3.20**	-1.94*	-0.97**	-0.73	-0.63**	-3.58
L3	-5.33**	3.40**	1.88**	0.14	-8.83	0.12	0.87*
L1	-1.38	2.03*	2.68*	0.34	7.27**	0.09	5.92**
T2	-2.22*	2.02*	-1.37**	1.19**	-6.57**	-0.37	2.67**
T3	4.62**	0.20	1.94**	1.22**	1.93**	0.52	1.85**
T4	5.12**	-8.13**	-2.27**	-1.72**	-3.73**	0.24	-4.24**
T5	3.12**	-4.99**	1.58**	-0.66**	-2.07**	-0.28	-1.77**
T6	3.28**	0.87	0.36	-0.66**	6.93**	-0.70*	-2.09**
T7	-6.22**	-8.30	-2.83**	-0.19	-13.90**	-1.02**	-2.09**
T8	-9.88**	8.37*	-2.17**	-1.34**	-10.07**	1.63**	-2.34**
T9	4.78**	5.70	1.78**	0.84**	17.77**	0.16	5.01**
T10	-1.22*	2.03	0.33	0.98**	2.43**	-0.27	-2.92**

phenotypes, for all the ten traits viz, days to first flower, plant height, productive tillers. per plant, panicle length, number of grain per panicle, 1000 grain weight, grain yield per plant, grain length, grain breadth, grain L/B ratio. The greater magnitude of SCA variance than GCA variance indicated the role of non additive genes. The magnitude of additive variance was much greater than dominance variance for all the characters both when F= 0 and F-1 there by indicating the predominant role of additive gene action in the expression of the characters

The mean performance of three lines, ten testers and thirty hybrids for Days to first flower was 72.00 days (L_1) and among testers (78.00) days), plant height ranged from 84.00 (L_2) to 96.00 cm (L_1) and T_8 (62.00 cm) was significant. The number of productive tillers ranged from 16.62 (T_8) to 33.03 (T_1). The tester T_3 registered the maximum panicle length of 26.33 cm. For filled grains per panicle the parents L_3 (149.50) exhibit significant positive value over the parental mean of 131.69. For 1000 grain weight, the mean values ranged from 18.09 g (L_2) to 27.02 g (T_8). Positive and significant values for grain yield per plant was higher than the hybrid mean (36.57 g) were observed in L_3 (38.41 g), T_5 (44.98 g). T_{10} (40.92 g) and T_2 (46.52 g). The mean performance for grain length ranged from 8.00 mm to 8.15 mm. For grain breadth the mean ranged from 2.45 mm (L_2) to 3.07 mm (L_1). The mean performance for grain L/B ratio ranged from 2.71 (L_1) to 3.25 (L_3).

The gca effects of the lines for days to first flower ranged from -5.33 (L_3) to 7.22 (L_1), for testers, the range was from -9.88 (T_8) to 5.12 (T_4). For plant height it ranged from -3.20 (L_2) to 3.40 (L_3) gca effects for testers ranged from -8.30 (T_7) to 8.37 (T_8). Productive tillers per plant the lines L_3 (1.88) had the maximum significant and positive gca effect while testers T1, T3, T5, and T9, had positive and significant gca effects. The highest sca effect was noticed in the cross L2 x T8, significant and positive effects were observed in only four out of thirty combinations. Among the lines, for panicle length the range of gca effects varied from -0.97 (L2) to 0.83 (L1),in testers was from -1.72 (T4) to 1.22 (T3). The highest sca effects were noticed in the crosses L2 x T8 (1.76) and L3 x T7 (1.19). For filled grains per panicle the line Li exhibited significant gea effect while testers T1, T3, T6, T9 and T10 had significant and positive gca effects. Eleven out of thirty hybrids exhibited significant and positive sca effects. In 1000 grain weight the lines had a range of -0.63 (L2) to 0.51 (L1) and significantly positive sca effect was observed in the line Li only. The gca effects of testers varied from -1.02 (T7) to 1.63 (T5). Grain yield per plant has the highest gca effect in L1 (2.77) while L2 recorded lowest value (-3.58). All the testers showed significant gca effects while T4, T5, T6, T7, Ts and T10 exhibited significantly negative gca effects. The gca effect of lines for grain length ranged from -0.10 (L2) to 0.14 (L3) and for

Table-3 : Specific combining ability effects of the hybrids.

Parents	Days to first flowering	Plant height	No.of productive tillers/ plant	Panicle length	No. of grains/ panicle	1000 grain weight	Grain Yield / plant
L1XT1	-1.72	-2.13	2.24**	-0.11	2.93*	-0.23	0.13
L1XT2	-5.88**	-3.80**	-1.24*	-0.38	-3.73**	-0.28	-0.13
L1XT3	4.28**	2.20	0.13	-0.11	-1.73	0.27	3.72
L1XT4	5.78**	-1.47	-0.04	-0.31	-2.07	-0.03	-1.30
L1XT5	-1.22	-0.13	-0.59	-0.47	0.27	-0.41	1.51
L1XT6	9.22**	-2.47*	1.67*	0.61	-9.73**	1.88**	-0.46
L1XT7	1.12	13.70**	0.67	0.63	21.60**	-1.17	-0.57
L1XT8	-16.22**	0.53	-3.06**	-0.71*	-15.73**	0.03	-6.41**
L1XT9	5.12*	-5.30*	0.60	0.58	4.93**	1.30**	2.41*
L1XT10	-0.38	-1.13	-0.33	0.29	3.27**	-1.37**	1.10
L2XT1	1.88	-1.13	1.15	0.53	-0.27	-0.07	-0.08
L2XT2	3.72*	-1.80	0.40	0.23	-2.93*	-0.15	-0.64
L2XT3	-3.62*	-3.80**	-1.11	-0.16	2.57*	-0.94*	4.58*
L2XT4	-2.62	-4.47**	0.22	0.09	-1.27	0.06	1.09
L2XT5	1.38	-0.63	-0.06	0.36	1.07	-0.11	0.96
L2XT6	-5.28**	4.03**	-3.30**	-0.87*	1.07	-1.87**	-5.16**
L2XT7	-6.78**	16.20	-0.75	-1.82**	-15.60**	2.56**	-6.71**
L2XT8	17.88**	-6.97*	4.97**	1.76**	32.57**	-0.66	12.30**
L2XT9	-10.28**	3.20**	-1.90**	0.60	-9.77**	-1.86**	5.79**
L2X10	3.72*	-4.63**	0.38	-0.71*	-7.43**	3.02**	-0.55
L3XT1	-0.17	3.27**	-3.38**	-0.41	-2.67*	0.29	-0.05
L3XT2	2.17	5.60*	0.84	0.15	6.67**	0.42	0.77
L3XT3	-0.67	1.60	0.98	0.28	-0.83	0.67	-8.31**
L3XT4	-3.17*	5.93*	-0.12*	0.23	3.33**	-0.03	0.21
L3XT5	-0.17	0.77	0.65	0.11	-1.33	0.52	-2.46**
L3XT6	-3.83*	-1.57	1.63*	0.27	8.67**	-0.02	5.62**
L3XT7	5.67**	-29.92*	0.07	1.19**	-6.00**	-1.39**	7.27**
L3XT8	-1.67	6.43*	-1.90**	-1.04**	-16.83**	0.63	-5.88**
L3XT9	5.77**	2.10	1.29	-1.18**	4.83**	0.56	23.38**
L3XT10	-3.33*	5.77*	-0.06	0.41	4.17**	-1.65**	-0.55

testers the range was from -0.19 (T5) to 0.17 (T2), whereas five hybrids recorded sca effects.

The gca effects of lines for grain breadth varied from -0.12 (L2) to 0.14 (L3). L2 and L3 exhibited significant gca effects. The gca effects of testers ranged from -0.28 (T7) to 0.18 (T9). The gca effects of lines varied for grain L/B ratio varied from -0.12 (L3) to 0.09 (L). L, showed positive significant gca effect and L3 showed negative significant gca effects. The sca effects for this trait varied from -0.33 (L3 x T6) to 0.22 (LI X T8).

Good general combiner for various traits were also been reported by Chakraborty et al. (2009), Waghmode et al. (2011), Utharasu and Anandakumar (2013) and Kolom *et al,.* (2014) and S. C. Gosh *et al.,* (2020)

The gene action is decided by the ratio of GCA and SCA variance. The ratio of GCA and SCA were less than unity revealed the predominance of dominance gene action for all the drought tolerant and yield attributing traits. This result is in accordance with the earlier findings of Suresh *et al.* (2013) for grain yield and productive tillers per plant, Utharasu and Anandkumar (2013) for dry root weight and root/shoot ratio, Yogameenkshi and Vivekanandan (2015) for productive tillers per plant, panicle length, filled grains per panicle and 100 grain weight, Sathya and Jebaraj (2013) for drought and related character, Karpagam et al. (2016) for 70 % relative water content, dry root weight, root length, root thickness, root volume and root/shoot ratio.

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Effect of Supplementation of Moringa Leaf Powder in Nutrient Utilization on Pratapdhan Chicken under Organic Management System

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Abstract

An experiment was conducted at Poultry Farm, Department of Animal Production, Rajasthan College of Agriculture, MPUAT Udaipur (Rajasthan) to find out the Effect of supplementation of Moringa Leaf Powder on growth and production performance of Pratapdhan chicken under organic management system. Three hundred sixty Pratapdhan chicks of 4 weeks were utilized for a period of 22 weeks (12 week for growth and 10 week for egg production). The chicks were wing banded and distributed randomly in six treatment groups, consisting of 60 chicks in each treatment group with three replication of 20 birds each. Six treatment compared were, T_1: Control (conventional feed), T_2: Feed of organic origin, T_3: Feed of organic origin + 2.5% Moringa Leaf Powder, T_4: Feed of organic origin + 5% Moringa Leaf Powder, T_5: Feed of organic origin + 7.5% Moringa Leaf Powder, T_6: Feed of organic origin + 10% Moringa Leaf Powder. Experiment results revealed that, supplementation of various levels of MLP supplemented diets had comparable body weight gain and feed conversion ratio (FCR) during 16th week, whereas MLP 2.5 and 5% diets have improved the body weight gain and FCR (P 0.05) with an enhanced overall (P 0.05) growth performance. The dry matter digestibility coefficient, ether extract digestibility coefficient, crude protein digestibility coefficient, crude fiber digestibility coefficient and NFE digestibility coefficient was significantly higher in the birds fed 5% Moringa Leaf Powder included diets as compared to the control and 10% MLP during growth period. The data revealed that all parameters of carcass traits in different treatments were significantly different except organ weight which was found to be non-significant. However, the live weight, dressed weight, eviscerated weight and dressing weight (%) of supplemented diet fed 5% (T_4) MLP birds was significantly higher ($P<0.05$) than control.

Key words : *Nutrition, moringa oelifera leaf powder, digestibility coefficient, crude protein, organic management, pratapdhan chicken*

Introduction

India has largest livestock population in the world. The livestock plays vital role in the economy of Indian farmers. In the 20th Livestock Census, the total poultry population in India is 851.81 million, which is 16.8 per cent higher than the numbers in the 19th Livestock Census.The total backyard poultry in the country is 317.07 million in 2019, increased by 45.8 per cent over previous Census.

In Rajasthan total poultry population is 14.6 million (20th livestock census). Which about 2 per cent of India.Rajasthan ranks 17th in poultry population in India. Out of total poultry population, 37.8 per cent is under backyard production system in Rajasthan. However, the southern Rajasthan has about 16.30per cent of total poultry of Rajasthan and it also has 41.20per cent of total poultry of Rajasthan under backyard system.

According to FAOSTAT production data (2020), India ranks 3rd in egg production and 8th in meat production in the world. Egg production in the country has increased from 78.48 billion in 2014-15 to 122.11 billion in 2020-21. The per capita availability of egg was 91 eggs in 2020-21. Meat production in the country has increased from 6.69 million tonnes in 2014-15 to 8.80 million tonnes in 2020-21 (Economic Survey, 2021-22). The agriculture sector has experienced buoyant growth in the past two years. The sector, which is the largest employer of workforce, accounted for a sizeable 18.80 per cent (2021-22) in Gross Value Added (GVA) of the country registering a growth of 3.60 per cent in 2020-21 and 3.90 per cent in 2021-22. Growth in allied sectors including livestock, dairying and fisheries has been the major drivers of overall growth in the sector. The livestock sector has grown at a CAGR (compound annual growth rate)of 8.15 per cent over the last five years ending 2019-20. Livestock sector contributed 4.35 per cent of total GVA in 2019-20 (Economic Survey, 2021-22).

Research Methodology

The present research entitled "Effect of supplementation of Moringa Leaf Powder in Nutrient utilization on Pratapdhan chicken under organic management system" was conducted for a period of 22 weeks (12 week for growth and 10 week for egg production). Nutrient utilization metabolic trial was conducted at 16and at 28th week age. From each treatment the 6 birds were randomly selected and shifted in cage. The birds were individually fed with experimental treatment diet. The birds were given adaptation period of 6 days followed by 3 days collection of excreta voided. During the collection period quantity of feed offered, feed left over and excreta voided were recorded and taken for determination of nutrient utilization. The quantity of excreta voided by individual treatment bird was collected and weighed quantitatively after every 24 hours at 8:00 a.m. Representative feed samples were collected for proximate analysis. Similarly aliquot of faecal sample were also processed for nutrient analysis. The proximate principle in the feed and faeces were analysed as per AOAC, 2003.

The digestibility of nutrients was calculated using following formula.

Digestibility percentage

$$= \frac{\text{Nutrient in feed} - \text{Nutrient in faeces}}{\text{Nutrient in feed}} \quad 100$$

To estimate GE balance, the gross energy of the dried and ground sample of feed ingredients and excreta were determined using adiabatic bomb calorimeter. The GE balance was calculated by following formula

$$\text{GE balance} = \text{GE in feed} - \text{GE in faeces}$$

Results and Discussion

A metabolic trial was conducted at 16^{th} week of age for one week with three days collection period to study the digestibility and balance of energy and nitrogen. The data pertaining to the nutrient utilization during metabolic trial is presented in Table-1.

The dry matter intake (DMI) of Pratapdhan chickens was 70.20±3.14, 72.76±4.50, 77.80±1.09, 80.99±0.67, 74.64±4.23 and 66.20±0.64g in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. Significantly ($p<0.05$) higher DMI was found in T_4 as compared to rest of the treatment groups expect T_2, T_3 and T_5. Significantly lowest DMI was found in T_6 as compared to rest of the treatment groups. The digestible DMI was 63.51±1.12, 58.20±4.20, 58.45±2.00, 54.29±4.59, 51.95±3.04, and 47.66±0.90 g in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The lowest digestible DMI was observed in T_6 as compared to rest of the treatment groups. The difference between T_1, T_2, T_3, T_4 and T_5 was found non-significant.

The digestibility coefficient of dry matter (DM) was 78.40±0.76, 77.86±1.75, 75.09±1.35, 74.42±1.68, 73.93±1.88, and 72.00±1.18in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The digestibility coefficient of dry matter was significantly ($p<0.05$)higher in T_1 as compared to rest of the treatment groups except T_2, T_3 and T_4. Significantly lowest digestibility coefficient of DM was found in T_6 as compared to rest of the treatment groups except T_3, T_4 and T_6.

The crude protein intake (CPI) was 14.87±0.66, 15.73±0.97, 16.67±0.28, 17.13±0.14, 16.06±0.91 and 14.50±0.14 g in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The CPI was significantly higher in T_4as compared to rest of the treatment groups except T_2 and T_5. Significantly lowest crude protein intake was found in T_1 and T_6 as compared to rest of the treatment groups except T_2, T_3 and T_5.The digestible CPI was 11.11±0.54, 11.24±0.91, 12.87±0.58, 13.93±0.27, 11.92±0.72and 11.51±0.27g in T_1, T_2, T_3, T_4, T_5 and T_6,respectively. The digestible CPI was significantly higher T_4as compared to rest the treatment groups except T_3. The difference between T_1, T_2, T_3,$T_5$and T_6as well as between T_3 and T_4 was found non-significant.

The crude protein (CP) digestibility coefficient was 74.67±0.32, 71.28±1.34, 77.15±2.79, 81.29±1.11, 74.17±0.30 and 79.41±1.24 in T_1, T_2, T_3, T_4, T_5 and T_6,respectively. The CP digestibility coefficient was significantly ($p<0.05$)higher in T_3,$T_4$and $T_6$and lowest in T_2 as compared to rest of the treatment groups.The difference between T_3,T_4 and T_6 as well as difference between T_1 and $T_5$was found non-significant.

The crude fiber (CF) intake was 2.33±0.10, 2.42±0.15, 2.58±0.04, 2.69±0.02, 2.48±0.14 and 2.20±0.02g in T_1, T_2, T_3, T_4, T_5 and T_6,respectively. The CF intake was significantly higher in T_4as compared to rest of the treatment groups except T_2, T_3 and T_5. Significantly lowest crude fibre intake was found in T_6 as compared to rest of the treatment groups except T_1, T_2 and T_5.The digestible CF intake was 1.59±0.10, 1.67±0.15, 1.79±0.08, 1.99±0.04, 1.83±0.14 and 1.45±0.04g in T_1, T_2, T_3, T_4, T_5 and T_6,respectively. The digestible CF intake was significantly higher in T_4 as compared to rest of the treatment groups except T_3 and T_5. Significantly lowest digestible CF intake was found T_6 as compared to rest of the treatment groups except T_1 and T_2.

The digestibility coefficient of crude fiber was 68.28±1.83, 68.82±2.07, 69.42±1.83, 73.91±1.0, 73.55±2.33 and 65.85±1.66 in T_1, T_2, T_3, T_4, T_5 and T_6,respectively. The digestibility coefficient of crude fiber was higher in T_4 and T_5 followed by T_1, T_2 and T_3. Lowest value was found in T_6. The difference between T_4 and T_5 as well as difference between T_1, T_2 and $T_3$was found non-significant.

The ether extract (EE) intake was 1.61±0.07, 1.67±0.10, 1.79±0.03, 1.86±0.02, 1.72±0.10 and 1.52±0.0g in T_1, T_2, T_3, T_4, T_5 and T_6,respectively. The ether extract intake was significantly highest in T_4 as

Table-1 : Effect of Moringa Leaf Powder on digestibility during growth of Pratapdhan chicken.

	T_1	T_2	T_3	T_4	T_5	T_6	SEm±
DM intake	70.20±3.14^{bc}	72.76±4.50^{abc}	77.80±1.09^{ab}	80.99±0.67^{a}	74.64±4.23^{abc}	66.20±0.64^{c}	0.45
Digestible DMI	63.51±1.12^{a}	58.20±4.20^{a}	58.45±2.00^{a}	54.29±4.59^{a}	51.95±3.04^{a}	47.66±0.90^{b}	1.32
DM digestibility coefficient	78.40±0.76^{a}	77.86±1.75^{ab}	75.09±1.35^{abc}	74.42±1.68^{abc}	73.93±1.88^{bc}	72.00±1.18^{c}	0.42
CP intake	14.87±0.66^{b}	15.73±0.97^{ab}	16.67±0.28^{bc}	17.13±0.14^{a}	16.06±0.91^{ab}	14.50±0.14^{b}	0.15
Digestible CPI	11.11±0.54^{b}	11.24±0.91^{b}	12.87±0.58^{ab}	13.93±0.27^{a}	11.92±0.72^{b}	11.51±0.27^{b}	0.10
CP digestibility coefficient	74.67±0.32^{b}	71.28±1.34^{c}	77.15±2.79^{a}	81.29±1.11^{a}	74.17±0.30^{b}	79.41±1.24^{a}	0.09
Crude fiber intake	2.33±0.10^{bc}	2.42±0.15^{abc}	2.58±0.04^{ab}	2.69±0.02^{a}	2.48±0.14^{abc}	2.20±0.02^{c}	0.03
Digestible Crude Fiber	1.59±0.10^{bc}	1.67±0.15^{bc}	1.79±0.08^{ab}	1.99±0.04^{a}	1.83±0.14^{ab}	1.45±0.04^{c}	0.01
CF digestibility coefficient	68.28±1.83^{b}	68.82±2.07^{b}	69.42±1.83^{b}	73.91±1.0^{a}	73.55±2.33^{a}	65.85±1.66^{c}	0.05
EE intake	1.61±0.07^{bc}	1.67±0.10^{abc}	1.79±0.03^{ab}	1.86±0.02^{a}	1.72±0.10^{abc}	1.52±0.0^{c}	0.09
Digestible EE	1.26±0.07^{bc}	1.31±0.11^{bc}	1.41±0.05^{ab}	1.52±0.03^{a}	1.40±0.10^{ab}	1.16±0.02^{c}	0.09
EE digestibility coefficient	77.70±1.28^{ab}	78.07±1.46^{ab}	78.49±1.29^{ab}	81.65±0.73^{a}	81.40±1.64^{a}	75.98±1.17^{b}	1.82
NFE Intake	47.30±2.11^{abc}	49.02±3.03^{abc}	52.42±0.87^{ab}	54.57±0.45^{a}	50.29±2.85^{abc}	44.60±0.43^{c}	0.61
Digestible NFE Intake	31.98±2.07^{bc}	33.49±3.12^{bc}	36.03±1.57^{ab}	39.99±0.89^{a}	36.73±2.89^{ab}	29.00±0.80^{c}	0.65
NFE digestibility coefficient	67.51±1.87^{bc}	68.05±2.12^{b}	68.67±1.88^{b}	73.27±1.06^{a}	72.90±2.39^{a}	65.01±1.71^{c}	0.78
GE intake (Kcal/bird/day)	224.65±17.37c	232.82±24.96^{abc}	248.94±7.12^{ab}	259.16±3.72^{a}	238.84±23.44^{abc}	211.83±3.53^{c}	13.13
GE balance (Kcal/bird/day)	130.14±17.30^{bc}	137.04±25.82^{bc}	147.86±14.68^{ab}	169.27±8.45^{a}	155.20±24.61^{ab}	115.60±8.29^{c}	14.63
N Intake	2.38±0.09	2.52±0.14	2.67±0.09	2.74±0.04	2.57±0.12	2.32±0.04	0.01
N balance	1.78±0.09^{bc}	1.80±0.14^{bc}	2.06±0.09^{bc}	2.23±0.04^{bc}	1.91±0.1^{bc}	1.84±0.04^{c}	0.01

Means with the same superscript in a particular row do not differ significantly ($p<0.05$) from each other.

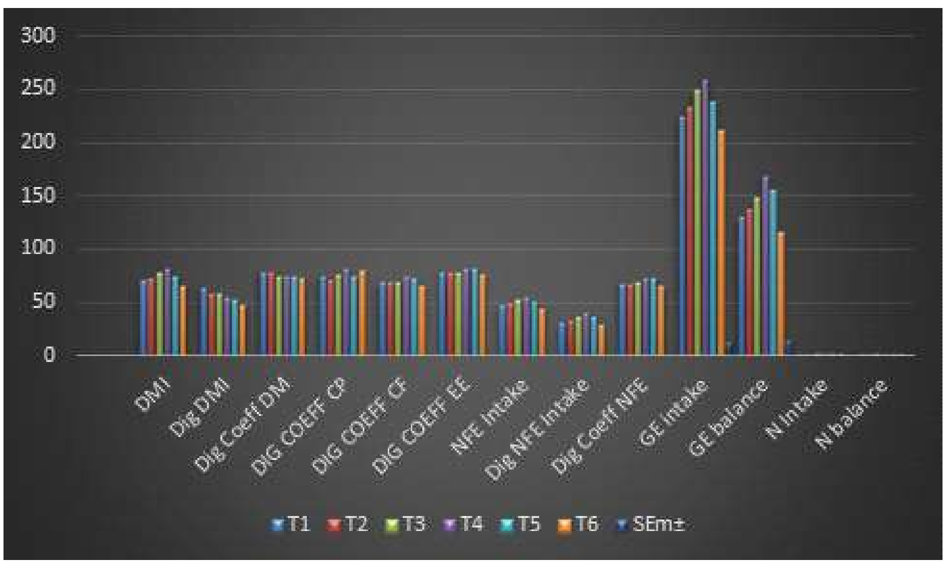

Fig.-1 : Digestibility coefficient during growth of Pratapdhan chicks.

compared rest of the treatment groups except T_2, T_3 and T_5. Significantly lowest ether extract intake was found in T_6 as compared to rest of the treatment groups except T_1, $T_2$and T_5. The digestible ether intake was 1.26±0.07, 1.31±0.11, 1.41±0.05, 1.52±0.03, 1.40±0.10and 1.16±0.02g in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The digestible etherextract intake was significantly higher in T_4as compared rest of the treatment groups except T_3 and T_5. Significantly lowest digestible ether extract intake was found in T_6 as compared to rest of the treatment groups except T_1 and T_2.

The digestibility coefficient of ether was 77.70±1.28, 78.07±1.46, 78.49±1.29, 81.65±0.73, 81.40±1.64 and 75.98±1.17 in T_1, T_2, T_3, T_4, T_5 and T_6,respectively. Digestibility coefficient of ether extract was higher in T_4 and T_5as compared rest of the treatment groups except T_1, T_2 and T_3. Significantly lowest Digestibility coefficient of ether extract was found in T_6 as compared to rest of the treatment groups except T_1, T_2 and T_3.

The nitrogen free extract (NFE) intake was 47.30±2.11, 49.02±3.03, 52.42±0.87, 54.57±0.45, 50.29±2.85 and 44.60±0.43g in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The NFE intake was significantly higher in T_4as compared rest of the treatment groups except T_1, T_2, T_3 and T_5. Significantly lowest NFE intake was found in T_6 as compared to rest of the treatment groups except T_1, T_2 and T_5.The digestible NFE intake was 31.98±2.07, 33.49±3.12, 36.03±1.57, 39.99±0.8, 36.73±2.89 and 29.00±0.80g in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The digestible NFE intake was significantly higher in T_4 as compared to rest of the treatment groups except T_3 and T_5. Significantly lowest digestible NFE was found in T_6 as compared to rest of the treatment groups except T_1 and T_2.

The digestibility coefficient of NFE was 67.51±1.87, 68.05±2.12, 68.67±1.88, 73.27±1.06, 72.90±2.39 and 65.01±1.71 in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The digestibility coefficient of NFE was significantly lowest in T_6 as compared to rest of the treatment group except T_1. The digestibility coefficient of NFE was found significantly highest in T4 and T5. The difference between T_4 and T_5 as well as between T_1, T_2 and T_3 and between T_1 and $T_6$was found non-significant.

The gross energy (GE) intake was 224.65±17.37, 232.82±24.96, 248.94±7.12, 259.16±3.72, 238.84±23.44 and 211.83±3.53 Kcal/bird/day in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The GE intake was significantly higher in T_4as compared rest of the treatment groups except T_2, $T_3$and T_5. Significantly lowest GE intake was found in T_1 andT_6 as compared to rest of the treatment groups except T_1, $T_2$and T_5.

The gross energy (GE) balance was 130.14±17.30, 137.04±25.82, 147.86±14.68, 169.27±8.45, 155.20±24.61 and 115.60±8.29 Kcal/bird/dayin T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The GE balance was significantly higher in T_4 as compared rest of the treatment groups except $T_3$and T_5. Significantly lowest GE balance was found in T_6 as compared to rest of the treatment groups except T_1 and T_2.

The nitrogen intake was 2.38±0.09, 2.52±0.14, 2.67±0.09, 2.74±0.04, 2.57±0.12and 2.32±0.04 gin T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The difference in nitrogen intake in different treatment groups was non-significant. All the birds in different treatment groups were in positive nitrogen balance. The nitrogen balance was 1.78±0.09, 1.80±0.14, 2.06±0.09, 2.23±0.04, 1.91±0.1and 1.84±0.04g in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The difference in nitrogen balance in different treatments was non-significant.

Discussion on Nutrient utilization : The result of nutrient utilization obtained are discussed under the following subs-heads.

Nutrient digestibility : The digestibility coefficient of DM was significantly higher in T_1 as compared to other dietary treatments except T_2.The digestibility coefficient of dry matter was 8.89, 8.13, 4.29, 3.36 and 2.68 per cent higher in T_1, T_2, T_3, T_4 and T_5 as compared to T_6. The crude protein intake was significantly higher in T_4 as compared to rest of the treatment groups except T_2 and T_5 while difference among T_1, T_2, T_3, T_5 and T_6 was non-significant. The digestibility coefficient of CP was significantly higher at 81.29% in T_4, 79.41% in T_6 and 77.15% in T_3 followed by 74.67% in T_1, 74.17% in T_5 and lowest at 71.28% in T_2. The digestibility coefficient of crude fibre was significantly higher in T_4 and T_5 and lowest in T_6 as compared to rest of the treatment groups. The difference between T_1, T_2 and T_3 were non-significant. The digestibility coefficient of EE was significantly higher in T_4 and T_5 as compared to T_6. The digestibility coefficient of NFE was significantly higher in T_4 and T_5 as compared to rest of the treatment groups while lowest values were found in T_6 as compared to rest of the treatment groups except T_1. The energy intake was significantly lower in T_1 and T_6 as compared to other treatment groups which did not differ among themselves. Similar trend was observed in energy balance and the birds in all dietary treatment groups were in positive energy balance. All the birds in different experiment groups were in positive nitrogen balance. Higher crude protein digestibility reported at higher level of 6% MOLM inclusion may be due to the highly digestible nature of *Moringa oleifera* leaf (Fahey 2005). Protein digestibility in Moringa based diets was higher, possibly due to a greater percentage (82-91) of pepsin-soluble protein and only 1-2% of acid-detergent insoluble protein. Ossebi (2010) reported that the Moringa leaves up to 24 per cent in feed did not cause adverse effects on nutrient absorption and could significantly increase protein digestibility, energy and mineral utilization. Makkar and Becker (1996) reported that the crude fibre digestibility decreased in chickens consuming diets with higher fibre (MOLM) levels compared with the control diet. Generally, fibre ratio (insoluble vs. soluble fibre) play a critical role on the rate of digestion and absorption of nutrients. Sebola *et al*. (2015) reported significant effect on apparent digestibility of CP, NDF, ADF, CF and EE. In diet MOLM (87.0%) had highest crude protein digestibility followed by MOLM (85.4%). Dalukdeniya *et al*. (2016) reported improved digestibility of dry matter and organic matter on addition of the Moringa 4-6% in diets than controls. These findings are in agreement with previous research of Hernandez *et al*. (2004) reported that plant extract supplements can increase the digestibility of nutrients in the digestive tract of poultry. Herbal extracts can increase the activity of pancreatic enzymes and micro environmental conditions for better utilization of nutrients in mice (Ramakrishna *et* *al*. 2003). Similarly, Ossebi (2010) reported that Moringa leaves up to 24% in feed did not cause adverse effects on nutrient absorption and could significantly increase protein digestibility, energy and mineral utilization.

Melesse *et al*. (2011) studied that the effect of *Moringa stenopetala* leaf meal (MSLM) on nutrient intake in Rhode Island Red chicks and reported that the daily feed, dry matter and CP intake of the chicks fed MSLM diets were higher than that of the control diet. The result indicated that MSLM is a potential plant protein supplement and could be included to 6% in the diet of grower chicks to substitute expensive conventional protein sources. Nworgu and Fasogbon (2007) observed lower CP intake in growing pullet fed 2, 4 and 6% levels of *C.pubescens* leaf meal compared to those on control diet. Okafor *et al*. (2014) reported that the true faecal digestibility value of the test (92.0 %) and control group (90.0 %) revealed that the nutritional of the test rational in terms of protein utilization was better in 20 % level of MLP fed group. In contrary to this, Amadi (2016) reported that daily retained nitrogen and nitrogen retention coefficient decreased in values following increase (0, 5, 10 and 15 per cent) in MOSM inclusion diets.

Conclusion

A metabolic trial was conducted at 16th weeks of age for one week with three days collection period to study the digestibility and balance of energy and nitrogen. Significantly higher DMI was found in T_4 as compared to rest of the treatment groups expect T_2, T_3 and T_5. The digestibility coefficient of dry matter was significantly higher in T_1 as compared to rest of the treatment groups except T_2, T_3 and T_4. The CPI was significantly higher in T_4 as compared to rest of the treatment groups except T_2 and T_5. Significantly lowest crude protein intake was found in T_1 and T_6 as compared to rest of the treatment groups except T_2, T_3 and T_5.The CP digestibility coefficient was significantly higher in T_3, T_4 and T_6 and lowest in T_2 as compared to rest of the treatment groups. The difference between T_3, T_4 and T_6 as well as difference between T_1 and T_5 was found non-significant. The digestibility coefficient of crude fiber was higher in T_4 and T_5 followed by T_1, T_2 and T_3. Digestibility coefficient of ether extract was higher in T_4 and T_5 as compared rest of the treatment groups except T_1, T_2 and T_3. Significantly lowest digestibility coefficient of ether extract was found in T_6 as compared to rest of the treatment groups except T_1, T_2 and T_3.The digestibility coefficient of NFE was significantly lowest in T_6 as compared to rest of the treatment group except T_1. The digestibility coefficient of NFE was found significantly highest in T_4 and T_5. The gross energy (GE) intake was significantly higher in T_4 as compared rest of the treatment groups except T_2, T_3 and T_5.Similar trend was observed in gross energy balance and the birds in all dietary treatment groups were in positive energy balance. All the birds in different experiment groups were in positive nitrogen balance. The nitrogen balance was 1.78±0.09, 1.80±0.14, 2.06±0.09, 2.23±0.04, 1.91±0.1and 1.84±0.04 g in T_1, T_2, T_3, T_4, T_5 and T_6, respectively. The difference in nitrogen balance in different treatments was non-significant.

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Microencapsulation of Fish Oil : Application in Functional Food Development

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Introduction

Consumers' demand for healthy food products is increasing worldwide. Today foods are not intended only to satisfy hunger and provide necessary nutrients for humans. It also intended to prevent nutrition-related diseases and improve physical and mental well-being. In this regard, functional foods play an outstanding role. The foods that enriched with functional components to offer medical and physiological benefits to reduce the risk of chronic diseases beyond their basic nutritional functions are called as functional foods.

Fish oil is an excellent source of omega- 3 fatty acids especially EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid). Omega -3 fatty acids are found to have numerous benefits for human health which includes reduction of joint pain, prevention of rheumatoid arthritis, cancer, psoriasis, reduction of risk of coronary heart disease, vision improvement and brain developments (Adam et al., 2003). Many studies encourage the adequate intake of omega-3 fatty acids by pregnant and lactating women to support overall health and development of retina and brain in foetus. Omega-3 fatty acids content in seafood and fish oil are given in table-1.

The US Food and Drug Administration (FDA) has also recommended fish and algal oils for food fortification. Due to its unsaturated nature fish oils are susceptible to oxidation and it can be reduced by addition of antioxidant or preferably microencapsulation. Recently, micro-encapsulated fish oil has wide application in various food products which includes infant foods, health drink, milk-based products, juices, pastas, bakery products etc (Desai & Park, 2005; Jeyakumari *et al.,* 2016). Apart from these fish oils also marketed as capsule and powder form. Recommended level of EPA and DHA intake suggested by world health organization (WHO) and American Heart association is 0.7g/day.0.5-1.0g/day respectively. In addition to consumption of fish, intake of fish oil fortified food will meet the daily requirement of omega-3 fatty acids.

Microencapsulation : Microencapsulation is a process of coating of small particles of solid or liquid material (core) with protective coating material (matrix) to produce microcapsules in the micrometer to millimeter range. It is one of the methods of protecting sensitive substances and producing active ingredients with improved properties. The substance that is encapsulated may be called the core material, the active agent, internal phase, or payload phase. The substance that is encapsulating may be called the coating, membrane, shell, carrier material, wall material, external phase or matrix.

Microencapsulation Methods : The microcapsules are prepared by a variety of methods. The microencapsulation process can be divided in to physical and chemical process. Physical process includes spray drying, spray chilling, rotary disk atomization, fluid bed coating, stationary nozzle coextrusion, centrifugal head coextrusion, submerged nozzle coextrusion, and pan coating. Chemical process includes phase separation, solvent evaporation, solvent extraction, interfacial polymerization, simple, and complex coacervation and in situ polymerization (Zuidam & Heinrich, 2010)

Method used for microencapsulation of fish oil : The most commonly used commercial techniques for microencapsulation of fish oil are spray drying, freeze drying and complex coacervation. Emerging microencapsulation methods of fish oil includes spray granulation and fluid bed film coating, electrospraying and encapsulation using ultrasonic atomizer.

Spray-drying : It is widely used for the encapsulation of food additives, functional ingredients, and flavors. The major process involves dispersion of the substances to be encapsulated in a carrier material followed by atomization and dehydration of the atomized particles. During this process a film is formed at the droplet surface, there by retarding the larger active molecules while the smaller water molecules are evaporated. The particle size varied between 10 and 400 um. Morphology of encapsulates produced by this method are matrix type.

Freeze-drying/Lyophilization : It is one of the most useful processes for drying of thermo sensitive substances. The major steps involved in this process are (1) mixing of core in coating solution; (2) freeze-drying of the mixture; and (3) grinding (option). The particle size varies from 20 to 5000 µm. Morphology of encapsulates

Table-1 : Omega-3 fatty acid content in Seafood and Fish oil.

Seafood	Omega-3 (EPA + DHA) g/100 g	Fish oil	Fatty acid
Mackerel	1.8-5.3	Sardine oil	10 - 20% EPA
Salmon	1.0-2.0	Tuna oil	5 - 6% EPA
Trout	0.5-1.6	Mackerel oil	10 - 15% EPA
Tuna	0.5-1.6	Eel oil	8 - 12% EPA
Halibut	0.5-1.0	Salmon egg oil	15 - 30% EPA
Shrimp	0.2-0.4	Shark oil	20.6% EPA + DHA
Cod, plaice, flounder	~ 0.2	Cod liver oil	10% EPA + DHA

Adapted from Belda and Pourchet-Campos (1991) and Park et al. (1997).

Table-2 : Advantages and Disadvantages of various microencapsulation methods.

Methods	Advantage	Disadvantage
Spray drying	Simple method, fast and easy to scale-up, equipment is readily available; cost of spray-drying method is 30–50 times cheaper; both hydrophilic and hydrophobic polymer can be used; ideal for production of sterile materials.	considerable amounts of the material can be lost during the process due to sticking of the microparticles to the wall of the drying chamber; process variables that should be optimized for encapsulation
Spray Chilling or Spray Cooling	least expensive; active compounds released within a few minutes after being incorporated in the food stuff.	special handling and storage conditions can be required
Fluid bed coating	uniform layer of shell material onto solid particles; high thermal efficiency; lower capital and maintenance costs.	control of air stream and air temperature is a critical factor
Freeze drying	It is used for encapsulation of heat-sensitive materials and aromas; minimize the product oxidation.	high energy use, the long processing time, 30–50 times more expensive than Spray drying
Coacervation	It is used to encapsulation of polyphenols and water-soluble compounds.	mass production is difficult due to agglomeration
Liposome Entrapment	mainly studied for clinical application as pharmaceutical drug carriers	high cost, low stability and low encapsulation yield
Inclusion Complexation	the unique release characteristics and the protection of unstable and high value specialty flavor chemicals.	limited amount of flavor (9–14%) can be incorporated; very expensive; chance for undesirable adulteration of the flavor due to presence of cyclodextrin

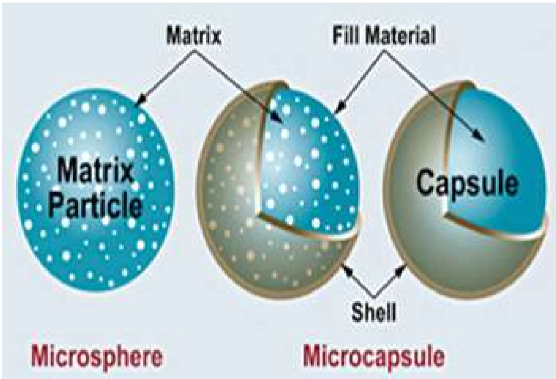
Table-3 : Wall materials used for microencapsulation of fish oil.

Microencapsulation methods	Wall materials used for microencapsulation of fish oil
Spray drying	Gelatin, maltodetrin, casein, lactose, sodium caseinate,dextrose equivalence, highly branched cyclic dextrin, methylcellulose, hydroxypropyl methycellulose, n-octenylsuccinate, derivatized starch/glucose syrup, sugar beet pectin, gum Arabic, corn syrup
Freeze drying	Sodium caseinate, carbohydrate, egg white, gum Arabic, lactose and maltodetrin
Electrostatic layer by layer (multilayer) deposition and spray drying	Lecithin and chitosan
Double emulsification and subsequent enzymatic gelation (fish oil)	Soy protein, whey protein, sodium caseinate, Transglutaminase
Ultrasonic atomization and freeze drying (fish oil)	Chitosan
Electrospraying	Zein prolamine (corn protein)
Spray granulation and fluid bed film coating	Soybean soluble polysachharide (P), maltodextrin, hydroypropyl betacyclodetrin (HPBCD)

produced by this method are matrix type. (Atmane et al., 2006; Zuidam & Shimoni, 2010).

Coacervation : In this method, the core material is emulsified in the protein solution, and formation of coacervate wall is initiated by changing either the temperature, pH, or by adding a concentrated salt solution. The resultant microcapsules are isolated by centrifugation or filtration and might be dried by spray drying or fluid bed drying. The particle size varies from 10 to 800 µm. (Fang & Bhandari, 2010; Zuidam & Shimoni, 2010).

Spray Chilling or Spray Cooling : In the spray chilling, the coating material is melted and atomized through a pneumatic nozzle into a vessel generally containing a carbon dioxide ice bath (temperature -50°C) as in a hot-melt fluidized bed followed by droplets adhere on



particles and solidify forming a coat film. The particle size varies from 20–200 µm. It is used for encapsulation of aroma compounds to improve heat stability.

Fluid Bed Coating : It is widely used in the food, pharmaceutical and cosmetic industry. The major process involved in fluid bed coating are (1) preparation of coating solution; (2) fluidization of core particles; (3) coating material is sprayed through a nozzle on to the particles and film formation is initiated; and (4) drying. The size of the particle varies from 5 to 5000 µm.

Liposome Entrapment : Liposome consists of an aqueous phase that is completely surrounded by a phospholipid-based membrane. When phospholipids, such as lecithin, are dispersed in an aqueous phase, the liposomes form spontaneously. One can either have aqueous or lipid soluble material enclosed in the liposome. Microfluidization, ultrasonication, and reverse-phase evaporation technique can be used to produce different varieties of liposomes for specific purposes. The particle size varies from 10 to 1000 µm. (Anu Puri et al., 2009;mPegg & Shahidi, 2007; Zuidam & Shimoni, 2010).

Inclusion Complexation : In this method, -cyclodextrin is typically used as the encapsulating medium. -cyclodextrin molecule forms inclusion complexes with compounds that can fit dimensionally into its central cavity. These complexes are formed in a reaction that takes place only in the presence of water. This reaction can be accomplished by stirring or shaking the cyclodextrin and core material to form a complex, which could then be easily filtered and dried. Molecules that are less polar than water (i.e., most flavor substances) and have suitable molecular dimensions to fit inside the cyclodextrin interior can be incorporated into the molecule. The particle size varies from 5 to 15 µm. (Pegg & Shahidi, 2007; Zuidam & Shimoni, 2010; Desai & Park, 2005).

Electro spraying : In this method encapsulates are produced in nano size with improved oxidative stability (Sergio et al.2010).

Spray granulation and fluid bed film coating : In this method fish oil is emulsified and spray dried. Then it will be coated with hydroxyl propyl betacyclodextrin. This method is under developmental stage and it need further development for commercial production.

Ultrasonic atomizer : In this method ultrasonic atomizer are used to produce encapsulates relatively narrow size distribution.

Wall material/Coating Material used for microencapsulation of fish oil : The coating material should be capable of forming a film that is cohesive with the core material be chemically compatible and nonreactive with the core material and provide the desired coating properties, such as strength, flexibility, impermeability, optical properties, and stability. Coating material should also have the properties such as stabilization of core material, inert toward active ingredients, controlled release under specific conditions, tasteless, non-hygroscopic, no high viscosity, soluble in an aqueous media or solvent, or melting and economical (Hammad et al., 2011). Wall material/ Coating Material used for microencapsulation of fish oil is given in table-3.

Application of Microencapsulated fish oil in Food Industry : Microencapsulation can potentially offer numerous benefits to the materials being encapsulated. Microencapsulated fish oil can be used in a wide assortment of foods. For example, Novomega, omega-3 fatty acids encapsulated product is marketed for use in bakery products. The encapsulation system of the Novomega is specially formulated for long chain n-3 fatty acids, and results in a product that eliminates strong fish oil tastes and odors. Two other fish oil encapsulated powders, Marinol™ omega-3HS, and Marinol DHA HS are marketed in US. Another omega-3 microencapsulated fish oil powder, MEG-3 has been introduced in the Canadian and US markets. These powders have been included in to bakery, milk and beverage markets (Pszczola, 2005). Bakery products are generally used as a source for incorporation of different nutritionally rich ingredients for their diversification (Sudha et al., 2007). Jeyakumari et al. (2016) observed that cookies fortified with fish oil microencapsulates was comparable with neat sample (without fish oil encapsulates). Yep et al. (2002) have shown that bread enriched with microencapsulated tuna oil (MTO) increases DHA and determined the acute and chronic effects of low doses of long chain (LC) n-3 PUFA (100 mg/day) on plasma LC n-3 PUFA levels using a novel delivery form. Agnikumar et al. (2015) reported that cake fortified with microencapsulated fish oil improved the oxidative stability of the product.

Jeyakumari *et al.* (2016) studied fish oil microencapsulates fortified pasta and noodles. Oxidative studies revealed that fish oil encapsulates incorporated pasta and noodles had lower peroxide value and thiobarbituric acid reactive substances than bulk fish oil added one. Verardo et al. (2009) were studied 1.2% encapsulated fish oil incorporated in Spaghetti and found improved nutritional quality. Shirin et al. (2019) developed microencapsulated fish oil enriched bread and found that there was no significant difference between enriched with 1% fish oil microcapsules and control on texture, appearance and crumb.

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Effect of Different Plant Products against French Bean *Colletotrichum lindemuthianum* Sacc. and Magn.

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Abstract

Bean anthracnose caused by *Colletotrichum lindemuthianum* is a seed borne disease prevailing throughout the world including India which leads to 100% yield loss in bean field. In present investigation, under *in vivo* condition, all the treatments were significantly reduced disease on foliage. Highly effective botanical with minimum disease incidence at 70, 80 and 90 DAS was found in Neem (34.37%) as compare to all other treatments. Maximum number of pods per plant (22.55), minimum per cent infected pods per plant (10.82%), maximum pod weight 142.70 (gm/plant) and highest total yield 3.42 (kg/plot) were recorded in Neem. Hence, Neem spray is the best treatment to reduce disease intensity of foliage infection at 10% concentration. The results of experiments conducted at *in vivo* condition shows that *C. lindemuthianum* can be managed by botanicals. All botanicals are economical in minimizing the disease intensity as well as friendly for environment.

Key words *: French bean, anthracnose, Colletotrichum lindemuthianum, India, per cent disease intensity.*

Introduction

French bean (*Phaseolus vulgaris* L.,) is one of the most important leguminous vegetable and has the ability to fix atmospheric nitrogen through root nodules. It belongs to the family Fabaceae and the chromosome number of French bean is 2n=22. French bean has originated in warm temperate region of Central America (Mexico and Guatemala) and South America, mainly the Andean regions. It was brought to India from Europe during the 17^{th} century and today French bean is also known by various names *viz.,* common bean, kidney bean, dwarf bean, haricot bean, snap bean, string bean, fresh bean or garden bean. Seeds are kidney shaped as the name implies. French bean is one of the most popular and widely grown vegetable in India. In India it is called as Farash bean and Rajma (Choudhary *et al.,* 2016). French bean is a broadly grown crop in India genus *Phaseolus* has around 70 species, only 5 bean species *P. vulgaris, P. dumosus, P. scoccineus, P. lunatus* and *P. acunfolius* have been cultivated to date. It is consumed as vegetable when pods are immature, delicate and tender, green shelled or as dry pulse. The green pods are rich in calcium, potassium, phosphorus and iron. The seeds are highly proteinaceous that contain high lysine, carbohydrate, vitamin A and minerals. Green plants are used as fodder and as green manure (Swarup, 2014).

The leading French bean producing countries are India, Myanmar, Brazil, USA, China and China mainland, Mexico, Tanzania, Uganda, Kenya, Indonesia and Turkey. Worldwide French bean is grown over an area of 1.48 Million hectares with annual production of 17.6 Million MT and the productivity is 11.95 Tonnes per hectares (FAOSTAT 2018). In India, according to National Horticulture Board (NHB) 2018-19 report the area under bean cultivation is 228 ha with 2257 MT production. The highest French bean production state in India is Gujarat with production of about 645.56 MT in area of 62.61 ha.

The major diseases that are found in common bean field are anthracnose (*Colletotrichum lindemuthianum*), rust (*Uromysis appendicculates*), angular leaf spot (*Phaeoisariopsis griseola*) and common bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) in Ethiopia (Amin *et al*., 2014). Anthracnose of bean in the hills of Uttarakhand appears in the second or third week of June and reaches the maximum damaging stage from the beginning of August to mid-September. Heavy and frequent rain with moderate temperature (19-25?) and high humidity (<70%) favored the progress of anthracnose disease of French bean (Aggarwal *et al.,* 2016). The early symptoms of disease appear on the lower leaf surface along the veins, which is red to purplish red discoloration. First the disease appears as round to irregular shape with small brown to black spots on the pods and leaves. The spots increase in the size; these lesions become enlarged and form a necrotic lesion. The loss can approach to 100% when badly contaminated seed is planted under condition favourable for disease development (Junaid *et al.,* 2014).

The anthracnose of bean is caused by the hemibiotrophic fungus *Colletotrichum lindemuthianum* (Sacc. & Magn.) Scribne. Its perfect stage was originally

Table-1 : Omega-3 fatty acid content in Seafood and Fish oil.

Seafood	Omega-3 (EPA + DHA) g/100 g	Fish oil	Fatty acid
Mackerel	1.8-5.3	Sardine oil	10 - 20% EPA
Salmon	1.0-2.0	Tuna oil	5 - 6% EPA
Trout	0.5-1.6	Mackerel oil	10 - 15% EPA
Tuna	0.5-1.6	Eel oil	8 - 12% EPA
Halibut	0.5-1.0	Salmon egg oil	15 - 30% EPA
Shrimp	0.2-0.4	Shark oil	20.6% EPA + DHA
Cod, plaice, flounder	~ 0.2	Cod liver oil	10% EPA + DHA

Adapted from Belda and Pourchet-Campos (1991) and Park et al. (1997).

Table-2 : Advantages and Disadvantages of various microencapsulation methods.

Methods	Advantage	Disadvantage
Spray drying	Simple method, fast and easy to scale-up, equipment is readily available; cost of spray-drying method is 30–50 times cheaper; both hydrophilic and hydrophobic polymer can be used; ideal for production of sterile materials.	considerable amounts of the material can be lost during the process due to sticking of the microparticles to the wall of the drying chamber; process variables that should be optimized for encapsulation
Spray Chilling or Spray Cooling	least expensive; active compounds released within a few minutes after being incorporated in the food stuff.	special handling and storage conditions can be required
Fluid bed coating	uniform layer of shell material onto solid particles; high thermal efficiency; lower capital and maintenance costs.	control of air stream and air temperature is a critical factor
Freeze drying	It is used for encapsulation of heat-sensitive materials and aromas; minimize the product oxidation.	high energy use, the long processing time, 30–50 times more expensive than Spray drying
Coacervation	It is used to encapsulation of polyphenols and water-soluble compounds.	mass production is difficult due to agglomeration
Liposome Entrapment	mainly studied for clinical application as pharmaceutical drug carriers	high cost, low stability and low encapsulation yield
Inclusion Complexation	the unique release characteristics and the protection of unstable and high value specialty flavor chemicals.	limited amount of flavor (9–14%) can be incorporated; very expensive; chance for undesirable adulteration of the flavor due to presence of cyclodextrin

Table-3 : Wall materials used for microencapsulation of fish oil.

Microencapsulation methods	Wall materials used for microencapsulation of fish oil
Spray drying	Gelatin, maltodetrin, casein, lactose, sodium caseinate,dextrose equivalence, highly branched cyclic dextrin, methylcellulose, hydroxypropyl methycellulose, n-octenylsuccinate, derivatized starch/glucose syrup, sugar beet pectin, gum Arabic, corn syrup
Freeze drying	Sodium caseinate, carbohydrate, egg white, gum Arabic, lactose and maltodetrin
Electrostatic layer by layer (multilayer) deposition and spray drying	Lecithin and chitosan
Double emulsification and subsequent enzymatic gelation (fish oil)	Soy protein, whey protein, sodium caseinate, Transglutaminase
Ultrasonic atomization and freeze drying (fish oil)	Chitosan
Electrospraying	Zein prolamine (corn protein)
Spray granulation and fluid bed film coating	Soybean soluble polysachharide (P), maltodextrin, hydroypropyl betacyclodetrin (HPBCD)

described as *Glomerella lindemuthianum* (Sacc. & Magn.) Shear, later, the name *Glomerella cingulata* f. sp. *phaseoli* has been proposed for the perithecial stage. Bean anthracnose is caused by *C. lindemuthianum* (Sacc. & Magn.). Colony of this fungus on PDA medium was grey when young and turn into dark black having compact mycelial growth at late stage. The word anthracnose is a Greek word meaning ‘coal’. It was first described from plant specimens obtained in Germany 1875 reported by Fufa (2015). In India, its incidence was noticed for the first time in Nilgiri hills in 1915 (Pandey, 2018).

Bean anthracnose is seed borne disease. Infection of a susceptible cultivar favorable conditions leading to an epidemic and may result in 100% yield loss in India (Misal *et al.,* 2019). In Himachal Pradesh, the disease occurrence of this disease has been reported to range from 5.0-65.0% in diverse location and cause greater economic loss in certain years (Sharma *et al.,* 1994). Common bean is attacked by *C. lindemuthianum* from seedling to maturity, depending on the environmental condition that are essential for the initiation and development of the disease (Amin *et al.,* 2014). Numerous epidemics have occurred in Italy and Germany. Severe economic loss has also been reported from America, Venezuela, Colombia and Brazil (Aggarwal *et al*., 2016). So the present study was carried out to find out the efficacy of different botanicals against bean anthracnose.

Materials and Methods

A field experiment was conducted during *kharif* season 2020 at Vegetable Research and Demonstration Block, College of Horticulture, VCSG UUHF Bharsar, Six different plants extracts was evaluated against *Colletotrichum lindemuthianum*. This experiment was conducted by Randomized Complete Block Design. The treatments spray schedule as initiated at the disease appearance stage and totally three sprays were taken at 10 days interval. The required quantities of botanicals were either measured with pipette out and suitably dissolve in a requisite quantity of water to get desired concentrations. Spraying was done using manually operated with hand sprayer.

Experimental Design and Layout : Seeds were sown in the beds with Randomized Complete Block Design with three replications in plot of 1.35 cm 1.20 cm size. The plant was spaced at 45 cm between row to row and 15 cm plant to plant twenty four plants per plot. The observations were taken in five randomly selected plants from each treatment in each replication. The observation was recorded using following rating scale.

Per cent disease index (PDI) was recorded by five leaves on plants are selected randomly and rating of each leaves is done by using a 0-9 rating scale (Table 3.3) given by Mayee and Datar (1986).

Category	Grade/numerical value	Leaf area infected
I	0	Disease free
II	1	1
III	3	1-10
IV	5	11-25
V	7	26-50
VI	9	>51

Disease intensity was calculated with the help of following formula and the scoring table given by wheeler 1969.

$$\text{PDI} = \frac{\text{Summation of all numarical rating}}{\text{No. of plant observed Maximum grade value (9)}} \quad 100$$

Apart from this observations on Per cent disease incidence total no. of pods, pods weight from 5 randomly selected plants at every picking was recorded and divided by total no. of plants of all harvest to calculate the mean pod weight/plant in grams. The operation was done for each treatment separately. Yield was recorded every picking in gram and added up for all the picking to obtain total yield per plant. The total yield/plant was multiplied with total no. of plants/plot to obtain total yield per plot in kilograms. The operation was done for each treatment separately. Statistical analysis of the data simple randomized complete block design was performed with the help of OPSTAT.

Results and Discussion

Different treatments, botanicals *viz.,* Garlic, Neem, Ginger, Onion, Papaya, Aloe vera and Control were evaluated against *C. lindemuthianum.* The experiment was conducted in RCBD to know the effect of fungicides on anthracnose of bean (*C. lindemuthianum*). Based on disease incidence, the per cent disease intensity of pathogen was calculated and also recorded.

Per cent Disease intensity : Six botanicals are used against anthracnose fungus. The minimum per cent disease intensity was recorded in foliar spray of Neem leaves extract at 1st, 2nd and 3rd spray i.e. 28.57, 26.30 and 24.50% Choudhary *et al.,* (2017) also observed the present disease intensity is 17.71, 21.29 and 23.57% at 30, 45 and 60 DAS when foliar spray with Neem leaves extract against anthracnose of greem gram caused by *C. lindemuthianum.*

Table-1 : Effect of different botanicals on per cent disease intensity (PDI) 1st, 2nd and 3rd spray at days after sowing (DAS).

Treatments	Per cent Disease Intensity (PDI)		
	After 1st spray	After 2nd spray	After 3rd spray
Control	35.58 (36.60)	38.22 (38.17)	41.33 (39.99)
Onion	30.43* (33.46)	29.36* (32.79)	27.34* (31.51)
Ginger	30.04* (33.22)	28.80* (32.44)	26.74* (31.13)
Neem	28.57* (32.30)	26.30* (30.83)	24.50* (29.65)
Papaya	31.92* (34.38)	30.55* (33.54)	28.67* (32.36)
Garlic	29.57* (32.93)	27.80* (31.80)	25.59* (30.37)
Aloe vera	31.53* (34.14)	30.10* (33.26)	27.98* (31.92)
S.E.(d)	0.53	0.63	0.63
C.D. (0.05)	1.18	1.39	1.39

Number of pods per plant : Number of pods per plant is a yield contributing parameter in French bean Pandey, (2018). Highest number of pods (22.55) was observed in Neem and the minimum number of pods (15.86) observed in control without treatment. This data was according to yield assessment in mung bean due to anthracnose (*C. lindemuthianum*) under natural field condition conducted by Misal *et al.,* (2019).

Per cent infected pods per plant : Number of infected pods per plant was determined as the average number of infected pods of five randomly pre-tagged plants. The highest percentage of pod infection was recorded from the control (25.44%) whereas the least per cent of pod infection from Neem (10.82%). This data was according to yield loss assessment in common bean due to anthracnose (*C. lindemuthianum*) Mohammed *et al.,* (2019).

Per cent disease incidence (PDI) 70, 80 and 90 days after transplanting (DAS) : Under *in vivo* condition all treatments were found effective on reducing the disease incidence as compared to control. Minimum disease incidence was observed in Neem i.e. 20.80, 27.33 and 34.37% at 70, 80 and 90 DAS with maximum yield 3.42 kg. Reddy *et al.,* (2019) also observed that foliar spray with Neem oil is effective to reduce disease in field condition. Per cent disease incidence was noticed by this treatment was 70%.

Treatments	Per cent disease incidence		
	70 DAS	80 DAS	90 DAS
Control	30.02 (33.21)	38.15 (38.13)	44.60 (41.88)
Onion	22.22* (28.11)	29.63* (32.96)	37.22* (37.58)
Ginger	21.62* (27.69)	29.16* (32.67)	36.70* (37.27)
Neem	20.80* (27.12)	27.33* (31.51)	34.37* (35.87)
Papaya	23.02* (28.64)	30.56* (33.55)	38.27* (38.20)
Garlic	21.05* (27.30)	28.53* (32.27)	35.36* (36.47)
Aloe vera	22.97* (28.62)	30.07* (33.24)	37.98* (38.02)
S.E.(d)	0.94	0.51	0.43
C.D.$_{(0.05)}$	2.08	1.14	0.95

Pod weight (gm/plant) and Total yield : Main aim to this experiment was to reduce disease and get the maximum yield and pod weight. It was selected five plants randomly and pod weight was calculated. Maximum pod weight was observed in case of Neem (142.70 gm) and minimum pod weight was noticed in case of untreated Control (101.82). The present investigation revealed the maximum yield was obtained in Neem (3.42 kg) at 20% followed by Garlic (3.18 kg) whereas, the minimum yield was found in Control (2.44 kg). This data was according to yield loss assessment in common bean due to anthracnose (*C. lindemuthianum*) under sub temperate condition by Sharma *et al.,* (2008); Padder *et al.,* (2010) also observed the similar yield in common bean. Choudhary *et al.,* (2017) also observed that Neem gave the highest yield.

Conclusions

Management of bean anthracnose in Bharsar, Pauri Garhwal condition. Our recent study was based on different treatments showed that. All the treatments were significantly reduced disease on foliage. Highly effective botanical with minimum disease incidence at 70, 80 and 90 DAS was neem (34.37%) as compare to all other treatments found with minimum disease intensity after 1st, 2nd and 3rd spray that is neem (24.50%), maximum number of pods per plant (22.55), minimum per cent infected pods per plant (10.82%), maximum pod weight 142.70 (gm/plant) and highest total yield 3.42 (kg/plot) were recorded in neem. Hence, neem spray is the best treatment to reduce disease intensity of foliage infection at 10% concentration.

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Growth and Yield Attributes of Chickpea (*Cicer arietinum* L.) in Association with Teak (*Tectona grandis*) Based Agroforestry System

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Abstract

An investigation was carried out to assess the directional and spatial influence of bund planted teak trees on chickpea grown in association during 2020-21 in Northern Dry Zone (Zone III) of Karnataka, India. At short distance from the tree lines, growth attributes of chickpea were significantly reduced on western and eastern directions of North–South tree line compared to northern and southern directions of East–West tree line, while significantly higher number of pods per plant, seed yield per plant and hundred seed weight (72.00, 30.93 g plant^{-1} and 17.90 g, respectively) were recorded in control without trees. The magnitude of reduction followed southern, northern, eastern, western directions. However at 12.0–17.0 m from the tree lines, growth attributes were not different from control in any direction. Further, significantly lower number of pods per plant (51.34), seed yield per plant (22.23 g plant^{-1}) and hundred seed weight (11.85 g) were recorded closer to the tree line (S1-2.0–7.0 m distance), but increased and reached the highest (66.37, 28.67 g plant^{-1} and 15.33g, respectively) at 12.0–17.0 m away from tree line and were comparable to control irrespective of directions of planting. Overall, at latitude 15^0 09 N it was found that east–west tree planting had lower inhibitory interference on associated Chickpea.

Key words : *Interface, teak, tree line, direction, canopy, shade.*

Introduction

Socio-economic and environmental sustainability could be achieved through better management of natural resources, and on-farm species diversification through agroforestry is one such option as it enables building resilience to changing climate (Atta-Krah *et al*. 2004; Schroth *et al.* 2004). Agroforestry is a land use system where farmers deliberately retain or grow woody perennials in combination with the field crops and/or livestock on the same unit of land management either alternatively or at the same to get diversified products to meet their basic requirement such as fuel wood, timber, fodder and food (Nair 1985; Chittapur *et al*. 2017). Besides, tree based land use systems offer several ecosystem services which benefit the agricultural practices through improvement in soil fertility, soil and water conservation, enhancement of water quality, carbon sequestration and biodiversity conservation (Jose 2009; Chittapur and Patil 2017).

However, agroforestry land use systems often having significant species diversity, with variation in density and their arrangement in the field are more complex in structure and function than monoculture, particularly in competitive and complementary effects (Schroth *et al*. 2004; Muturi *et al*. 2005; Bayala *et al*. 2015). Interactions in agroforestry systems are more complex and extended compared to the annual inter-cropping due to presence of perennial trees, and these effects depend on the characteristics and nature of trees, density, age and their arrangement (Rao *et al*. 1998). Besides, the effects are site specific and vary over time, and depend on management (Coe *et al*. 2014; Barrios *et al*. 2012). Hence, understanding the nature of interactions between the tree and crop assumes importance to determine the management practices to realise higher economical and ecological benefits from agroforestry systems.

Traditionally most preferred agroforestry system practiced by the farmers under rainfed ecosystem is scattered planting or parkland system which is simplest and most suitable under small holder management (Nair, 1993). Farmers also prefer the trees on the bunds and farm boundaries with varying density. For instance, Doddabasawa *et al*. (2017a) reported 15 to 40 trees per hectare in the study area. Among different species, neem (*Azadirachta indica*), a multipurpose and predominant tree species of semi-arid regions, is often retained by farmers on bunds and boundaries. Among the crops,

Table-1 : Growth performance of teak trees in experimental site.

Sl. No.	Particulars	North–south direction		East–west direction	
1.	Tree density	38		38	
2.	Age (Year)	10		10	
3.	Tree height (m)	6.80 (±0.69)		6.60 (±1.00)	
4.	Bole height (m)	4.41(±0.69)		3.77 (±0.69)	
5.	GBH (cm)	64.45 (±7.18)		59.52 (±9.75)	
6.	Canopy spread (m)	Towards east	4.22 (± 0.86)	Towards north	4.18 (±0.69)
		Towards west	4.30 (±0.82)	Towards south	4.08 (±0.72)
		Sum	8.52 (±1.68)	Sum	8.26 (±1.41)
7.	Tree volume (m^3 $tree^{-1}$)	0.22 (±0.05)		0.19 (±0.06)	

Note : Values in the parentheses indicate the standard deviation.

Table-2 : Growth parameters of chickpea as influenced by direction and distance from tree line in teak based agroforestry system.

Treatments	Plant height (cm)			No. of branches $plant^{-1}$			Total dry matter production (g $plant^{-1}$)		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
				DIRECTION (M)					
M_1	24.47^{ab}	30.75^{ab}	33.13^{ab}	5.30^{bc}	5.88^{ab}	5.88^{ab}	5.91^{ab}	13.15^{b}	19.54^{bc}
M_2	23.11^{b}	29.37^{b}	31.28^{b}	4.88^{c}	5.40^{b}	5.40^{b}	5.70^{b}	12.70^{b}	18.29^{c}
M_3	25.07^{a}	31.10^{ab}	33.69^{a}	5.47^{ab}	6.00^{a}	6.00^{a}	6.11^{ab}	13.54^{b}	20.50^{ab}
M_4	26.26^{a}	32.03^{a}	34.27^{a}	5.74^{a}	6.35^{a}	6.35^{a}	6.30^{a}	14.82^{a}	21.32^{a}
S. Em±	0.71	0.63	0.74	0.15	0.16	0.15	0.14	0.42	0.56
				DISTANCE (S)					
S_1	21.92^{c}	28.16^{c}	30.28^{c}	4.25^{c}	4.52^{c}	4.52^{c}	5.44^{c}	11.93^{c}	17.37^{c}
S_2	24.83^{b}	31.03^{b}	33.33^{b}	5.46^{b}	6.00^{b}	6.00^{b}	5.96^{b}	13.33^{b}	19.56^{b}
S_3	27.42^{a}	33.26^{a}	35.66^{a}	6.31^{a}	7.16^{a}	7.16^{a}	6.61^{a}	14.65^{a}	22.81^{a}
S. Em±	0.61	0.54	0.64	0.13	0.14	0.13	0.12	0.36	0.48
				INTERACTION (M×S)					
M_1S_1	0.53^{gh}	5.55^{fg}	11.00^{ef}	0.77^{gh}	5.42^{ef}	11.86^{de}	17.19^{ef}	0.53^{gh}	5.55^{fg}
M_1S_2	0.59^{b-f}	6.10^{b-f}	12.65^{c-e}	0.93^{c-f}	5.86^{c-e}	13.04^{a-e}	19.34^{c-e}	0.59^{b-f}	6.10^{b-f}
M_1S_3	0.63^{a-c}	6.58^{ab}	14.54^{bc}	1.06^{a-c}	6.44^{a-c}	14.56^{ab}	22.10^{bc}	0.63^{a-c}	6.58^{ab}
M_2S_1	0.51^{h}	5.20^{g}	10.10^{f}	0.70^{h}	5.07^{f}	11.23^{e}	15.77^{f}	0.51^{h}	5.20^{g}
M_2S_2	0.58^{c-g}	5.90^{c-f}	12.14^{c-e}	0.89^{d-g}	5.74^{c-f}	12.62^{b-e}	18.56^{d-f}	0.58^{c-g}	5.90^{c-f}
M_2S_3	0.62^{a-d}	6.42^{a-c}	13.29^{cd}	1.02^{b-d}	6.28^{a-d}	14.24^{a-c}	20.55^{b-d}	0.62^{a-d}	6.42^{a-c}
M_3S_1	0.55^{f-h}	5.69^{e-g}	11.89^{d-f}	0.84^{fg}	5.58^{d-f}	12.23^{c-e}	18.15^{d-f}	0.55^{f-h}	5.69^{e-g}
M_3S_2	0.59^{b-f}	6.20^{a-e}	13.00^{cd}	0.97^{c-f}	6.00^{c-e}	13.57^{a-d}	19.99^{c-e}	0.59^{b-f}	6.20^{a-e}
M_3S_3	0.64^{ab}	6.72^{ab}	15.53^{ab}	1.11^{ab}	6.76^{ab}	14.83^{a}	23.37^{ab}	0.64^{ab}	6.72^{ab}
M_4S_1	0.57^{d-g}	5.81^{d-g}	12.00^{de}	0.87^{e-g}	5.69^{d-f}	12.39^{c-e}	18.37^{d-f}	0.57^{d-g}	5.81^{d-g}
M_4S_2	0.60^{b-f}	6.40^{a-d}	13.16^{cd}	1.00^{b-e}	6.23^{b-d}	14.08^{a-c}	20.37^{cd}	0.60^{b-f}	6.40^{a-d}
M_4S_3	0.67^{a}	6.81^{a}	16.99^{a}	1.16^{a}	6.98^{a}	14.99^{a}	25.22^{a}	0.67^{a}	6.81^{a}
S. Em±	0.02	0.21	0.63	0.05	0.25	0.72	0.97	0.02	0.21
				REST *VS.* CONTROL					
Control	0.69	7.65	18.10	1.19	7.07	16.40	26.63	0.69	7.65
S. Em±	0.02	0.39	1.03	0.05	0.24	0.71	1.2	0.02	0.39
C.D. (P=0.05)	0.06	1.21	3.10	0.16	0.70	2.06	3.7	0.06	1.21

Note : Means with same alphabets do not differ significantly as per DMRT

M : Direction from tree row　　M_1 : Eastern direction　　S : Distance from tree line

M_2 : Western direction　　S_1 : 2.0-7.0 m

M_3 : Northern direction　　S_2 : 7.0-12.0 m

M_4 : Southern direction　　S_3: 12.0-17.0 m

DAS : Days after sowing

Table-3 : Number of pods per plant, number of seeds per pod, seed yield per plant and hundred-seed weight of chickpea as influenced by direction and distance from tree line in teak based agroforestry system.

Treatments	Number of pods plant^{1}	Seed yield plant^{-1} (g)	Hundred-seed weight (g)
DIRECTION (M)			
M_1	58.85^{ab}	24.99^{ab}	13.25^{ab}
M_2	56.38^{b}	23.81^{b}	12.73^{b}
M_3	60.14^{ab}	26.03^{a}	13.82^{ab}
M_4	62.39^{a}	26.67^{a}	14.25^{a}
S. Em±	1.44	0.70	0.38
DISTANCE (S)			
S_1	51.34^{c}	22.23^{c}	11.85^{c}
S_2	60.61^{b}	25.22^{b}	13.36^{b}
S_3	66.37^{a}	28.67^{a}	15.33^{a}
S. Em±	1.24	0.61	0.33
INTERACTION (M×S)			
M_1S_1	50.54^{f}	21.83^{fg}	11.59^{f}
M_1S_2	59.80^{b-d}	24.92^{c-f}	12.84^{c-f}
M_1S_3	66.22^{ab}	28.22^{a-c}	15.32^{ab}
M_2S_1	48.25^{f}	20.19^{g}	11.34^{f}
M_2S_2	58.12^{c-e}	24.11^{d-f}	12.45^{d-f}
M_2S_3	63.12^{a-c}	27.14^{a-d}	14.38^{a-c}
M_3S_1	51.93^{ef}	23.12^{e-g}	12.10^{ef}
M_3S_2	61.40^{b-d}	25.86^{b-e}	13.90^{b-e}
M_3S_3	67.07^{ab}	29.11^{ab}	15.45^{ab}
M_4S_1	54.64^{d-f}	23.80^{d-f}	12.35^{d-f}
M_4S_2	62.77^{a-c}	26.00^{b-e}	14.26^{a-d}
M_4S_3	69.41^{a}	30.20^{a}	16.15^{a}
S. Em±	2.49	1.22	0.65
REST *VS.* CONTROL			
Control	72.00	30.93	17.90
S. Em±	2.53	1.22	0.95
C.D. (P=0.05)	7.38	3.57	2.88

Note: Means with same alphabets do not differ significantly as per DMRT
M: Direction from tree row; M_1: Eastern direction; S: Distance from tree line
M_2: Western direction; S_1: 2.0-7.0 m
M_3: Northern direction; S_2: 7.0-12.0 m
M_4: Southern direction; S_3: 12.0-17.0 m

pigeonpea [*Cajanus cajan* (L) Millsp.], a leguminous plant with deep tap root system and drought tolerance, is a more successful grain crop under rainfed agroecosystem grown either sole or in association with short duration annuals as intercrops or with perennial tree crops in an agroforestry system. However, the studies on tree- crop competition of teak and chickpea especially the directional and spatial influence of bund planted practices to realise higher economical and ecological benefits from agroforestry systems needs to be studied.

Materials and Methods

The present investigation was carried out on farmer's field in Koppal district of Karnataka, India during 2020–21. The study site was located 15º 09' N Latitude and 76º 47' E Longitude at an altitude of 572 m above mean sea level and falls under Agro-climatic Zone-III of Karnataka. The zone is characterized by semi-arid climate with short monsoon, mild winter and hot summer and the average annual rainfall ranges from 464.5 to 785.7 mm. However, during the experimental period (2020–21) the annual rainfall was rather low (603.40 mm) and the average monthly minimum and maximum temperatures were 20.42 and 32.22 ^{o}C, respectively. The average relative humidity fluctuated between 25.41 to 55.91 per cent. The soil of the study site was red sandy loam belonging to the order *Alfisols* with low to medium available nutrient status.

Teak trees were present on the bund perfectly in two directions north–south and east–west with 38 trees in each direction and the average age of the trees was 10 years (Table-1). Ten trees in each direction were randomly selected and measured for their height, girth, crown spread, biomass and volume by non harvesting method by using the following equation (Chaturvedi and Khanna 1981).

Volume = (g^2/4p) b; Where, g is girth at breast height (m), b is bole height (m) and p is 3.14.

The tree height was measured with the help of Ravi altimeter (Blume-Leiss Altimeter 2012) from the ground level to the tip of the tree and expressed in meter, bole height was measured with the help of measuring tape from ground to crown point and expressed in meter, tree girth at breast height from the ground level was measured, and canopy spread was determined in east–west and north–south directions and expressed in meter.

In the study phenological events of teak trees such as flowering, fruiting, appearance of new leaves and shedding of old leaves were recorded by visiting the field every month. Teak is an evergreen multipurpose species flowers from June to September, fruiting occurs from November to January and new leaves appear between February and March while old leaver are shed from December to February. The chickpea crop was sown on 12th of November 2020 and harvested on 28th of February 2021.

The experiment was laid out in a split plot design with three replications. There were 12 treatment combinations selectively randomized with one outside control with a net plot size of 3.3×3.3 m (10.89 m^2) for each treatment. Directions from tree line (E-Eastern direction, W-Western direction, N-Northern direction and S-Southern direction) formed the main plots and distances from tree line (S_1-2.0–7.0 m, S_2- 7.0–12.0 m and S_3-12.0–17.0 m) formed the subplots (the chickpea crop was sown at 2 m away from the tree line). Observations on chickpea (cv. JG-11) on plant height, number of branches per plant and total dry matter production were recorded at 60, 90 days after sowing (DAS) and at harvest. Yield parameters like number of pods plant, seed yield per plant hundred seed weight (g) were recorded at harvest.

Data from crop were analysed and interpreted following Fisher's method of analysis of variance of a split plot design at probability level of 0.05 using Microsoft Excel 2010 (Panse and Sukhatme 1967). The variance in split plot design were divided into the main plot (Factor Direction), sub plot (Factor Distance) and interaction (Direction X Distance), main plot analysis was computed using product of replication and main factor. Similarly sub plot analysis was computed by the product of replication and sub factor, the interaction analysis was computed by the product of main factor and sub factor at level of significance (P-0.05). Further, to know the difference between means post hoc test was performed by using Duncan's Multiple Range Test (DMRT) at probability level of 0.05 using M-STAT software. In the study, only third order interactions were considered for interpretation. The data were also subjected to *'t'* test where the means of main factor, sub factor and interactions were compared with outside control at probability level of 0.05.

Results and Discussion

Directional influence of tree planting on field crop : The present research on tree crop competition averaged over distances revealed influence of tree line orientation on growth and yield attributes of associated chickpea. Interestingly, variations between east (E) and west (W) side planted crop with North–South tree line and north (N) and south (S) planted crop with East– West tree line did not differ significantly. However, the latter that is north and south planted crop of East– West tree line was significantly superior to the former for most attributes. Among the four directions, chickpea on the southern (S) side of East–West tree line had significantly higher growth attributes such as plant height (26.26, 32.03 and 34.27 cm, respectively), number of branches per plant (5.74, 6.35 and 6.35, respectively) and total dry matter production (6.30, 14.82 and 21.32 g plant^{-1}) respectively at 60, 90 DAS and at harvest than the crop on western direction (W) of North–South orientated bund planted teak (23.11, 29.37 and 31.28 cm plant height, 4.88, 5.40 and 5.40 branches plant^{-1}, and 5.70, 12.70 and 18.29 g plant^{-1}, respectively at 60 and 90 DAS and at harvest) closely followed by crop on the northern (N) side of East–West planted teak line (Table-2). Reductions in different directions from the tree line followed the order southern-northern [eastern-western directions].

Again averaged over distances, yield attributes followed similar trend and on either side of North–South tree line or on East– West tree line values were comparable, while among the directions particularly between S and W the differences were significant (Table-3). Chickpea on southern also recorded higher yield attributes namely number of pods per plant, seed yield per plant and hundred seed weight (62.39 plant^{-1}, 26.67 g plant^{-1}, and 14.25 g, respectively) closely followed by N with East–West tree line which was on par, while S was superior to W of North–South tree line, the latter had lower values of yield components (56.38 plant^{-1}, 23.81 g plant^{-1}, and 12.73 g, respectively).

Extent of competitive zone from the tree line : In the present research, averaged over directions from the tree line, significantly lower plant height (21.92, 28.16 and 30.28 cm, respectively), number of branches per plant (4.25, 4.52 and 4.52 cm, respectively) and total dry matter production (5.44, 11.93 and 17.37 g plant^{-1}, respectively at 60, 90 DAS and harvest) were observed when chickpea was closer to teak line (S_1:2.0-7.0 m distance). However, these values improved as the distance from the tree line increased and significantly higher plant height (27.42, 33.26 and 35.66 cm, respectively), number of branches per plant (6.31, 7.16 and 7.16, respectively) and total dry matter production (6.61, 14.65 and 22.81 g plant^{-1}, respectively at 60, 90 DAS and harvest) were recorded at far away distance (S_3:12.0–17.0 m) (Table 2). Yield parameters, similar to growth components revealed significant differences due to planting distances from teak tree line averaged across directions. Significantly lower number of pods per plant (51.34), seed yield per plant (22.33 g plant^{-1}) and hundred seed weight (11.85 g) were recorded closer to teak tree line (S_1:2.0–7.0 m distance) and the values increased away from the tree line and reached the maximum (66.37 and 28.67g plant^{-1} and 15.33, respectively) at 12.0–17.0 m distance (S_3) (Table 3).

Interactional effect of direction and distance from the tree line : Interactional effect of direction and distance from teak tree line on growth and development of chickpea in agroforestry system revealed significant differences for plant height, number of branches and total dry matter production at 60, 90 DAS and at harvest (Table 2). Number of pod yield per plant, seed yield per plant and hundred seed weight (Table 3) revealed significant differences due to interaction of direction and distance. At similar distances on Eastern and Western of North–South tree line the values were comparable and so were the performance on Southern and Northern of East–West tree line at similar distances, and at distance of 12.0–17.0 m in all the directions in both the tree orientations (ES3/WS3/NS3/SS3) values were on par with the control without trees. This suggests that the major determinable factors in the present investigation were orientation and distance rather than the interaction between them.

In the present assessment on directional and spatial influence of bund planted teak trees on chickpea revealed significantly higher growth and yield parameters by the crop on southern direction of East–West bund planted teak trees; East being comparable, while these parameters revealed significantly lower performance on western direction of North–South bund planted teak trees. Further, the reduction of yield was in the order W–E, N–S directions. These results are in line with Soumya (2015) who assessed performance of finger millet with different tree species reported 30.72 per cent reduction in yield of finger millet in an agroforestry system with different tree species. She reported better grain yield on southern side (22.24 q ha^{-1}) compared to northern side (19.07 q ha^{-1}) and this was attributed to higher growth and yield parameters on southern side compared to northern side and she also observed improvement in yield with increasing in distance from tree line and reported percent increase in yield by 14.47 at 2.5–5 m distance over 0–2.5 m from tree line.

As one moved near the tree line there was greater limitation probably due to tree shade and competition. Parandiyal *et al.* (2008) in their study on directional influence of trees on rainfed crops in south-eastern Rajasthan, India observed lower yield of pigeonpea in western direction as compared to eastern direction of north–south planted tree line and lower yields on northern direction as compared to southern direction of east–west planted tree line. They attributed these differences to variation in length and duration of shading by the trees under the conditions of their experiment.

Dupraz *et al*. (2018) suggested that crop irradiance is a key factor for crop success. From their study on the influence of latitude on the light availability for intercrops in an agroforestry system they recommended to set the tree line orientation to East–West at low latitudes (350, close to the tropic circle). At such low latitudes, the sun path stays close to the East–West axis during the whole year. With East–West tree line, long shades produced during the mornings and afternoon is projected on the neighbor trees, while the shade around midday is very short due to the position of the sun close to the zenith. This results in high mutual shading between trees and low shading of trees on the cropped alley. Probably for the same reason the tree height and canopy spread in East–West line were lower than that of North–South tree line in the present study. With North–South tree line, more shade is projected over the cropped alley. For high sun elevations (low latitudes) East–West tree lines allow the trajectory of the sun to be visible by the crop almost all day long.

In the present research significantly lower growth, yield attributes were observed near the tree line at distance 2.0–7.0 m which were improved with increasing distance from the tree line. Similarly, Mutanal (1998) working on hedgerow intercropping system with groundnut at University of Agricultural Sciences, Dharwad, India indicated higher leaf area index and plant height in sole groundnut as compared to teak, Grass followed by teak, subabul and teak. He recorded significant reduction in leaf area index and plant height of groundnut up to 1–4 m distance. Doddabasawa *et al*. (2017b) made an assessment of neem based agroforestry system in Karnataka and observed no difference in grain yield, biomass yield and harvest index among agroforestry systems (boundary, bund and scattered planting) but within a system there was significant reduction in grain and biomass yield of pigeonpea at 5 m distance from the neem tree line compared to the distance of 10 m and they reported that the variation within the system were mainly due to density of trees. In the present investigation at a distance of 12.0 m -17.0 m there was no significant difference in chickpea performance with tree even under scarce rains observed during 2020-21 due to no shading effect or competition for growth resources while at 2.0–7.0 m from tree line there was significant reduction as the crop was immediately below the tree canopy and was under greater limiting influence from trees.

Conclusions

The present investigation on tree crop interface in teak based agroforestry system revealed difference in growth and yield of chickpea on different directions and distances from tree line which can be attributed to the variation of length and hours of shading by the trees. Therefore, the proposed hypothesis that field crops respond differently depending on the tree planting orientation is accepted. For a given tree density, in order to increase crop irradiance and performance in chickpea-teak based agroforestry system we recommend to set the tree line orientation to East– West at low latitudes. Other management practices such as lopping during the cropping period to reduce shading and trenching beside tree line to reduce root competition could further boost crop growth.

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An Insight into the Profile of Reliance Foundation Information Services Beneficiaries in Guntur District of Andhra Pradesh

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Abstract

Reliance Foundation Information Service (RFIS) programme is a PPP initiative of Reliance Foundation along with Acharya N.G. Ranga Agricultural University, Andhra Pradesh raised to render effective services to the farming community. Using the modern means of information and communication technology, RFIS is addressing farmers needs through a variety of services like mobile text messages, mobile voice messages, knowledge on wheels programme, video conference, field awareness programmes, toll free number (1800 419 8800), phone in live, veterinary camps, bulletins & broadcasts and jio chat. In the present study, profile characteristics of RFIS beneficiaries along with impact of RFIS in Guntur district is discussed. The study was conducted as part of M.Sc (Ag.) programme during 2018-19. Ex post facto research design was followed in the present investigation. A total of 120 beneficiaries were selected for the study by simple random sampling. The study revealed that that more than half of the respondents were middle aged (50.83%), 28.33 per cent were educated up to middle school and less than half of the respondents had marginal (48.33%) land holdings, low (48.33%) farming experience, occupation was agriculture (46.66%). It was also found that less than two third of the respondents had medium (65.00%) annual income, 44.17 per cent of the respondents had low social participation. It also found that less than three fourth of the respondents had medium (72.50%) extension contact, 58.33 per cent of the respondents has medium information seeking behaviour, majority of the respondents had medium (87.50%) material possession, a little less than two third of the respondents had medium (64.17%) mass media utilization and 40.00 per cent of the respondents has received high training. The computed 'r' values of occupation, extension contact, information seeking behaviour, mass media utilisation and training received had positive and significant correlation with the impact of RFIS. The variables land holding, annual income and social participation were found to have negative but significant correlation with the impact of RFIS.

Key words : *Reliance foundation information services, public private partnership, information and communication technology.*

Introduction

A Memorandum of Understanding (MOU) was signed between ANGRAU and Reliance Foundation for implementing Information Services (RFIS) programme for the benefit of farming community in Public Private Partnership (PPP) mode in 2014. ANGRAU promised to act as the technical partner from its Krishi Vigyan Kendras (KVKs), District Agricultural Advisory and Transfer of Technology Centres (DAATTCs), Agricultural Research Stations (ARS).With this technical support Reliance foundation is providing information services to farmers on need based and location specific information in the name of Reliance Foundation Information Services. RFIS has been implemented in all the districts of Andhra Pradesh with highest number of users in Guntur district. Hence the study was conducted in Guntur district of Andhra Pradesh.

RFIS is disseminating the agricultural information though mobile text messages, mobile voice messages, knowledge on wheels programme, video conference, field awareness programmes, toll free number (1800 419 8800), phone in live, veterinary camps, bulletins & broadcasts and jio chat.

Materials and Methods

The study was conducted as a part of M.Sc (Ag.) programme in Andhra Pradesh state during the year 2018-2019. Ex-post facto research design was used. The study was conducted in Guntur district with a sample size of 120 respondents. The data was collected using an interview schedule. Independent variables included age, education, land holding, farming experience, occupation, annual income, social participation, extension contact, information seeking behavior, material possession, mass media utilization, training received and impact of RFIS were studied. Statistical tools namely mean, standard deviation, frequency, percentage were used.

Results and Discussion

A perusal of Table-1 revealed that more than half of the respondents were middle aged (50.83%), followed by young (26.67%) and old age (22.50%). The sample consisted of all the age groups but the farmers belonging

Table-1 : Distribution of respondents according to profile characteristics.

S. No.	Independent variables	Category	Respondents (n=120)	
			F	%
1.	Age	Young (Below 35 years)	32	26.67
		Middle (35 to 58 years)	61	50.83
		Old age (Above 58 years)	27	22.50
2.	Education	Illiterate	9	7.50
		Functionally Illiterate	13	10.84
		Primary School (1^{st} - 5^{th} class)	21	17.50
		Middle School (6^{th} & 7^{th} class)	34	28.33
		High School (7^{th} – 10^{th} class)	25	20.83
		College Education	7	5.83
		Graduation	11	9.17
		Post-Graduation	—	—
3.	Land holding	Marginal (Below 1 ha)	58	48.33
		Small (1 – 2 ha)	43	35.83
		Semi Medium (2 – 4ha)	16	13.34
		Medium (4 – 10ha)	3	2.50
		Large (Above 10ha)	—	—
4.	Farming experience	Low (<10 years)	58	48.33
		Medium (11 – 20 years)	52	43.33
		High (>20 years)	10	8.34
5.	Occupation	Agriculture	56	46.66
		Agriculture + livestock	31	25.83
		Agriculture + Agriculture labour	23	19.17
		Agriculture + Business	8	6.67
		Agriculture + Private Job	2	1.67
6.	Annual Income	Low (< Rs. 74618.00)	15	12.50
		Medium (Rs.74618.00-Rs. 281506.00)	78	65.00
		High (>Rs. 281506.00)	27	22.50
7.	Social participation	Low (< 20.11)	53	44.17
		Medium (20.11-31.79)	48	40.00
		High (>31.79)	19	15.83
8.	Extension contact	Low (<13.14)	21	17.50
		Medium (13.14-23.12)	87	72.50
		High (>23.12)	12	10.00
9.	Information seeking behaviour	Low (<14.95)	17	14.17
		Medium (14.95-23.03)	70	58.33
		High (>23.03)	33	27.50
10.	Material possession	Low (<8.96)	1	0.83
		Medium (8.96-12.62)	105	87.50
		High (> 12.62)	14	11.67
11.	Mass media utilisation	Low (<6.68)	15	12.50
		Medium (6.68-12.84)	77	64.17
		High (>12.84)	28	23.33
12.	Training received	Low (<2.32)	34	28.33
		Medium (2.31-4.88)	38	31.67
		High (> 4.88)	48	40.00

*F = Frequency % = Per cent

to middle age category are more when compared to young and old age. This could be accounted for the reason that the middle aged people are more active in their work and profession. Moreover middle aged farmers might be more energetic, enthusiastic and efficient compared to young and old, hence they were sampled for the study. On the whole it is also observed that young and middle age categories together constitute more than the old age. The probable reason might be that senior citizens are less engaged in farming because of their health and other reasons.

More than one fourth of the respondents were

Table-2: Relationship between the profile characteristics and the impact of ANGRAU supported RFIS on beneficiary farmers.

Variable	Age	Education	Land holding	Farming experi-ence	Occupa-tion	Annual Income	Social participation	Extension contact	Information seeking behaviour	Material posses-sion	Mass media utilization	Training received	Impact
Age	1	0.090NS	-0.054NS	0.029NS	-0.078NS	0.094NS	0.036NS	-0.030NS	-0.070NS	0.032NS	0.157NS	0.216*	-0.105NS
Education	0.090NS	1	0.077NS	0.199*	-0.140NS	-0.004NS	0.061NS	0.014NS	0.021NS	0.009NS	0.133NS	-0.092NS	-0.018NS
Land holding	-0.054NS	0.077NS	1	0.068NS	-0.123NS	0.287**	0.121NS	-0.085NS	-0.197*	-0.051NS	-0.038NS	-0.268**	-0.308**
Farming experience	0.029NS	0.199*	0.068NS	1	0.088NS	0.036NS	-0.059NS	0.053NS	0.055NS	-0.044NS	0.115NS	-0.134NS	-0.059NS
Occupation	-0.078NS	-0.140NS	-0.123NS	0.088NS	1	0.294**	-0.092NS	0.109NS	0.060NS	0.009NS	-0.039NS	-0.028NS	0.259**
Annual Income	0.094NS	-0.004NS	0.287**	0.036NS	0.294**	1	0.223*	-0.358**	-0.132NS	-0.136NS	-0.077NS	-0.004NS	-0.909**
Social participation	0.036NS	0.061NS	0.121NS	-0.059NS	-0.092NS	0.223*	1	-0.111NS	-0.080NS	-0.046NS	0.015NS	0.070NS	-0.223*
Extension contact	-0.030NS	0.014NS	-0.085NS	0.053NS	0.109NS	-0.358**	-0.111NS	1	0.018NS	0.086NS	0.086NS	-0.040NS	0.330**
Information seeking behaviour	-0.070NS	0.021NS	-0.197*	0.055NS	0.060NS	-0.132NS	-0.080NS	0.018NS	1	-0.007NS	0.231**	0.276**	0.247**
Material possession	0.032NS	0.009NS	-0.051NS	-0.044NS	0.009NS	-0.136NS	-0.046NS	0.086NS	-0.007NS	1	0.174NS	0.001NS	0.099NS
Mass media utilisation	0.157NS	0.133NS	-0.038NS	0.115NS	-0.039NS	-0.077NS	0.015NS	0.086NS	0.231**	0.174NS	1	0.238**	0.283**
Training received	0.216*	-0.092NS	-0.268**	-0.134NS	-0.028NS	-0.004NS	0.070NS	-0.040NS	0.276**	0.001NS	0.238**	1	0.312**
Effectiveness	-0.094NS	-0.013NS	-0.313**	-0.027NS	0.262**	-0.917**	-0.215*	0.329**	0.281**	0.068NS	0.276**	0.329**	0.918**
Impact	-0.105NS	-0.018NS	-0.308**	-0.059NS	0.259**	-0.909**	-0.223*	0.330**	0.171NS	0.099NS	0.084NS	-0.012NS	1

*Significant ** Highly Significant

educated up to middle school (28.33%), followed by high school (20.83%), primary school (17.50%), functionally illiterate(10.84%) graduation (9.17%), illiterate (7.50%), intermediate (5.83%) and none of them were post graduates. The sample for the study included farmers with no education, functionally literate and who were educated from primary school to graduation. Many sections of the people were included for the study. However, respondents who were illiterate were meager and they might be taking help of their children at home to read and translate the mobile messages and other information services provided by RFIS. They might be active participants in other programmes conducted by reliance foundation where much formal or no education will suffice.

Less than half of the respondents had marginal (48.33%) land holdings, followed by small (35.83%), semi medium (13.34%) and medium (2.50%). None of the respondents possessed large land holdings. Land fragmentation and division of joint families to nuclear families could be accounted for the above findings.

Less than half of the respondents had low (48.33%) farming experience, followed by medium (43.33%) and high (8.33%) farming experience. The experience of the respondents corresponds to their age. However greater proportion of the respondents are found in low to medium farming experience when compared to high farming experience category.

It is evident that less than half of the respondents occupation was agriculture (46.66%), followed by agriculture + livestock (25.83%), agriculture + agriculture labour (19.17%), agriculture + business (6.67%) and agriculture + Private Job (1.67%).It is found that either agriculture is the sole occupation or is practiced by the farmers in combination with other occupations. This could be justified that during their free time after farm works subsidiary occupations are practiced for additional income. It is also observed that most of the farmers depended not only on agriculture but has an alternate occupation to survive on. The reason could be marginal and small land holdings.

Less than two third of the respondents had medium (65.00%) annual income, followed by high (22.50%) and low (12.50%) annual income. This trend corresponds to their land holding and occupation. Less than half of the respondents had low social participation (44.17%), followed by medium (17.50%) and high (15.83%) social participation. This trend corresponds to their annual income. The farmers with low and medium annual income were more engaged in farming and allied occupations for increasing their annual income. The farmers with high annual income participated in social activities, held positions in various social organisations.

Table-3 : Multiple Linear Regression (MLR) analysis of selected independent variables with impact of RFIS.

	Regression coefficient	Standard Error	t Stat
Age	-0.2415	0.6079	-0.3972NS
Education	-0.1099	0.2684	-0.4094NS
Land holding	-1.1143	0.5740	-1.9413*
Farming Experience	-0.5147	0.4915	-1.0473NS
Occupation	0.7538	0.8684	0.8680*
Annual income	-0.6817	0.0475	-14.3671**
Social participation	-0.0773	0.2571	-0.3006NS
Extension contact	0.1991	0.1044	1.9065*
Information seeking behaviour	0.2145	0.1651	1.2996*
Material possession	0.1371	0.2096	0.6540*
Mass media utilization	0.0506	0.1518	0.3337*
Training received	0.3398	0.4353	0.7807*
Intercept value : 87.67	R^2 value=0.785		F = 32.70

Adjusted R Square = 0.761NS - Non-significant
**Significant at 0.01 level of probability
*Significant at 0.05 level of probability

The table also indicated that less than three fourth of the respondents had medium (72.50%) extension contact, followed by low (17.50%) and high (10.00%) extension contact. This trend is in contrast to their annual income. The farmers with low and medium annual income approached extension agencies for farm advices for increasing their annual income. But the farmers with high annual income did not have much contact extension agencies for farm advices because of the lack of time and busy work in farm.

More than half of the respondents belonged to medium (58.33%) information seeking behaviour, followed by high (27.50%) and low (14.17%) information seeking behaviour. This trend is in contrast to land holding. As the land holding increased among the farmers they did not much seek the farm information. This implies that the respondents with less land holdings searched farm information from various organisations and as well approached them for further clarification of the agro advisories. This could also be interpreted as the farmers land holding increased their responsibility and work at farm increased, hence did not spare much time in searching farm information.

Majority of the respondents had medium (87.50%) material possession, followed by high (11.67%) and low (0.83%) material possession. Today every house has TV and smart phone they have become necessities for entertainment and communication. Hence negligible portion of the respondents were found in low category of material possession. Depending on annual income and need, farmers either rent or own farm machinery. Today custom hiring centres are renting out basic farm machinery used in farming, hence there is less need for farmers to purchase the equipment. Hence it is observed that majority of the respondents fell in the category of medium material possession. Moreover the quest for information further motivated the respondents to use mass media to a greater extent and also attend the training programmes.

Less than two third of the respondents had medium (64.17%) mass media utilisation, followed by high (23.33%) and low (12.50%) mass media utilisation. This trend corresponds to information seeking behaviour and training received. The farmers who were in search of agricultural information used mass media to a greater extent and also attended training programmes indicating that as information seeking behaviour increased the mass media utilisation and training received also increased.

Less than half of the respondents were found in high (40.00%) training received category, followed by medium (31.67%) and low (28.33%) training received category. This trend corresponds to information seeking behaviour and mass media utilisation and contrast with land holding. The farmers who were in search of agricultural information sought the information on the training programmes venue from various mass media channels and attended the training programmes, indicating that as information seeking behaviour increased the training received also increased. The farmers with more land holdings did not show much interest in receiving training on farm aspects or were much busy with their farming and did not spare time for undergoing trainings.

Relationship between profile and the impact of ANGRAU supported RFIS on beneficiary farmers : An attempt has been made to find out if there exists any relationship between the profile characteristics of the respondents namely age, education, land holding, farming experience, occupation, annual income, social participation, extension contact, material possession, mass media utilisation and training received and the impact of RFIS services. The Spearman's rank correlation matrix depicting the relationship between the profile characteristics and the impact of ANGRAU supported RFIS on beneficiary farmers is presented in table 2.

It is evident from Table-2 that computed 'r' values of occupation, extension contact, information seeking behaviour, mass media utilisation and training received had positive and significant correlation with the impact of RFIS. The above findings indicate that, as the number of occupations, extension contact, information seeking behaviour, mass media utilisation and training received increased the impact of RFIS also increased. It might be due to the fact that, as the number of occupations increased the respondents contacted various sources for information namely extension personnel, mass media and participated in various training programmes and practiced the agro advisories and reaped benefits which could be accounted for increased impact of RFIS.

The variables land holding, annual income and social participation were found to have negative but significant correlation with the impact of RFIS. This clearly indicates that the respondents with less land holding, less annual income and less social participation experienced more impact of RFIS. The above farmers with an urge to increase their annual income effectively used the RFIS services and spent more time in practicing agriculture than in social activities as a result of which more impact was experienced by the respondents.

The variables age, education and farming experience had negative and non-significant correlation with the impact of RFIS. The variable material possession was found to have positive but non-significant correlation with the impact of RFIS. The variables age, education, farming experience and material possession are not barriers for using RFIS and hence did not play any significant role in influencing the impact of RFIS on the respondents.

Multiple linear regression (MLR) analysis of selected independent variables with impact of RFIS : An attempt has been made to find out the amount of contribution made by the Profile characteristics in explaining the variation in the dependent variable i.e., impact of RFIS. The results were presented in Table 4. The MLR equation can be fit as

$$Y=87.675-0.2415X_1-0.1099X_2-1.1143X_3-0.5147X_4+0.7538X_5-0.6817X_6-0.0773X_7+0.1991X_8+0.2145X_9+0.1371X_{10}+0.0506X_{11}+0.3398X_{12}$$

It was observed from Table 3 that the twelve independent variables with the Impact of RFIS on the farmers taken on multiple linear regression analysis gave the Co-efficient of Determination (R^2) as 0.785. Hence, it could be concluded that all the selected independent variables put together contributed 78.50 per cent of the total variation in the impact RFIS on the farmers, leaving the rest to the extraneous factors.

The regression coefficient further revealed that the profile characteristics namely occupation, extension contact, information seeking behaviour, material possession, mass media utilisation and training received were found to be positive and significantly contributed to the impact of RFIS. Land holding and annual income were found to be negative and significantly contributed to the impact of RFIS. Age, education, farming experience, social participation did not significantly contribute to the impact of RFIS.

Conclusions

It is a positive sign that the PPP venture, Reliance Foundation Information Services with a joint collaboration with Acharya N.G. Ranga Agricultural University and Reliance Foundation has created a considerable impact on the clientele. Agro advisories should be in such a way that they create technical impact and economic impact on the beneficiaries paving way for social impact. This RFIS venture is succeeding in providing socio-economic and technical impact on the farming community. Hence more this type of Public private Partnerships has to be encouraged in Agriculture sector in order to prosper the farming community and the country as well.

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Effectiveness of ANGRAU Supported Reliance Foundation Information Services on Beneficiary Farmers

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Abstract

ANGRAU, the state Agricultural university of Andhra Pradesh working for the welfare of the farming community since its establishment. Understanding the need of strengthening the present extension services in addressing the multifaceted farmer's needs it has signed a MoU with Reliance Foundation Information Services (RFIS). ANGRAU with the vast experiential knowledge through its decades of services to farming community through KVK, DAATTC, and ARS agreed to be the knowledge partner in this MoU. ANGRAU together with RFIS working in Public Private Partnership (PPP) mode for the upliftment of farming community. The study was conducted as part of M.Sc (Ag.) programme during 2018-19. It was found that 60.84 per cent of the respondents perceived medium effectiveness of RFIS, followed by low (21.66%) and high (17.50%). It is evident that the independent variables namely occupation, extension contact, information seeking behaviour, mass media utilisation and training received had positive and significant correlation with the effectiveness of RFIS. The variables land holding, annual income and social participation were found to have negative but significant correlation with the effectiveness of RFIS. The selected independent variables put together contributed 83.70 per cent of the total variation in the effectiveness RFIS on the farmers, leaving the rest to the extraneous factors.

Key words *: ANGRAU, reliance foundation information services, MoU, public private partnership and effectiveness.*

Introduction

Over the past decade, the so-called "public-private partnerships" (PPPs) have been of increasing importance all over the world in extending the ability of government organizations to provide services in difficult economics. According to the U.S. State Department, "Such partnerships have leveraged the creativity, innovation, and core business resources of private partners for greater impact on global issues. In most countries these PPP arrangements have been aimed at overcoming broad public sector constraints in relation to either a lack of public capital or a lack of public sector capacity, resources and specialized expertise to develop, manage and operate infrastructure assets. Public Private Partnerships are now commonly used to accelerate economic growth, development and infrastructure delivery and to achieve quality service delivery. The need for PPPs in many countries has been accelerated by the public sector's recognition of the vital role of modern infrastructure in economic growth, and PPP`s are now accepted as an important avenue for funding major public sector infrastructure projects. RFIS is one of such public private partnership project for which a Memorandum of Understanding (MOU) was signed between ANGRAU and Reliance Foundation in 2014 for implementing Information Services Programme to work in a PPP mode through RFIS (Reliance Foundation Information Services).

RFIS is disseminating the agricultural information though mobile text messages, mobile voice messages, knowledge on wheels programme, video conference, field awareness programmes, toll free number (1800 419 8800), phone in live, veterinary camps, bulletins & broadcasts and jio chat.

The study of the profile of the respondents would help the extension stakeholders to acquaint with the existing situation of farmers related to age, education, land holding, farming experience, occupation, annual income, social participation, extension contact, information seeking behavior, material possession, mass media utilization and training received by the respondents. Based on these profile characteristics appropriate programmes and trainings may be formulated for updating technical knowhow on agriculture. The study would unearth the effectiveness of RFIS on farmers. The findings of effectiveness of RFIS indicates usefulness and extent of adoption of information. Based on this information the efficiency of RFIS could be improved and made still better.

The regression analysis would reveal the contribution of independent variables on dependent variables. These findings would be of use to the partners in the consortium of PPP to further streamline the services and extend enhanced benefits to the ultimate users. This

Table-1 : Usefulness of RFIS as perceived by the respondents.

S.No.	Item	Category																			
		Mobile text message		Mobile voice message		Knowledge on wheels programme		Video conference		Field awareness programme		Toll free number		Phone in live		Veterinary camps		Bulletins & Broadcast		Jio chat	
		F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
1.	Land preparation	12	10.00	9	7.50	54	45.00	3	2.50	42	35.00	5	4.17	7	5.83	—	-	11	9.17	4	3.33
2.	Selection of crops	36	30.00	39	32.50	67	55.83	32	26.67	54	45.00	52	43.33	62	51.67	—	-	32	26.67	14	11.67
3.	Selection of varieties	41	34.17	23	19.17	58	48.33	49	40.83	68	56.67	72	60.00	61	50.83	—	-	13	10.83	9	7.50
4.	Sowing time	21	17.50	16	13.33	59	49.17	63	52.50	71	59.17	43	35.83	81	67.50	—	-	24	20.00	11	9.17
5.	Soil testing & STBFA	91	75.83	89	74.17	54	45.00	37	30.83	43	35.83	21	17.50	32	26.67	—	-	16	13.33	19	15.83
6.	Weed management	32	26.67	46	38.33	23	19.17	62	51.67	71	59.17	65	54.17	71	59.17	—	-	35	29.17	18	15.00
7.	Irrigation scheduling	14	11.67	21	17.50	12	10.00	26	21.67	34	28.33	29	24.17	39	32.50	—	-	14	11.67	16	13.33
8.	Intercultural operations	17	14.17	19	15.83	36	30.00	42	35.00	51	42.50	62	51.67	72	60.00	—	-	32	26.67	16	13.33
9.	Pest management	54	45.00	39	32.50	89	74.17	91	75.83	99	82.50	93	77.50	96	80.00	—	-	54	45.00	27	22.50
10.	Disease management	61	50.83	67	55.83	72	60.00	75	62.50	82	68.33	89	74.17	96	80.00	—	-	59	49.17	29	24.17
11.	Farm mechanisation	15	12.50	13	10.83	22	18.33	21	17.50	62	51.67	69	57.50	27	22.50	—	-	15	12.50	7	5.83
12.	Labour management	11	9.17	9	7.50	16	13.33	13	10.83	26	21.67	17	14.17	12	10.00	—	-	10	8.33	16	13.33
13.	Harvesting	21	17.50	16	13.33	27	22.50	32	26.67	37	30.83	15	12.50	11	9.17	—	-	14	11.67	6	5.00
14.	Drying &storage	13	10.83	17	14.17	15	12.50	23	19.17	27	22.50	31	25.83	26	21.67	—	-	29	24.17	12	10.00
15.	Weather information	87	72.50	89	74.17	16	13.33	35	29.17	21	17.50	36	30.00	14	11.67	—	-	67	55.83	54	45.00
16.	Marketing	15	12.50	19	15.83	21	17.50	15	12.50	11	9.17	37	30.83	15	12.50	—	-	69	57.50	38	31.67
17.	Governmental schemes	2	1.67	5	4.17	13	10.83	2	1.67	6	5.00	12	10.00	6	5.00	—	-	6	5.00	11	9.17
18.	Credit & finance	2	1.67	4	3.33	13	10.83	5	4.17	6	5.00	7	5.83	6	5.00	—	-	2	1.67	6	5.00
19.	Insurance	89	74.17	91	75.83	32	26.67	12	10.00	57	47.50	34	28.33	16	13.33	—	-	32	26.67	16	13.33

*F = Frequency % = Per cent

Table-2 : Adoption of information disseminated by RFIS by the respondents.

S. No.	Item	Fully adopted		Partially adopted		Not adopted	
		F	%	F	%	F	%
1.	Land preparation	24	20.00	72	60.00	24	20.00
2.	Selection of crops	54	45.00	62	51.67	4	3.33
3.	Selection of varieties	69	57.50	44	36.67	7	5.83
4.	Sowing time	45	37.50	59	49.17	16	13.33
5.	Soil testing & soil test based fertilizer application	75	62.50	37	30.83	8	6.67
6.	Weed management	35	29.17	63	52.50	22	18.33
7.	Irrigation scheduling	32	26.67	59	49.16	29	24.17
8.	Intercultural operations	46	38.33	49	40.84	25	20.83
9.	Pest management	68	56.67	32	26.66	20	16.67
10.	Disease management	71	59.17	39	32.50	10	8.33
11.	Farm mechanisation	34	28.33	68	56.67	18	15.00
12.	Labour management	22	18.33	75	62.50	23	19.17
13.	Harvesting	36	30.00	53	44.17	31	25.83
14.	Drying and storage	16	13.33	63	52.50	41	34.17
15.	Weather related information	89	74.17	13	10.83	18	15.00
16.	Marketing	62	51.67	36	30.00	22	18.33
17.	Governmental schemes	62	51.67	29	24.16	29	24.17
18.	Credit and finance	11	9.17	59	49.17	50	41.66
19.	Insurance	73	60.83	21	17.50	26	21.67

*F = Frequency % = Per cent

Table-3 : Distribution of respondents according to their effectiveness of RFIS. (n=120)

Sr. No.	Category	F	%
1.	Low (<334.13)	26	21.66
2.	Medium (334.13-525.45)	73	60.84
3.	High (> 525.45)	21	17.50
	Total	120	100.00
	Mean = 429.79	SD = 95.66	

*F = Frequency % = Per cent

Table-4 : Relationship between profile and the effectiveness of ANGRAU supported RFIS on beneficiary farmers.

Sr. No.	Variable	Effectiveness
1.	Age	-0.094NS
2.	Education	-0.013NS
3.	Land holding	-0.313**
4.	Farming experience	-0.027NS
5.	Occupation	0.262**
6.	Annual Income	-0.917**
7.	Social participation	-0.215*
8.	Extension contact	0.329**
9.	Information seeking behaviour	0.281**
10.	Material possession	0.068NS
11.	Mass media utilisation	0.276**
12.	Training received	0.329**

would be of immense help to government, policy makers and administrators to promote such PPP models. Apart from these the results would be applicable elsewhere under similar situations.

Objective of the study : To study the profile of beneficiary farmers of ANGRAU supported Reliance Foundation Information Services (RFIS), assess the effectiveness as well as to find out the relationship between profile and the effectiveness of ANGRAU supported RFIS on beneficiary farmers.

Materials and Methods

The study was conducted as a part of M.Sc (Ag.) programme in Andhra Pradesh state during the year 2018-2019. Ex-post facto research design was used.

Sampling procedure : The procedure adopted for selection of the locale of the study and respondents is given below.

Locale of study : The study was conducted in Andhra Pradesh state during the year 2018-2019. The state of Andhra Pradesh was selected purposively as the researcher belongs to this state and is familiar with the local language.

Selection of district : The major focus of the study is on "Impact of ANGRAU supported Reliance Foundation Information Services (RFIS)". Hence, Guntur district was selected purposively for the study as highest number of RFIS beneficiaries are present in this district.

Selection of mandals : Guntur district consists of fifty seven mandals. Out of which, three mandals viz.,Sattenapalle, Vatticherukuru and Pedakakani were

Table-5 : Multiple Linear Regression (MLR) analysis of selected independent variables with effectiveness of RFIS.

Sr. No.	Variable	Regression coefficient	Standard Error	t Stat
1.	Age	6.8468	5.5991	1.2229NS
2.	Education	-0.0935	2.4727	-0.0378NS
3.	Land holding	-10.1707	5.2875	-1.9236*
4.	Farming Experience	-0.2400	4.5269	-0.0530NS
5.	Occupation	8.0441	7.9987	1.0057*
6.	Annual income	-7.8213	0.4371	-17.8942**
7.	Social participation	-2.4127	2.3680	-1.0189NS
8.	Extension contact	1.1265	0.9619	1.1712*
9.	Information seeking behaviour	0.7057	1.5204	0.4642*
10.	Material possession	-2.4730	1.9305	-1.2810NS
11.	Mass media utilization	1.0883	1.3982	0.7784*
12.	Training received	1.4024	4.0095	0.3498*
	Intercept value: 599.74	R^2 value=0.837		F = 45.87

Adjusted R Square = 0.819NS - Non-significant
**Significant at 0.01 level of probability, *Significant at 0.05 level of probability

purposively selected for the study based on the presence of highest number of RFIS beneficiaries.

Selection of villages : From each of the selected mandal, four villages were selected using simple random sampling procedure. Dhulipalla, Kantepudi, Nandigama and Rentapalle villages from Sattenapallemandal; Karempudipadu, Vinjanampadu, Karnepaduand Yammurufrom Vatticherukurumandal;Nambur, Venigandla, Takellapadu and Koppuravuru from Pedakakani mandal were selected for the study. Thus a total of twelve (12) villages were selected for the study.

Selection of respondents : From each of the selected villages, 10 respondents who received Reliance Foundation Information Services since two years were selected by using simple random procedure. Thus total sample comprised of 120 respondents. The data was collected using an interview schedule. Independent variables included age, education, land holding, farming experience, occupation, annual income, social participation, extension contact, information seeking behavior, material possession, mass media utilization, training received. Effectiveness of RFIS was taken as dependent variable. Statistical tools namely mean, standard deviation, frequency, percentage, correlation and multiple linear regression were used.

Effectiveness was referred to the effect that was created on the respondent as a result of RFIS. In this study effectiveness of RFIS was operationalised as the integrated effect caused by the usefulness and adoption of the information services. Usefulness is referred to the practicality of the information provided by the various programmes of RFIS. Adoption is referred to the extent to which the respondents practice the information provided to them on crop management.

The individual respondents scores on the two components namely usefulness, topic of interest and adoption of information services was summed up to get the individual respondent total score of effectiveness of RFIS. The high score means higher impact of the RFIS on the respondent. Using mean and standard deviation as a measure of check, the respondents were classified into three categories as low (< mean- SD), medium (mean $\pm$SD) and high (> mean+SD).

Results and Discussion

Usefulness of RFIS : It is evident from Table-1 that more than three fourth of the respondents expressed that mobile text messages were useful for getting information on soil test based fertilizer application (75.83%), followed by insurance (74.17%), weather related information (72.50%), disease management (50.83%), pest management (45.00%), selection of varieties (34.17%), selection of crops (30.00%), weed management (26.67%), sowing time (17.50%), harvesting (17.50%) intercultural operations (14.17%), farm mechanization (12.50%), marketing (12.50%), irrigation scheduling (11.67%), drying and storing (10.83%), labour management (9.17%), government schemes, credit & finance (1.67%).

More than three fourth of the respondents expressed that mobile voice messages were useful for getting information on insurance (75.83%), followed by weather related information (74.17%), soil testing and soil test based fertilizer application (74.17%), disease management (55.83%), weed management (38.33%), selection of crops & pest management (32.50%), selection of varieties (19.17%), irrigation scheduling (17.50%), inter cultural operations (15.83%), marketing (15.83%), drying and storage (14.17%), sowing time

(13.33%), harvesting (13.33%), farm mechanization (10.83%), land preparation & labour management (7.50%), government schemes (4.17%) and credit & finance (3.33%).

Less than three fourth of the respondents expressed that knowledge on wheels programme was useful for getting information on pest management (74.17%), followed by disease management (60.00%), selection of crops (55.83%), sowing time (49.17%), selection of varieties (48.33%), soil testing and soil test based fertilizer application & land preparation (45.00%), intercultural operations (30.00%), insurance (26.67%), harvesting (22.50%), weed management (19.17 %), farm mechanisation (18.33 %), marketing (17.50 %) , labour management and weather related information (13.33%), drying and storage (12.50%) and government schemes, credit& finance (10.83%).

More than three fourth of the respondents expressed that video conferences were useful for getting information on pest management (75.83%), followed by disease management (62.50%), sowing time (52.50%), weed management (51.67%), selection of varieties (40.83%), intercultural operations (35.00%), soil testing and soil test based fertilizer application (30.83%), weather related information (29.17%), harvesting and selection of crops (26.67%), irrigation scheduling (21.67%), drying and storage (19.17%), farm mechanisation (17.50%), marketing (12.50%), labour management (10.83%), insurance (10.00%), credit and finance (4.17%), land preparation (2.50%) and government schemes (1.67%).

With regard to field awareness programs 82.50 per cent of the respondents expressed that they were useful for pest management, followed by disease management (68.33%), sowing time (59.17%), selection of varieties (56.67%), insurance (47.50%), selection of crops (45.00%), intercultural operations (42.50%), soil testing and soil test based fertilizer application (35.83%), land preparation (35.00%), harvesting (30.83%), irrigation scheduling (28.33%), drying and storage (22.50%), labour management (21.67%), weather related information (17.50%), marketing (9.10%) and government schemes, credit & finance (5.00%).

More than two third of the respondents expressed that toll free number was found useful for getting information on pest management (77.50%), followed by disease management (74.17%), selection of varieties (60.00%), farm mechanization (57.50%), weed management (54.17%), inter cultural operations (51.67%), selection of crops (43.33%), sowing time (35.83%), marketing (30.83%), weather related information (30.00%), insurance (28.33%), drying and storage (25.83%), irrigation scheduling (24.17%), soil testing and soil test based fertilizer application (17.50%), labour management (14.17%), harvesting (12.50%), government schemes (10.00%), credit & finance (5.83%) and land preparation (4.17%).

With regard to phone in live programmes 80.00 per cent of the respondents expressed that they were useful in getting information on pest and disease management, followed by sowing time (67.50%), inter cultural operations (60.00%), weed management (59.17%), selection of crops (51.67%), selection of varieties (50.83%), irrigation scheduling (32.50%), soil testing and soil test based fertilizer application (26.67%), farm mechanisation (22.50%), drying & storage (21.67 %), insurance (13.33%), marketing (12.50%), weather related information (11.67%), labour management (10.00%), harvesting (9.17%), land preparation (5.83%), government schemes, credit & finance (5.00%).

Adoption of Information Disseminated by RFIS : It is evident from table-2 that 20.00 per cent of respondents expressed that they fully adopted the information on land preparation, followed by partially adopted (60.00%) and not adopted (20.00%). With regard to the information on selection of crops 45.00 per cent respondents fully adopted, followed by partially adopted (51.67%) and not adopted (3.33%). With regard to the information on selection of varieties 57.50 per cent of respondents fully adopted, followed by partially adopted (36.67%) and not adopted (5.83%). More than one third of the respondents fully adopted (37.50%) the information on sowing time, followed by partially adopted (49.17%) and not adopted (13.33%). Less than two third of respondents fully adopted the information on soil testing & soil test-based fertilizer application (62.50%), followed by partially adopted (30.83%) and not adopted (6.67%).

With regard to the information on weed management 29.17 per cent of the respondents fully adopted, followed by partially adopted (52.50%) and not adopted (18.33%). More than one fourth of respondents fully adopted (26.67%) the information on irrigation schedule, followed by partially adopted (49.16%) and not adopted (24.17%). With regard to the information on intercultural operations 38.33 per cent of the respondents fully adopted, followed by partially adopted (40.84%) and not adopted (20.83%). With regard to the information on pest management 56.67 per cent of the respondents fully adopted, followed by partially adopted (26.66%) and not adopted (16.67%). With regard to the information on disease management 59.17 per cent of the respondents fully adopted, followed by partially adopted (32.50%) and not adopted (8.33%). More than one fourth of the respondents fully adopted (28.33%) the information on farm mechanisation, followed by partially adopted (56.67%) and not adopted (15.00%).

With regard to the information on labour management 18.33 per cent of the respondents fully adopted the information, followed by partially adopted (62.50%) and not adopted (19.17%).

Less than one third of the respondents fully adopted (30.00%) the information on harvesting, followed by partially adopted (44.17%) and not adopted (25.83%). A meagre proportion of 13.33 per cent of the respondents fully adopted information on drying & storage, followed by partially adopted (52.50%) and not adopted (34.17%). Less than three fourth of the respondents fully adopted the information on weather related information (74.17%), followed by partially adopted (10.83%)and not adopted (15.00%).

More than half of the respondents fully adopted the information on marketing (51.67%), followed by partially adopted (30.00%) and not adopted (18.33%). With regard to credit and finance 9.17 per cent each of the respondents fully adopted the information, followed by adopted (49.17%) and not adopted (41.66%). With regard to the information on insurance60.83 per cent of the respondents fully adopted (60.83%), followed by partially adopted (17.50%) and not adopted (21.67%).

Location specific and farmer specific information is a pre requisite for full adoption of a technology. The other reasons for partial adoption of a technology also need to be probed in. A considerable proportion of the respondents were also found in not adopted category. Hence efforts need to be put for bringing them to partially and fully adopted categories.

Overall Effectiveness of RFIS in Addressing the Information Needs of the Farmers : It is revealed from Table 3 that 60.84 per cent of the respondents perceived medium effectiveness of RFIS, followed by low (21.66%) and high (17.50%).The results correspond to usefulness and adoption with the information provided by RFIS. The proportion of the respondents in medium and high category of effectiveness is greater than that observed in low. It could be concluded that the major proportion of the respondents fell in the category of medium to high effectiveness of RFIS. The results are in conformity with that reported by Kumari *et al.* (2018).

Relationship between profile and the effectiveness of ANGRAU supported RFIS on beneficiary farmers : The Spearman's rank correlation matrix depicting the relationship between the profile characteristics and the Effectiveness of ANGRAU supported RFIS on beneficiary farmers is presented in Table-4. The findings indicate that, as the number of occupations, extension contact, information seeking behaviour, mass media utilisation and training received increases the effectiveness of RFIS also increases. It might be due to the fact that, as the number of occupations increase the respondents contact extension personnel from time to time for various agro advisories to get maximum benefits from different occupations. As well the respondents seek information from various sources like mass media and even show interest to participate in various training programmes for expert advises.

The variables land holding (-0.313**), annual income (-0.917**) and social participation (-0.215*) were found to have negative but significant correlation with the effectiveness of RFIS. This clearly indicates that the respondents with less land holding, less annual income and less social participation experienced more effectiveness of RFIS. The above farmers with an urge to increase their annual income effectively used the RFIS services and spent more of their time in practicing agriculture than in social activities.

The variables age (-0.094NS), education (-0.013NS) and farming experience (-0.027NS) had negative and non-significant correlation with the effectiveness of RFIS. The variable material possession (0.068NS) was found to have positive but non-significant correlation with the effectiveness of RFIS. The variables age, education, farming experience and material possession are not barriers for using RFIS by the farmers.

Multiple Linear Regression (MLR) analysis of selected independent variables with effectiveness of RFIS : An attempt has been made to find out the amount of contribution made by the profile characteristics in explaining the variation in the dependent variable i.e., the effectiveness of RFIS. The results were presented in Table-5. The MLR equation can be fit as

$$Y=599.7446+6.8468X_1-0.0935X_2-10.1707X_3-0.2400X_4+8.0441X_5-7.8213X_6—2.4127X_{7+}1.1265X_{8+}0.7057X_9-2.4730X_{10}+1.0883X_{11}+1.4024X_{12}$$

It is observed that the twelve independent variables with the effectiveness of RFIS on the farmers taken on multiple linear regression analysis gave the Co-efficient of Determination (R^2) as 0.837. Hence, it could be concluded that all the selected independent variables put together contributed 83.70 per cent of the total variation in the effectiveness RFIS on the farmers, leaving the rest to the extraneous factors

Conclusions

Agricultural extension system could be made more effective through sharing of experiences by both public and private extension service providers. "Working together can harness the abilities and strengths of each other and in many cases they have an impact far beyond what one partner could achieve on its own." To reach the unreached reliance foundation with knowledge partners as ANGRAU is implementing RFIS in PPP consortium. This RFIS venture is found effective in providing sound scientific knowledge to the farmers and thus helping for the upliftment of the farming community. Hence more this type of Public private Partnerships has to be encouraged in Agriculture sector in order to prosper the farming community and the country as well.

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Diversification in Indian Agriculture is a Strategy for an Alternative Income : A Review

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Abstract

In India, land-based livelihoods of small and marginal farmers are increasingly becoming unsustainable, since their land is no longer able to meet the requirements of food for the family and of fodder for their livestock due to continues fragmentation of land and increasing population. So we have to search a way of alternative income for better standard of living of farmers and his coming generation in future, which could reduce poverty and risk on farm and enhancing the farmers' income means they have to diversified their source of income through sift some members of their family from farm activities to nonfarm activities. It would help in reducing disguised unemployment in agricultural sector of India. Diversification in Indian agriculture might be from less remunerative crop to high-value crops and from farm activities to nonfarm activities could potentially augment farm incomes of the farmers, particularly in a developing country like India where demand for high-value food products has been increasing more rapidly than that for staple crops. Indian agriculture is tremendously dominated by smallholders. Diversification in agriculture means including high value crops and allied activities (poultry, gaotry, fishery, bee keeping and mushroom cultivation, vermicompost etc). In this review article author had tried to summarize nature and extent of diversification in India and how diversification could help in reducing poverty and augmenting farm income.

Key words : *diversification, transformation, livelihood, poverty, farm size, income and index*

Introduction

Traditionally, agricultural diversifications referred to a subsistence kind of farming where in farmers were cultivating varieties of crops on a piece of land and undertaking several enterprises on their farm portfolio. Household food and income security were the basic objectives of agricultural diversification. In the recent decades, agricultural diversification is increasingly being considered as a panacea for many ills in the agricultural development of the country (Jha, 2009). Concept of crop diversification means competition among various grown crops for space in a given region. It also means raising a variety of crops involving intensity of competition amongst field crops for arable land the keener the competition, the higher the magnitude of crop diversification. It is a concept which is opposite to crop specialization. It is an indicator of multiplication of crops which obviously involves intensive competition among the growing crops. (Singh, 1976). By conventionally, agricultural diversifications referred to a subsistence kind of farming where in farmers or growers were cultivating varieties of crops on a piece of land and undertaking several enterprises on their farm portfolio to reduce the risk or failure of single activity. Basic objectives of agricultural diversification were household food and income security. (Abro, 2012: Meena *et. al.,* 2016). Diversification in rural livelihoods is the subject of conceptual and policy-based research because income from farming has come under pressure due to population explosion (Barrett *et al*., 2001; Davies, 1993; Ellis, 1998; Bryceson, 1999). It is being realized for some time that rural people no longer remain confined to crop production, fishing, forest management or livestock-rearing but combine a range of occupations to construct a diverse portfolio of activities (Dercon and Krishanan, 1996; Ellis, 2000; Unni, 1996).

In fact, livelihood diversification is a process by which rural households construct a diverse portfolio of activities and social support capabilities in their struggle for survival and improvement in their standards of living (Ellis, 1998). A recent study by Food and Agriculture Organization (FAO) on farming systems and poverty has suggested that diversification is the most important source of poverty reduction for small farmers in South and South-East Asia (FAO/World Bank, 2001).

Nature and Extent of Crop Diversification : There has been a vast increase in diversification of commercial crops after WTO. Crop diversification is influenced by a number of infrastructural and technological factors. The results have revealed that crop diversification influences production. The study has suggested that the creation of basic infrastructural facilities like sustained supply of irrigation water, markets, fertilizer availability, proper roads and transportation is an essential pre-requisite for creating enabling conditions for fostering the process of agricultural development and crop diversifications, as most of these parameters are found to influence the nature and extent of crop diversification (Acharya et. al., 2011**).** The average farm size has increased in the case of the small farms while in the case of medium and large farms it has decreased. Introduction of new farm technology, new high yielding varieties, transportation technology, per capita income, regulated markets, are the main influencing factors (Balishter *et. al.,* 1985). The crop diversification is considered as an important tool for acceleration of agricultural growth in India by promoting food and nutritional security, income and employment generation, poverty alleviation, judicious use of natural resources and ecological management. Important factors determining crop diversification, pattern of crop diversification, problems and prospects associated with crop diversification are discussed in this paper. To measure the diversification they were used the Simpson index of diversification (Behera *et. al.,* 2007).

Based on evidence from the quinquennial surveys on employment by the National Sample Survey Organization (NSSO), it has been argued that, as part of the process of change associated with the green revolution, rural India was witnessing an agricultural growth-induced diversification in economic activity in favour of non-agricultural activities. The results examine that argument using evidence relating to India as a whole and the state of West Bengal in particular. The analysis suggests that the observed occupational diversification in rural India over the last decade-and-a-half was not so much a fall-out of rural dynamism in the wake of the Green Revolution, but a reflection of the fact those two-and-a-half decades after the green revolution began in India, much of the country is yet to experience the impact of that process. For these they used ogive index, entropy index, and composite entropy index. (Chandrasekhar 1993). The agriculture diversification particularly the changing cropping pattern has been contributing significantly to the rural development in West Bengal. Agricultural diversification was strongly influenced by price policy, infrastructure development, urbanization, technological improvements, and rainfall; etc. which is important agricultural state of India over a long period of time. The spatiotemporal nature of crop diversification in the state in terms of some crop diversification indices like herfindhal index, ogive index, entropy index and maximum entropy index calculated (De 2000).

The Diversification of the rural economy is largely dependent on agricultural activities. At the farm level it may take place in the form of wider varieties of crops as well as new varieties of old crops. A new measure of crop diversifications are developed, and experimented with the form economy of west Bengal. The mode of farming, the degree of mechanization and the farm size have been effective in enhancing diversification. The diversification was more pronounced in the capitalist farms than in the peasant farms. Mechanization affects diversification directly. Small farms are more crops diversified than medium and large farms. Regression of farm business income (FBI) entails that both CD and VD have direct significant impact on FBI (Dipti and Gunendra 1986). Income and crop diversification have been identified as essential strategies for raising income and reducing rural poverty. The diversification into a number of income sources and crops grown were very high. The determinants of income diversification were number of children less than 12 years old, number of adults above 60 years old, availability of electricity in the household and distance from local market. The determinants of crop diversification were, age and level of education of the household head, number of extension visits, availability of tractor hiring services and returns from crop production. Most household's occupations in the study area were no longer agriculture based, however their willingness to diversify was significantly influenced by their socioeconomic characteristics (Ibrahim *et. al*., 2009)

The cropping pattern in terms of percentage share of individual crops in gross cropped area has been worked out. Entropy indexes (EI), modified entropy index (MEI) and composite entropy index (CEI) were used to quantify crop diversification. The study has shown that there existed wide temporal changes in the cropping pattern. The area of sorghum was being replaced by soybean and soybean attained a prestigious position in the cropping pattern of Marathwada region. Latur division and Marathwada region diversified more than the Aurangabad division. Osmanabad, Parbhani and Nanded districts showed increasing levels of diversification while Jalana and Latur districts showed low level of diversification. Aurangabad and Beed have been found more or less stable in crop diversification (Jadhav *et. al*., 2014). The changes in land utilization pattern, to estimate growth rates of area, production and productivity of major crops grown in Maharashtra state, and has estimated the growth rate of fertilizer consumption. The study has revealed that area under forest and other fallow land was non-significant, and the area under cultivable waste land, net sown area, the total cropped area was negatively significant. The positive growth rates were noticed in area, production and productivity of major crops. This indicates that agricultural development is taking place in the desired direction. The use of nitrogenous fertilizer has been found

Diversification of agricultural systems :

Diversification types	Description of diversification	Main characteristics
Increased structural diversity	It makes crops within the field more structurally diverse; for example, strip intercropping, which consists of the production of more than one crop in strips that are narrow enough for the crops to interact, yet wide enough to permit independent cultivation.	Farm level; same land unit
Genetic diversity in monoculture	Growing mixed varieties of a species in a monoculture.	Farm level; same land unit
High-value crops	A shift from less profitable and sustainable crop or cropping system to more profitable and sustainable crop or cropping system.	Farm level; same land unit
Crop rotations	Temporal diversity through crop rotations.	Farm level; different spaces; different times
Polyculture	Growing two or more crop species and wild varieties within the field. Spatial and temporal diversity of crops.	Farm level; different spaces; different times.
Diversify field with noncrop vegetation	Growing weed strips or vegetation banks in and alongside crops.	Farm level; different spaces
Mixed farming	Crops and livestock.	Farm level; different spaces; different times.
Agroforestry	Growing crops and trees together.	Farm level; different spaces; different times.
Mixed landscapes	Development of larger scale diversified landscapes with multiple ecosystems.	Larger scale; spatial; temporal

Modified from Lin (2011).

no significant, but use of phosphatic and potassic fertilizers was significant in Maharashtra. These results will help in launching different programmes for developing agriculture in the state (Jadhav *et. al.,* 2014).

The agriculture diversification in South Asia patterns, determinants, and policy implications. Observed that south Asian countries are gradually diversifying with some intra country variation in favour of high value commodities namely fruits, vegetables, livestock and fisheries. Agricultural diversification is strongly influenced by price policy, infrastructure development, urbanization and technological improvements, rain fed areas have more benefitted as a result of agricultural diversification in favor of high value crops by substituting inferior coarse cereals. Agricultural diversification is also contributing to employment opportunities in agriculture and increasing exports. The extent of diversification noticed with respect to cropping patterns, livestock, diary, and fishery, was measured by Simpson index of diversification, for the year 1981-82 and 1991-92, the result established as 0.61 for the year 1981-82, and 0.65 for 1991-92. It concludes that there was diversification in cropping patterns (Joshi *et. al*., 2004). The role of crop diversification in output growth in India: a state-level analysis and found that diversification, as one of the major tools of policy, drew widespread attention in India in the recent past in the face of stagnant growth, incomplete agricultural transformation and low productivity. The four dimensions of diversification-number of crops, spread of cropping pattern, proportion of high value crop in the cropping pattern and shift in cropping pattern mix. The finding examines the link between different dimensions of diversification and the growth of output in India, in the last three decades. The result shows that there was great heterogeneity in terms of typology of diversification within the states with no clear-cut link of one type of diversification with income and risk pattern. The temporal picture shows that the role of crop diversification (change in crop mix) in the output growth was increased in India over time. However, the results suggest that diversification towards high value is not sufficient for increasing growth. It is also important that these high value crops remain remunerative over the period of time, through proper technological and market development, otherwise the gains from diversification will be meager. To measure such diversity he used Simpson index of diversity, Entropy index, and Modified entropy index (Mehta (2009).

Crop diversification can play an important role in the development of Indian agriculture. Their study focused on two main issues viz. changing cropping pattern and the farmers change in preference towards high-value cash crops. The findings of the study suggested that cropping pattern in Indian agriculture in terms of acreage has been skewed towards food grain crops. The production towards high-value crops has demonstrated an increasing trend (Mishra *et. al*., 2014). Analyzed the disparities in agricultural growth across Indian states and explores the determinants of agricultural growth. However, to stimulate growth in the states where agriculture is lagging behind, a higher emphasis on increasing the area under irrigation, expenditure on agricultural research, area under fruits and vegetables, number of regulated markets, length of roads, cold storage facilities and institutional credit for investment purposes is needed. Private sector should be involved in public–private-partnership mode for improving the infrastructure in this sector (Pandey *et. al.,* 2015).

It was observed that the extent of diversification was more in the period 1995-2005, compared to 1985-1995. As per the results obtained, there was no statistical significant impact on the agreement on Agriculture (AOA) policy on Karnataka agriculture as a whole. But, in some districts like Bangalore rural, Kodagu and Shimoga showed considerable changes in cropping pattern from both the periods (Rathod *et. al*., 2011). The effect of crop diversification of rice-wheat cropping system on productivity and profitability and observed that rice-wheat cropping system, being considered back bone of food self-sufficiency in many Asian countries, was facing sustainability problem and a need of crop diversification of this system is felt in recent years. A field study conducted for two years (1995-96 and 1996-97) at the Indian Agricultural Research Institute, New Delhi on a sandy clay loam soil indicated that partial diversification by inclusion of moonbeam during summer (May-June) in rice-wheat system resulted in an increase in productivity and profitability. However, highest productivity was achieved when wheat was replaced by potato (followed by moonbeam in summer) and highest profitability was achieved when wheat was replaced by clover. Rice-wheat-moonbeam cropping system recorded the maximum harvest density index, multiple cropping indices and simultaneous cropping index, indicating higher land use efficiency than other rice based cropping systems (Sharma and Sharma 2005).

The pattern of diversification across states or crops in India has been schematized and various determinants of diversification have been deciphered. To objectively confer the empirical resonance, values of Simpson index have been estimated. The diversification index (SID) has been found between the range from 0.47 (West Bengal) to 0.90 (Karnataka) in 1990-91 and from 0.40 (Orissa) to 0.92 (Karnataka) in 2000-01. The increase in diversification index signifies shift towards non-food grain crops. In Karnataka, though the index has increased, but the similar increases in area under food grains imply shift from course to fine cereals. Agricultural diversification is influenced by a number of infrastructural and technological factors. The coefficients have indicated that the presence of electricity and road density are negatively associated with the diversification. In the year 2001-02, large share of export earnings has come from non-traditional items, namely rice, fruits, vegetables, livestock and marine products, signifying positive boost to diversification (Singh et. al., 2006). The role of crop specialization and diversification in agricultural transformation was investigated empirically. Changes in aggregate land productivity are associated structurally with inter-crop and inter-district reallocation of land use. Results from a region with the oldest history of agricultural commercialization in developing countries show that cropping patterns of subsistence agriculture changed substantially, with rising concentration of crop acreage in districts with higher and growing productivity. Rapid specialization in crop production was observed at the district level recently, after a phase with sporadic specialization. These changes reflected comparative advantage and contributed to the improvement in aggregate land productivity (Kurosaki , 2003).

How diversified is your State's agriculture, and observed that the each state's agricultural production diversification was measured for 1984 and 1988. To analyze diversification the techniques used were Herfindhal index and Simpson index. Very little difference existed between the types of index used or the year computed. Linear regressions of the coefficient of variation of receipts on diversification measures implies diversification among states have no impact on variability of components (Tauer (1990). Agricultural diversification into non-traditional export crops has long been recognized as an important strategy by the Government to increase and stabilize export earnings for sustainable economic development and farmers' incomes. The study demonstrated that cocoa farmers have diversified cocoa cultivation to some extent into growing other crops such as oil palm, citrus, cassava, cocoyam, etc. to expand their sources of income. This was confirmed by Simpson Index of diversification estimated to be 0.9. The proportions of farmers diversifying into other crops alongside cocoa were: 36.3% diversified into one crop, 26.7% cultivated two additional crops, 16.0%, three or more crops and 21.0% focused only on cocoa cultivation. The multinomial regression analysis suggested that age of cocoa farm, access to credit and cocoa growing region (Western, Brong-Ahafo and Central) were statistically significant (P<0.05) determinants of cocoa farming diversification. It is recommended that Government should sustain cocoa production by convincing farmers to replant old cocoa farms and modernize traditional cocoa farming practices; improve access to credit facilities for farmers; and develop alternative livelihood improvement strategies of other crops in addition to cocoa for farmers (Aneani *et. al.,* 2011). Experiments were conducted in Skierniewice in carrot and onion grown in monoculture and in leek and celeriac cultivated with three methods: with cover crops residues cut and incorporated 10-12 cm deep with the soil; in mulch with desiccated cover crops residues cut and left on the soil surface and without cover crops. On the base of obtained results the species composition of weed communities and the abundance of individual species were determined and the assessment of biodiversity using diversity indexes. It was proved that crop species and cultivation system affected the diversity of weeds species composition (Anyszka and Kohut 2011). The economics of diversification of farming with diary enterprise and they observed that the crop cultivation in India was subject to a high degree of risk and uncertainty and provides only seasonal, irregular and uncertain incomes to the farmers. The results noticed that it was essential that farmer incorporate such enterprises in their production programme which yield regular and evenly distributed income throughout the year. Diary animals are one such enterprise which provides more certain and regular flow of income dairy farming has three dimensional benefits (Thovre and Galgalikar 1985).

Conclusions

Diversification has been pursued in many countries as a way to improve the long–term viability of agriculture by enhancing the profitability and overall stability of the sector. The shift to other crops or economic activities. Diversification of agriculture means developing a larger number of crop or enterprise – mix in favour of high value and more remunerative enterprises. It can help to ensure food security, generate employment and alleviate poverty and conserve natural resources. The food basket is diversifying in favour of livestock, fruits and vegetables. To meet the challenge, the production strategy should be to encourage diversification of the production system without sacrificing the basic obligation of ensuring food security. In India the agricultural economy has been diversifying from the crop sector towards its complimentary enterprises, such as livestock and fisheries. Diversification of agriculture can play a key role in increase in income of agriculture Sector.

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Analysis of Aspirations among Rural Youth in Yavatmal and Ahmednagar District of Maharashtra

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Abstract

Youth are the future of a nation and the overall development of any nation depends on the regimented, active and competent strength of youth. An exploratory study with *ex post facto* design conducted with randomly selected 160 sample rural youth from two districts Yavatmal and Ahmadnagar of Maharastra recorded various responses on different aspirations pursued by them in their life. 60% of the respondent wanted to pursue higher education. 36 per cent of the respondents were highly aspired to become a member of gram panchayat and 28% of the respondents had very high aspirations to join a regional/political party or a student union. (46.25%) very highly aspired to participate in social development activities followed by village development activities (45.62) and 40.62 per cent of respondents were having very high aspirations to organize adult education camps, farmers schools to enhance the knowledge of farmers. Around half of the respondents very highly aspired to start their own business and around 37 per cent of them were having high level of aspiration to do their own business. A majority of the respondents (46.25%) had very low level of aspirations to do unskilled jobs as their main occupation. More than two fifth of the respondents (41.25%) highly aspired to do farming. there is a positive and significant correlation between overall aspirations and respondent?s education, achievement motivation, economic motivation and mass media utilization, at 1 per cent level of significance. Father?s education of the respondents was found positively correlated at 5 per cent level of significance. A weak positive and significant correlation was found between overall aspirations and annual family income, social participation at 5 per cent level of significance, while there was a negative and significant correlation between overall aspirations and family size. Thus it shows that those respondents, who were having higher education and higher achievement motivation, economic motivation, social participation and mass media utilization had high overall aspirations.

Introduction

Youth are the future of a nation and the overall development of any nation depends on the regimented, active and competent strength of youth. According to the official figures for the 2011 census, there are about 460 million young people in the country and this number is predicted to increase up to 464 million by 2021. Out of this population, about 70.00 per cent are rural youth and the remaining 30.00 per cent are urban youth (Census, 2011). National Youth Policy (2014) modified it and defined „youth? as persons in the age group of 15-29 years. With their enthusiasm, energy, capacity to do hard work and willingness to serve others, rural youth have a vital role to play in improving the welfare of the community and in agricultural development. Rural youth are the precious human assets which can play a crucial role in the activities of development, agriculture and other related activities. The Indian constitution provides for the human rights and freedoms but the system is not capable of fulfilling all the rights and thus, in a democratic environment they are turned into aspirations. It is therefore, necessary to help the rural youth in having desirable aspirations. Intodia et al. (1993) defined aspirations as ambitions of an individual, in educational usage usually seen as academic, social or occupations and concerned with performance, prestige and status. According to them, aspiration level was the standard of achievement that a pupil sets for himself / herself. So we can say that aspirations represent the individual?s reflection of his/her several socio-psychological phenomena like attitude, behavior and beliefs. The development of personal, social, economic and spiritual aspects of rural youth are possible only when their needs, aspirations, stress, habits and values of life are recognized early and guided properly. Aspirations give a direction to our life and put one self into action for their fulfilment. A youth puts many efforts to convert his/ her aspirations into reality and enjoy them. Rural youth of the 21st century have number of requirements but our economy is not capable to satisfy all of these and therefore they converted into aspiration. To fulfil the various aspirations a person makes some efforts and undergoes through stress. There are some studies are available in the field of career aspirations, occupational aspirations of rural youth towards rural development but still there is no integrated study available which studied aspirations of the rural youth. so there are many gaps in study of aspirations. Therefore a multidimensional study on aspirations among rural youth was conducted which will help in gaining more insights into the different aspirations of rural youth fulfilling the gaps.

Research Methodology

An exploratory study was carried out in purposively selected Yavatmal and Ahmadnagar districts of Maharastra. *Ex post* *facto* research design was adopted for this study, since the phenomenon has already taken place. In this research rural youth of the abov mentioned districts were taken as sample of the study. The total sample size was 160. Respondents were selected through proportionate random sampling and data were collected through personal interview technique with the help of well-structured and pre tested interview schedule. Different types of aspirations were categorized into political, social, educational, occupational and general aspirations. Agricultural aspirations as a specific occupation for a rural youth were also measured. To measure the educational, political, social and general aspirations of rural youth teacher made scales used by Murlidhar (2013) were used with suitable modifications. The occupational aspirations were measured through scale used by Narendran (2002) with required modifications. The responses collected on a 5 point continuum from very high, high, medium, low and very low level of aspirations. Based on the weighted mean of total score obtained by the respondents on each aspiration they were ranked. Overall aspiration of rural youth towards rural development was measured by adding the score of political, social, education, and occupational aspiration of rural youth towards self-development and then the rural youth were categorized as low, medium and high level of aspirations on the basis of cumulative square root frequency. The general aspirations of rural youth measured separately. As the rural youth interviewed in this study are engaged directly or indirectly with the agriculture therefore, Agriculture as an occupation, the level of aspirations of rural youth towards agriculture was measured separately and ranked on the basis of weighted mean and categorized into low, medium and high level of agricultural aspiration through cumulative square root frequency method. Relationship between independent variables like Age, Education, Father's education, Mother's education, Family size, Land holding, Annual income, Mass media exposure, Extension contact, Social participation, Achievement motivation, Economic motivation with the extent of overall aspiration of rural youth was analysed using Pearson correlation coefficient.Empirical data were tabulated and analysed using Statistical Package for social sciences and R studio software for computing frequency, percentage, correlation analysis were used.

Results and Discussion

In the present study aspiration was operationalized as the extent of orientation of rural youth towards political, social, educational, occupational and general attributes. The various aspirations were measured, analyzed, presented and are discussed below.

Educational Aspirations : To measure the extent of education a person wants to get, two questions were asked. Then different aspirations of rural youth were analyzed and presented in Table-1

About 60 per cent of the respondents wanted to continue their further education while 40 percent did not want to continue because some of them had already completed their education and some of them really did not want to continue. Around 68 per cent of the above 60 per cent respondents wanted to pursue education up to graduation and 26 per cent up to post graduation and above.

Table-1 shows the distribution of respondents on different educational aspirations as well as the rank of different educational aspirations on the basis of their mean scores. The table shows the extent respondents aspired to study different streams in their higher studies.

Table-1 shows the educational aspirations of rural youth. To pursue science stream in higher education was ranked first followed by agriculture, art and commerce, while studying B. Ed in higher education was ranked last. The table depicted that, more than 30 per cent rural youth aspired very highly to study science in their higher studies and same number of respondents were having very high aspirations to pursue agriculture for higher education. Around same number of rural youth respondents had low aspirations for B.Ed and commerce and around one third of the respondents (32.5%) highly aspired to pursue agriculture for higher studies.

Political Aspirations : The extent of orientation of a person towards various political activities e.g. up to what extent a person wants to become the member of a political party, were measured, analyzed and presented in the table-2. The data in the above table depicts the respondents? aspirations regarding development of their political career. The data shows that, to become a member of regional or national political party ranked first followed by to become gram panchyat member and to join any student union such as ABVP/NSUI and to become a member of cooperative society ranked last.The table shows that around 36 per cent of the respondents highly aspired to become a member of gram panchayat and around equal number of respondents (28%) had very high aspirations to join a regional/political party and to join a student union. More than half of the respondents had low to very low aspirations to become a member of a cooperative society.

Social Aspirations : The extent of orientation of a respondent towards different social activities i.e.participation in social development activities and having interest to work with a NGO was measured and presented in the table 3. Participation in village development activities were ranked first followed by participation in social development activities. The respondents were least interested to work with a NGO and ranked it last. In case of social aspirations of rural youth, it is observed from Table 4 that nearly half of respondents (46.25%) very highly aspired to participate in social development activities followed by village development

Table-1 :

Question	Yes (*)	No (*)	Total (*)		
Q.1. Are you still continuing your studies? (Yes/No)	96 (60.0)	64 (40.0)	160 (100.0)		
Question	High School (%)*	Higher secondary (%)*	Graduation (%)*	PG& <(%)*	Total (%)
Q. 2. If yes, up to what level you want to study?	0	4 (4.16)	66 (68.75)	25 (26.0)	96 (100.0)

*Percentage is given in parenthesis.

About 60 per cent of the respondents wanted to continue

Educational aspirations	Frequency and (%)* of respondents (N=160)						
	V. High	High	Modera te	Low	V. Low	Mean	Rank
Science	50 (31.25)	38 (23.75)	28 (17.5)	32 (20.0)	12 (7.5)	3.75	I
Commerce	14 (8.75)	38 (23.75)	40 (25.0)	49 (30.62)	19 (11.8)	2.86	IV
Art	31 (19.37)	32 (20.0)	30 (18.75)	35 (21.87)	32 (20.0)	2.96	III
Agriculture	49 (30.62)	52 (32.5)	33 (20.62)	22 (13.75)	4 (2.5)	3.51	II
B.Ed.	9 (5.62)	26 (16.25)	33 (20.62)	49 (30.62)	43 (26.8)	2.72	V

activities (45.62) and 40.62 per cent of respondents were having very high aspirations to organize adult education camps, farmers schools to enhance the knowledge of farmers. Only 14.37 per cent of the respondents had very high aspiration to work with a NGO and one fourth (25. 62%) of the rural youth were moderately interested to work with a NGO.

Occupational Aspirations : A respondent?s extent of orientation towards different occupational aspirations is given in the table-4.

The data in the table 4 revealed that most of the respondents want to start their own business as their main occupation and ranked it first followed by service occupation, farming, skilled occupation like mechanic or technician and ranked unskilled occupation like factory worker, laborer last. Around half of the respondents very highly aspired to start their own business and around 37 per cent of them were having high level of aspiration to do their own business. A majority of the respondents (46.25%) had very low level of aspirations to do unskilled jobs as their main occupation. More than two fifth of the respondents (41.25%) highly aspired to do farming.

Overall Aspirations : The total scores of Educational, Political, Social and Occupational aspirations were added to determine the overall aspirations. Then, the respondents were classified into low, medium and high aspirations group based on their total score by cumulative square root frequency way of classification. The results are given in table-5.

The table-5 shows the overall aspirations of rural youth and 46.25 per cent rural youth had medium level of overall aspirations followed by high overall aspiration (28.13%) and low overall aspirations (25.63%). The mean score of overall aspirations was 61.99 and standard deviation was 6.61. District wise as well gender wise analysis of the overall aspirations of rural youth was also performed and the findings are given in the table 6 and table 7 respectively . Table-6 shows the overall aspirations of both the districts separately and there was slight difference between the overall aspirations of both districts. Yavatmal had 45 per cent respondents with medium overall aspirations and 28.75 per cent respondents with high overall aspirationsWhereas, in Ahmednagar, around 42 per cent of the rural youth had medium level of overall aspirations with equal number of youth (28.75%) in both low and high overall aspirations. Mean of overall aspirations of Yavatmal was 62.23 and for Ahmednagar, it was found 61.88. Overall aspirations of both male and female respondents were also measured separately to compare whether there is any difference between their overall aspirations or not and it was found that male respondents were having less medium overall aspirations (32.71%)respondents than female respondents (43.4 % respondents). The mean score of overall aspirations of male respondents was little higher (62.93) than female respondents (60.26).

Agricultural Aspirations : As rural youth remain engaged in agricultural activities directly or indirectly, so specifically agriculture as an occupation the agricultural aspirations of the respondents were also studied by measuring their extent of orientation toward different agricultural and allied practices as an agricultural aspiration on five point continuum from very high-5 to very low-1. The various agricultural aspirations were then ranked on the basis of their mean score. The table-8 shows the distribution of various agricultural aspirations ranked on the basis of mean score.

It is evident from the table 8 that respondents were mostly interested in use of improved seeds and modern agronomic practices hence ranked it first out of 10 agricultural aspirations followed by horticultural crops cultivation and

Table-2 : Distribution of respondents on different Political aspirations.

Political Aspirations	Frequency and (%)* of respondents (N=160)						
	V. High		V. High		V. High		V. High
Gram panchayat member	57 (35.62)	32 (20.0)	31 (19.3)	26 (16.25)	14 (8.75)	3.57 5	II
Cooperative society member	23 (14.37)	45 (28.12)	8 (5.0)	43 (26.87)	41 (25.62)	2.78 8	IV
National/region al political party member	46 (28.75)	43 (26.87)	29 (18.1)	23 (14.37)	19 (11.87)	3.46 3	I
Student union member (ABVP/NSUI)	44 (27.5)	27 (16.87)	13 (8.12)	38 (23.75)	38 (23.75)	3.00 6	III

Table-3 : Distribution of respondents on different social aspirations.

Social Aspirations	Frequency and (%)* of respondents (N=160)						
	V. High	High	Moderate	Low	V. Low	Mean	Rank
Participation in social development activities	74 (46.25)	53 (33.12)	25 (15.62)	5 (3.12)	3 (1.87)	4.18 8	II
Participation in village development activities	73 (45.62)	67 (41.87)	15 (9.37)	5 (3.12)	0 (0.0)	4.3	I
Interested in organizing adult education camp, farmers school	65 (40.62)	36 (22.5)	15 (9.37)	35 (21.87)	9 (5.62)	3.70 6	III
Interested in work with a NGO	23 (14.37)	45 (28.12)	41 (25.62)	26 (16.25)	25 (15.62)	3.09 (4)	IV

Table-4 : Distribution of respondents on different occupational aspirations.

Occupational Aspirations	Frequency and (%)* of respondents (N=160)						
	V. High	High	Moderate	Low	V. Low	Mean	Rank
Service (Doctor, Scientist, Engineer etc.)	73 (46.62)	23 (14.37)	28 (17.5)	17 (10.62)	19 (11.87)	3.71	II
Farming (Ag. & allied)	24 (15.0)	66 (41.25)	27 (16.87)	39 (24.37)	4 (2.5)	3.41	III
Business	78 (48.75)	59 (36.87)	7 (4.37)	14 (8.75)	2 (1.25)	4.23	I
Glamour (Film Star, Sports person etc.)	24 (15.0)	29 (18.12)	31 (19.37)	38 (23.75)	38 (23.75)	2.76	V
Skilled occupation (Mechanic, driver etc.)	24 (15.0)	28 (17.5)	28 (17.5)	61 (38.12)	19 (11.87)	2.85	IV
Unskilled Occupation (Laborer, factory worker)	4 (2.5)	11 (6.87)	27 (16.87)	44 (27.5)	74 (46.25)	1.91	VI

*Percentage is given in parenthesis.

Table-5 : Distribution of respondents on overall aspirations (N=160)

Categories	f	%
Low (<58.08)	41	25.63
Medium (58.08-65.83)	74	46.25
High (>65.83)	45	28.13
Total	60	100
Mean	61.99	
SD	6.61	

organic farming. The respondents aspired to become agri-entrepreneurs and ranked it fourth. Three agricultural aspirations which were ranked last were dairying (X), precision farming (IX) and apiculture or bee keeping (VIII).

The respondents were categorized into low, medium and high agricultural aspirations groups through cumulative square root frequency procedure which is presented in the table 9 along with the mean score and standard deviation of the respondents.

Table-6 : District wise distribution of the overall aspirations of rural youth.

Categories	Yavatmal		Categories	Ahmednagar	
	f	%		f	%
Low (<58.54)	21	26.25	Low (<59.53)	23	28.75
Medium (58.54-66.1)	36	45	Medium (59.53-66.1)	34	42.5
High (>66.1)	23	28.75	High >66.1)	23	28.75
Total	80	100	Total	80	100
Mean	62.23		Mean	61.88	
Standard Deviation	6.9		Standard Deviation	6.4	

Table-7 : Gender wise distribution of the respondents on overall aspirations (N=160)

Categories	Female		Categories	Male	
	f	%		f	%
Low (<57.39)	18	33.96	Low (<59.14)	37	34.58
Medium (57.39-63.41)	23	43.4	Medium (59.14-66.89)	35	32.71
High (>63.41)	12	22.64	High (>66.89)	35	32.71
Total	53	100	Total	107	100
Mean	60.26		Mean	62.93	
Standard Deviation	5.57		Standard Deviation	6.96	

Table-8 : Distribution of various agricultural aspirations based on their mean score and rank. (N=160)

Agricultural Aspirations	Mean Score	Rank
Organic Farming	4.019	III
Use of improved seeds and modern scientific techniques	4.55	I
Crop Production	3.85	IV
Dairy	2.88	X
Poultry	3.08	VII
Apiary (bee farming)	3.03	VIII
Horticultural crops	4.20	II
To join a Farmer Producer Company	3.60	VI
To become an agri-entrepreneur	3.78	V
Precision farming through polyhouse	3.02	IX

Table-9 : Distribution of respondents on agricultural aspirations.

Categories	f	%
Low (<32.46)	40	25
Medium (32.46-38.07)	69	43.13
High (>38.07)	51	31.88
Total	160	100
Mean	36.06	
Standard Deviation	5.14	

Distribution of respondents on agricultural aspirations

More than two-fifth (43.13%) of rural youth were having medium level of agricultural aspirations followed by high agricultural aspirations (31.88%) and low agricultural were also studied by asking five multiple choice general questions which represent the extent of orientation of a person towards general things with five choices in each question. The options represent an ordinal level and assigned the score 1 for option „a? to 5 for option „e?. The table-10 shows the frequency and percentage distribution of respondents on their general aspirations.

The data depicted in Table 10 reveals the general aspirations of respondents in which, more than one-third of the respondents (34.38%) did not have any aspiration about their house alteration or construction in next five years, around 30 per cent of the rural youth aspired to construct one pucca house in next five years. Half of the respondents were having educational expectation of their life partner up to graduation and above and near about one-third of them were

Table-10 : Distribution of respondents on different general aspirations (N=160)

General Aspirations	Frequency and (%)* of respondents (N=160)				
	(a)	(b)	(c)	(d)	(e)
House alteration/construction	None	Minor-epairs	One kuccha-house	One pucca house	Two pucca house
	55 (34.38)	17 (10.63)	18 (11.25)	47 (29.38)	23 (14.38)
Husband's/Wife's education	Illiterate	Primary	Middle	High school	College and more
	0 (00.0)	15 (9.37)	15 (9.37)	50 (31.25)	80 (50.0)
Children's education	Illiterate	Primary	Middle	High school	College and more
	0 (00.0)	0 (00.0)	0 (00.0)	10 (6.25)	150 (93.75)
Income enhancement	None	<25%	25-50%	50-75%	>75%
	1 (0.62)	56 (35.0)	45 (28.13)	52 (32.5)	6 (3.75)
Land holding enhancement	None	1-2 acres	2-4 acres	4-6 acres	>6 acres
	28 (17.5)	66 (41.25)	37 (23.13)	26 (16.25)	3 (1.87)

Table-11 : Distribution of respondents based on their total general aspirations.

Categories	f	%
Low <15.71)	44	27.5
Medium (15.71-19.23)	69	43.13
High (>19.23)	47	29.38
Total	160	100
Mean	17.4	
SD	3.13	

Table-12 :

Independent Variables	Correlation Coefficient
Age	0.02.02
Education	0.347**
Father's Education	0.344*
Mother's Education	0.08
Family Size	-0.27*
Land Holding	0.02
Annual Income	0.191*
Mass Media utilization	0.39**
Extension contact	0.021
Social participation	0.195*
Achievement motivation	.57**
Economic motivation	0.453**

**-Significant at 0.01 levels *- Significant at 0.05 levels

expecting a life partner with having education up to high school. No respondent aspired to have a illiterate life partner. Similarly when asking about their expectations about their children?s education in future, 93.75 per cent of the respondents expected their children?s education up to graduation and above and only 10 respondents were having aspirations about their children?s education up to high school. About one-third of the rural youth (32.5%) aspired to increase their income by 50 to 75 per cent in next five years and more than one-third (35.00%) of the respondents aspired to increase their income level by less than 25 per cent only. The last question of the general aspiration scale was about aspirations of a person to increase his/her size of land holding in next five years and the results from the above table 10 show that, more than two-fifth (41.25%) of the respondents were having aspiration to increase their land holding only by 1-2 acre in next five years followed by 23.13 per cent who aspired to increase land holding by 2-4 acre in next five years. The respondents based on the total score of their general aspirations were categorized through cumulative square root frequency into low, medium and high general aspirations groups. The results are presented in the table 11 along with mean and standard deviation scores.

The table 11 shows that more than two-fifth (43.13%) of the rural youth respondents were having medium level of general aspirations. Around 30 per cent respondents fell in the category of high general aspirations group followed by low general aspirations group (27.5%). The mean score of respondents on their general aspirations was 17.4 with standard deviation of 3.13.

Relationshipbetweenindependentvariables andexten of overall aspirations of rural youth.

To find out the relationship between the selected independent variables of rural youth and their overall aspirations, Pearson correlation coefficient was computed and the results obtained by the correlation analysis are presented in table-12

It is evident from the table-12 that, there is a positive and significant correlation between overall aspirations and respondent?s education, achievement motivation, economic motivation and mass media utilization, at 1 per cent level of significance. Father?s education of the respondents was found positively correlated at 5 per cent level of significance. A weak positive and significant correlation was found between overall aspirations and annual family income, social participation at 5 per cent level of significance, while there was a negative and significant correlation between overall aspirations and family size. Thus it shows that those respondents, who were having higher education and higher achievement motivation, economic motivation, social participation and mass media utilization had high overall aspirations.

Conclusion

The study concluded that the rural youth in the Yavatmal and Ahmadnagar districts of Maharastra have medium to high overall aspirations and also very high level of agricultural aspirations like organic farming and horticultural crops cultivation. There were suggestion put forward by the rural youths about enhancing the aspirations among rural youth with the help of government and private sector by providing them quality educational and employment opprtunitites so that they can realize on their dreams and contribute to the well being of the nation.

Conflict of interest

The author has no conflict of interest.

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Influence of Weed Management and Nitrogen Fertilization on Yield and Nutrient Uptake of Barley (*Hordeum vulgare* L.)

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Abstract

Field experiment were conducted during *rabi* 2012–13 and 2013–14 at the Research Farm of SKNAU, Jobner (Rajasthan), India to assess the performance of weed management practices and nitrogen (N) fertilization on productivity and nutrient uptake in barley. Results showed that the highest grain (52.16 q ha^{-1}), straw (71.38 q ha^{-1}) and biological yield (123.54 q ha^{-1}) were obtained with two hand weeding (HW) treatment. Metsulfuron methyl @ 4.0 gha^{-1} at 30-35 DAS was found the next better and the best herbicidal treatment produced the grain, straw and biological yields of 47.69, 64.03 and 111.72 q ha^{-1} and recorded the maximum harvest index (42.69%) and minimum weed competition index (8.57%). Results further indicated that two HW and metsulfuron methyl @ 4.0 gha^{-1} at 30-35 DAS were found significantly better treatments in enhancing N, P and K concentration in grain and straw as well as their uptake and protein content in grain. Successive increase in level of N upto 60 kg ha^{-1}significantly improved most of the growth and yield attributing characters over it's lower levels. It also produced 20.8, 20.6 and 20.7 per cent more grain, straw and biological yields than control and improved the nutrient concentration in grain and straw and their uptake by crop. Based on response studies, 73.06 kg ha^{-1} was found to be the optimum level of N for barley. Overall, metsulfuron methyl at 4 g ha^{-1} and N application @ 90 kg ha^{-1} proved their superiority for weed management and productivity in barley in hot semi–arid region of western India.

Key words *: Barley, nitrogen, yields, nutrient concentration and uptake, protein content, weed management.*

Introduction

Barley (*Hordeum vulgare* L.) is the world's 4th important cereal crop after wheat, rice and maize. The major use of barley grain is in brewing industry for manufacturing malt being used for making beer, industrial alcohol, whisky, malt syrups, brandy, malted milk, vinegar and yeast. Among *rabi* cereals, barley ranks next to wheat both in acreage and production in India. It is preferred crop in semi–arid areas because it requires lesser water and is fairly tolerant to salinity, alkalinity, frost and drought situations. It is also more suited to dryland and '*diara land*' as compared to wheat. Barley is generally grown on marginal and sub–marginal lands with low inputs where the conditions for wheat production are not favorable. In Rajasthan, it is mostly grown on light–textured soils, low in nitrogen and organic matter with poor moisture retentive capacity. a number of constraints limit the barley production in this region, the major being it's cultivation on marginal and sub marginal lands specifically saline and alkaline soils with poor quality irrigation inadequate nutrition, moisture stress and severe weed infestationof both grassy and broadleaved. So, there is an urgent need to evolve appropriate weed management strategy for both grassy and broadleaf weeds for exploring the yield potential of this crop.

Conventional cultural practices of weed management are time-consuming and labour-intensive, however, the additional benefits of providing greater aeration, improving root growth enabling greater absorption of moisture and nutrients from deeper soil layers and moisture conservation cannot be ignored. The increasing demand of labour due to rapid industrialization and adoption of intensive and multiple cropping systems, sometimes the farmers fail to carry–out the timely agricultural operations, if any, makes thesituation very grim. Thus, to combat this situation, exploring the possibility of a suitable broad–spectrum and cost–effective herbicide deserves dire attention. In general, chemical weed management is more cost–effective and easy compared to manual weeding. From plant nutrition point of view, nitrogen is a vitally important and is one of the universally deficient plant nutrients in most of Indian soils especially inherited light–textured soils in semi–arid region of Rajasthan. It is an essential constituent of plant proteins and chlorophyll and is present in many other compounds of greater physiological importance in plant metabolism *viz.,* nucleotides, phospholipids, enzymes, hormones, vitamins etc. It governs to a considerable degree the utilization of carbohydrates, potassium, phosphorous and other elements. In intensive agriculture, adoption of exhaustive high yielding varieties has further led to heavy nutrient mining particularly N, but the fertilizer use remained below than its removal (Choudhary and Suri, 2014). Hence, there is an urgent need to revisit the N requirement of barley for breaking the barriers to harness higher productivity. Nitrogen–use efficiency can be improved through effective management of weeds thereby minimizing N depletion by weeds and, thus, adding to better crop N uptake and consequently higher N–use efficiency. Thus, keeping in view above aspects, current experimentation was conducted to evolve efficient weed management and nitrogen fertilization strategy to minimize the weed infestation with minimal nutrient depletion by weeds, better weed control indices with higher wheat productivity and profitability in barley crop under hot semi-arid region of Rajasthan, India.

Materials and Methods

The field experiment was conducted during *rabi* seasons of 2012–13 and 2013–14 at Research Farm of SKN Agricultural University, Jobner (Rajasthan), India [27^0 05' N latitude; 75^0 28' E longitude; 427 m altitude]. The soil of the experimental field was loamy–sand with low organic carbon (0.2%), low in available nitrogen (129.6 kg ha^{-1}), medium in available phosphorus (14.1 kg ha^{-1}) and potassium (148.8 kg ha^{-1}), and slightly alkaline pH (8.3). The experiment was laid–out in split–plot design replicated thrice. The main–plot treatments comprised 07 weed control measures [Weedy check (WC); hand–weeding (HW) once at 25 days after sowing (DAS); HW twice at 25 & 50 DAS; 2,4–D ester @ 0.5 kg ha^{-1} at 30 DAS; metsulfuron methyl @ 4 g ha^{-1} at 30 DAS; sulfosulfuron @ 25 g ha^{-1} at 30 DAS; carfentrazone ethyl 15 g ha^{-1} at 30 DAS], and sub–plot treatments comprised 04 nitrogen (N) levels [0, 30, 60 and 90 kg N ha^{-1}]. Barley 'RD–2052' was used as test crop. Post–emergence application of herbicides 2, 4–D ester, metsulfuron–methyl, sulfosulfuron, and carfentrazone ethyl was done at 30 DAS as per treatments using knapsack hydraulic sprayer with water spray volume of 700 litres ha^{-1}. Sulfonylurea herbicides were applied with their surfactants. In hand–weeding earmarked plots, HW was done at 25 and 50 DAS using *kassi/khurpi*. N was applied through urea as per treatments in two equal splits *i.e.* half as basal at the time of sowing and remaining half as top–dress after first irrigation at 20 DAS. A uniform dose of 30 kg P_20_5 ha^{-1} was drilled through single super phosphate 8–10 cm deep at the time of last ploughing. Bullock drawn desi plough was used for *pora* sowing in rows spaced at 22.5 cm with average depth of 5 cm and seed rate @ 100 kg ha^{-1}. All plant–protection measures were adopted to ensure healthy crop. The unthreshed produce from net plot area (3.0 m x 1.35 m) after thorough sun drying was weighed for recording the biological yield and expressed in terms of yield in quintals per hectare. For harvest index the ratio of economical yield (grain yield) to biological yield was worked out and expressed in percentage (Singh and Stoskopf, 1971). N concentration was determined by modified Kjeldhal method while total P determined using sulphuric-nitric-perchloric acid digest procedure and potassium concentration in plant extract was determined by flame photometric method The uptake of nitrogen, phosphorus and potassium by barley crop at harvest was computed using the formula. Protein content in grain was calculated from the per cent nitrogen in the grain multiplied by the factor of 6.25 (Simson *et al.*, 1965).

Results and Discussion

Yield attributes and yield

Effect of weed management practices : All the weed control treatments produced significantly higher grain, straw and biological yield of barley in comparison to weedy check. Twice HW at 25 and 50 DAS produced the maximum grain, straw and biological yields of 52.16, 71.38 and 123.54 q ha^{-1} and thus out yielded rest of the treatment. Being at par with one HW at 25 DAS and 2, 4-D ester at 0.5 kg ha^{-1}, application of metsulfuron methyl at 4 g ha^{-1} registered an excellent increase of 49.1, 42.3 and 45.1 per cent in grain, straw and biological yields, respectively over weedy check and thus found as the next better and most superior herbicidal treatment. Different weed control treatments could not influence the harvest index of barley upto the level of significance during both years of investigation as well as in pooled analysis. Differential competitive ability of various weed species found in experimental field, it has been further established that for similar weed densities, a composite stand of weed species is always more competitive than solid stand of a single weed species. Two hand weeding treatment provided the long time weed control and hence resulted in appreciably higher yields over to unweeded plots. Post-emergence application of metsulfuron-methyl at 4 g ha^{-1}, one HW at 25 DAS and 2,4-D ester at 0.5 kg ha^{-1} were the next equally effective treatments enhancing yield attributes and yield of barley. They also improved the grain yield by margin of 49.1, 45.5 and 40.5 per cent respectively over the weedy check. The corresponding increase in straw yield was 42.3, 42.0 and 35.3 per cent and biological yield was 45.2, 43.5 and 37.4 per centrespectively. Remaining at par with each other, sulfosulfuron and carfentrazone ethyl also gave 26.6 and 19.0 per cent higher grain yield, 22.4 and 18.7 per cent higher straw yield over weedy check, respectively but they were foundto be statistically inferior to the above described treatments. The higher grain and straw yields obtained under superior treatments could be better explained with their effectiveness in weed control in comparison to control. These treatments kept the crop

Table-1 : Effect of weed control and nitrogen levels on seed, straw and biological yields (qha^{-1}) and harvest index (%).

Treatments	Grain yield			Straw yield			Biological yield			Harvest index (%)		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Weed management practices												
Weedy check	30.97	33.00	31.98	42.39	47.58	44.99	73.36	80.58	76.97	42.21	40.99	41.60
One HW at 25 DAS	44.67	48.40	46.53	61.45	66.35	63.90	106.12	114.5	110.43	42.09	42.22	42.16
Two HW at 25 & 50 DAS	49.60	54.72	52.16	69.38	73.38	71.38	118.97	128.10	123.54	41.68	42.76	42.22
2,4-D ester @ 0.5 kg/ha (30-35 DAS)	43.18	46.68	44.93	58.33	63.39	60.86	101.51	110.07	105.79	42.53	42.45	42.49
Metsulfuron methyl @ 4.0 g/ha (30-35 DAS)	45.33	50.05	47.69	61.63	66.43	64.03	106.96	116.48	111.72	42.37	43.01	42.69
Sulfosulfuron @ 25 g/ha (30-35 DAS)	38.85	42.14	40.49	52.11	58.05	55.08	90.96	100.19	95.57	42.71	42.10	42.40
Carfentrazone ethyl @ 15 g/ha (30-35 DAS)	36.06	40.09	38.07	50.39	56.45	53.42	86.44	96.54	91.49	41.71	41.57	41.64
SEm+	1.31	1.40	0.96	1.69	1.86	1.25	3.41	3.32	2.38	1.68	1.68	1.19
CD (P=0.05)	3.73	3.99	2.79	4.82	5.31	3.66	9.75	9.50	6.95	NS	NS	NS
CV (%)	10.97	10.75	-	10.34	10.44	-	12.09	10.80	-	13.77	13.78	-
Nitrogen levels (kg/ha)												
0	35.53	39.99	37.76	49.70	53.45	51.58	85.23	93.44	89.34	41.70	42.72	42.21
30	41.51	44.84	43.18	55.01	60.10	57.56	96.52	104.94	100.73	43.02	42.65	42.83
60	43.78	47.47	45.63	59.35	65.07	62.21	103.13	112.54	107.84	42.46	42.10	42.28
90	44.12	47.75	45.94	62.04	68.02	65.03	106.16	115.77	110.97	41.57	41.17	41.37
SEm+	0.71	0.86	0.68	1.15	1.38	1.03	1.63	1.56	1.48	0.79	0.79	0.74
CD (P=0.05)	2.01	2.47	1.91	3.29	3.94	2.90	4.65	4.44	4.17	NS	NS	NS
CV (%)	7.84	8.81	-	9.33	10.24	-	7.64	6.68	-	8.62	8.62	-

Table-2 : N concentration (%) in grain and straw and grain protein content (%) of barley as affected by various weed control treatments and N levels.

Treatments	Grain			Straw			Protein content		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Weed management practices									
Weedy check	1.44	1.46	1.45	0.598	0.600	0.599	8.97	9.11	9.04
One HW at 25 DAS	1.71	1.71	1.71	0.713	0.717	0.715	10.70	10.71	10.71
Two HW at 25 & 50 DAS	1.72	1.74	1.73	0.726	0.731	0.728	10.77	10.88	10.82
2,4-D ester @ 0.5 kg/ha (30-35 DAS)	1.70	1.71	1.70	0.710	0.714	0.712	10.63	10.68	10.65
Metsulfuron methyl @ 4.0 g/ha (30-35 DAS)	1.72	1.73	1.72	0.722	0.730	0.726	10.74	10.82	10.78
Sulfosulfuron @ 25 g/ha (30-35 DAS)	1.59	1.59	1.59	0.651	0.662	0.656	9.93	9.92	9.93
Carfentrazone ethyl @ 15 g/ha (30-35 DAS)	1.55	1.58	1.56	0.648	0.650	0.649	9.66	9.88	9.77
SEm+	0.04	0.04	0.03	0.017	0.016	0.012	0.24	0.26	0.17
CD (P=0.05)	0.11	0.12	0.08	0.048	0.046	0.034	0.67	0.74	0.51
CV (%)	8.11	8.56	-	8.57	8.19	-	7.99	8.70	-
Nitrogen levels (kg/ha)									
0	1.51	1.51	1.51	0.623	0.618	0.621	9.46	9.45	9.45
30	1.61	1.62	1.62	0.673	0.683	0.678	10.07	10.15	10.11
60	1.69	1.70	1.70	0.708	0.719	0.714	10.58	10.64	10.61
90	1.71	1.74	1.73	0.719	0.726	0.723	10.69	10.89	10.79
SEm+	0.03	0.03	0.02	0.010	0.011	0.009	0.13	0.14	0.12
CD (P=0.05)	0.08	0.08	0.06	0.027	0.031	0.024	0.36	0.39	0.33
CV (%)	7.53	7.70	-	6.44	7.29	-	5.71	6.08	-

Table-3 : Effect of weed control measures and nitrogen levels on P concentration (%) in grain and straw of barley.

Treatments	grain			straw		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Weed management practices						
Weedy check	0.341	0.351	0.346	0.110	0.123	0.117
One HW at 25 DAS	0.426	0.430	0.428	0.135	0.149	0.142
Two HW at 25 & 50 DAS	0.429	0.440	0.435	0.138	0.152	0.145
2,4-D ester @ 0.5 kg/ha (30-35 DAS)	0.423	0.421	0.422	0.134	0.148	0.141
Metsulfuron methyl @ 4.0 g/ha (30-35 DAS)	0.428	0.438	0.433	0.137	0.151	0.144
Sulfosulfuron @ 25 g/ha (30-35 DAS)	0.381	0.387	0.384	0.124	0.136	0.130
Carfentrazone ethyl @ 15 g/ha (30-35 DAS)	0.379	0.384	0.382	0.122	0.135	0.128
SEm+	0.012	0.010	0.008	0.003	0.003	0.002
CD (P=0.05)	0.035	0.028	0.023	0.009	0.010	0.007
CV (%)	10.51	8.19	-	8.84	8.14	-
Nitrogen levels (kg/ha)						
0	0.353	0.358	0.356	0.112	0.124	0.118
30	0.394	0.401	0.398	0.126	0.139	0.133
60	0.423	0.432	0.428	0.136	0.150	0.143
90	0.435	0.439	0.437	0.139	0.154	0.147
SEm+	0.006	0.005	0.005	0.002	0.002	0.002
CD (P=0.05)	0.016	0.013	0.013	0.006	0.007	0.005
CV (%)	6.37	5.19	-	8.00	7.40	-

Table-4 : Effect of weed control practices and nitrogen levels on K concentration (%) in grain and straw of barley.

Treatments	grain			straw		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Weed management practices						
Weedy check	0.371	0.383	0.377	1.371	1.382	1.376
One HW at 25 DAS	0.451	0.461	0.456	1.541	1.562	1.551
Two HW at 25 & 50 DAS	0.455	0.464	0.459	1.552	1.567	1.559
2,4-D ester @ 0.5 kg/ha (30-35 DAS)	0.450	0.459	0.454	1.533	1.561	1.547
Metsulfuron methyl @ 4.0 g/ha (30-35 DAS)	0.452	0.462	0.457	1.551	1.564	1.557
Sulfosulfuron @ 25 g/ha (30-35 DAS)	0.413	0.421	0.417	1.453	1.472	1.462
Carfentrazone ethyl @ 15 g/ha (30-35 DAS)	0.410	0.418	0.414	1.451	1.469	1.460
SEm+	0.012	0.011	0.008	0.027	0.030	0.020
CD (P=0.05)	0.035	0.031	0.024	0.077	0.085	0.059
CV (%)	9.77	8.53	-	6.29	6.83	-
Nitrogen levels (kg/ha)						
0	0.397	0.407	0.402	1.374	1.392	1.383
30	0.426	0.434	0.430	1.472	1.491	1.482
60	0.444	0.452	0.448	1.557	1.574	1.566
90	0.447	0.459	0.453	1.568	1.586	1.577
SEm+	0.006	0.005	0.005	0.020	0.019	0.016
CD (P=0.05)	0.018	0.013	0.014	0.056	0.055	0.045
CV (%)	6.88	4.85	-	6.05	5.89	-

almost weed free during 40-70 DAS that markedly reduced the competition for nutrients and other growth resources by weeds and as a consequence reduction in dry matter and nutrient depletion by weeds occurred. Slow growing short statured crops suffer more due to weed competition than fast canopy forming and taller crops. Reduced weed-crop competition under these superior treatments, saved a considerable amount of nutrients for crop growth that led to enhanced crop growth by utilizing greater moisture and nutrients from deeper soil layers. These favorable effects in rhizosphere were more conspicuous in one and two HW treatments as these

Table-5 : Effect of weed control practices and nitrogen levels on total nutrient uptake by crop (kg ha^{-1}) at harvest.

Treatments	N uptake			P uptake			K uptake		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Weed management practices									
Weedy check	70.06	76.99	73.53	15.35	17.54	16.45	6.99	7.87	7.43
One HW at 25 DAS	120.76	131.11	125.93	27.49	30.87	29.18	11.53	12.65	12.09
Two HW at 25 & 50 DAS	136.36	149.51	142.93	31.04	35.43	33.23	13.07	14.09	13.58
2,4-D ester @ 0.5 kg/ha (30-35 DAS)	115.27	125.59	120.43	26.24	29.20	27.72	10.93	12.09	11.51
Metsulfuron methyl @ 4.0 g/ha (30-35 DAS)	122.85	135.72	129.29	28.01	32.13	30.07	11.65	12.75	12.20
Sulfosulfuron @ 25 g/ha (30-35 DAS)	96.03	105.78	100.91	21.39	24.35	22.87	9.21	10.36	9.79
Carfentrazone ethyl @ 15 g/ha (30-35 DAS)	88.71	100.49	94.60	19.93	23.15	21.54	8.82	10.01	9.42
SEm+	4.57	4.47	3.20	0.90	1.03	0.68	0.47	0.42	0.32
CD (P=0.05)	13.06	12.76	9.32	2.56	2.95	2.00	1.34	1.20	0.92
CV (%)	14.78	13.13	-	12.82	13.01	-	15.81	12.80	-
Nitrogen levels (kg/ha)									
0	85.48	94.28	89.88	18.30	21.16	19.73	8.29	9.12	8.71
30	104.82	114.83	109.82	23.53	26.61	25.07	9.93	10.97	10.45
60	117.17	128.70	122.94	26.87	30.58	28.73	11.26	12.46	11.86
90	121.12	133.73	127.42	28.11	31.76	29.94	11.78	13.06	12.42
SEm+	1.30	1.07	1.54	0.67	0.76	0.58	0.26	0.26	0.22
CD (P=0.05)	3.71	3.05	4.33	1.92	2.18	1.63	0.75	0.73	0.63
CV (%)	7.55	6.15	-	12.71	12.69	-	11.61	10.25	-

improved soil tilth by making it vulnerable for the plants to utilize water and air. All these favorable effects of weed control treatments led to significant improvement in various yield attributing characters of barley *viz.*, effective tillers/plant, grains/spike, spike length and test weight by providing better source-sink relationship. The significant higher values of yield attributes coupled with higher crop dry matter under superior treatments can be ascribed as the most probable reason of higher grain yield. The increase in grain yield of barley was also due to high harvest indices that showed greater partitioning of assimilates towards sink in the weed free environment. Under weed infested condition, although, the vegetative growth reached a level but the sink was not sufficient enough to accumulate the requisite photosynthates translocating towards grain formation. Similar findings were also reported by nadeem *et al.* (2007) and surin *et al.* (2013) in wheat and kumar *et al.* (2010).

Weed-crop competition may pull down crop yield by suppressing yield attributes. In the present study, the yield attributes increased significantly by adopting various weed control treatments as compared to weedy check, though, their efficacy varied with respect to yield attributing characters depending on the spectrum of their weed control. The better expression of yield attributes might be due to poor resurgence frequency and growth of weeds as evident from weed dry matter studies in these plots (Table-1).Immense increase in crop dry matter as well as yield attributing parameters of barley having significant and positive correlation with grain yield, negative and significant correlation between weed dry matter accumulation and nutrient depletion by weeds further confirms findings of the present investigation. Regression studies also indicated that unit decrease of 1.0 kg weed dry matter at harvest increased the grain yield of barley by 98 kg ha-1. The considerably higher grain yield thus obtained under twice HW and metsulfuron methyl treatments was obviously due to the cumulative effect of lowest weed-crop competition and higher value of growth and yield determining characters. On the other hand, relatively poor yield attributes and yield recorded under inferior treatments like sulfosulfuron might be attributed to the poor crop growth due to insufficient weed control that could not reduce the weed-crop competition to the tune as achieved under above mentioned superior treatments. Further more, the most severe competition throughout the crop season due to unrestricted weed growth under weedy check plots increased the depletion of nutrients and moisture by weeds thereby adversely effecting the crop growth. It also reduced the translocation of photosynthates towards grain formation having adverse effect on yield attributes which in turn reduced the yield to the minimum level.

Results obtained in present investigation are strongly supported with the finding of Singh and Singh (2005), Pisal and Sagarka (2013) and Singh *et al.* (2013) in wheat.

Effect of N fertilization : Application of nitrogen at 60 kg ha^{-1} produced grain, straw and biological yields of barley to the tune of 45.63, 62.21 and 107.84 q ha^{-1}which were significantly higher than 30 kg N ha^{-1} and control. However, it was found at par with 90 kg N ha^{-1}, wherein the maximum yields were obtained. Varying level of N could not influence harvest index of barley upto the level of significance during both the years and in pooled analysis.Since, an adequate supply of N during initial stages of plant is considered important in promoting vegetative growth, ascending rates of nitrogen application increased the dry matter production through increasing the assimilating area and tillering, thereby increasing the size of sink in terms of flowering and seed setting. Thus, N fertilization stimulated seed setting and enhanced the ear bearing tillers, grains/spike. The improved growth and profuse tillering due to N fertilization coupled with increased photosythates on one hand and greater mobilization of photosynthates towards reproductive structures on the other, might have been responsible for improvement in yield attributes of barley.The grain, straw and biological yield of barley also increased with every increasing in level of N upto 60 kg ha-1. As grain yield is primarily a function of cumulative effect of yield attributing characters, the higher values of these attributes can be assigned as the most probable reason for significantly higher grain yield. It is well evinced from the positive correlation between crop dry matter and nutrient uptake by the crop.These improvements suggests greater availability of metabolites and nutrients synchronized for growth and development of each reproductive structure. N and P fertilization plays a vital role in improving major aspects of yield determination *i.e.* formation of vegetative structure for nutrient absorption, photosynthesis and strong sink strength through development of reproductive structure and production of assimilates to fill economically improved sink and source strength. Further, the correlation analysis also substantiated strong dependence of grain yield ongrain attributes *viz*., grains/spike (0.954), spike length (0.978) and test weight (0.920). Sharma and Verma (2010) have also documented significant positive influence of nitrogen application on yield attributes and yield of barley crop. Straw yield was also recoded higher with increasing rates of N application. It might be due to improved biomass per plant at successive growth stages and increase in various morphological parameters like plant height, number of tillers etc. Higher grain and straw as explained earlier due to N fertilization led to significantly higher biological yield. Significant improvement in yield attributes and yield due to N application has been also reported by Katiyar and Uttam (2007) in barley and Jat *et al.* (2014) in wheat.

Nutrient concentration and uptake by crop

Effect of weed management practices : Two HW at 25 and 50 DAS,one HW at 25 DAS, application of metsulfuron methyl at 4 g/ha and 2, 4-D ester at 0.5 kg/ha witnessed significantly higher N, P and K concentration in weed dry matter at harvest stage of the crop than weedy check. However, they showed statistical equivalence among themselves. N, P and K in grain and straw of barley were significantly improved due to most of the weed control treatments over weedy check. Two HW at 25 and 50 DAS, metsulfuron methyl at 4 gha^{-1}, one HW at 25 DAS and 2,4-D ester at 0.5 kg ha^{-1}were the superior treatments in this regarded.Being at par among themselves, treatments also registered significantly higher protein content of 19.7, 19.2, 18.5 and 17.8 per cent, respectively in grain than weedy check treatment. Weed control treatments also showed profound increase in uptake of N, P and K by the crop at harvest as compared to control. Two hand weedings treatment recorded significantly highest uptake of N, P and Kha^{-1}(142.93, 33.23 and 13.58 kg ha-1), among all the treatments thereby increasing it to the extent of 94.4, 102.0 and 82.8 per cent, respectively over weedy check. Application of metsulfuron-methyl at 4 gha^{-1}, one HW at 25 DAS and 2,4-D ester at 0.5 kg ha^{-1} were the next superior and equally effective treatments that also witnessed 75.8, 71.2 and 63.8 per cent higher uptake of N; 82.8, 77.4 and 68.5 per cent higher uptake of P and 64.2, 62.7 and 54.9 per cent higher uptake of K than weedy check treatment, respectively. It is an exclusively broad-leaved weed killer in wheat and barley and enters the plant through the root zone and foliage. Inside the susceptible plants, they act by inhibiting the biosynthesis of acetolactate synthase (als); a key enzyme required in the biosynthesis of essential amino-acids, valine and isoleucine in plants. This results in rapid inhibition of plant cell division and growth. Higher concentration of nutrients in crop can be ascribed mainly to the greater availability of nutrients under reduced crop-weed competition under different weed control treatments as per their efficiency that would otherwise have been utilized by fast growing weeds under infested conditions. The extent of increase due to sulfosulfuron and carfentrazone ethyl was 37.2 and 28.7 for n; 39.0 and 31.0 per cent for p and 31.8 and 26.8 per cent for k uptake, respectively.

Superiority of the treatments described above is directly associated with similar variation in weed control and dry matter accumulation. These treatments provided almost weed free environment to crop at early growth stage, wherein the major portion of the basal dose of fertilizer applied to the soil was available for crop in contrast to weedy check. While, the applied nutrients under weedy check were taken up mainly by weeds due to their greater competitiveness and better root system. More availability of nutrients for the crop under comparatively weed free situation under superior treatments might have increased their concentration in the plants, which ultimately resulted in higher crop dry matter and yields. Thus, increase in crop dry matter and grain and straw yields with a concomitant increase in nutrient concentration seemed to be the most important reason of higher uptake of nutrients by crop under these treatments. Such findings have also been reported by Kanojia and Nepalia (2006) in wheat, Singh *et al.* (2009) in barley and Khokhar and Nepalia (2010) in wheat.

Effect of N fertilization : Nutrient concentration in grain and straw of barley exhibited significant enhancement in response to applied N. N, P and K concentration in grain and straw of barley were maximized with N fertilization at 90 kg Nha^{-1}. However, these showed statistical similarity with 60 N ha^{-1}. Every increase in graded levels of nitrogen brought about significantly higher uptake of N, P and K upto 60 kg ha-1overit's lower levels and control. It was found at par with 90 kg N ha^{-1} wherein, the maximum uptake of 127.42 kg N; 29.94 kg P and 12.42 kg K kg ha^{-1} were recorded.Protein content in barley grain increased with progressive increase in level of N upto 60 kg ha-1. The positive influence of N fertilization on nutritional status of grain and straw could be associated with greater availability of nutrients in soil environment along with extraction and translocation towards plant system. The adequate supply of N in early crop season resulted in greater availability of nutrients including P and K and of N in particular in crop root zone. The greater availability of nutrients coupled with accelerated metabolic activities at the cellular level might have increased the nutrient extraction and accumulation in various parts of the plants. The increased accumulation of nutrients especially of N with greater metabolism led to greater translocation of these nutrients to reproductive structures of the plants. Thus, plants maintained a critical concentration at cellular level. It seems to be the most probable reason of higher concentration of nutrients in grain and straw at harvest due to increased levels of N fertilization. The significant variation in N concentration can also be attributed to higher functional activity of roots for longer duration under enriched N levels. Higher bio-mass production of crop in terms of grain and straw yield together with higher concentration of nutrients might have associated with significantly higher uptake of N, P and K by the barley crop under increasing rates of N fertilization (Table 5). As nitrogen is critical for synthesis of protein (a part of basic structures of all amino acids)its content in grain is essentially a manifestation of its N content. Therefore, higher concentration of N in grain due to ascending rates of N upto 60 kg ha-1exhibited significantly higher protein content. The results are supported with the findings of Rawat (2001), Roy and Singh (2006), Mattas *et al.* (2011) and Meena *et al.* (2012) in barley.

Conclusions

Based on the results of two years of experimentation, it is concluded that two hand weedings at 25 and 50 DAS proved to be the most effective measure of weed control in barley for harvesting maximum grain yield (52.2 q ha^{-1}) and net returns (Rs 73678 ha^{-1}) with a B:C ratio of 3.99. Producing the grain yield of 47.69 q ha^{-1} and fetching net returns of Rs 68846 ha^{-1} with maximum B:C ratio (4.37), post emergence application of metsulfuron methyl @ 4 g ha^{-1} (at 30-35 DAS) was found as the best herbicidal treatment for minimizing weed competition index and next better option for weed control under labour scarce conditions. Among the N levels, application of 60 kg N ha^{-1} to barley produced significantly higher grain yield (45.63 q ha^{-1}) and net returns (Rs 64411 ha^{-1}) with a B:C ratio of 3.99, and thus proved to be the most remunerative level in barley and can be recommended under loamy sand soils in semi arid regions of Rajasthan. Based on production function, nitrogen fertilization at 73.06 kg ha^{-1} was worked out to be the optimum dose for barley. Overall, application of metsulfuron methyl @ 4 g ha^{-1} at 30–35 DAS and N @ 90 kg ha^{-1} proved to be best among all the herbicidal treatment for efficient weed management, productivity and profitability in barley (*Hordeum vulgare* L.*)* in hot semi–arid region of western India.

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Response of NPK, Biofertilizers and Plant Saping on Economices of African Marigold

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Abstract

A field experiment was conducted during winter season of 2014-15 to study the response of NPK, biofertilizers and plant spacings on growth and yield of African marigold. The economics of maximum B: C ratio (6.00) was recorded with combined application of 100 % RDF of NPK + *Azotobacter* + PSB + 60 x 45 spacing cm and maximum net returns (₹ 283267 ha^{-1}) was recorded with same combination of treatments. This treatment was significantly superior over other treatment combinations except 100% RDF of NPK + 60 x 45 cm (₹ 262726 ha^{-1}) which was found at par.

Key words : *Azotobacter, PSB, African marigold, net Return, B:C Ratio.*

African marigold (*Tagetes erecta* L.) is a popular and commercial flowering annual that is grown in almost all of India's states. It is in high demand for garland, cut flowers, and decorative reasons during various festivals. It can be used as a potted plant, as well as for bedding, edging, garland making, veni, religious offerings, and other things. To achieve a high decorative value of plant while lowering production costs, sustainable flower production requires effective fertiliser management (Vedavathi et al., 5; Zhang et al., 6). Nutrient status of the plants can be a pointer to the response of plant to the fertilization and internal content of the nutrients determine the fertilizer requirements. Kumar and Singh (2) are of the opinion that closer spacing provides more number of plants but deteriorates the quality of flower and reduce yield per plant, whereas, wider spacing gives good quality flowers but lower yield. So, optimum spacing is required to provide better quality flowers as well as higher yield.

Present study was carried out at the experimental farm of Department of Horticulture, S.K.N. College of Agriculture, Jobner, Jaipur (Rajasthan) during rabi season, 2014-15. Jobner is situated 45 km west of the Jaipur at 75-28' East longitude and 26-5' North latitude at an altitude of 427 meters above mean sea level. The climate of this region is typically semi-arid characteri-zed by aridity of the atmosphere, scarcity of water with extremity of temperature both during summer and winter. The maximum temperature touches around 45.5°C during May and June, while in December and January it falls below 1°C. The average rainfall varies between 400-500 mm. The fertilizer recommendation of 100% RDF of (NPK- 120:80:60 kg / ha) and seedling treated with biofertilizer (Azotobacter and PSB). The treatments consisted seven combination of fertilizer i.e. F_0 (Control), F_1 (50% RDF of NPK), F_2 (50% RDF of NPK + *Azotobacter* + PSB), F_3 (75% RDF of NPK), F_4 (75% RDF of NPK + *Azotobacter* + PSB), F_5 (100% RDF of NPK), F_6 (100% RDF of NPK + Azotobacter + PSB), and three combination of plant spacings viz. D_1 (45-45 cm), D_2 (60-45 cm), D_3 (60-60 cm) which were replicated three times in randomized block design with factorial approach. One month-old seedlings were transplanted at different spacings. Randomization of treatments was done with the help of random number table (Fisher, 1).

Economics

1. Gross Income (₹) = Total crop production x Value of the product (both main and by product)

2. Total cost = Common cost + Treatment cost

3. Net return (₹/ha)

Net return (₹/ha) of individual treatment was calculated by deduction of cost of cultivation from the gross return of particular treatment.

Net return = Gross Return – Total Cost of Cultivation

1. Benefit : Cost ratio

In order to find out net benefit : Cost ratio, the net return from individual treatments was divided by their respective cost of cultivation, which included cost of treatment also.

B:C Ratio = Net return/ Total Cost of Cultivation

In order to evaluate the effect of different treatments on vegetative growth and yield characters, the data were statistically analyzed as per Panse and Sukhatme (3).

Net Returns : Interactive effect between NPK, bio

Table-1 : General cost of cultivation for African marigold.

S.No.	Particulars	Unit (ha^{-1})	Rate ($Unit^{-1}$)	Cost ha^{-1} (Rs.)
A.	Land preparation	10 hrs (by tractor)	800	8000
	Sub total	-	-	8000
B.				
1.	Labour charges	15 man days	160	2400
2.	Layout of field			
3.	Raising of seedlings	6 man days	160	960
4.	Transplanting	13 man days	160	2080
5.	Weeding and hoeing	15 man days	160	2400
6.	Irrigation	30 man days	160	4800
7.	Drenching of fungicides	6 man days	160	960
8.	Harvesting and selling	20	160	3200
9.	Electricity	20	300	6000
10.	Miscellaneous	-	-	3240
	Total			34040

Table-2 : Economics of different treatments of African marigold cultivation.

Treatments	Common cost (₹ ha^{-1})	Treatments cost (₹ ha^{-1})	Total cost (₹ ha^{-1})	Yield (q ha^{-1})	Gross return (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
F_0D_1	34040	8888.5	42928.5	54.19	81279	38351	0.89
F_0D_2	34040	6666.5	40706.5	77.21	115810	75103	1.84
F_0D_3	34040	5000.0	39040	62.21	93310	54270	1.39
F_1D_1	34040	12001.2	46041.2	74.17	111254	65213	1.42
F_1D_2	34040	9779.2	43819.2	105.68	158520	114701	2.62
F_1D_3	34040	8112.7	42152.7	85.15	127723	85570	2.03
F_2D_1	34040	12241.2	46281.21	94.66	141985	95704	2.07
F_2D_2	34040	10019.2	44059.2	134.87	202306	158247	3.59
F_2D_3	34040	8352.7	42392.7	108.67	163002	120609	2.85
F_3D_1	34040	13557.6	47597.6	117.21	175818	128221	2.69
F_3D_2	34040	11335.6	45375.6	167.01	250514	205138	4.52
F_3D_3	34040	9669.1	43709.1	134.56	201844	158135	3.62
F_4D_1	34040	13797.6	47837.6	133.00	199499	151662	3.17
F_4D_2	34040	11575.6	45615.6	189.50	284255	238640	5.23
F_4D_3	34040	9909.1	43949.1	152.69	229030	185081	4.21
F_5D_1	34040	15114.0	49154	144.89	217328	168174	3.42
F_5D_2	34040	12892.0	46932	206.44	309658	262726	5.60
F_5D_3	34040	11225.5	45265.5	166.33	249497	204232	4.51
F_6D_1	34040	15354.0	49394	154.61	231913	182519	3.70
F_6D_2	34040	13132.0	47172	220.29	330439	283267	6.00
F_6D_3	34040	11465.5	45505.5	177.49	266241	220736	4.85

Sale price of African marigold yield = ₹ 15/kg, Urea = 5.8 kg^{-1}, SSP = 7 kg^{-1}, MOP = 16.5 kg^{-1} PSB 120 kg^{-1} *Azotobacter*/PSB=120 kg^{-1}

fertilizers and different plant spacing was found to be significant with respect to net returns (Table-2). The maximum net returns (₹ 283267 ha^{-1}) was recorded with combined application of 100% RDF of NPK + *Azotobacter* + PSB + 60 x 45 cm spacng. This treatment was significantly superior over other treatment combinations except 100% RDF of NPK + 60 x 45 cm (₹ 262726 ha^{-1}) which was found at par. Treatments 100 % RDF of NPK + *Azotobacter* + PSB + 60 x 45 cm plant spacing and 100% RDF of NPK + 60 x 45 cm plant spacing registered an increase in net returns to order of 277.17 and 249.82 per cent, respectively over control. Maximum net return realization of ₹ 171862 in cabbage at plant spacing of 30 ? 30 cm had also been reported by Prakash et al. (4).

B:C Ratio : Interactive effect between NPK, bio fertilizers and different plant spacing had significant effect on B: C ratio (Table-2). The maximum B : C ratio (6.00) was recorded with combined application of 100 % RDF of NPK + *Azotobacter* + PSB + 60 x 45 cm spacing. This treatment was significantly higher over other treatment combinations. However, application of 45 x 45 cm with control gave minimum B: C ratio (0.89). Treatments 100% RDF of NPK + *Azotobacter* + PSB + 60 x 45 cm plant spacing and 100% RDF of NPK + 60 x 45 cm plant spacing registered increased B:C ratio to the tune of 226.08 and 204.34 per cent, respectively.

On the basis of the experiment as well as economic point of views, an application of bio fertilizers in combination with chemical fertilizers produced its significant impact on net returns and cost of benefits ratio. The treatments (F_6 D_2) were found economical, profitable and proved highly remunerative under the Jobner (Rajasthan, India) conditions for growing the marigold cv. 'Pusa Narangi Gainda', which also improved the soil health.

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Correlation and Path Analysis Studies in Horsegram *(Macrotyloma uniflorum)*

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Abstract

In the present investigation 49 horsegram genotypes were grown in two replication at Instructional Farm at BTC College of Agriculture and Research Station, Bilaspur (Chhattisgarh) during the *Mid-Kharif* season 2017-18 in simple lattice design and studied under ten characters: days to flowering, days to maturity, plant height, number of branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight, and seed yield per plant, percent plant population**.** The correlation for non-quantitative character on the seed yield per plant at genotypic level indicates that out of the nine character six were significantly positively correlated with seed yield. Number of pods per plant have highest value for correlation in seed yield , however 100 seed weight is positively correlated with seed yield is and number of secondary branches per plant have highly positive significant correlation with seed yield indicates that positive selection for these traits can enhance the seed yield in horse gram. No. of seeds per pod and plant height are positively correlated with seed yield at genotypic level. The character days to maturity exhibited significant negative correlation with seed yield. Path analysis at the level of genotypic correlation reported that highest direct effect showed by days to flowering followed by no. of sec. branches per plant and no. of seed per pod 100 seed weight had positive significant correlation with seed yield per plant.

Key words : *Horsegram, GCV, PCV, heritability, genetic advance, correlation.*

Introduction

Horsegram (*Macrotyloma uniflorum)* is one of the lesser known arid legume crop which belongs to the family *Leguminosae* and scientifically known as *Macrotyloma uniflorum* Moth bean, cow pea, cluster bean are the other crops belonging to the arid legume group. Horsegram is cultivated in tropics and subtropics and mostly grown under dryland and rainfed cultivation. This crop have not received the importance due to their low acreage coverage at National and international level. It is the toughest arid legume which is being grown on the poor soil encountered in much adverse condition which may not allowed to grow other crops. Horsegram is a crop of semi-arid legume is a basically crop of tribal and hilly areas. It is being cultivated during the mid *kharif* season under the rainfed condition in the upland soils. In India horsegram is grown from North West Himalayan Hilly reason down to the extreme Southern States Tamil Nadu of country. It is also being cultivated in other states Uttarakhand, Himachal Pradesh, Madhya Pradesh, Gujarat, Rajasthan Maharashtra, Karnataka, Chhattisgarh and the area inhibited by tribal farmers in the country. In India horsegram is cultivated in 0.30-0.40 million hectare with the production of 0.20-0.26 million tones. Major area of cultivation confines to Karnataka, Maharashtra, Orissa, Andhra Pradesh, Madhya Pradesh, Tamil Nadu and Chhattisgarh. (Anonymous, 2021). In Chhattisgarh it is being cultivated in an area of approximately 40,000 hectare with the productivity of 324 kg hectare^{-1}. In Chhattisgarh it is being cultivated in tribal dominated agro climatic zones of Baster Plateau and Northern Hill regions. This crop is also cultivated in Hilly and backward areas of Chhattisgarh plain zone. Horsegram is locally known as hirwa, harwa or kulthi. Tribals of the state are cultivating the local land races and admixture of local type with varrying seed coat color from white to black with the different intermittent color and seed can easily be classified based on their seed coat color. Horsegram is a photosensitive crop and flower at a specific day length with determinate to indeterminate growth habit with different maturity duration and varying productivity Being a rainfed crop and sown in mid *kharif* season its productivity is depend upon the withdrawal of monsoon under early monsoon withdrawal (mid september) early variety perform better while late varieties do better under the late withdrawal of monsoon (mid October).

Materials and Methods

The field experiment was carried out during *Mid-Kharif* 2017 at the Research cum instructional Farm of BTC College of Agriculture and Research Station, Bilaspur, (CG) with 49 genotypes with two replications were imposed in simple lattice design.

Experiment Layout : The experiment was laid out in simple lattice design with two replications. The crop was provided with protective irrigation and recommended doses of fertilizers.

Table-1 : List of 49 diverse horsegram genotypes used in experiment.

S. No.	Genotypes	S. No.	Genotypes	S.No.	Genotypes
1.	THG 15-09	18.	Chhattisgarh Kulthi-03 (check)	35.	THG 15-30
2.	THG 15-25	19.	THG 15-16	36.	VLG 15 (check)
3.	BHG 15-1	20.	THG 15-02	37.	THG 15-28
4.	THG 15-14	21.	THG 15-33	38.	BSP 17-03
5.	THG 15-21	22.	THG 15-08	39.	THG 15-15
6.	THG 15-03	23.	THG 15-27	40.	THG 15-19
7.	THG 15-34	24.	BSP 16-2	41.	THG 15-06
8.	THG 15-12	25.	CRHG 19	42.	THG 15-35
9.	THG 15-29	26.	THG 15-20	43.	AK-42 (check)
10.	BSP 17-01	27.	THG 15-05	44.	THG 15-31
11.	THG 15-13	28.	AK 53 (check)	45.	BSP 15-02
12.	THG 15-22	29.	THG 15-11	46.	INDIRA KULTHI 1 (check)
13.	THG 15-01	30.	THG 15-23	47.	THG 15-17
14.	THG 15-32	31.	BSP 17-02	48.	THG 15-07
15.	THG 15-10	32.	Chhattisgarh Kulthi-02 (check)	49.	THG 15-24
16.	THG 15-26	33.	THG 15-18		
17.	BASTAR KULTHI 15	34.	THG 15-04		

Table-2 : Skeleton of Analysis of variance (ANOVA).

Source of variation	Degrees of freedom	Sums of square	Mean sums of square or variance	F value	Expected variance
Replication	r-1	$S.S._r$	$V_r = S.S._r/(r-1)$	V_r/V_e	
Genotype	g-1	$S.S._g$	$V_g = S.S._g/(g-1)$	V_g/V_e	$^{2}_{e}\ \ r\ ^{2}_{g}$
Error	(r-1)(g-1)	$S.S._e$	$V_e = S.S._e/(r-1)\ (g-1)$		$^{2}_{e}$
Total	rg-1	$S.S._t$			

Location (C.G.)	:	BTC CARS, Bilaspur
Crop	:	Horsegram
Season	:	*kharif* 2017
Design	:	simple lattice design
Number Of Genotypes	:	7×7=49
Replication	:	02
Spacing	:	30 cm × 10 cm (R×P)
Plot size	:	4 rows of 5 meter length
Fertilizer doses	:	20:40:20 kg NPK ha^{-1}.

Collection of Data : Five competitive plants were randomly tagged for recording observations for each entry in each replication for observing all the quantitative characters and mean of each character was used for statistical analysis.

Yield and its contributing characters

Days to 50% flowering (days) : The number of days required from sowing to 50% flower emergence was recorded on plot basis.

Days to maturity (days) : The number of days required to achieve physiological maturity was recorded on plot basis.

Plant height (cm) : The height of the main shoot of each plant was recorded from the base of the plant to the tip of the main stem.

Number of branches per plant : The number of branches of each plant was recorded from the base of the plant to the tip of the main stem.

Number of secondary branches per plant : The number of secondary branches of each plant was recorded from the base of the plant to the tip of the main stem.

Number of pods per plant : Total number of pods were counted in each 5 pods of the sampled plants and averaged to find average number of pods per plant. measured on selected plants.

Plant population (%) : Plant population was recorded at 20 days after sowing. This was done by counting the number of plant in each net plot area.

Number of seeds per pod : It was recorded by counting the numbers of seed in five competitive pods.

100 seed weight (g) : Hundred seeds of each genotype were counted, weighted and mean of two samples were recorded in grams.

Table-3 : Genotypic and phenotypic correlation between seed yield and yield attributing characters in horsegram.

S. No.		Days to flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of secondary branches per plant	Number of pods per plant	Plant population	Number of seeds per pod	1000 seed weight (g)	Seed yield per plant (g)
		Genotypic and phenotypic correlation matrix									
1.	Days to flowering	1.0000	0.652**	0.0560	0.0323	-0.213*	0.1702	-0.295*	-0.425**	0.1494	-0.0078
2.	Days to maturity	0.0020	1.0000	-0.0454	0.0623	-0.0206	-0.1002	-0.1278	-0.0352	-0.0360	-0.231*
3.	Plant height (cm)	0.002	-0.126	1.0000	-0.0133	-0.0837	0.385**	-0.0960	0.1154	0.376**	0.243*
4.	Number of branches per plant	-0.026	-0.058	-0.012	1.0000	0.505**	0.379**	0.1280	0.318*	0.1458	0.1353
5.	Number of secondary branches per plant	-0.072	0.023	-0.081	0.438**	1.0000	0.250*	0.1468	0.250*	0.1959	0.438**
6.	Number of pods per plant	-0.052	0.051	0.363**	0.339**	0.240*	1.0000	-0.0246	0.215*	0.232*	0.516**
7.	Plant population (%)	0.052	0.022	0.075	-0.035	-0.089	0.028	1.0000	0.211*	-0.0803	0.004
8.	Number of seeds per pod	0.140	0.057	0.085	0.220*	0.150	0.154	-0.047	1.0000	0.1256	0.293*
9.	100 seed weight (g)	0.063	0.031	0.260*	0.129	0.148	0.166	0.110	0.109	1.0000	0.513**
10.	Seed yield per plant (g)	0.039	0.081	0.226*	0.126	0.422**	0.477**	-0.033	0.190	0.386**	1.0000

R value at 5% = 0.198, 1% = 0.327

Table : Direct and indirect effect of yield attributing characters on seed yield of horsegram (genotypic).

	Days to flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of secondary branches per plant	Number of pods per plant	Plant population	Number of seeds per pod	100 seed weight (g)	Correlation with Seed yield per plant (g)
	PATH matrix of Seed yield									
Days to flowering	0.527	0.344	0.029	0.017	-0.112	0.089	-0.155	-0.224	0.078	-0.007
Days to maturity	-0.321	-0.492	0.022	-0.030	0.010	0.049	0.063	0.017	0.017	-0.231*
Plant height (cm)	-0.0006	0.0005	-0.011	0.0001	0.0009	-0.004	0.001	-0.001	-0.004	0.243*
Number of branches per plant	-0.012	-0.023	0.004	-0.370	-0.186	-0.140	-0.047	-0.117	-0.054	0.135
Number of secondary branches per plant	-0.108	-0.010	-0.042	0.257	0.510	0.127	0.074	0.127	0.100	0.438**
Number of pods per plant	0.041	-0.024	0.094	0.092	0.061	0.245	-0.006	0.052	0.057	0.516**
Plant population (%)	-0.003	-0.001	-0.001	0.001	0.001	-0.0003	0.010	0.002	-0.0009	0.004
Number of seeds per pod	-0.171	-0.014	0.046	0.128	0.100	0.086	0.085	0.403	0.050	0.293*
100 seed weight (g)	0.040	-0.009	0.100	0.039	0.052	0.062	-0.021	0.033	0.267	0.513**
Correlation with Seed yield per plant (g)	-0.007	-0.231*	0.243*	0.135	0.438**	0.516**	0.004	0.293*	0.513**	1.000
Partial R^2	-0.004	0.114	-0.002	-0.050	0.223	0.126	0.0001	0.118	0.137	

Seed yield per plant (g) : Plant wise seed yield in gram was hand threshed, cleaned and weighed.

Statistical analysis

Analysis of variance : Analysis of variance was worked out for each character separately. Procedure of analysis of variance adopted was as per Singh and Chaudhary (1985). For this the data for each character was arranged in tabular form as follows :

Where,

r = number of replications

g = number of genotypes

v = ^{2} = variance

^2_r = replication variance

^2_g = genotypic variance

^2_e = error variance

Parameters of genetic variation

Mean : The mean is calculated by the following formula

$$\bar{X} \quad \frac{X_i}{N}$$

Where,

$\bar{X}$ = Mean of character concerned

X_i = Sum of all observation of ith character

N = Number of observations

Range : The range of distribution was expressed by the limit of the smallest and the largest value of observations.

Critical Differences (C.D.) : In order to compare the means of various entries (genotypes), it is required to calculate the Critical Difference (C.D.) by the following formula :

$$\text{C.D.} = \text{S.E.} \times t$$

Where,

$$\text{S.E.} = \sqrt{\frac{2Ve}{r}}$$

S.E = is standard Errors of the difference of two genotype means to be compared and is equal to

t = is tabulated value at 5% or 1% level of significance for the degree of freedom (df) of Error Mean square.

Coefficient of variance

Genotypic coefficient of variance (GCV)

Where,

$$\text{GCV\%} = \frac{\sqrt{^2_g}}{\bar{X}_i} \quad 100$$

^2_g = genotypic variance = $^2_g \quad \frac{v_g \quad v_e}{r}$

Where,

^2_g = genotypic variance

v_g = variance due to genotypes

v_e = variance due to error

r = number of replications

$\bar{X}_i$ = mean of observations of ith character.

Phenotypic coefficient of variance (PCV)

$$PVC\,\% \quad \frac{\sqrt{^2_g}}{\bar{X}_i} \quad 100$$

Where,

^2_p = phenotypic variance = $^2_p \quad ^2_g \quad ^2_e$

Where,

^2_p = phenotypic variance

^2_g = genotypic variance

^2_e = error variance

$\bar{X}_i$ = mean of all observations of ith character

Heritability (Broad sense) : Heritability in a broad sense was calculated by the following formula suggested by Allard (1999).

$$H^2(b) \quad \frac{^2_g}{^2_p} \quad 100$$

Where,

H^2 (b) = heritability in broad sense

^2_g genotypic variance

^2_p phenotypic variance

Genetic advance : Expected genetic advance (GA) was calculated by the method suggested by Johnson *et al.* (1955) as follows :

$$GA \quad K \quad _p h^2$$

Where,

K = constant (standard selection differential) having the value of 2.06 at 5% selection.

$_p$ = phenotypic standard deviation

h^2 = heritability.

Genetic advance as percentage of mean : Genetic advance as percentage of means was calculated by Johnson *et al.* (1955).

$$GA \text{ as \% mean} = \frac{GA}{\bar{X}} \quad 100$$

Where,

GA = genetic advance

$\bar{X}$ = mean of the character

Estimates of correlation coefficient : Correlation coefficient (r) is the measurement of relationship between two variables. It was estimated by using the formula given by Miller *et al.* (1958).

$$r_{(xy)} = \frac{\mathrm{Cov}\ (xy)}{\sqrt{\mathrm{Var}(x).\mathrm{Var}(y)}}$$

Where,

$r_{(xy)}$ = Correlation coefficient between variable *x* and *y*

Var (x) = Variance of x variable

Var (y) = Variance of y variable

Cov (xy) = Covariance between variable x and y

Genotypic, phenotypic and environmental correlation coefficients were computed by substituting corresponding variance and covariance in the above mentioned formula.

Significance of correlations : '*t*' test was applied to test the significance of the correlation coefficients. '*t*' values were calculated by using the following formula.

$$t \quad \frac{|r|}{\sqrt{1 \quad r2}} \quad \sqrt{n \quad 2}$$

Comparing '*t*' values at (n–2) degrees of freedom tested the significance of correlation coefficient (*r*). If calculated value of '*t*' is greater than the tabular value of '*t*' at (n–2) degree of freedom at given probability level, the coefficient of correlation is considered as significant.

Path coefficient analysis : The path analysis was originally developed by Wright (1921) and elaborated by Dewey and Lu (1959). Path coefficient analysis splits the correlation coefficients into the measures of direct and indirect effects of independent variables on dependent variable. If a character y is determined by correlated characters x_1, x_2 and x_3, a path diagram must be formulated. Thus we get a set of simultaneous equations as given below :

$$r\ (x_1,y) = a + r\ (x_1,\ x_2)\ b + r\ (x_1,\ x_3)\ c.$$

$$r\ (x_2,y) = b + r\ (x_2,\ x_1)\ a + r\ (x_2,\ x_3)\ c.$$

$$r\ (x_3,y) = c + r\ (x_3,\ x_1)\ a + r\ (x_3,\ x_2)\ b.$$

Considering the three factors i.e. x_1, x_2 and x_3, the simultaneous equations given above can be matrix notation as :

$$\begin{array}{ccccc} rx_1y & rx_1x_1 & rx_1x_1 & rx_1x_1 & a \\ rx_2y & rx_2x_1 & rx_2x_2 & rx_2x_3 & b \\ rx_3y & rx_3x_2 & rx_3x & rx_3x_1 & c \\ \mathrm{A} & & \mathrm{B} & & \mathrm{C} \end{array}$$

Where,

$r\,x_1y$ = Correlation coefficient between character x_1 and y.

$r\,x_2y$ = Correlation coefficient between character x_2 and y.

$r\,x_3y$ = Correlation coefficient between character x_3 and y.

a = Direct effect of character x_1 and y.

b = Direct effect of character x_2 and y.

c = Direct effect of character x_3 and y.

The solution for vector c may be obtained as follows:

$$A = B.C$$

$$\text{Or} \quad C = B^{-1}A$$

Where, B^{-1} = inverse of matrix B.

After calculating the values of path coefficient i.e. 'C' vectors the residual effect can be estimated by the given formula :

$$R = 1 - \quad (r_{ij})$$

Where,

R = Residual effect.

r_{ij} = Correlation coefficient between i^{th} character and j^{th} dependent variable.

Result and Discussion

Correlation with seed yield : The correlation for non-quantitative character on the seed yield per plant at genotypic level indicates that out of the nine Character six were significantly positively correlated with seed yield. Number of pods per plant (0.516**) have highest value for correlation in seed yield positive correlation of number of pods per plant with seed yield is also reported by Rakesh kumar (2021), Pawar et al (2020), Sunil *et al* (2014), Prabha *et al* (2010), Raina *et al* (2007), Prakash and Khanure (2000) however 100 seed weight (0.513**) is positively correlated with seed yield is supported by Alle *et al* (2016), Pandya *et al* (2003) Neelima *et al* (2020) and number of secondary branches per plant have highly positive significant correlation with seed yield (0.438**) indicates that positive selection for these traits can enhance the seed yield in horse gram supported by Roopdevi *et al* (2002) moreover the supporting reference for positive association of secondary branches per plant it with seed yield is a new finding. No. of seeds per pod (0.293*) and plant height (0.243*) are positively correlated with seed yield at genotypic level. Alle *et al* (2016), Singh and Salam (2021), Rama *et al* (2007) also found positive association of 100 seed weight with seed yield and also reported a positive association between seed yield and plant height. The character days to maturity exhibited significant negative correlation (-0.231*) with seed yield, this present finding is in accordance of finding of Singh *et al* (2020), Bhadait (2005).

Correlation among yield attributing traits : The correlation among the yield attributing traits at genotypic level is presented in table and significant correlation is being discussed here :

Days to 50% flowering had significant positive association with days to maturity (0.652**) indicate that increase in the days to flowering can delayed the crop maturity under rainfed condition. Days to 50% flowering have highest significant negative correlation with number of seeds per pod (-0.425**) Rakesh kumar (2021**)**, followed by plant population% (-0.295*), no. of secondary branches per plant (-0.213*). Days to maturity did not show any significant association with other yield attributing traits studied in present investigations. Plant height have significant positive association (0.385**) with no. of pods per plant and 100 seed weight (0.376**) supported by Rama *et al (2007).*, and Raina *et al.(2007).*

Number of branches per plant have highly significant positive association with number of secondary branches per plant (0.505**) indicate that as number of branches increase number of secondary branches also increase in horsegram, more over number of branches per plant also have significant positive association with number of pods per plant (0.379**) number of pods per plant indicate that a genotype have more branches per plant have high number of pods per plant, similarly number of branches per plant have positive association with number of seeds per pod (0.318*) also found by Rakesh kumar (2021). No. of secondary branches per plant exhibited similar trend of association and no. of pods per plant (0.250*) and no. of seeds per pod (0.250*). No. of pods per plant have positive significant correlation with 100 seed weight (0.232*) and no. of seeds per pod (0.215*). Plant population (%) have only positive significant association with no. of seeds per pod (0.211*).

The genotypic correlation found in the present investigation and discard above were used to find out the direct and indirect effect of these characters on seed yield of horse gram presented in Table.

Direct effect on seed yield of horsegram : Path analysis at the level of genotypic correlation reported that highest direct effect showed by days to flowering (0.527) followed by no. of sec. branches per plant (0.510) and no. of seed per pod (0.403) Singh (1990). The highest direct negative effect showed by days to maturity (-0.492) followed by no. of branches per plant (-0.370) supported by Rakesh kumar (2021). Days to 50% flowering showed negative insignificant correlation with seed yield per plant (-0.007) and positive direct effect (0.527) on grain yield also found by Sarkar *et al* (2005). Days to maturity had negative significant correlation with seed yield per plant (-0.231*) and negative direct effect on seed yield (-0.492) also found by Singh *et al* (2020). Plant height had positive significant correlation with seed yield per plant (0.243*) also supported by Pandya *et al* (2003) and it had negative direct effect on seed yield (-0.011). No of branches per plant had positive insignificant correlation with seed yield per plant (0.135) and it had negative direct effect on seed yield (-0.370). No. of sec. branches per plant had positive significant correlation with seed yield per plant (0.438**) and positive direct effect on seed yield (0.510). No of pods per plant had positive significant correlation with seed yield per plant (0.516) Singh and Salam (2021) and it had positive direct effect on seed yield (0.245) also found by Prakash and Khanure (2000), Alle *et al* (2016), Khulbe *et al* (2013), Paliwal *et al* (2005), Nagarajan (1999), while positive direct effect through plant height (0.094), no of branches per plant (0.092), no of sec. branches per plant (0.061) no of seeds per pod (0.052) and 100 seed weight(0.057). Plant population had positive insignificant correlation with seed yield per plant (0.004) and it had positive direct effect on seed yield (0.010) while positive indirect effect through no of seeds per pod (0.002) and negative indirect effect through days to flowering (-0.003). .No of seeds per pod had positive significant correlation with seed yield per plant (0.293*) and it had positive direct effect on seed yield per plant (0.403) also supported by Pawar *et al* (2020), Lad *et al* (1999). 100 seed weight had positive significant correlation with seed yield per plant (0.513**). It had positive direct effect on seed yield per plant (0.267).

Indirect effect on seed yield of horsegram : Days to flowering showed positive indirect effect via days to maturity (0.344) and negative indirect effect through no. of sec branches per plant (-0.112), plant population (-0.155) and no. of seeds per pod (-0.244). Days to maturity had negative indirect effect through days to flowering (-0.321) and no of branches per plant (-0.030). Plant height had negative indirect effect through no of pods per plant (-0.004), 100 seed weight (-0.004). No of branches per plant had negative indirect effect through no of sec. branches per plant (-0.186), no of pods per plant (-0.140), plant population (-0.047), no. of seeds per pod (-0.117) and 100 seed weight (-0.054). No. of sec. branches per plant had positive indirect effect through no of branches per plant (0.257), no of pods per plant (0.127), no of seeds per pod (0.127) and 100 seed weight (0.100). No of seeds per pod had positive indirect effect through no of branches per plant (0.128), no of sec. branches per plant (0.100), no of pods per plant (0.086), plant population (0.085) and negative indirect effect through days to flowering (-0.171). 100 seed weight had positive indirect effect on seed yield through no of seeds per pod (0.033), no. of pod per plant (0.062), no. of sec. branches per plant(0.052), no of branches per plant (0.039) and plant height (0.100). Plant population had negative indirect effect through days to flowering (-0.003).). Plant population had positive indirect effect through no of seeds per pod (0.002) and negative indirect effect through days to flowering (-0.003).

The residual effect found under investigation was 0.581 which showed that the character under study was sufficient for the investigation.

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Survey for Prevalence of Cumin Blight in Gujarat

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Abstract

Cumin (*Cuminum cyminum* L.) an important seed spice crop is largely grown in the states of Rajasthan and Gujarat. In Gujarat, the major cumin growing areas are Arnej, Jagudan, Patan, Radhanpur, Sanand, Mandal, Dhandhuka, Rapar, Tharad and Unjha. The survey was conducted in each block (tehsil) depending upon the cropping intensity. In the year 2016, maximum disease intensity was recorded in Tharad (35.49%) followed by Radhanpur (32.24%) whereas in 2018, maximum disease intensity was recorded in Radhanpur (34.40%) followed by Jagudan (33.40%).

Key words: *Cumin, survey, disease intensity.*

Introduction

Cumin (*Cuminum cyminum* L.) is a flowering plant in the family Apiaceae, native to southwestern Asia including the Middle East. Although cumin is thought to have uses in traditional medicine, there is no high-quality evidence that it is safe or effective as a therapeutic agent (Boning, 2010). Traditional uses of cumin include anti-inflammatory, diuretic, carminative and antispasmodic. It has also been used as an aid for treating dyspepsia, jaundice, diarrhea, flatulence and indigestion. Cumin powder has been used as a poultice and suppository and has been smoked in a pipe and taken orally (Patel and Srinivasan, 2004).

The present investigation on "Epidemiology and Management of Alternaria blight of cumin (*Cuminam ciminum* L.) caused by *Alternaria burnsii* (Uppal, Patel and Kamat)" was conducted at the Department of Plant Pathology, B.A. College of Agriculture and at an instructional farm of Krishi Vigyan Kendra, Anand Agricultural University, Arnej, takuka: Dholka, district: Ahmedabad, Gujarat during *Rabi* 2016-17 and 2018-19, respectively. The disease is quite destructive in all the cumin growing areas.

Materials and Methods

The survey was carried out in the major cumin growing areas of Gujarat during the *Rabi* seasons of 2016 and 2018. During the survey ten cumin fields were surveyed from each block (tehsil) depending upon the cropping intensity. Disease was recorded in each field in each of five quadrates i.e. each of four corners and one in the centre of the field each representing overall scenario of that area. Diseased samples were collected for isolation and identification of pathogen and fields were assessed for incidence of blight. Stratified random samples were taken from major cumin growing areas of Gujarat *viz*., Arnej, Jagudan, Patan, Radhanpur, Sanand, Mandal, Dhandhuka, Rapar, Tharad and Unjha (Table-1).

Disease intensity was scored using 0-5 disease rating scale as suggested by Jat (2015). Observations for disease severity were recorded by visual scoring on scale as follows :

0 = Free from disease

1 = 1-10 Per cent area of leaf and umbel blighted

2 = 11-20 Per cent area of leaf, stem and umbel blighted

3 = 21-35 Per cent area of leaf, stem and umbel blighted

4 = 36-60 Per cent area of leaf, stem and umbel blighted

5 = more than 60 Per cent area of leaf, stem and umbel blighted

Per cent disease was calculated by using following formula as suggested by Wheeler (1969).

$$\text{PDI} = \frac{\text{Sum of numerical disease rating}}{\text{No. of plants assessed} \quad \text{Maximum diseases rating}} \quad 100$$

Results and Discussion

Survey was conducted during rabi 2016-17 and 2018-19 in major cumin growing areas of Gujarat viz., Arnej, Jagudan, Patan, Radhanpur, Sanand, Mandal, Dhandhuka, Rapar, Tharad and Unjha. During the survey, ten cumin fields were surveyed. The results presented in Table 4.1 showed that the disease was present and prevalent in all the area that was surveyed during crop seasons: 2016-17 and 2018-19 in the range of 12.02 to 35.44 per cent. In the year 2016 maximum disease

Table-1 : Survey for prevalence of cumin blight in cumin growing areas of Gujarat during Rabi 2016 and 2018.

Area surveyed	Disease Intensity (%)	
	2016-17	**2018-19**
Arnej	27.80	25.80
Jagudan	31.62	33.40
Patan	21.80	18.20
Radhanpur	32.24	34.40
Sanand	16.61	15.80
Mandal	18.64	12.02
Dhandhuka	23.20	25.03
Rapar	31.80	30.09
Tharad	35.44	31.40
Unjha	28.60	26.40
Average	26.77	25.25

intensity was recorded in Tharad (35.44%) followed by Radhanpur (32.24%). Whereas, during 2018, maximum disease intensity was recorded in Radhanpur (34.40%) followed by Jagudan (33.40%). The disease causes heavy losses in Rajasthan and Gujarat, sometimes total failure of the crop due to this disease has been observed in Haryana (Mehra *et al.,* 1998), Gujarat (Gemawat and Prasad, 1972; Dange *et al.,* 2002, Mehra *et al.,* 2002, Kumar *et al*., 2002).

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Effect of Nutrient Management on Yield and Quality of Carrot under Grid Region of Madhya Pradesh

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Abstract

The experiment was conducted at the Nursery, Department of Horticulture, College of Agriculture, Gwalior, Rajmata Vijyaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during the session 2015 - 2016. The experiment was laid out in Randomized Block Design with eight treatments consisting of T_1: Control, T_2: 80:70:60 kg NPK/ha, T_3: 100:80:70 kg NPK/ha, T_4: 120:90:80 kg NPK/ha, T_5: 80:70:60 kg NPK/ha + VC @ 2.5 q/ha, T_6: 80:70:60 kg NPK/ha + VC @ 5.0 q/ha, T_7: 80:70:60 kg NPK/ha + VC @ 7.5 q/ha and T_8: 80:70:60 kg NPK/ha + VC @ 10 q/ha. Various yield parameters viz. size of root (l x d), weight of root, leaf to root ratio, biological yield, yield (kg/ha) and TSS were recorded during the study. Results showed that different treatments exerted significant effect on all the yield parameters and yield except TSS. T_8: 80:70:60 kg NPK/ha + VC @ 10 q/ha over rest of the treatments including control followed by T_7: 80:70:60 kg NPK/ha + VC @ 7.5 q/ha and T_6: 80:70:60 kg NPK/ha + VC @ 5.0 q/ha.

***Key words :** Daucus carota, vermicompost and NPK fertlizer.*

Introduction

Carrot (*Daucus carota* L.) belongs to the family umbeliferae and is an important cool season root vegetable is a biennial and is usually cultivated as an annual crop in the tropics which is grown all over the world. The inclusion of carrots in human diet is highly appreciated due to high nutritional and positive impact on human health and immunity systems (Bressani, 2000). It is used as salad and cooked vegetable in soups, stews, curries, preparation of jams, pickles, and sweet dishes. The area, production and productivity of carrot in India is estimated to be 62.41 thousand ha**,** 1073.71 thousand MT and 20.7 MT/ha**,** respectively. (NHB, 2015) Vermicompost is made up primarily of C, H and O, and contains nutrients such as NO_3, PO_4, Ca, K, Mg, S and micronutrients which exhibit similar effects on plant growth and yield as inorganic fertilizers applied to soil (Singh *et al*., 2008). Similarly, vermicompost contains a high proportion of humic substances which provide numerous sites for chemical reaction; microbial components known to enhance plant growth and disease suppression through the activities of bacteria (*Bacillus*), yeasts (*Sporobolomyces* and *Cryptococcus*) and fungi (*Trichoderma*), as well as chemical antagonists such as phenols and amino acids (Nagavalemma *et al.*, 2004). Soils amended with these products have the ability to retain moisture, improve soil structure and cation exchange capacity, have a higher rate of plant growth hormones and humic acids, higher microbial population and activity, and less root pathogens or soil borne diseases and overall improvement in plant growth and yield (Kale *et al*., 1992).

Materials and Methods

The present experiment was conducted at research farm of college of agriculture Gwalior. The experiment comprises with eight treatment of. The experiment was laid out in Randomized Block Design with eight treatments consisting of T_1: Control, T_2: 80:70:60 kg NPK/ha, T_3: 100:80:70 kg NPK/ha, T_4: 120:90:80 kg NPK/ha, T_5: 80:70:60 kg NPK/ha + VC @ 2.5 q/ha, T_6: 80:70:60 kg NPK/ha + VC @ 5.0 q/ha, T_7: 80:70:60 kg NPK/ha + VC @ 7.5 q/ha and T_8: 80:70:60 kg NPK/ha + VC @ 10 q/ha. Various yield parameters viz. size of root (l x d), weight of root, leaf to root ratio, biological yield, yield (kg/ha) and TSS were recorded during the study.

Results and Discussion

Yield and yield attributes parameter : Size of root (l x d) measured and result showed maximum values under T_8 (80:70:60 kg NPK/ha + VC @ 10 q/ha) followed by T_7 (80:70:60 kg NPK/ha + VC @ 7.5 q/ha) and T_4 (120:90:80 kg NPK/ha) while the minimum size of root (l x d) was recorded under T_1 (control). Size of root was maximum in plants involving higher amount of vermicompost ts. Root length increase indicates efficient absorption of water followed by transport and influence plant growth directly via the supply of plant growth regulating substances (PGRs) proposed by Alam *et al.* (2007), Yourtchi *et al.* (2013) and Ramamurthy *et al.* (2015).

Weight of root measured and showed maximum values under T_8 (80:70:60 kg NPK/ha + VC @ 10 q/ha)

Table-1 : Effect of nutrient management on Length of root, Width of root, weight of root and Leaf to root ratio.

Treatments	Length of root (cm)	Width of root (cm)	Weight of root (kg)	Leaf to root ratio
T_1: Control	11.81	2.24	67.31	0.41
T_2: 80:70:60 kg NPK/ha	12.64	2.49	77.24	0.37
T_3: 100:80:70 kg NPK/ha	13.74	2.62	89.27	0.34
T_4: 120:90:80 kg NPK/ha	16.73	3.02	102.21	0.33
T_5: 80:70:60 kg NPK/ha + VC @ 2.5 q/ha	15.06	2.78	97.99	0.35
T_6: 80:70:60 kg NPK/ha + VC @ 5.0 q/ha	16.08	2.90	90.32	0.33
T_7: 80:70:60 kg NPK/ha + VC @ 7.5 q/ha	16.93	3.28	106.64	0.31
T_8: 80:70:60 kg NPK/ha + VC @ 10 q/ha	17.26	3.62	115.22	0.31
S.Em.	0.026	0.015	0.826	0.005
CD	0.079	0.045	2.505	0.017

Table-2 : Effect of nutrient management on biological yield, Yield (t/hac).

Treatments	Biological yield (t/ha)	Yield (t/ha)	Branched root	Cracked root	TSS (Brix%)
T_1: Control	26.43	18.79	12.85	11.85	12.95
T_2: 80:70:60 kg NPK/ha	33.54	24.54	8.04	9.81	13.12
T_3: 100:80:70 kg NPK/ha	35.30	26.41	8.22	9.19	13.03
T_4: 120:90:80 kg NPK/ha	41.78	31.34	6.93	8.70	13.04
T_5: 80:70:60 kg NPK/ha + VC @ 2.5 q/ha	38.70	28.59	6.74	8.52	13.02
T_6: 80:70:60 kg NPK/ha + VC @ 5.0 q/ha	40.60	30.45	7.33	9.82	13.11
T7: 80:70:60 kg NPK/ha + VC @ 7.5 q/ha	45.27	34.47	7.11	8.07	13.10
T8: 80:70:60 kg NPK/ha + VC @ 10 q/ha	47.45	36.31	6.00	6.11	13.14
S.Em.	0.225	0.082	1.725	2.126	0.047
C.D.	0.682	0.249	5.232	NS	NS

Cracked root (%) and TSS

followed by T_7 (80:70:60 kg NPK/ha + VC @ 7.5 q/ha) and T_4 (120:90:80 kg NPK/ha) while the minimum weight of root was recorded under T_1 (control).

Leaf to root ratio was found maximum under T_1 (control) followed by T_2 (80:70:60 kg NPK/ha), while the minimum leaf to root ratio was recorded under both in T_8 (80:70:60 kg NPK/ha + VC @ 10 q/ha) and T_7 (80:70:60 kg NPK/ha + VC @ 7.5 q/ha).

Biological yield was measured and showed maximum values under T_8 (80:70:60 kg NPK/ha + VC @ 10 q/ha) followed by T_7 (80:70:60 kg NPK/ha + VC @ 7.5 q/ha) and T_4 (120:90:80 kg NPK/ha) while the minimum biological yield was recorded under T_1 (control).

Yield of carrot was measured and showed maximum values under T_8 (80:70:60 kg NPK/ha + VC @ 10 q/ha) followed by T_7 (80:70:60 kg NPK/ha + VC @ 7.5 q/ha) and T_4 (120:90:80 kg NPK/ha) while the minimum biological yield was recorded under T_1 (control).

The reason for increased yield by the application of vermicompost could be due to the solubilization effect of plant nutrients by addition of FYM and vermicompost leading to increase uptake of NPK Sharma et al. (2015). The findings are similar with Oliveira *et al.* (2001) which showed growth and yield of carrot, were found superior with vermicompost. The results are also in agreement with experiment conducted by vermicompost leading to increased uptake of NPK .Besides, Organic manure plays a direct role in plant growth as a source of all necessary macro and micro–nutrients in available forms during mineralization, improving the physical and physiological properties of soil Bhattarai and Maharjan (2013), Alam *et al.* (2007), Mamta *et al.* (2012), Suthar (2009) and Mathivanan *et al.* (2014) Mamta *et al.* (2012), Suthar (2009) and Mathivanan *et al.* (2014).

Conclusions

It is concluded that the Treatment T_8 (80:70:60 kg NPK/ha + VC @ 10 q/ha) was found superior over rest of the treatments under study, which significantly recorded the desirable values of plant growth and yield. The results indicate that the vermicompost application has increased plant height, number of leaves/plant, average leaf area, size of root (L x D), weight of root, biological yield and root yield. Substitution of soil with 10 q/ha and 7.5 q/ha vermicompost along with different ratio of inorganic fertilizers significantly increased growth and yield of carrot progressively.

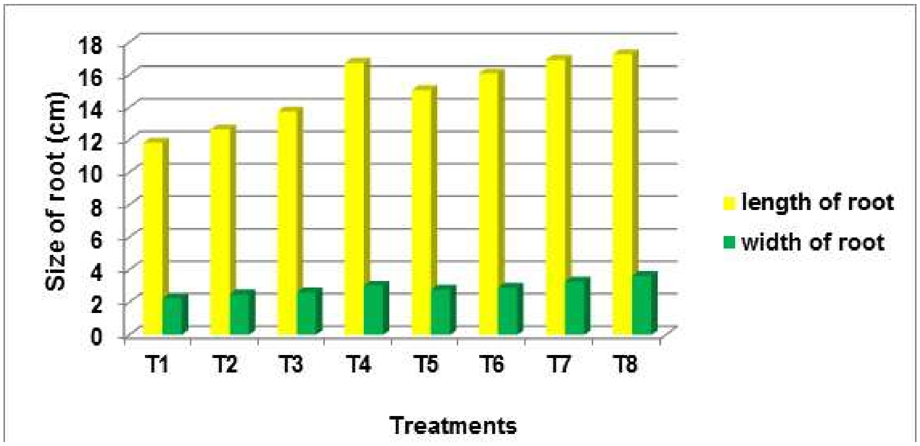

Fig.-1 : Effect of different treatments on size (length and width) of root.

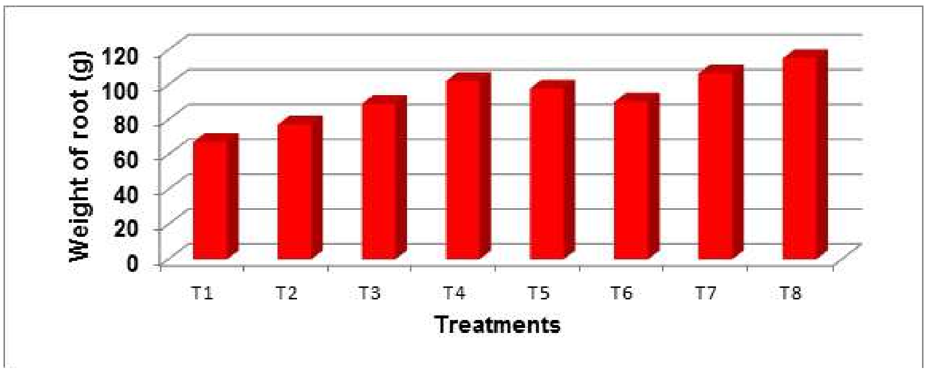

Fig.-2 : Effect of different treatments on weight of root.

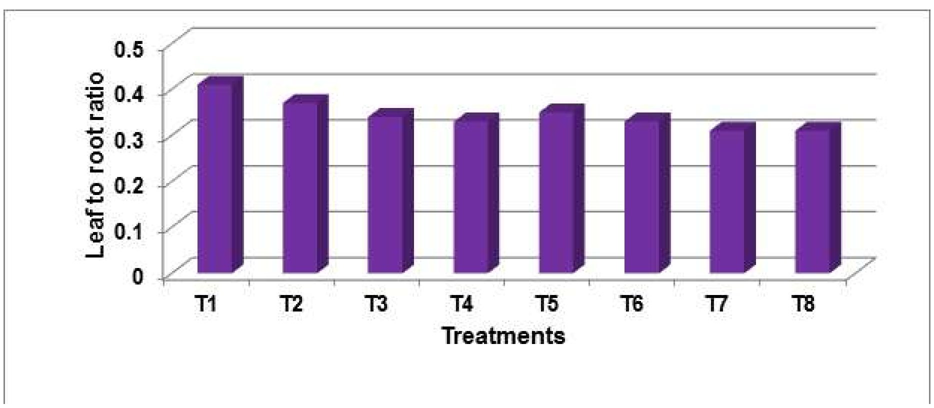

Fig.-3 : Effect of different treatments on leaf to root ratio.

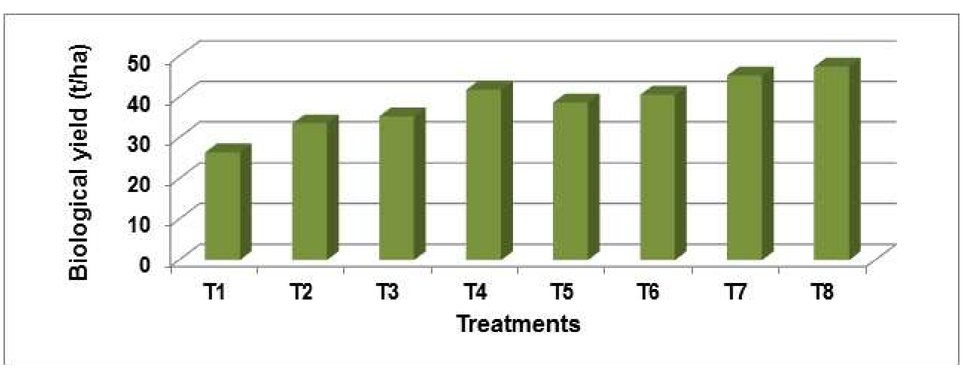

Fig.-4 : Effect of different treatments on biological yield of carrot.

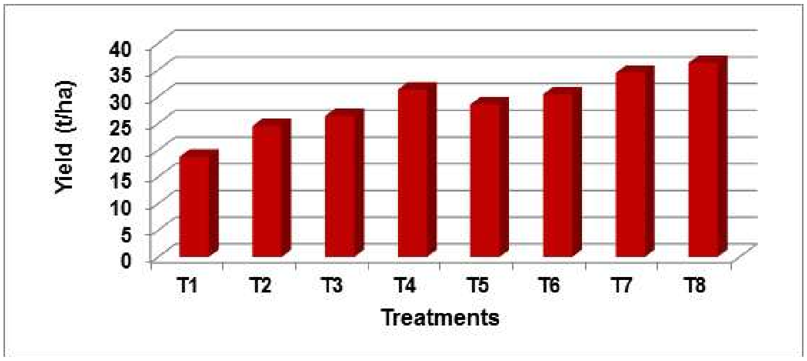

Fig.-5 : Effect of different treatments on yield of Carrot.

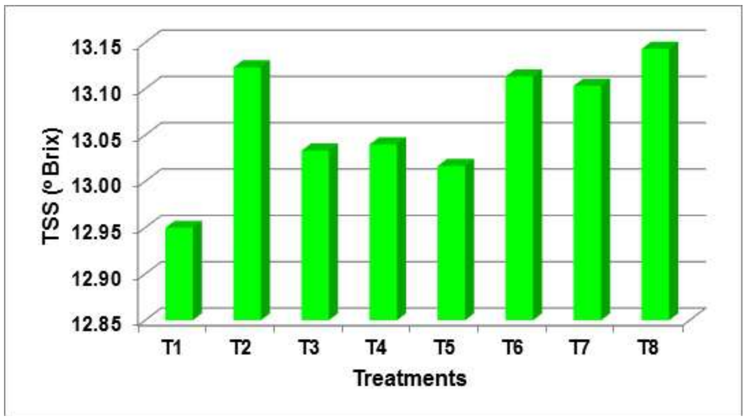

Fig.-6 : Effect of different treatments on number of branched roots.

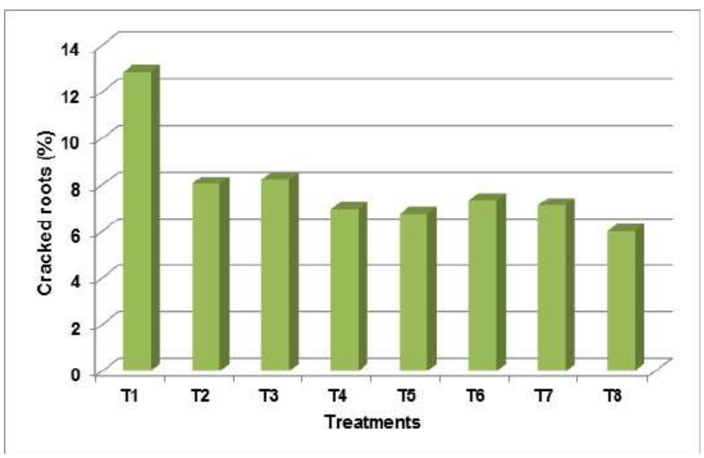

Fig.-7 : Effect of different treatments on cracked roots.

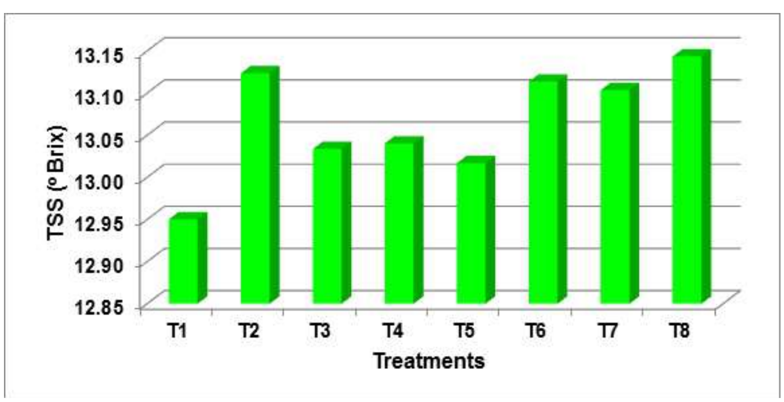

Fig.-8 : Effect of different treatments on quality of carrot TSS.

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Emotional Maturity of Competitive Exam Oriented Students Scross Gender and Community

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Abstract

Emotional maturity refers to ability to understand, and manage, emotions. Emotional maturity enables to create the life desire. A life filled with happiness and fulfillment; define success in our own terms, not societies, and strive to achieve it. Emotional development is one of the major aspects of human growth and development. The aim of the present study is to examine the emotional maturity level among the competitive exam oriented students. Emotional Maturity Scale (EMS) developed and administrated by investigator self was used to measure emotional maturity of students. The study comprised to a sample of 500 students of competitive exam oriented students from based on rural and urban areas in Aurangabad State of Maharashtra. The reliability was calculated which were 0.72. After analysis of the results, it was found that there is the emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence State of being competent)) of urban student are significantly different from urban students. And also found that The emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence (State of being competent)) of male are significantly different from female.

Key words : *Emotions, maturity, emotional maturity, competitive exam, students.*

Introduction

This extent of reactivity determines our emotional maturity. Parent income, gender, community, age of student and faculties of students are major role in contributing to healthy development of competitive exam oriented students. The personality, attitudes and behaviour of students into accepting responsibility making decisions, teaming with groups (i.e. gender, community) developing healthy relationship and enhancing self –importance. Emotional stability is one of the several important indicators of behaviour of student.

Materials and Methods

The present study was carried out at Dr. Babasahed Ambedkar Marathwada University Aurangabad Department of Statistics. The Sample Was Collected By Various Competitive Classes In Aurangabad.

Emotional Maturity Scale (EMS) : For having an idea about the levels of emotional maturity of school principals, Emotional Maturity Scale (2010) developed by Yashvir Singh and Mahesh Bhargava was used. EMS has a total of 48 items.

EMS is based on five broad factors of emotional maturity under the five categories given in below table.

Five Factors of Emotional Maturity :

Sr. No.	Areas	Total no. of Items
A	Intrapersonal awareness	10
B	Interpersonal awareness	10
C	Interpersonal management	10
D	Intrapersonal management	10
E	Independence (State of being competent)	8
	Total	

Likert scale : The most widely used in the Likert scale Likert (1932) developed the principle of measuring attitudes by asking people to respond to a series of statements about a topic, in terms of the extents to which they agree with them, and so tapping into the cognitive and affective components of attitudes.

When was likert scale created?

Definition : A Likert scale is a psychological measurement device that is used to gauge attitudes, values, and opinions. It functions by having a person complete a questionnaire that requires them to indicate the extent to which they agree or disagree with a series of statements.

Tool Used : Emotional Maturity Scale (EMS) developed and administered by researcher or investigator self was used to the Emotional Maturity of the students for the purpose of data collection. It is consisted 60 items with the following five dimensions :

Table-1 : Summary table of Gender mean rank of Emotional Maturity of Students.

	Ranks			
	Gender	N	Mean Rank	Sum of Ranks
SCORE Total	Male	75	59.56	4467.00
	Female	75	91.44	6858.00
	Total	150		

Table-2 : Table of male and female students of Emotional Maturity score.

	Score A	Score B	Score C	Score D	Score E
Mann-Whitney U	8535.000	8383.000	10022.000	6734.000	9205.000
Wilcoxon W	19860.000	19708.000	21347.000	18059.000	20530.000
Z	-3.619	-3.821	-1.638	-6.017	-2.729
Asymp. Sig. (2-tailed)	0.000	0.000	0.102	0.000	0.006
a. Grouping Variable : Gender					
Asymp. Sig. (2-tailed) – 0.000					
a. Grouping Variable : Gender					

Decision::From the above table p-value = 0.000 is less than l.o.s of alpha value at (5%).

Table-3 : Summary table of community mean rank of Emotional Maturity of Students.

	Community	N	Mean Rank	Sum of Ranks
SCORE Total	Rural	150	148.41	22261.00
	Urban	150	152.59	22889.00
	Total	300		

From table-3 shows that mean rank of urban student is greater than rural students.

Table-4 : Urban and rural students Emotional Maturity score.

	Score A	Score B	Score C	Score D	Score E
Mann-Whitney U	10744.500	10430.000	11222.500	11196.000	10787.000
Wilcoxon W	22069.500	21755.000	22547.500	22521.000	22112.000
p-value	0.500	0.274	0.971	0.943	0.537
a. Grouping Variable : Community					

Table-5 : Table of urban and rural students of Emotional Maturity score using Mann-whitney U test.

	SCORE Total
Mann-Whitney U	10936.000
Wilcoxon W	22261.000
Z	-0.418
Asymp. Sig. (2-tailed)	0.676

From the above table-5 shows that p-value=0.676 is greater than l.o.s of alpha value at (5%).

Needs Satisfaction

Emotional Openness

Social Adjustment

Personal Integration

Decision Making : These draft tool 60 statements divided to 12 statements each dimension set against five point Scale i.e. Always, Frequently, Sometimes, Rarely and Never. Scoring procedure for positive items: 5, 4, 3, 2, 1 respectively Always, Frequently, Sometimes, Rarely and Never. Scoring procedure for negative items: 1, 2, 3, 4, 5 respectively Always, Frequently, Sometimes, Rarely and Never. The researcher standardized the tool according to his study sample. The tool provided to the experts in the Education Department of Kalyani University, State of West Bengal, to establish content validity. Reliability of the tool has established by Split- half method. The reliability of the tool is 0.72. Therefore, the tool is reliable.

Statistical Techniques Used : In the present study, various statistical measures such as Descriptive and Inferential statistics i.e. Mean, Standard Deviation (S.D.), and In the present study, various statistical measures such as Descriptive and Inferential statistics i.e. Mean, Standard Deviation (S.D.), and Mann Whitney u test have used to find out Emotional Maturity of competitive exam oriented Students with respect to their Gender and Location.

Variables of the Study : In the present research study, the variables are as under-1. Dependent variable: (a)

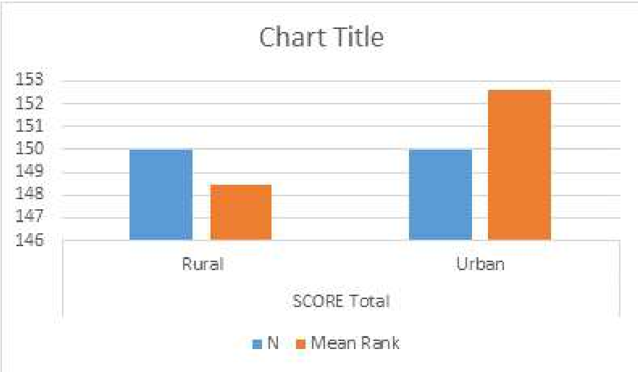

Chart-1 : Score total of urban and rural students.

Emotional Maturity 2. Independent variables: (a) Gender and (b) Location.

Need of the Study : Emotional maturity of competitive exam oriented student at higher age stage of students life takes a vital role for developed their personality. Though we call the man a judge of justice, there is no reason to doubt his conduct that controlled by the emotions. If you do not know the nature of human life, its behavior cannot analyze in a comprehensive way. Moreover, in order to lead a healthy life in society, there is a need for proper development of the student's emotional maturity. The conscious mental process of social life has specially controlled by the person's emotional behavior. So if the development of the emotion has not developed properly, then the development of life has not fulfilled. A person who cannot properly develop a positive response to emotional maturity he/she cannot considered as a perfect man. In such a situation, emotional maturity has needed to adapt to the norms of behavior for develop a good human being.

Results and Discussion

Hypothesis :

H_0 : The emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence (State of being competent)) of male are not significantly different from female.

V/s

H_1 : The emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence (State of being competent)) of male are significantly different from female.

From table 1 shows that mean rank of male and female students in that table fond that mean rank of female students is greater than male students.

Hence null hypothesis is rejected and alternative hypothesis is accepted. From table-2 shows that p value is less than l.o.s.of alpha value hense reject null hypothesis and it conclude that The emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence (State of being competent)) of male are significantly different from female.

The same result is reported by] Roy, Sushil [3] that there was significant difference between in Emotional Maturity of Higher Secondary School students with respect to their gender in the Bongaon Town, State of West Bengal.

Hypothesis [2]

H_0 : The emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence State of being competent) of rural student are not significantly different from urban student.

V/s

H_1 : The emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence State of being competent)) of rural student are significantly different from urban student.

From the above table-5 shows that p-value=0.676 is greater than l.o.s of alpha value at (5%).

Hence null hypothesis is accepted and alternative hypothesis is rejected. Hence it conclude that the emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence State of being competent)) of rural student are not significantly Different from urban student. Therefore, the null hypothesis (1) formulated earlier i.e. "There is no significant difference between male and female university students in emotional maturity" is partially accepted. This is also supported by Manoharan, *et al* (2007).

Sing also reported that it was found no significant difference between rural and urban, male and female, rural male and rural female and urban male and urban female senior secondary school students in relation to emotional maturity.

The findings also revealed that there is significant difference between male and female, post graduate university students and research scholars on personality disintegration dimension of emotional maturity. Study showed that males and total post graduate students are emotionally immature than females and research scholars respectively on personality disintegration dimension of emotional maturity. Same results found by Gakher (2003), Meenakshi & Saurashtra (2003) and Kour M.(2001), which found there is no significant difference between males and females on emotional maturity.

Conclusions

The present study highlights the relationship between emotional maturity of compiatative exam male and female students. It is found that The emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence (State of being competent)) of male are significantly different from female. And also fou that The emotional maturity score (inter, intra personal awareness, inter, intra personal management, Independence State of being competent)) of rural student are not significantly Different from urban student.

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Effect of Faculty on Emotional Maturity of Competitive Exam Oriented Students

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Abstract

Emotional maturity refers to ability to understand, and manage, emotions. Emotional maturity enables to create the life desire. A life filled with happiness and fulfillment; define success in our own terms, not societies, and strive to achieve it. Emotional development is one of the major aspects of human growth and development. The aim of the present study is to examine the emotional maturity level among the competitive exam oriented students. Emotional Maturity Scale (EMS) developed and administrated by investigator self was used to measure emotional maturity of students. The study comprised to a sample of 500 students of competitive exam oriented students from based on rural and urban areas in Aurangabad State of Maharashtra. The reliability was calculated which were 0.72. After analysis of the results, it was found that there is no statistically significant difference between education (faculty) and on emotional maturity score of the students.

Key words *: Emotions, maturity, emotional maturity and and competitive exam oriented students.*

Introduction

This extent of reactivity determines our emotional maturity. parent income, gender, community, age of student and faculties of students are major role in contributing to healthy development of competitive exam oriented students. The personality, attitudes and behaviour of students into accepting responsibility making decisions, teaming with groups (i.e. gender, community) developing healthy relationship and enhancing self–importance. Emotional stability is one of the several important indicators of behaviour of student. Bhanwer (2012) found significant difference between the group of adolescent girls and boys on their Emotional Maturity. Adolescent boys were less emotionally mature than girls. Subramanian (2011) found that the high school boys have greater emotional maturity than the high school girls. Sinha (2014) found significant difference between boys and girls student in term of their emotional maturity. The difference obtained between these two mean is significant on 0.01 levels. It means that boys have better emotional maturity than their girls. The basic purpose of this study is to find out the effect of faculty on emotional maturity of competitive exam oriented students.

Materials and Methods

The present study was carried out at Dr. Babasahed Ambedkar Marathwada University Aurangabad Department of Statistics. The Sample Was Collected By Various Competitive Classes In Aurangabad.

Emotional Maturity Scale (EMS) : For having an idea about the levels of emotional maturity of school principals, Emotional Maturity Scale (2010) developed by Yashvir Singh and Mahesh Bhargava was used. EMS has a total of 48 items.

EMS is based on five broad factors of emotional maturity under the five categories given in below table.

Five Factors of Emotional Maturity :

Sr. No.	Areas	Total no. of Items
A	Intrapersonal awareness	10
B	Interpersonal awareness	10
C	Interpersonal management	10
D	Intrapersonal management	10
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	Total	

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When was likert scale created?

Definition : A Likert scale is a psychological measurement device that is used to gauge attitudes, values, and opinions. It functions by having a person complete a questionnaire that requires them to indicate the extent to which they agree or disagree with a series of statements.

Tool Used : Emotional Maturity Scale (EMS) developed and administered by researcher or investigator self was used to the Emotional Maturity of the students for the purpose of data collection. It is consisted 60 items with the following five dimensions :

Needs Satisfaction

Emotional Openness

Social Adjustment

Personal Integration

Decision Making : These draft tool 60 statements divided to 12 statements each dimension set against five point Scale i.e. Always, Frequently, Sometimes, Rarely and Never. Scoring procedure for positive items: 5, 4, 3, 2, 1 respectively Always, Frequently, Sometimes, And Rarely and Never. Scoring procedure for negative items: 1, 2, 3, 4, 5 respectively Always, Frequently, Sometimes, Rarely and Never. The researcher standardized the tool according to his study sample. The tool provided to the experts in the Education Department of Kalyani University, State of West Bengal, to establish content validity. Reliability of the tool has established by Split- half method. The reliability of the tool is 0.72. Therefore, the tool is reliable.

Statistical Techniques Used : In the present study, various statistical measures such as Descriptive and Inferential statistics i.e. Mean, Standard Deviation (S.D.), and In the present study, various statistical measures such as Descriptive and Inferential statistics i.e. Mean, Standard Deviation (S.D.), and Mann Whitney u test have used to find out Emotional Maturity of competitive exam oriented Students with respect to their faculty. And using

Kruskal Wallis : determines if the median for two groups is different.

Need of the Study : Emotional maturity of competitive exam oriented student at higher age stage of students life takes a vital role for developed their personality. Though we call the man a judge of justice, there is no reason to doubt his conduct that controlled by the emotions. If you do not know the nature of human life, its behavior cannot analyze in a comprehensive way. Moreover, in order to lead a healthy life in society, there is a need for proper development of the student's emotional maturity. The conscious mental process of social life has specially controlled by the person's emotional behavior. So if the development of the emotion has not developed properly, then the development of life has not fulfilled. A person who cannot properly develop a positive response to emotional maturity he/she cannot considered as a perfect man. In such a situation, emotional maturity has needed to adapt to the norms of behavior for develop a good human being.

Variables of the Study : In the present research study, the variables are as under-1. Dependent variable: (a) Emotional Maturity 2. Independent variables: (a) parent income (b) faculty (*Science, Commence, Art, Eng. Agri.)*

Statistical Techniques Used : In the present study, various statistical measures such as Descriptive and Inferential statistics i.e. Mean, Standard Deviation (S.D.), and To study the Education (Faculty) (Science, Commence, Art, Eng., Agri.) on emotional maturity score (inter, intra personal awareness, inter, intra personal management) using Kruskal Wallis test.

Table-1 : Overall percentage of different faculty of students.

Faculty of the students	Frequency	Percent
Science	149	49.66
Commerce	49	16.33
Art	102	34
Total	300	100

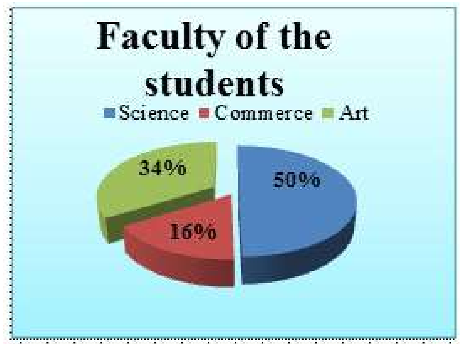

Table-1 revealed that overall percentage of different faculty of students are gives competitive exam.

Above pie-chart shows the faculty wise distribution of the respondents. We shows that the 50% of competitive exam oriented students are from Science faculty whereas 34% of students are from Commerce faculty and16% of students are from arts faculty.

Table-2 : Mean rank of education faculty.

	Education (faculty)	N	Mean Rank
SCORE Total	Science	149	145.99
	Commerce	49	138.99
	Art	102	162.62
	Total	300	
b. Grouping Variable : Education			

Table-3 : Chi-square value of education faculty.

	SCORE Total
Chi-Square	3.259
Df	2
Asymp. Sig.	0.196
a. Kruskal Wallis Test	
b. Grouping Variable : Education	

From the Table-2 and 3 it is observed that the.value=0.196 is greater than level of significance of alpha value at (5%).hence There is no statistically significant difference between education (faculty) and emotional maturity score of the students.

Decision : From the above table p-value=0.196 is greater than level of significance of alpha value at (5%). Find same result by Sandhu D. and Singh B[8].

The Gunde Rajendra [8] is reported against by the above result there is significant difference among faculties of the college students regarding their emotional maturity. Arts and Commerce as well as Arts and Science Faculties differ significantly on emotional maturity. Arts students are significantly more mature than Commerce and Science students.

Conclusions

The present study highlights the relationship between emotional maturity and various education faculties' students. It is found that There is no statistically significant difference between education (faculty) and emotional maturity score of the students.so the various faculties of education is not affected by emotional maturity score of competitive exam oriented students.

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Studies on Biochemical Variability in Parental Lines and Hybrids of Sweet Corn (sh2) *(Zea mays* L. var saccharata) under Low Temperature Stress

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Abstract

In India, Sweet corn is predominantly grown in winter season where seed germination and early seedling growth is adversely affected due to low temperatures and is a major bottle neck in sweet corn cultivation. An study was conducted to study the enzymatic activities and ROS content of parental lines and hybrids to study the effect of sub optimum temperatures. For the study, two *shrunken*2 based sweet corn hybrids; CMVL Sweet Corn-1 (VSL16/ VSL4) and Pusa Super Sweet Corn-2 (SWT16/ SWT17) along with their respective parental lines were used. The seeds were imbibed at 10°C and 25°C temperature for three days and the changes observed in the activity of antioxidant enzymes and reactive oxygen species (ROS) was quantified. Under suboptimum temperatures, activities of hydrolyzing (-amylase) and antioxidant enzyme (superoxide dismutase) were subdued however there was no difference in peroxidase activity among genotypes. Lower enzymatic activities and free radical content were observed at low temperature (10^{0}C) than optimum temperature (25^{0}C) conditions. Hybrids showed higher enzymatic activities at low temperature as compared to parental lines indicating higher capacity to counter the produced ROS.

Introduction

After rice and wheat, maize (*Zea mays* L.) is the third most important cereal crop. The nutrient-rich cereal is grown on 193.7 million hectares of land worldwide, with yields of 1147.7 million tonnes and productivity rates of 5.92 t/ha (FAOSTAT, 2020). Maize has become an industrial crop around the world, with the majority of it being used for feed (61%) and food (17%), as well as in the starch and processing sectors (22%). USA, China, and Brazil are the three main producers of maize wherein India ranks 4th and 7th in acreage and production respectively. In India, maize is cultivated on an area of 9.2 million ha with an average production and productivity of 27.8 million tonnes and 2.9 t/ha respectively (2018-19). The average production and productivity of maize in India are 27.8 million tonnes and 2.9 t/ha, respectively, with 9.2 million hectares of total cultivated area (2018-19).

Maize genotypes having kernels with enhanced biological and economical value are denoted to as "specialty corn". Sweet corn (*Zea mays* L. *var saccharata*) is one among the specialty maize which is distinguished by high sugar content in the kernels. In sweet corn, several endosperm mutants are used to increase kernel sugar content, like *shrunken* 2, *brittle* 1, *sugary* 1 and *sugary enhancer*. The *shrunken* 2 (*sh*2) mutants have highest sucrose (29.9%) with better keeping quality among them, thus is being most widely used in the sweet corn breeding programme (Mehta *et al*., 2017). Despite these superior qualities, the commercial adoption and widespread use of *sh*2 hybrids is constrained because of low seedling vigour, field emergence and inconsistent stand establishment (Douglass, 1993).

Sweet corn has poor seed germination and vigour which is caused by inadequate nutrient supply during seed germination due to the low starch content and higher imbibition rates leading to significant solute leakage and susceptibility to physical damage and biotic stresses (Styer *et al*., 1983). There was a positive correlation between seed quality and the starch content and negative association between seed quality and protein content of maize seed (Ajayi *et al.,* 2005). Imbibition could occur at low temperatures and caused harm to embryos or emerging seedlings. The physiological quality of plants, seed enzymatic expressions, and seedling performance are all impacted by low temperature regimes (Santos *et al*., 2015).

The poor and irregular germination of seeds took place due to injury from cold water imbibition stress and when seeds sown in soils at 10^{0}C or below (Cohn and Obendorf, 1978) and induced chilling injury leading to reactive oxygen species (ROS) production which caused oxidative damages to several macromolecules and cellular structures (Apel and Hirt, 2004) causing poor seedling establishment. Thus, low temperature exposure can cause alterations in expression levels of some enzymes. Studies on seed germination, field emergence and bio-physical and biochemical activities under low temperature stress in specialty maize reported sweet corn to be most vulnerable to low temperature (Mir *et al*., 2014) and anti-oxidant enzyme activities and ROS mechanism played a key role in controlling seed vigour and storage potential of speciality corns (Sharma, 2017). Endogenous defence mechanism enzymes like POD and CAT quenched the reactive oxygen species (ROS) and protected the membranes from the injuries (Foyer and Noctor, 2003). ROS scavenging has a direct relation with seed vigour where seed imbibition or radicle protrusion were related primarily with increase in antioxidant activity and an increase of lipoxygenase activity was found associated with hypocotyl elongation initiation (Bailly *et al.,* 2002). The higher antioxidant defence system increased the chilling tolerance of maize seedlings (Ahmad *et al.,* 2012) along with improved germination speed and root and shoot growth. Antioxidants played a major role in defence mechanism system against the free radicals in plant cells, as they protected and prohibited lipids oxidative deterioration and maintained functional and structural cell integrity (Govindaraj *et al.,* 2017).

In India, Sweet corn is predominantly grown in winter season. Seed germination, field emergence, seedling growth and crop stand is adversely affected during winter season (December-February) due to low temperatures (<10^{o}C) (Parera *et al.,* 1996) and is a major bottle neck in sweet corn cultivation under farmers' field. Keeping in view the above-mentioned background the current research was undertaken to assess biochemical variability in maize genotypes under low temperature "Studies on biochemical variability in parental lines and hybrids of sweet corn (*sh*2) (*Zea mays L. var saccharata*) under low temperature stress".

Materials and Methods

The study was conducted with the parental lines and hybrids of public bred sweet corn hybrids; CMVL sweet corn-1 and Pusa Super Sweet corn-2.

Female	Male	Hybrid
VSL16 (G1)	VSL4 (G2)	CMVL sweet corn-1 (G3)
SWT16 (G4)	SWT17 (G5)	Pusa Super Sweet corn-2 (G6)

The seeds of parental lines and hybrids of CMVL sweet corn-1 (VSL16/ VSL4) and Pusa Super Sweet corn-2 (SWT16/ SWT17) were procured from Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora and Maize section, Division of Genetics, ICAR-IARI, New Delhi.

Biochemical studies : The seeds were imbibed at 10^{0}C and 25^{0}C temperature for three days and the changes observed in the activity of antioxidant enzymes and reactive oxygen species (ROS) was quantified. Following estimations were done for biochemical assessment of seeds*.*

-amylase activity (Kato-Noguchi and Macias, 2005) : Take 0.5 g seed extract in 2ml of 100mM HEPES KOH buffer (pH7.5) containing 1mM EDTA, 5mM DTT,5 mM $MgCl_2$and $NaHSO_3$. The extract was centrifuged for 15 minutes at 13000g and the pallet obtained washed with extraction buffer and was centrifuged against 13000g. Supernatants obtained from repeated centrifugations were combined and used for -amylase assay. The crude extract was heat treated at 70°C for nearly 15 minutes in presence of 3 mM $CaCl_2$, to inactivate -amylase. 50 l of aliquot from crude extract (heat treated) was added to 0.15 ml assay mixture containing 50mM sodium acetate buffer (pH 5.2) and 10mM $CaCl_2$. The tubes incubated for 15minutesafter adding 0.1ml of substrate (2.5% boiled soluble potato starch), after cooling. Another aliquot of 250 l was taken from this mixture and treated with 500 l DNS solution (40mM DNS, 1mM K-Na tartrateand400mM NaOH heated at 50°C and filtered using filter paper) for 5 minutes at 105°C. The final volume of tubes was made up to 5ml using distilled water and absorbance taken at 530nmin a spectrophotometer. A standard graph prepared using maltose in the range 0 to 100 g/ml and the enzyme activity was expressed as mg maltose mg^{-1} FW min^{-1}.

Peroxidase activity (Rao, 1996) : Pre weighed 200mg seed sample homogenized in liquid nitrogen. Add Homogenized powder was added in 1.5ml of ice cold 50mM sodium phosphate buffer (pH-7.0) containing 5mM -mercaptoethanol, 2mM EDTA and 4% of PV-40. The homogenate centrifuged at 4^{0}C for 30 minutes at 30000×g and supernatant collected.1.5ml of 100mM Na-phosphate buffer (pH 7.0), 0.4ml of enzyme extract, 0.12 ml of H_2O_2 solution (10mM), and 0.48 ml of guaiacol (20 mM) were added. The reaction started on addition of guaiacol (20mM). Increased absorbance was recorded for 3 minutes at interval of 1 minute at 470nm using a spectrophotometer. Reaction mixture without the enzyme served as blank. The calculated enzyme activity was as per extinction coefficient of the oxidation product, tetra guaiacol 2.66 mM^{-1}cm^{-1}. Enzyme activity expressed as ìmol tetra guaiacol produced min^{-1} g^{-1} of fresh weight of seed.

Superoxide dismutase (Dhindsa *et al.*, 1981) : Enzyme extract same as in case of peroxidase activity. The assay mixture was prepared by adding 1.5 ml of 201mM methionine solution, one ml of 1.72 mM nitroblue tetrazolium (NBT, stored at 4^{0}C) solution and 0.75ml of 1% Triton X-100 solution in 27 ml of Na-phosphate buffer (50mM, pH 7.8). 0.1 ml of enzyme extract and 0.03ml of 0.12mM riboflavin added in one ml of assay mixture. The tubes were placed in light box for 8minutes providing uniform light intensity. The absorbance was recorded at 560nm using a spectrophotometer. A reaction without addition of enzyme after exposure to light served as blank.

Table-1 : Effect of temperature on enzymatic activities of sweet corn genotypes.

Genotype / Enzyme Activity	-Amylase (mol/g FW/min)			Peroxidase (mol/g FW/min)			SOD (mol/g FW/min)			Superoxide (O^{2-}) (A_{540}/min/g FW)			Peroxide (H_2O^{2-}) (µmol/g FW)		
	10°C	25°C	Mean	10°C	25°C	Mean	10°C	25°C	Mean	10°C	25°C	Mean	10°C	25°C	Mean
G_1	0.063	0.237	0.150	0.207	0.238	0.223	26.20	29.22	27.71	0.446	0.817	0.631	0.103	0.124	0.113
G_2	0.074	0.247	0.160	0.282	0.303	0.292	24.87	28.29	26.58	1.122	1.228	1.175	0.122	0.152	0.137
G_3	0.081	0.270	0.176	0.338	0.388	0.363	31.89	32.34	32.11	1.269	1.523	1.396	0.166	0.187	0.177
G_4	0.093	0.233	0.163	0.251	0.281	0.266	26.15	28.40	27.28	0.553	0.643	0.598	0.088	0.142	0.115
G_5	0.108	0.134	0.121	0.271	0.298	0.284	29.10	31.00	30.05	0.569	0.899	0.734	0.083	0.121	0.102
G_6	0.152	0.239	0.196	0.336	0.376	0.356	32.51	34.46	33.49	1.294	1.313	1.304	0.161	0.186	0.174
Mean	0.095	0.227		0.281	0.314		28.45	30.62		0.875	1.071		0.121	0.152	
	C.D.	SE(m)		C.D.	SE(m)		C.D.	SE(m)		C.D.	SE(m)		C.D.	SE(m)	
Temp.	0.008	0.003		NS	0.022		1.671	0.569		0.073	0.025		0.02	0.007	
Genotype	0.013	0.004		NS	0.038		2.894	0.986		0.127	0.043		0.035	0.012	
Interaction (A×B)	0.018	0.006		NS	0.053		NS	1.394		0.18	0.061		NS	0.017	

(G_1: VSL16, G_2: VSL4, G_3: CMVL sweet corn-1, G_4: SWT 16, G_5: SWT 17, G_6: Pusa Super Sweetcorn-2)

Determination of superoxide (O_2^-) : Superoxide (O_2^-) production was determined by following the procedure given by Schopfer (2001), by the reduction of Na, 3-[1-[(phenylamino)-carbonyl]-3, 4tetrazolium] (4-methoxy-6-nitro) benzenesulfonic acid hydrate (XTT). 20 germinating sweet-corn seeds were incubated overnight in 5 ml of 50 mM K-phosphate buffer (pH 7.0) containing 500ìM XTT at 25°C in a shaker in absence of light. The absorbance changes were recorded at 15-minute interval at 470 nm using a spectrophotometer (Biowave II WPA).

Hydrogen peroxide measurement (H_2O_2) : Hydrogen peroxide was estimated following the procedure given by Mukherjee *et al*., (1983) formation of titanium-hydro peroxide complex.

Titanium reagent : 1 g titanium dioxide and 10 g potassium sulphate were mixed and digested with 150 ml of conc. H_2SO_4 for 4 hours at 100°C on the hot plate. The mixture was cooled after digestion and was diluted to 1.5 l volume using distilled water. The solution was stirred over a magnetic stirrer cum heater at 80°C till the solution became clear transparent.

0.5g ground seeds were taken in 10 ml of acetone (cooled)in a chilled mortar and pestle kept in an ice bucket. The homogenate formed was filtered using a Whatman no.1 filter paper and followed by addition of 4 ml titanium reagent and also 5ml ammonium hydroxide solution to precipitate out the titanium hydroperoxide complex. The reaction mixture was centrifuged for 10 minutes at 10,000g. The obtained precipitate was dissolved in 10 ml of 2M conc. H_2SO_4 and re-centrifuged. The observance taken at 415nm against blank and H_2O_2 expressed as mol per gram of fresh weight of seed.

Result and Discussion

The seeds were imbibed at 10°C and 25°C temperature for three days and the changes observed in the activity of antioxidant enzymes and reactive oxygen species (ROS) was quantified. The data recorded on the biochemical activities of sweet corn seeds under optimum and suboptimum conditions is depicted in the Table-7.

-Amylase activity : -Amylase enzyme is responsible for starch mobilization during early germination stage in seeds. The activity of -amylase among genotypes was statistically different under both the temperatures i.e. 10°C and 25°C. The highest activity of -Amylase was observed in CMVL sweet corn-1 (G3) (0.270 ìmol/g FW/min) followed by VSL4 (G2) (0.247 mol/gFW/min) which was statistically at par with Pusa Super Sweetcorn-2 (G6) (0.239 ìmol/gFW/min) at 25°C. The lowest activity of -Amylase was measured at 10°C inVSL16 (G_1) and VSL4 (G_2) (at par 0.063 and 0.074 mol/gFW/min respectively) which were at par (Table-1) (Fig.-1). An increased chilling tolerance in maize inbred lines was associated with the increase in concentration of proline, soluble sugars, peroxidase and catalase activities in maize (Guan *et al*., 2009) which favoured higher germination index, root and shoot dry weight, root length, shoot height and reduced mean germination time (MGT). In the present study, the seeds imbibed at 10°C and 25°C temperature for three days biochemical activities of sweet corn seeds under optimum and suboptimum conditions, exhibited lower activities of hydrolyzing (-amylase) and antioxidant enzyme (superoxide dismutase) under suboptimum temperatures however there was no difference in peroxidase activity among genotypes. Hybrids had higher enzymatic activities of both

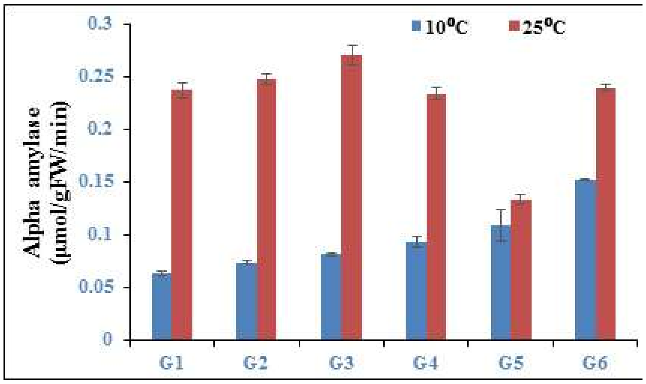

Fig.-1 : Alpha amylase activity in sweet corn genotypes under different temperature regimes.

hydrolyzing and antioxidant enzymes as compared to parental lines.

-amylase is an enzyme that acts primarily on starch stored in a seed initiating the process of germination. á-amylase activity at suboptimum temperature (10°C) was found less as compared to under optimum temperature (25°C) for all genotypes. The lower emergence and vigour in sweet corn genotypes at lower temperature as compared to suboptimum and optimum temperature conditions could be attributed to lower activities of -amylase enzyme. Catao et al., (2017) observed negative correlation of á-amylase activity in seed under low temperatures.

Peroxidase assay (ìmol/gFW/min) : Peroxidase enzyme breaks down H_2O_2 into water and oxygen. The peroxidase activity was not statistically significant in sweet corn seeds exposed to 10°C and 25°C imbibition temperature (Table-1) (Fig.-2). Peroxidase enzyme acts on hydrogen peroxide accumulated in seed changing it into water molecules. An increased cold tolerance in maize inbred lines was associated with the increased peroxidase activity which improved seedling performance at low temperature (Guan *et al*., 2009). But contrastingly in our study the activities of both hydrolysing and antioxidant enzymes were subdued under low temperatures. Similar results have been reported by Cyrus *et al*., (2015) that reduction in seed vigour was associated with the reduction of peroxidase, catalase and SOD activities.

Super oxide dismutase activity (SOD) : The super oxide dismutase activity of genotypes was statistically different under both the imbibition temperatures i.e. 10°C and 25°C, except genotype CMVL sweet corn^{-1} (G_3) where the activity was found at par (31.89 and 32.34 ìmol/gFW/min). The SOD activity was highest, in Pusa Super Sweetcorn-2 (G_6) (34.46 mol/gFW/min) in seeds imbibed at 25°C. The lowest SOD activity was observed in VSL4 (G_2) (24.87 mol/gFW/min) at imbibition at 10°C of (Table-1) (Fig.-2). The antioxidant enzymes played a major role in defence mechanism system against the free radicals in plant cells (Govindaraj *et al.,* 2017). Superoxide dismutase (SOD) enzyme acts on superoxide free radicals, is responsible for free radical quenching and lowering the deleterious effect of ROS in the seed. Enhanced SOD activity also helped in controlling the production of malonaldialdehydes and haxanal, thus improved germination and vigour of maize seeds. Pinhero *et al.,* (1997) examined the role of antioxidant enzymes in protecting maize seedlings for chilling injury and observed enhanced activities of superoxide dismutase (SOD) and chilling tolerance in maize. The higher antioxidant defence system increased the chilling tolerance of maize seedlings along with improved germination speed and root and shoot growth (Ahmad *et al.,* 2012).

Superoxide radical (O_2^-) and Hydrogen peroxide (H_2O_2) content : The quantification of superoxide anion radical results is represented in Table-7. The highest concentration of superoxide anion radicals was observed for CMVL sweet corn^{-1} (G_3) (1.523 ÄA_{540}/min/g FW)after exposure at 25°C imbibition temperature followed by CMVL sweet corn-1 (G_3) after exposure at 10°C which was significantly at par with Pusa Super Sweetcorn-2 (G_6) (1.294 and1.313 A_{540}/min/g FW) at 10°C and 25°C imbibition temperature. The lowest concentration of superoxide radicals was observed for VSL16 (G_1) (0.446 A_{540}/min/g FW) at 10°C imbibition temperature (Table-1) (Fig.-3).

The concentration of H_2O_2 was found to be significantly higher at 25°C as compared to 10°C exposure temperature. The hybrid genotypes [CMVL sweet corn-1 (G_3) and Pusa Super Sweetcorn-2 (G_6)] had significantly higher H_2O_2 content than their respective parental lines. The highest H_2O_2 was observed in CMVL sweet corn-1(G_3) (0.187 ìmol/g FW) at 25°C which was statistically at par with Pusa Super Sweetcorn-2 (G_6) (0.186 ìmol/g FW). Whereas the lowest H_2O_2 activity was observed in VSL16 (G_1), SWT 16 (G_4) and SWT 17 (G_5) in (0.103, 0.088 and 0.83ìmol/g FW respectively) which were at par (Table-1) (Fig.-3).

ROS such as superoxide radicals ($O_2^{.-}$) and hydrogen peroxide (H_2O_2) are generated in mitochondrion, peroxisome and apoplastic spaces in a germinating seed. Hydrogen peroxide and superoxide free radicals are among the major free radicals produced in seed during respiration. These free radicals are produced in higher amount during germination. H_2O_2 acts as a secondary messenger in seed germination process and promotes germination (Barba-Espin *et al.,* 2011). The level of H_2O_2 in the seeds is maintained by several enzymes such as peroxidase, superoxide dismutase, oxalate oxidase, amine oxidase and nicotinamide adenine

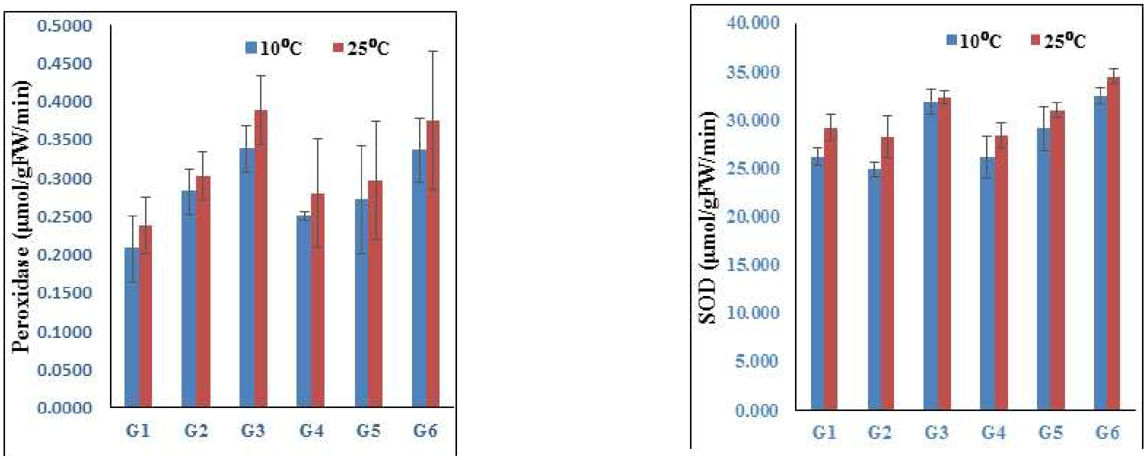

Fig.-2 : Peroxidase (POX), Superoxide dismutase (SOD) activity in sweet corn genotypes under different temperature regimes.

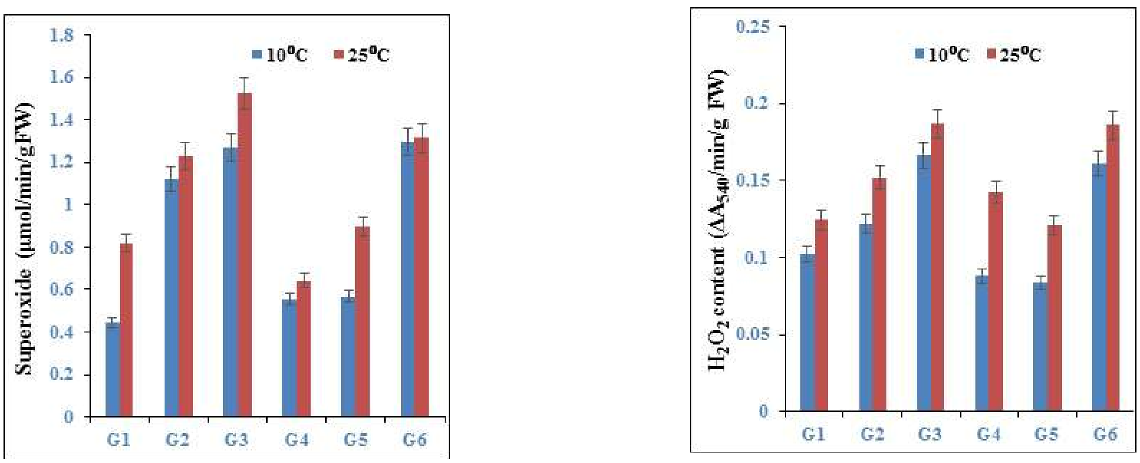

Fig.-3 : Superoxide (O_2^-), Hydrogen peroxide (H_2O_2) content in sweet corn genotypes under different temperature regimes.

dinucleotide phosphate oxidase (membrane linked NADPH oxidase) (Bolwell and Wojtaszek, 1997). In our study, free radical production at 10°C was lower as the seeds were metabolic less active under suboptimum conditions. Sharma (2017) also reported role of ROS mechanism in seedling performance in specialty maize.

Conclusion

Under suboptimum temperatures, activities of hydrolyzing (-amylase) and antioxidant enzyme (superoxide dismutase) were subdued however there was no difference in peroxidase activity among genotypes. Lower enzymatic activities and free radical content were observed at low temperature (10°C) than optimum temperature (25°C) conditions. Hybrids showed higher enzymatic activities at low temperature as compared to parental lines indicating higher capacity to counter the produced ROS. Information generated on variability among parental lines and hybrids of sweet corn for various biochemical activities under low temperature conditions will be helpful in identifying parental lines for low temperature tolerance based on their enzymatic activities and capacity to counter the produced ROS and further utilization in hybrid development.

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Honey Bee Forecasting by ARIMAX Model Using Weather Variables

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Abstract

Historical data has been considered for forecasting of honey bee population. For the purpose, autoregressive integrated moving average with explanatory variables has been applied along with all estimation procedures. There are ARIMAX technique employed for forecasting of honey bee population on time based data of Surguja district of Chhattisgarh. Data of Weather variables viz. maximum temperature, minimum temperature rainfall and Precipitation is taken from meteorological observatory of Rajmohini Devi College of, Agriculture and Research Station Ambikapur, Chhattisgarh as input variables in ARIMAX model. Comparative study of the fitted models is carried out from the viewpoint of mean absolute percentage error (MAPE), root mean squared error (RMSE). After comparison resulted that ARIMAX (1,1,1) and ARIMAX (1,1,0) model provided a lower RMSE from other models for yield and production respectively.

Key words: *Forecasting, ARIMAX, honey bee population.*

Introduction

Bee keeping is an art of keeping and manipulating of bees for purpose obtaining honey, a food of high nutritional and medicinal value and bee wax which is used in preparation cosmetic, boot polish and water proof paint. Bee keeping is the one of the oldest traditions in India for collecting the honey. Bee keeping is also play important role to increase agriculture productivity through pollination. About 80 % crops are cross pollinated, as they need to receive pollen from other plant of same species with the help of external agents. yield is increased about 44% in mustard, 32- 45% in sunflower & 17-20% in cotton though bee pollinators. among all G-20 countries, India has sixth rank in honey production and first position in all SAARC Countries with total production 1.2 lakh metric tons in 2017 -18 (Source: http://www.indiastat.com). Honey production has increased from 76,150 MTs (2013) to 1,20,000 MTs (2019-20) which is 57.58 % increase. In India Export of honey has increased from 28,378.42 MTs (2013-14) to 59536.74 MTs (2019-20) which has 109.80 % increased. Punjab is the major state in beekeeping in the nation, with around 35,000 beekeepers delivering around 1500 metric tons honey. This is more than 39% of the nation's total honey production.

Honey bee population is influenced by many parameters in which weather parameters viz., Temperature, rainfall, relative humidity, sunshine hours and wind speed are play a vital role in determining abundance and distribution of honeybee's population. But even today, a very few theoretical frameworks are available to examine the effect of climate on population dynamics of honey bees. so that continue monitoring of honey bee if essential work for beekeeper for higher productivity of honey. It is also subject of attention for aphidologists and honey bee researchers. (Meikle and Holst 2015). Honey bees have made behavioral changes before rainfall, which is enormously important for their survival in severe weather conditions (He et al. 2016). Different bee species also prefer to forage at different temperatures, weather directly impacts hygro and thermodynamic processes within the pollinator, impacting survival rate and energy cost of foraging (Vicens and Bosch 2000). Chouksey at el. (2018a) employed ARIMAX models for forecasting of Rice yield for different nutrient combinations of Raipur district of Chhattisgarh. Chouksey at el. (2018b) used combination of AR and MA order ARIMAX model for different nutrient combinations of nitrogen content and organic carbons included as an input variable. They found that ARIMAX model out performed as compared to ARIMA model.

Materials and Methods

Weekly data of honey bee population from 2014 to 2020 of Surguja district of Chhattisgarh was collected from ACRIP honey bee project at RMD College of agriculture and research station Ambikapur. Weather data like Temperature (max. and min.), Evaporation, were collected from meteorological station at RMD college of agriculture & research station Ambikapur (C.G.).

Autoregressive Integrated Moving Average with explanatory variable (ARIMAX) – transfer function model : There is not possible to express the multivariate time series changing rules using the ARIMA model with only one time series. The reason is that the only ARIMA model is imperfect. Therefore, it is necessary to create a

Tablle-1 : Descriptive statistics of maximum temperature, minimum temperature, Evaporation, honey bee population.

	Honey bee population	Evaporation	Maximum temperature	Minimum temperature
Mean	108.14	3.2892	28.422	15.151
SD	83.167	1.4295	4.1515	5.7573
Minimum	15.800	1.0000	18.700	4.7000
Maximum	520.50	8.8000	40.300	23.700
Skew	1.5483	1.1557	0.4938	-0.0565
Kurtosis	2.4531	1.7189	0.3137	-1.3994

Table-2 : Autocorrelation check fTable-2 : Autocorrelation check for white noise of maximum temptature.

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr>ChiSq	Autocorrelations					
6	430.3	6	< 2.2e-16	0.791	0.650	0.560	0.420	0.299	0.185

Table-3 : Autocorrelation check for white noise of minimum temptature.

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr>ChiSq	Autocorrelations					
6	137.61	6	< 2.2e-16	0.917	0.863	0.799	0.695	0.575	0.444

Table-4 : Autocorrelation check for white noise of Evaporation.

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr>ChiSq	Autocorrelations					
6	368.74	6	< 2.2e-16	0.753	0.601	0.498	0.366	0.264	0.206

Table-5 : Autocorrelation check for white noise of honey bee population.

Autocorrelation Check for White Noise									
To Lag	Chi-Square	DF	Pr>ChiSq	Autocorrelations					
6	536.85	6	< 2.2e-16	0.813	0.716	0.617	0.515	0.398	0.306

Table-6 : Stationary test of maximum temperature time series.

Series Name	ADF test statistic				PP test statistic			
	Single mean	With trend	Probability		Single mean	With trend	Probability	
			Single mean	With trend			Single mean	With trend
Maximum temperature	-4.6076	2.4409	0.0012	0.0154	-4.7923	2.3586	0.0006	0.0191
Minimum temperature	-4.7923	-0.4362	0.0006	0.6631	-5.3976	-2.468	0.0000	0.0388
Evaporation	-8.7653	-2.3074	0.0000	0.0492	-3.0966	-2.5700	0.0022	0.0369
Honey bee population	-6.4828	-0.2014	0.0000	0.8405	-9.9985	-0.3874	0.0000	0.6988

Table-7 : Parameter estimation of ARIMAX (1 0 0)(0,0, 2) by maximum likelihood estimation method for honey bee population.

	Estimate	Std. Error	z value	Pr(>|z|)
AR1	0.8509	0.0332	25.60	< 2.2e-16***
SMA1	0.2436	0.0675	3.605	0.000311***
SMA2	0.1817	0.0753	2.413	0.015810*
Intercept	154.79	40.46	3.825	0.000130***
Temperature Maximum	-1.6949	1.609	-1.053	0.292313
Temperature Minimum	-2.003	1.421	-1.409	0.158730
Evoporation	6.0365	4.216	1.431	0.152241

Table-8 : Autocorrelation of residual of model ARIMAX (1,0,0) (0,0,2) for honey bee population.

To Lag	Chi-Square	DF	Pr>ChiSq
6	2.1759	6	0.9028
12	3.5473	12	0.9903
18	23.871	18	0.1593
24	27.835	24	0.2671

Table-9 : Performance of ARIMAX (1,0,0) (0,0,2) for honey bee population time series in training data set.

Criteria	ARIMAX
MASE	0.3915
RMSE	40.009
MAPE	34.2254
R SQUARE	0.7586

Table-10 : Performance of ARIMAX (1,0,0) (0,0,2) for honey bee population time series in testing data set.

Criteria	MASE	0.55599
	RMSE	57.6069
	MAPE	29.7258
	R SQUARE	0.4040

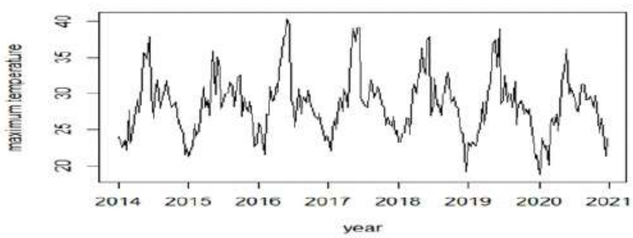

Figure-1 : Time series plot of maximum temperature.

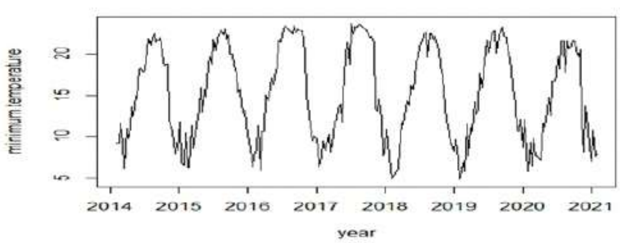

Figure-2 : Time series plot of minimum temperature.

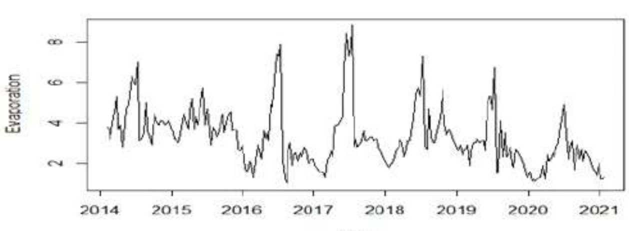

Figure-2 : Time series plot of minimum temperature.

model with multivariate ARIMAX model. Assume two time series denoted Y_t and X_t, which are both stationary. Then, the transfer function model (TFM) can be written as follows :

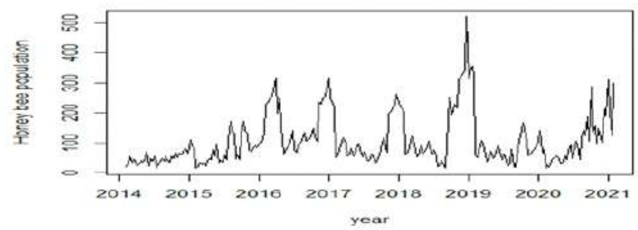

Figure-4 : Time series plot of honey bee population.

$$Y_t = C + V(B)\,X_t + N_t \qquad \ldots(2)$$

where: Y_t is the output series (nitrogen uptake); X_t is the input series (nitrogen content and organic carbon); C is constant term and N_t is the stochastic disturbance, i.e. the noise series of the system that is independent of the input series; $V(B)Xt$ is the transfer function (or impulse response function), which allows X to influence Y via a distributed lag and B is backshift operator.

Results and Discussion

The basic step in any statistical analysis is to know the behavior of the data which are taken into consideration by calculating summary statistics and by drawing plot of time series. The summary table of maximum temperature, minimum temperature, Evaporation and honey bee population indicates that the data under consideration is normal in nature with less skewness and kurtosis as compared to other weather variables. Figure 1 to Figure 4 illustrated that series has been near to stationary in nature.

The above time plots showed the weekly time series of maximum temperature, minimum temperature, Evaporation and honey bee population from 2014 to 2020. A perusal of figure 1 to 3 revealed a linear trend over time which indicates the all three time series under consideration were stationary in nature and Figure 4 illustrated that honey bee population series was near to stationarity. Based on the probability of chi-square value obtained in table 2 to table 5 confirms the all series were autocorrealated. Once the series is autocorrelated then, the next step is to go for stationarity testing of the series. which is further confirmed by the results of Augmented Dickey-Fuller (ADF) unit root test and Phillips-Peron unit root test (PP test) statistics given in table 6.

Table-6 illustrated that all time series under consideration is found to be stationary then there is no need for differencing of the series to make it stationary.

ARIMAX model for Honey bee population : The principal step in Box-Jenkins ARIMA model building is identification of the model. Different orders of Autoregressive (AR) and Moving Average (MA)

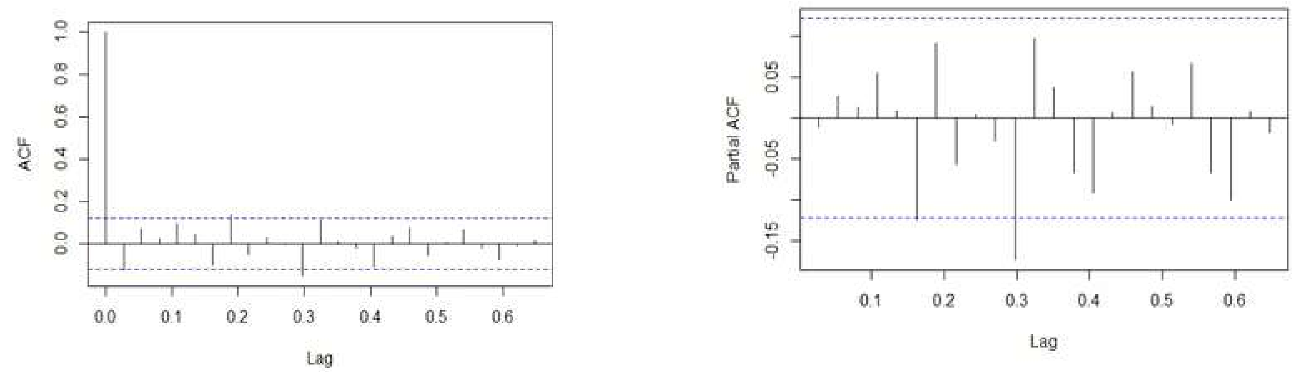

Figure-5 : ACF and PACF of residual of model ARIMAX (1,0,0)(0,0,2) of series honey bee population.

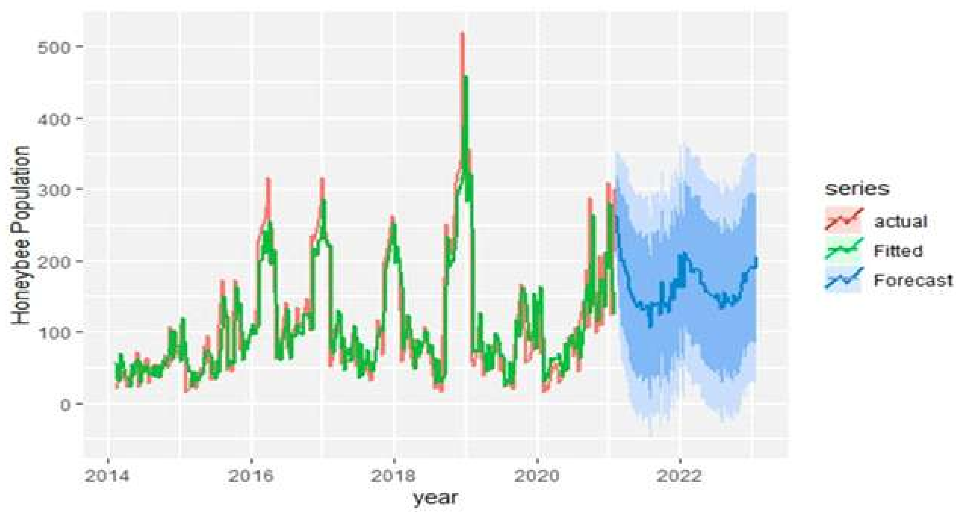

Figure-6 : Actual v/s ARIMA fitted plot of honey bee population time series with forecasting.

parameters p and q are considered and combination of the order which yields maximum log-likelihood and lowest values of Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) are considered as final model orders. For honey bee population with weather variables (Maximum temperature, Minimum temperature, Evaporation) time series based on lowest BIC values obtained, ARIMAX (1 0 0)(0,0,2) was found adequate for series honey bee population. Once the model order was determined then, next step is to go for parameter estimation of the model by maximum likelihood estimation method which is the second step in Box-Jenkins ARIMA model building procedure. The results of parameter estimation of ARIMAX (1 0 0) (0,0,2) is given in table 7.

The third and final step in ARIMA model building is diagnostic checking of the model. Based on the ACF and PACF plots (Figure 5) and probability of autocorrelation of the residuals obtained in table 8 one can infer that the residuals are non-autocorrelated.

After model building, next step is to go for model fitting called as training and based on obtained parameters; in-sample forecasting or holdout forecasting *i.e.* performance of model under testing data set is carried out. For time series under consideration 3 years weekly data (from 2018-2020) as holdout sample (testing) is used for comparing model performance based on MASE, RMSE and MAPE. The MASE, RMSE and MAPE values for both training and testing data set is given in table 9 and table 10 respectively. The observed and fitted plot and forecasting trend of the time series under consideration is also given in figure 6.

Conclusions

Honey bee population weekly data of Raipur district of Chhattisgarh have been analyzed and considering most important weather variables (maximum temperature, minimum temperature & evaporation) as input variables in ARIMAX model. Prediction for future value of Honey bee population has been done by the best selected ARIMAX model. Forecasted values of honey bee population showed less fluctuation for upcoming years. After study we can say that ARIMAX model may be helpful for researcher and policy makers of honey bee for forecasting and decision making.

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Study of Direct and Indirect Effects of Different Yield Components on Grain Yield in Bread Wheat Using Path Analysis for Timely and Late Sown Conditions

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Abstract

The present study entitled "Study of direct and indirect effects of different yield components on grain yield in bread wheat using path analysis for timely and late sown conditions" was carried out under normal (E_1 and E_3) and late sown condition (E_2 and E_4) during *rabi* 2019-20 and *rabi* 2020-21. The results of path coefficient analysis revealed that, under normal sowing (E_1 and E_3) of both the year of evaluation, harvest index showed high direct effect towards grain yield per plant, which was followed by biological yield per plant in phenotypic path analysis. Under late sowing (E_2) of first year of evaluation (*rabi* 2019-20), days to maturity and harvest index showed very high direct effects towards grain yield per plant, which was followed by biological yield per plant in phenotypic path analysis, while under late sowing (E_4) of second year of evaluation (*rabi* 2020-21), harvest index showed very high direct effects towards grain yield per plant, which was followed by biological yield per plant, days to anthesis and grain filling period in phenotypic path analysis. It was apparent from the path analysis that maximum direct effect as well as appreciable indirect influences was exerted by biological yield per plant and harvest index towards grain yield under both the sowing conditions. Both these characters also exhibited significant and positive association with grain yield per plant and hence, these may be considered as the most important yield contributing characters and due emphasis should be placed on these components while breeding for high yield in wheat. However, in late sown condition, more emphasis also may given to days to maturity, days to anthesis and grain filling period while selection.

Key words : *Wheat, path analysis, normal sowing, late sowing.*

Introduction

Wheat is widely grown all over the world and stands first among the cereals both in area and production. It has been described as the "King of Cereals" because of the acreage it occupies, and high productivity and prominent position it holds in the world food grain trade. Wheat is a crop of global significance grown in diversified environments. It is an important cereal crop of cool climate and plays an important role in food and nutritional security of world. It provides food for 40 per cent of the global population and contributes 20 per cent of the food calories (Bhutto *et al*., 2016). The nutria-rich cereal is grown in diversified environments; globally wheat occupies around 217 million hectares holding the position of highest acreage among all crops with an annual production hovering around 731 million tonnes (Anon., 2018).

Seed yield, a polygenic trait, is influenced by its various components directly as well as indirectly via other traits, which create a complex situation before a breeder for making selection. Therefore, path coefficient analysis could provide a more realistic picture of the interrelationship, as it considers direct as well as indirect effects of the variables by partitioning the correlation coefficient. Path coefficient is a standardized partial regression coefficient and measures the direct and indirect influence of one variable upon another thereby permitting the separation of the correlation coefficient into the component of direct and indirect effects. The original concept of path coefficient analysis was given by Smith (1936). The path coefficient analysis was carried out as per the method suggested by Dewey and Lu (1959).

Materials and Methods

The experimental materials consisted of 52 genotypes of bread wheat obtained from Wheat Research Station, Junagadh Agricultural University, Junagadh. These genotypes were sown on 18th November and 18th December under timely and late sown condition, respectively during *rabi* 2019-20 and *rabi* 2020-21 in Randomized Block Design (RBD) replicated thrice at the Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh, which created four different environments. Each genotype was sown in a single row plot of 3.0 m length with a spacing of 22.5 cm. All the recommended crop production and protection practices were followed timely for the successful raising of crop. The detail sowing time and year of experimentation is given in Table-1.

In each plot, five plants were randomly selected and tagged excluding terminal ones to minimize border effects. The observations were recorded on these five randomly selected plants in each genotype and in each replication for 16 different characters except days to 50 per cent heading, days to anthesis, grain filling period and days to maturity, which were recorded on plot basis. Mean values of all the characters studied were used for statistical analysis. The path coefficient analysis was carried out as per the method suggested by Dewey and Lu (1959). Following scales were used for the Rating of path coefficients was made as per the scale suggested by Lenka and Mishra (1973).

Table-1 : The details of environments.

Year of experiment	Environments	Date of sowing
Rabi 2019-20	E_1 (Normal sowing)	18th November, 2019
	E_2 (Late sowing)	18th December, 2019
Rabi 2020-21	E_3 (Normal sowing)	18th November, 2020
	E_4 (Late sowing)	18th December, 2020

Results and Discussion

The phenotypic correlation coefficients calculated for different pairs of characters were subjected to path coefficient analysis for partitioning these values into the direct and indirect effects. The results obtained for direct and indirect effects of various characters on grain yield per plant are presented environment wise in Table 2 to Table 5, respectively.

Normal sown condition of (E_1) of *rabi* 2019-20 : Under normal sowing (E_1) of first year of evaluation (*rabi* 2019-20), harvest index (0.9804) showed high direct effect towards grain yield per plant, which was followed by biological yield per plant (0.6104) in phenotypic path analysis (Table 2). Days to anthesis (0.1938) had low direct effect towards grain yield per plant, while other characters *viz*., grain filling period, plant height, spike length, number of spikelets per main spike, flag leaf area and SPAD chlorophyll meter reading had direct positive effect towards grain yield per plant. The remaining characters had very low direct negative effect on grain yield per plant. Lower residual effect (0.0926) for phenotypic path analysis was observed in this environment.

The phenotypic correlation between harvest index and grain yield per plant was highly significant and positive (r_p = 0.805) with the highest direct effect (0.9804) on grain yield per plant. Harvest index exhibited negative indirect effects on grain yield per plant *via* days to 50 per cent heading (-0.0094), days to maturity (-0.0162), plant height (-0.0015), spike length (-0.0008), number of spikelets per main spike (-0.0010), 1000 grain weight (-0.0009), biological yield per plant (-0.1706), flag leaf area (-0.0005) and SPAD chlorophyll meter reading (-0.0006), while positive and indirect effects on grain yield per plant was exhibited by harvest index through days to anthesis (0.0138), grain filling period (0.0061), number of productive tillers per plant (0.0011), number of grains per main spike (0.0024) and canopy temperature depression (0.0023).

The phenotypic correlation between biological yield per plant and grain yield per plant was significant and positive (r_p = 0.336) with the high direct effect (0.6104) on grain yield per plant. Biological yield per plant exhibited negative indirect effects on grain yield per plant *via* days to maturity (-0.0048), grain filling period (-0.0030), plant height (-0.0004), number of grains per main spike (-0.0029), harvest index (-0.2741), SPAD chlorophyll meter reading (-0.0056) and canopy temperature depression (-0.0023), while positive and indirect effects on grain yield per plant was exhibited by biological yield per plant through days to 50 per cent heading (0.0019), days to anthesis (0.0110), number of productive tillers per plant (0.0031), spike length (0.0008), number of spikelets per main spike (0.0012), 1000 grain weight (0.0002) and flag leaf area (0.0008).

Late sown condition of (E_2) of *rabi* 2019-20 : Under late sowing (E_2) of first year of evaluation (*rabi* 2019-20), days to maturity (1.2599) and harvest index (1.0343) showed very high direct effects towards grain yield per plant, which was followed by biological yield per plant (0.3733) in phenotypic path analysis (Table 3). Days to 50 per cent heading, number of productive tillers per plant and number of spikelets per main spike had very low direct positive effect towards grain yield per plant. The remaining characters had very low direct negative effect on grain yield per plant. Lower residual effect (0.0762) for phenotypic path analysis was observed in this environment. Days to maturity had very high direct effect on grain yield per plant, but had non-significant phenotypic correlation with grain yield per plant.

The phenotypic correlation between harvest index and grain yield per plant was highly significant and positive (r_p = 0.925) with very high direct effect (1.0343) on grain yield per plant. Harvest index exhibited negative indirect effects on grain yield per plant *via* days to anthesis (-0.4870), number of spikelets per main spike (-0.0005), 1000 grain weight (-0.0003), biological yield per plant (-0.1236), flag leaf area (-0.0004) and canopy temperature depression (-0.0016), while positive and indirect effects on grain yield per plant was exhibited by harvest index through days to 50 per cent heading (0.0198), days to maturity (0.2650), grain filling period (0.1915), number of productive tillers per plant (0.0198), plant height (0.0010), spike length (0.0003), number of grains per main spike (0.0009) and SPAD chlorophyll meter reading (0.0055).

The phenotypic correlation between number of productive tillers per plant and grain yield per plant was highly significant and positive (r_p = 0.687) with very low

Table-2 : Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on grain yield per plant of bread wheat under normal sown (E_1) condition during *Rabi*-2019-20.

Character	DH	DA	DM	GFP	NPTPP	PH	SL	NSPMS	NGPMS	TGW	BYPP	HI	FLA	SCMR	CTD	Phenotypic correlation with grain yield per plant
DH	-0.0600	0.1742	-0.1203	-0.0050	-0.0049	0.0019	0.0001	0.0010	-0.0011	-0.0016	-0.0189	0.1535	0.0014	-0.0039	0.0027	0.119
DA	-0.0539	0.1938	-0.1329	-0.0064	-0.0044	0.0019	0.0001	0.0009	-0.0013	-0.0019	0.0346	0.0696	0.0014	-0.0030	0.0004	0.099
DM	-0.0458	0.1636	-0.1575	0.0383	0.0007	0.0013	0.0003	0.0008	-0.0015	-0.0028	0.0188	0.1010	0.0007	-0.0008	-0.0014	0.116
GFP	0.0037	-0.0152	-0.0737	0.0818	0.0085	-0.0008	0.0004	0.0001	-0.0006	-0.0020	-0.0222	0.0732	-0.0009	0.0034	-0.0032	0.052
NPTPP	-0.0136	0.0394	0.0050	-0.0322	-0.0216	0.0007	0.0005	0.0010	-0.0001	0.0018	-0.0875	-0.0478	0.0011	-0.0003	0.0060	-0.148
PH	-0.0183	0.0595	-0.0327	-0.0098	-0.0025	0.0063	0.0004	0.0005	0.0007	-0.0006	-0.0376	-0.0637	0.0009	-0.0011	0.0026	-0.095
SL	-0.0017	0.0045	-0.0108	0.0073	-0.0021	0.0006	0.0047	0.0016	-0.0045	0.0007	0.0982	-0.3229	0.0012	-0.0019	0.0048	-0.220
NSPMS	-0.0155	0.0443	-0.0331	0.0011	-0.0054	0.0009	0.0019	0.0039	-0.0038	0.0017	0.1900	-0.2451	0.0013	-0.0021	0.0063	-0.054
NGPMS	-0.0062	0.0236	-0.0221	0.0050	-0.0001	-0.0004	0.0020	0.0014	-0.0106	0.0018	0.1675	-0.2239	0.0010	-0.0004	0.0005	-0.061
TGW	-0.0137	0.0517	-0.0602	0.0222	0.0054	0.0005	-0.0005	-0.0009	0.0026	-0.0072	-0.0204	0.1240	-0.0003	-0.0008	-0.0025	0.100
BYPP	0.0019	0.0110	-0.0048	-0.0030	0.0031	-0.0004	0.0008	0.0012	-0.0029	0.0002	0.6104	-0.2741	0.0008	-0.0056	-0.0023	0.336*
HI	-0.0094	0.0138	-0.0162	0.0061	0.0011	-0.0004	-0.0015	-0.0010	0.0024	-0.0009	-0.1706	0.9804	-0.0005	-0.0006	0.0023	0.805**
FLA	-0.0189	0.0596	-0.0255	-0.0168	-0.0054	0.0013	0.0012	0.0011	-0.0023	0.0005	0.1068	-0.1055	0.0045	-0.0058	0.0029	-0.003
SCMR	0.0105	-0.0256	0.0054	0.0126	0.0003	-0.0003	-0.0004	-0.0004	0.0002	0.0003	-0.1525	-0.0242	-0.0012	0.0224	-0.0061	-0.159
CTD	0.0060	-0.0029	-0.0080	0.0097	0.0047	-0.0006	-0.0008	-0.0009	0.0002	-0.0007	0.0507	-0.0815	-0.0005	0.0050	-0.0273	-0.047

*, ** Significant at 5 per cent and 1per cent levels, respectively. Residual effect: R= 0.0926

Where, DH = Days to 50 per cent heading, DA = Days to anthesis, DM = Days to maturity, GFP = Grain filling period, NPTPP = Number of productive tillers per plant, Ph = Plant height, SL = Spike length, NSPMS = Number of spikelets per main spike, MGPMS = Number of grains per main spike, TGW = 1000 grain weight, BYPP = Biological yield per plant, HI = Harvest index, FLA + Flag leaf area, SCMR = SPAD-chlorophyll meter reading, and CTD = Canopy temperature depression

Table-3 : Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on grain yield per plant of bread wheat under late sown (E_2) condition during *Rabi*-2019-20.

Character	DH	DA	DM	GFP	NPTPP	PH	SL	NSPMS	NGPMS	TGW	BYPP	HI	FLA	SCMR	CTD	Phenotypic correlation with grain yield per plant
DH	0.0691	-1.4159	0.9224	0.4095	0.0091	-0.0015	-0.0008	0.0011	-0.0004	-0.0009	0.0161	0.2963	-0.0018	0.0033	0.0050	0.311*
DA	0.0652	-1.5010	0.9152	0.4948	0.0107	-0.0012	-0.0009	0.0012	-0.0003	-0.0010	0.0014	0.3356	-0.0018	0.0052	0.0056	0.329*
DM	0.0506	-1.0903	1.2599	-0.2169	0.0036	-0.0002	-0.0023	0.0011	-0.0004	-0.0015	0.0407	0.2176	-0.0014	0.0041	0.0042	0.269
GFP	-0.0291	0.7628	0.2806	-0.9736	-0.0106	0.0015	-0.0016	-0.0003	0.0000	-0.0006	0.0491	-0.2034	0.0007	-0.0022	-0.0027	-0.129
NPTPP	0.0208	-0.5303	0.1509	0.3418	0.0303	-0.0010	-0.0002	0.0005	-0.0001	0.0006	-0.0055	0.6762	-0.0013	0.0023	0.0019	0.687**
PH	0.0118	-0.2071	0.0267	0.1647	0.0035	-0.0089	-0.0001	0.0001	-0.0011	0.0003	-0.0268	-0.1146	0.0007	-0.0061	0.0043	-0.153
SL	0.0062	-0.1504	0.3235	-0.1749	0.0007	-0.0001	-0.0091	0.0023	-0.0014	-0.0001	0.0685	-0.0380	-0.0010	0.0079	-0.0077	0.027
NSPMS	0.0135	-0.3208	0.2515	0.0516	0.0026	-0.0002	-0.0037	0.0057	-0.0015	0.0005	0.0826	-0.0973	-0.0016	0.0047	-0.0013	-0.014
NGPMS	0.0064	-0.1214	0.1136	0.0017	0.0008	-0.0024	-0.0030	0.0020	-0.0042	0.0005	0.1430	-0.2248	-0.0008	0.0067	0.0012	-0.081
TGW	0.0141	-0.3370	0.4546	-0.1301	-0.0042	0.0007	-0.0002	-0.0007	0.0005	-0.0043	0.0018	0.0770	0.0001	0.0034	-0.0030	0.073
BYPP	0.0030	-0.0055	0.1373	-0.1279	-0.0004	0.0006	-0.0017	0.0013	-0.0016	0.0000	0.3733	-0.3424	-0.0007	0.0072	-0.0021	0.040
HI	0.0198	-0.4870	0.2650	0.1915	0.0198	0.0010	0.0003	-0.0005	0.0009	-0.0003	-0.1236	1.0343	-0.0004	0.0055	-0.0016	0.925**
FLA	0.0242	-0.5236	0.3488	0.1440	0.0080	0.0012	-0.0017	0.0018	-0.0007	0.0001	0.0539	0.0844	-0.0051	0.0088	-0.0027	0.141
SCMR	-0.0045	0.1556	-0.1035	-0.0430	-0.0014	-0.0011	0.0014	-0.0005	0.0006	0.0003	-0.0531	-0.1136	0.0009	-0.0505	0.0034	-0.209
CTD	-0.0117	0.2874	-0.1818	-0.0884	-0.0019	0.0013	-0.0024	0.0003	0.0002	-0.0004	0.0270	0.0568	-0.0005	0.0059	-0.0293	0.062

*, ** Significant at 5 per cent and 1per cent levels, respectively

Residual effect: R= 0.0762

Where, DH = Days to 50 per cent heading, DA = Days to anthesis, DM = Days to maturity, GFP = Grain filling period, NPTPP = Number of productive tillers per plant, Ph = Plant height, SL = Spike length, NSPMS = Number of spikelets per main spike, MGPMS = Number of grains per main spike, TGW = 1000 grain weight, BYPP = Biological yield per plant, HI = Harvest index, FLA + Flag leaf area, SCMR = SPAD-chlorophyll meter reading, and CTD = Canopy temperature depression

Table-4 : Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on grain yield per plant of bread wheat under normal sown (E_3) condition during *Rabi*-2020-21.

Character	DH	DA	DM	GFP	NPTPP	PH	SL	NSPMS	NGPMS	TGW	BYPP	HI	FLA	SCMR	CTD	Phenotypic correlation with grain yield per plant
DH	-0.0509	0.0569	0.0067	0.0004	0.0031	0.0009	-0.0002	-0.0030	-0.0001	-0.0013	0.0304	0.0709	0.0033	-0.0032	-0.0017	0.112
DA	-0.0495	0.0585	0.0067	0.0006	0.0034	0.0009	0.0003	-0.0038	-0.0002	-0.0014	0.0414	0.0334	0.0038	-0.0022	-0.0041	0.088
DM	-0.0422	0.0489	0.0080	-0.0033	-0.0005	0.0006	0.0008	-0.0030	-0.0002	-0.0022	0.0204	0.0744	0.0021	0.0008	0.0006	0.105
GFP	0.0028	-0.0050	0.0038	-0.0070	-0.0064	-0.0004	0.0010	0.0006	-0.0001	-0.0018	-0.0295	0.0816	-0.0023	0.0049	0.0076	0.050
NPTPP	-0.0095	0.0121	-0.0002	0.0027	0.0165	0.0003	0.0023	-0.0049	-0.0001	0.0014	-0.0608	-0.0755	0.0030	-0.0025	-0.0139	-0.129
PH	-0.0154	0.0172	0.0016	0.0008	0.0015	0.0031	0.0011	-0.0007	0.0001	-0.0004	-0.0373	-0.0479	0.0022	0.0002	0.0031	-0.071
SL	0.0007	0.0009	0.0004	-0.0004	0.0022	0.0002	0.0176	-0.0074	-0.0006	0.0008	0.0851	-0.3426	0.0027	-0.0033	-0.0004	-0.244
NSPMS	-0.0087	0.0124	0.0014	0.0002	0.0045	0.0001	0.0073	-0.0179	-0.0004	0.0014	0.2100	-0.2442	0.0022	-0.0009	-0.0105	-0.043
NGPMS	-0.0053	0.0070	0.0011	-0.0003	0.0007	-0.0002	0.0079	-0.0055	-0.0013	0.0017	0.1916	-0.2347	0.0023	-0.0005	-0.0049	-0.041
TGW	-0.0104	0.0128	0.0029	-0.0020	-0.0037	0.0002	-0.0021	0.0041	0.0004	-0.0061	-0.0381	0.1241	-0.0002	0.0004	0.0031	0.085
BYPP	-0.0025	0.0039	0.0003	0.0003	-0.0016	-0.0002	0.0024	-0.0061	-0.0004	0.0004	0.6183	-0.2698	0.0018	-0.0047	-0.0016	0.341*
HI	-0.0037	0.0020	0.0006	-0.0006	-0.0013	-0.0002	-0.0061	0.0044	0.0003	-0.0008	-0.1702	0.9804	-0.0014	-0.0005	0.0025	0.806**
FLA	-0.0151	0.0199	0.0015	0.0014	0.0045	0.0006	0.0043	-0.0036	-0.0003	0.0001	0.0998	-0.1252	0.0110	-0.0075	-0.0053	-0.014
SCMR	0.0057	-0.0043	0.0002	-0.0012	-0.0014	0.0000	-0.0020	0.0005	0.0000	-0.0001	-0.0994	-0.0181	-0.0029	0.0290	-0.0006	-0.095
CTD	0.0024	-0.0069	0.0001	-0.0015	-0.0066	0.0003	-0.0002	0.0054	0.0002	-0.0005	-0.0282	0.0703	-0.0017	-0.0005	0.0346	0.067

*, ** Significant at 5 per cent and 1per cent levels, respectively

Residual effect: R= 0.0810

Where, DH = Days to 50 per cent heading, DA = Days to anthesis, DM = Days to maturity, GFP = Grain filling period, NPTPP = Number of productive tillers per plant, Ph = Plant height, SL = Spike length, NSPMS = Number of spikelets per main spike, MGPMS = Number of grains per main spike, TGW = 1000 grain weight, BYPP = Biological yield per plant, HI = Harvest index, FLA + Flag leaf area, SCMR = SPAD-chlorophyll meter reading, and CTD = Canopy temperature depression

Table-5 : Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on grain yield per plant of bread wheat under late sown (E_4) condition during *Rabi*-2020-21.

Character	DH	DA	DM	GFP	NPTPP	PH	SL	NSPMS	NGPMS	TGW	BYPP	HI	FLA	SCMR	CTD	Phenotypic correlation with grain yield per plant
DH	0.0021	0.3368	-0.2351	-0.0735	0.0051	-0.0018	0.0006	0.0012	-0.0017	-0.0031	0.0792	0.1842	0.0001	0.0010	-0.0018	0.293*
DA	0.0019	0.3745	-0.2289	-0.1168	0.0058	-0.0010	0.0008	0.0014	-0.0024	-0.0029	0.0853	0.2218	0.0005	0.0022	-0.0020	0.340*
DM	0.0016	0.2719	-0.3153	0.0765	0.0017	-0.0002	0.0013	0.0007	-0.0016	-0.0042	0.0582	0.1507	-0.0006	0.0007	-0.0017	0.240
GFP	-0.0006	-0.1669	-0.0920	0.2619	-0.0059	0.0011	0.0005	-0.0010	0.0012	-0.0014	-0.0430	-0.1124	-0.0014	-0.0022	0.0005	-0.162
NTPTP	0.0007	0.1382	-0.0340	-0.0977	0.0158	-0.0007	0.0003	0.0009	-0.0017	0.0009	0.0823	0.6149	0.0005	0.0021	-0.0007	0.722**
PH	0.0004	0.0378	-0.0072	-0.0289	0.0012	-0.0096	0.0001	0.0001	-0.0055	0.0004	0.0766	-0.2072	-0.0012	-0.0024	-0.0016	-0.147
SL	0.0002	0.0542	-0.0710	0.0240	0.0008	-0.0001	0.0058	0.0026	-0.0064	-0.0003	0.0997	-0.0880	-0.0023	0.0025	0.0028	0.025
NPTPP	0.0004	0.0736	-0.0321	-0.0369	0.0020	-0.0001	0.0021	0.0072	-0.0068	0.0025	0.1083	-0.1089	-0.0016	0.0013	0.0003	0.011
NGPMS	0.0002	0.0416	-0.0240	-0.0146	0.0012	-0.0025	0.0017	0.0023	-0.0212	0.0018	0.2752	-0.3301	-0.0014	0.0024	-0.0005	-0.068
TGW	0.0005	0.0814	-0.0983	0.0270	-0.0011	0.0003	0.0001	-0.0013	0.0029	-0.0135	0.0512	0.0071	0.0007	0.0016	0.0010	0.060
BYPP	0.0004	0.0830	-0.0476	-0.0292	0.0034	-0.0019	0.0015	0.0020	-0.0151	-0.0018	0.3851	-0.2959	-0.0003	0.0045	0.0000	0.088
HI	0.0004	0.0826	-0.0473	-0.0293	0.0097	0.0020	-0.0005	-0.0008	0.0070	-0.0001	-0.1133	1.0053	0.0018	0.0017	0.0006	0.920**
FLA	0.0000	0.0121	0.0118	-0.0246	0.0005	0.0008	-0.0009	-0.0008	0.0020	-0.0007	-0.0077	0.1237	0.0148	-0.0005	-0.0005	0.130
SCMR	-0.0001	-0.0453	0.0117	0.0315	-0.0019	-0.0013	-0.0008	-0.0005	0.0028	0.0012	-0.0947	-0.0919	0.0004	-0.0182	-0.0013	-0.209
CTD	-0.0004	-0.0679	0.0496	0.0124	-0.0010	0.0014	0.0015	0.0002	0.0011	-0.0012	0.0005	0.0542	-0.0007	0.0021	0.0109	0.063

*, ** Significant at 5 per cent and 1per cent levels, respectively

Residual effect: R= 0.1063

Where, DH = Days to 50 per cent heading, DA = Days to anthesis, DM = Days to maturity, GFP = Grain filling period, NPTPP = Number of productive tillers per plant, Ph = Plant height, SL = Spike length, NSPMS = Number of spikelets per main spike, MGPMS = Number of grains per main spike, TGW = 1000 grain weight, BYPP = Biological yield per plant, HI = Harvest index, FLA + Flag leaf area, SCMR = SPAD-chlorophyll meter reading, and CTD = Canopy temperature depression direct effect (0.0303) on grain yield per plant. Number of productive tillers per plant exhibited negative indirect effects on grain yield per plant *via* days to anthesis (-0.5303), plant height (-0.0010), spike length (-0.0002), number of grains per main spike (-0.0001), biological yield per plant (-0.0055) and flag leaf area (-0.0013), while positive and indirect effects on grain yield per plant was exhibited by this trait through days to 50 per cent heading (0.0208), days to maturity (0.1509), grain filling period (0.3418), number of spikelets per main spike (0.0005), 1000 grain weight (0.0006), harvest index (0.6762), SPAD chlorophyll meter reading (0.0023) and canopy temperature depression ((0.0019).

The phenotypic correlation between days to anthesis and grain yield per plant was significant and positive (r_p = 0.329), but it had very high negative direct effect (-1.5010) on grain yield per plant. Days to anthesis exhibited negative indirect effects on grain yield per plant *via* plant height (-0.0012), spike length (-0.0009), number of grains per main spike (-0.0009), 1000 grain weight (-0.0010) and flag leaf area (-0.0011), while positive and indirect effects on grain yield per plant was exhibited by days to anthesis through days to 50 per cent heading (0.0652), days to maturity (0.9152), grain filling period (0.4948), number of productive tillers per plant (0.0107), number of spikelets per main spike (0.0012), biological yield per plant (0.0014), harvest index (0.3356), SPAD chlorophyll meter reading (0.0052) and canopy temperature depression (0.0056).

The phenotypic correlation between days to 50 per cent heading and grain yield per plant was significant and positive (r_p = 0.311), but it had very low positive direct effect (0.0691) on grain yield per plant. Days to 50 per cent heading exhibited negative indirect effects on grain yield per plant *via* days to anthesis (-1.4159), plant height (-0.0015), spike length (-0.0008), number of grains per main spike (-0.0004), 1000 grain weight (-0.0009) and flag leaf area (-0.0018), while positive and indirect effects on grain yield per plant was exhibited by this trait through days to maturity (0.9224), grain filling period (0.4095), number of productive tillers per plant (0.0091), number of spikelets per main spike (0.0011), biological yield per plant (0.0161), harvest index (0.2993), SPAD chlorophyll meter reading (0.0033) and canopy temperature depression (0.0050).

Normal sown condition of (E_3) of *rabi* 2020-21 : Under normal sowing (E_3) of second year of evaluation (*rabi* 2020-21), harvest index (0.9804) showed high direct effect towards grain yield per plant, which was followed by biological yield per plant (0.6183) in phenotypic path analysis (Table 4). Characters *viz*., days to anthesis, days to maturity, number of productive tillers per plant, plant height, spike length, flag leaf area, SPAD chlorophyll meter reading and canopy temperature depression had direct positive effect towards grain yield per plant. The remaining characters had direct negative effect on grain yield per plant. Lower residual effect (0.0810) for phenotypic path analysis was observed in this environment.

The phenotypic correlation between harvest index and grain yield per plant was highly significant and positive (r_p = 0.806) with the highest direct effect (0.9804) on grain yield per plant. Harvest index exhibited negative indirect effects on grain yield per plant *via* days to 50 per cent heading (-0.0037), grain filling period (-0.0006), number of productive tillers per plant (-0.0013), plant height (-0.0002), spike length (-0.0061), 1000 grain weight (-0.0008), biological yield per plant (-0.1702), flag leaf area (-0.0014) and SPAD chlorophyll meter reading (-0.0005), while positive and indirect effects on grain yield per plant was exhibited by harvest index through days to anthesis (0.0020), days to maturity (0.0006), number of spikelets per main spike (0.0044), number of grains per main spike (0.0003) and canopy temperature depression (0.0025).

The phenotypic correlation between biological yield per plant and grain yield per plant was significant and positive (r_p = 0.341) with the high direct effect (0.6183) on grain yield per plant. Biological yield per plant exhibited negative indirect effects on grain yield per plant *via* days to 50 per cent heading (-0.0025), number of productive tillers per plant (-0.0016), plant height (-0.0002), number of spikelets per main spike (-0.0061), number of grains per main spike (-0.0004), harvest index (-0.2698), SPAD chlorophyll meter reading (-0.0047) and canopy temperature depression (-0.0016), while positive and indirect effects on grain yield per plant was exhibited by biological yield per plant through days to anthesis (0.0039), days to maturity (0.0003), grain filling period (0.0003), spike length (0.0024), 1000 grain weight (0.0004) and flag leaf area (0.0018).

Late sown condition of (E_4) of *rabi* 2020-21 : Under late sowing (E_4) of second year of evaluation (*rabi* 2020-21), harvest index (1.0053) showed very high direct effects towards grain yield per plant, which was followed by biological yield per plant (0.3851), days to anthesis (0.3745) and grain filling period (0.2619) in phenotypic path analysis (Table 5). Days to 50 per cent heading, number of productive tillers per plant, spike length, number of spikelets per main spike, flag leaf area and canopy temperature depression had very low direct positive effect towards grain yield per plant. The remaining characters had direct negative effects on grain yield per plant. Lower residual effect (0.1063) for phenotypic path analysis was observed in this environment.

The phenotypic correlation between harvest index and grain yield per plant was highly significant and positive (r_p = 0.920) with very high direct effect (1.0053) on grain yield per plant. Harvest index exhibited negative indirect effects on grain yield per plant *via*), days to maturity (-0.0473), grain filling period (-0.0293), spike length (-0.0005), number of spikelets per main spike (-0.0008), 1000 grain weight (-0.0001) and biological yield per plant (-0.1133), while positive and indirect effects on grain yield per plant was exhibited by harvest index through days to 50 per cent heading (0.0004), days to anthesis (0.0826), number of productive tillers per plant (0.0097), plant height (0.0020), number of grains per main spike (0.0070), flag leaf area (0.0018), SPAD chlorophyll meter reading (0.0017) and canopy temperature depression (0.0006).

The phenotypic correlation between number of productive tillers per plant and grain yield per plant was highly significant and positive (r_p = 0.722) with very low direct effect (0.0158) on grain yield per plant. Number of productive tillers per plant exhibited negative indirect effects on grain yield per plant *via* days to maturity (-0.0340), grain filling period (-0.0977), plant height (-0.0007), number of grains per main spike (-0.0017) and canopy temperature depression (-0.0007), while positive and indirect effects on grain yield per plant was exhibited by this trait through days to 50 per cent heading (0.0007), days to anthesis (0.1382), spike length (0.0003), number of spikelets per main spike (0.0009), 1000 grain weight (0.0009), biological yield per plant (0.0823), harvest index (0.6149), flag leaf area (0.0005) and SPAD chlorophyll meter reading (0.0021).

The phenotypic correlation between days to anthesis and grain yield per plant was significant and positive (r_p = 0.340) with high positive direct effect (0.3745) on grain yield per plant. Days to anthesis exhibited negative indirect effects on grain yield per plant *via* days to maturity (-0.2289), grain filling period (-0.1168), plant height (-0.0010), number of grains per main spike (-0.0024), 1000 grain weight (-0.0029) and canopy temperature depression (0.0020), while positive and indirect effects on grain yield per plant was exhibited by days to anthesis through days to 50 per cent heading (0.0019), number of productive tillers per plant (0.0058), spike length (0.0008), number of spikelets per main spike (0.0014), biological yield per plant (0.0853), harvest index (0.2218), flag leaf area (0.0005) and SPAD chlorophyll meter reading (0.0022).

The phenotypic correlation between days to 50 per cent heading and grain yield per plant was significant and positive (r_p = 0.293) with very low positive direct effect (0.0021) on grain yield per plant. Days to 50 per cent heading exhibited negative indirect effects on grain yield per plant *via* days to maturity (-0.2351), grain filling period (-0.0735), plant height (-0.0018), number of grains per main spike (-0.0017), 1000 grain weight (-0.0031) and canopy temperature depression (-0.0018), while positive and indirect effects on grain yield per plant was exhibited by this trait through days to anthesis (0.3368), number of productive tillers per plant (0.0051), spike length (0.0006), number of spikelets per main spike (0.0012), biological yield per plant (0.0792), harvest index (0.1842), flag leaf area (0.0001) and SPAD chlorophyll meter reading (0.0010).

The results of path coefficient analysis revealed that, under normal sowing (E_1) of first year of evaluation (*rabi* 2019-20), harvest index showed high direct effect towards grain yield per plant, which was followed by biological yield per plant in phenotypic path analysis. Days to anthesis had low direct effect towards grain yield per plant, while other characters *viz.*, grain filling period, plant height, spike length, number of spikelets per main spike, flag leaf area and SPAD chlorophyll meter reading had direct positive effect towards grain yield per plant. The remaining characters had very low direct negative effect on grain yield per plant. Under normal sowing (E_3) of second year of evaluation (*rabi* 2020-21), harvest index showed high direct effect towards grain yield per plant, which was followed by biological yield per plant in phenotypic path analysis. Characters *viz.*, days to anthesis, days to maturity, number of productive tillers per plant, plant height, spike length, flag leaf area, SPAD chlorophyll meter reading and canopy temperature depression had direct positive effect towards grain yield per plant.

Under late sowing (E_2) of first year of evaluation (*rabi* 2019-20), days to maturity and harvest index showed very high direct effects towards grain yield per plant, which was followed by biological yield per plant in phenotypic path analysis. Days to 50 per cent heading, number of productive tillers per plant and number of spikelets per main spike had very low direct positive effect towards grain yield per plant. Under late sowing (E_4) of second year of evaluation (*rabi* 2020-21), harvest index showed very high direct effects towards grain yield per plant, which was followed by biological yield per plant, days to anthesis and grain filling period in phenotypic path analysis. Days to 50 per cent heading, number of productive tillers per plant, spike length, number of spikelets per main spike, flag leaf area and canopy temperature depression had very low direct positive effect towards grain yield per plant.

Devesh *et al.* (2021) reported high and positive direct effect of harvest index on grain yield per plant. High and positive direct effect on grain yield per plant *via* biological yield per plant have been reported by Devesh *et al.* (2021); *via* days to maturity by Singh *et al.* (2015) and Chimdesa *et al.* (2017); and *via* grain filling period by Degewione *et al.* (2013).

The residual effect of the present study was 0.0926, 0.0762, 0.0810 and 0.1063 in E_1 (normal sown condition of first year), E_2 (late sown condition of first year), E_3 (normal sown condition of second year) and E_4 (late sown condition of second year), indicating that the characters studied contributed more than 90 to 93 per cent of the yield. It is suggested that maximum emphasis should be given to all the characters studied in selecting wheat with higher yield.

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Wild Honey Collection from Tribal Forest Areas under Bastar Division of Chhattisgarh : Opportunities and Constraints

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Abstract

This study intended to assess the contributions of beekeeping with respect to challenges and op-portunities in Tribal Forest Areas under bastar division of Chhattisgarh. For this, through purposive sampling technique a sample size of 80 bee keepers was selected from the four district of the Chhattisgarh (i.e; Bastar, Sukma, Dantewada and Bijapur). The data were collected from the sampled bee keepers using a pretested questionnaire by face to face interview in 2022 production period. The collected data were analyzed using frequencies, percentages, descriptive statistics, rank orders and paired t-test. Findings revealed that bee keeping is one of the important economic activities in the area with an average annual income of Rs. 527,275/- per household. Results of paired t-test confirmed that beekeeping has significant effect on household income. On average of 2 family members per household were engaged in the beekeeping activity. It also provided multiple sources of employment mainly in honey transportation and marketing, thus beekeeping not only served as an income generating activity but also an employment generating activity in present and in future. The major constraints in beekeeping were the expensive inputs, pest attack, lack of modern production and rearing techniques, and trainings which can be overcome by a comprehensive program focusing on the provision of low cost inputs, pesticides/insecticides, modern techniques and trainings, and value chain market facilities at the local and regional level.

Introduction

Apiculture is one of the important sub-sectors of agriculture which can help in reviving the economies of developing countries. Beekeeping is practiced for its multiple benefits which include honey, beeswax, industrial use, producing honeybee hives for sale, and for foreign exchange earnings thus making it a commercial agricultural enterprise currently around the globe (Okpokiri *et al.,* 2015). China ranked first in honey production and export followed by Argenti the importance of this enterprise as a money spinner.

Beekeeping is providing additional benefits which are linked with the natural role of bees in pollina- tion of plants and preservation of natural vegetation. Bee farming is relatively cheap to manage, as the man only do harvest while, the production is under- taken by the bees themselves. Moreover, it does not require high amounts of inputs like large expanse of land, feed, fertilizer, and water etc. to run and develop this enterprise. Thus, due to its relatively low labor na and New Zealand (Ayansola, 2012) which showsand other inputs requirements, it can be easily carried out with regular agricultural activities like crops growing, horticulture, and livestock production etc. (USAID, 2012; Okpokiri *et al.,* 2015). Beekeeping is a sustainable form of agriculture as its yield can be increased like other agricultural products by proper management. Beekeeping is practiced due to its eco- nomic and nutritional benefits in the form of honey marketing and consumption/intakes at household level (Babatunde *et al.,* 2007). Honey also offers medicinal benefits such as it is used for wounds, burns, cataracts, skin ulcer and scabies treatment or cure in rural households (Okpokiri *et al.,* 2015).

Beekeeping plays a vital role at household level in ru ral areas in reducing vulnerability, poverty, and to cope with stresses of crop failure etc. (Bradbear, 2009). It also has a considerable role in enhancing food security and food production through pollination of crops (MoARD, 2010). Beekeeping, in addition to its economic importance, has also social values in many developing countries. The number of honeybee colonies and hives owned serves as a major wealth ranking in some societies (Nuru, 2007). Beekeeping is important in the context of establishing and developing an empowered and self-reliant rural community due to its self-employment opportunities. The economic empowerment of rural communities can be achieved by establishing and developing this enterprise with minimal inputs (for example quality land requirement is not necessary as hives can be located on trees and ground both). Beekeeping is a decentralized forest and agriculture-based enterprise which does not dislocate communities and individuals from their inhibiting place. Beekeeping in various forms is practiced in most of the rural communities from many centuries. With the introduction of beekeeping as an enterprise and building the existing skills and capacities of small scale farmers can provide multiple benefits to them. This not only improve local knowledge and capacities in beekeeping, but also the development of this enterprise can benefit more people of the underdeveloped communities (FAO, 2012). In Chhattisgarh, bee keeping has significant contribution to household income and rural livelihoods (PARC, 2010-2011).

The people of the area had limited opportunities regarding income generation and livelihoods which mostly include agriculture, livestock rearing and small scale businesses conducted locally (FAO, 2015). Beekeeping is one of the small-scale businesses conducted actively in the Bajaur Agency of the area. In the Agency, where access to income is limited, small scale beekeeping can contribute significantly to the livelihoods of the people not only in the shape of employment generation and income provision but it can also improve the health of practitioners and the general population. The agency is expected to be potential for beekeeping activities so far there is no researchable information on beekeeping with respect to opportunities and constraints over there. Therefore; such study is important not only to highlight the con tribution of honey bee keeping to local community at various aspects of income generation and employment provision, but also in the aspect of identifying problems and opportunities with this enterprise. Therefore, to fill in this research gap this study was designed to study the effect of beekeeping in house- hold income and employment generation mainly.

Materials and Methods

The study is conducted in bastar division of Chhattisgarh state. Bee- keeping served as a source of livelihood to the house- holds who are engaged in this enterprise. Beekeeping not only provides employment to these families, but also served as a source of income generation, having a medicinal value and food for them. Due to financial and time constraints, all the beekeepers in the agency cannot be surveyed. So, those areas of the agency were selected where more number of beekeepers was found. This information was provided by the tribal beekeepers. In the light of this information, four districts namely Bastar, Sukma, Dantewada and Bijapur were purposively selected on the basis of more number of beekeepers over there. A total of only 80 beekeepers (target population) were found in the study area according to a list provided by the office of Non-Timber Forest Products (NTFP), Forest Department of Chhattisgarh government. So, all these beekeepers were not only the target population but also served as the sample size of this study. District wise, 27 beekeepers were found in Bastar, 27 in Sukma, 25 in Dantewada and 26 in Bijapur. Data were collected through a pre-tested questionnaire from these beekeepers in 2022 by face-to-face interview. Formal permissions were sought before initiating interview explaining the purpose and objectives of the study and usage of data for the research purpose. The collected data were then analyzed using descriptive statistics, frequencies, percentages, rank orders and paired t-test. To assess the effect of beekeeping in household income the paired t-test was employed. The study focused on bee- keeping opportunities and constraints by sampling beekeeper farmers from the four district of Bastar division due to limitations associated with time, re- source constraints and infrastructure. In this regard, the results cannot be representative of the whole trib al area or the entire country due to the small sample size. Most of the data collected were based on the re- call ability of the respondents who may not have giv en very accurate information due to memory lapses considering most of them had only basic education. However, the research recommendations may as well be applicable in other areas having similar ecological and socio-economic characteristics.

Results and Discussion

Demographics of beekeepers : The demographic data were collected from the study sample earlier to formatting the main quarry of bee- keeping contributions to income and employment provision. Some household level demographic details as information regarding the age, literacy and land ownership were acquired in order to improve our understanding of the beekeeping enterprise in the study area. The summary statistics are being presented in Table 1. The data show that 33%, 24%, 28% and 15 % respondents lie in the age group of 20 to 30 years, 31 to 40 years, 41 to 50 years, and in above 50 years, respectively. The results revealed that most of the honey bee keepers' age ranged from 20 to 40 years. This tallied with the findings of Baba et al. (2014) and Famuyide *et al*. (2014) who reported that in Nigeria most of beekeepers lie in the age range of 31 to 40 years. It further implies that majority of beekeepers are in their very active age which adds a good ad- vantage to the production level of honey in the study area. Data in Table 1 show that out of the total sampled beekeepers, 37.5 percent were illiterate and 62.5 percent were literate. It shows that majority of the beekeepers in the study area were literate. The result is in conformity with Onyekuru (2010) who found that majority of beekeepers in Enugu are literate. Of the total literate beekeepers, 18 percent, 14 percent, 30 percent and 38 percent were having primary, middle, secondary and graduate level of education, respectively. From the data, it is clear that majority beekeepers were graduated followed by secondary level of edu cation. Land size plays an important role in the enhancement of honey production as

Table-1 : Age, education and land ownership profiles of beekeepers in the study area.

Variables	Frequency	Percentage
Age (in years)		
20-30	26	33
31-40	19	24
41-50	22	28
Above 50	13	15
Total	80	100
Literacy status		
Illiterate	30	37.5
Literate	50	62.5
Primary	09	18
Middle	07	14
Secondary	15	30
Graduate	19	38
Total	80	100
Land ownership (in acres)		
Landless	32	40
Having land	48	60
Below 10	22	46
10-20	12	25
21-30	08	17
Above 30	06	12
Total	80	100

Table-2 : Family labour involved in beekeeping of the sampled beekeepers in the study area.

District	Frequency	Average
Bastar	49	1.81
Sukma	50	1.85
Dantewada	54	2.08
Bijapur	52	1.90
Overall area	205	1.87

Table-3 : Average annual income of the sampled beekeepers from honey production in the study area.

District	Total income (in Rs.)	Average income (in Rs.)
Bastar	8492800	314548
Sukma	13529997	401111
Dantewada	11595375	363815
Bijapur	5245000	451231
Overall Area	12549576	382676

it determines the purchasing power and also access to credit from for- mal sources because land is commonly used as collat eral in obtaining loan from the bank. Moreover, land- holding is directly related to increased income from the Non-Timber Forest Products including honey (Maleku, 2014). Data in Table-1 show that 40 percent respondents were landless while, 60 percent possessed land. It shows that majority of the honey beekeepers possessed land in the study area and the landless were also involved in honey beekeeping. Out of the total sampled beekeepers who possessed land, 46 percent had up to 10 acres, 25 percent had 11-20 acre, 17 per- cent had 21-30 acre and 12 percent had above 30-acre land. The below 10 acres' number of the respondents is 28%, 11-20 acres 14%, 21-30 acres 10%, above 30 acres is 8%. The results show that majority of bee- keepers are landless in the study area.

Family labor involvement in beekeeping : Beekeeping plays key role in employment generation which ultimately counted for poverty reduction. Table 2 indicates the data regarding man power involved in beekeeping in the study area. The involved manpower in beekeeping was mainly family labor. Data show that a total of 159 household/family members were involved in beekeeping activities in the study area. On the average 1.91 household/family members per household were involved in beekeeping. In case of districts, an average of 1.81 family members per household, 1.85 family members per household, and 2.08 family members per household were involved in beekeeping in Bastar, Sukma, Dantewada and Bijapur, respectively. The results show that in tehsil Nawagai slightly more family members were involved in beekeeping as compared to other tehsils. It can be assumed that in tehsil Nawagai more people are dependent on honey bee production as a source of employment and liveli- hood. Famuyide *et al.* (2014) also reported that in Ni geria mainly family labours was involved in honeybee keeping. The labor is mainly required at the times of processing and harvesting.

Annual income from beekeeping : Beekeeping served as an income generating actvity in rural areas of Chhattisgarh. Table-3 shows the data regarding average annual income of the sampled beekeepers from honey production in the study area. The average price of 1Kg honey was Rs. 800 in the study area. The results show that an average of Rs. 382676/- per an- num was derived from the sale of honey in the study area. It shows that honey production is an income generating activity and considerable part of house- hold income was derived from honey production. The fact is supported by Melaku *et al.* (2014), who report- ed that major sources of cash income for households, in absolute terms, were Non-Timber Forest Products, such as forest coffee, honey and spices. According to FAO (2011) beekeeping provide a more constant and regular income for the farm family. The highest annual income Rs. 451231 was obtained in Bijapur district from honey. In Bastar the average annual income from honey was Rs. 314, 548/- in Sukma was Rs. 401 111/- and in Dantewada it was Rs. 363,815/-. The results indicate that in district Bijapur the average annual income from honey was high followed by Sukma. While, in Bastar less average annual income was reported from

Table-4 : Paired t-test results of comparing annual income of beekeepers before and after beekeeping.

Annual income (Rs.) before beekeeping	Annual income (Rs.) after beekeeping	Difference	% Change	df	t-value	p-value
180300	382676	20237	292	79	5.615	.000

Table-5 : Beekeeping as a source of employment in the study area.

Employment Sources	Frequency
Beekeeping	80
Carpentry	11
Bees medicine/Tools shop	01
Local honey sale/Purchase shop	09
National honey sale/Purchase shop	03
Family labour involved in beekeeping	153
Transportation vehicles	126
Plastic bottle and cane shop	04
Retail honey seller	10
Engagement in beehives sale /Purchase	06
Total	400

Table-6 : Major constraints faced by sampled beekeepers in the study area.

Constraints	Frequency	Percentage	Rank Orders
Pest attack	28	23	2nd
Expensive inputs	43	36	1st
Lack of modern techniques and trainings	16	13	3rd
Marketing problems	11	09	4th
Poor Assistance from the Non-Timber Forest Office	04	03	7th
Scarcity of bee colonies	05	04	6th
Scarcity of flowering plants	08	08	5th
Lack of credit facilities	05	04	6th
Total	120	100	—

honey sale. This is due to the fact that honey yield was high in Bijapur followed by Sukma while, in Bastar the honey yield was low. So, the income is in direct relation with the production/yield.

Comparison of household income before and after beekeeping : The results of effect of beekeeping on household in- come are summarized in Table-4. The average annual income of households before and after beekeeping was Rs. 180,300/- and Rs. 382676/-, respectively as can be seen in Table-4. The result of paired t-test shows that significant differences exited between the income of households before and after beekeeping due to high t-ratio (5.615) and P-value (<0.05) with 292% change. The results are in conformity with Ki- fle *et al.,* (2014) who reported that income obtained from honey sales was significantly different among the sampled households before and after beekeeping in Ethiopia. The results further imply that the bee- keeping has a positive and significant effect on house- hold income in the study area. Thus, beekeeping is a significant income generating activity.

Employment generation from the beekeeping : Beekeeping is not only an income generating activity (from the sale of honey) in the study but it also gen erates employment opportunities to others. Table 5 represents the data regarding employment generation from beekeeping in the study area. Data show that beekeeping itself served as a source of employment and income generation for all the sampled beekeepers of the study area. The employment sources generated by beekeeping in the study area included carpentry, bees medicine shops/tools shops, local honey sale and purchase shop, national honey sale and purchase shops, labor involved in beekeeping, transportation vehicles, plastic bottle and cane shops, retail honey sellers and engagement in beehives sale and purchase. The results show that 11 respondents were involved in carpentry, 1 in bees' medicine/tool shop, 9 in local honey sale and purchase shop, and 3 in national hon ey sale and purchase shop. A total of 154 labors were involved in beekeeping which was mostly family labor and 126 family members of the sampled beekeepers had vehicles for transportation related to beekeeping. Similarly, 4 beekeepers had plastic bottle and cane shops, 10 were retail honey sellers, and 6 beekeepers were engaged in bee hives sale and purchase. The results show that beekeeping provided multiple sources of employment to 400 people in the study area. The major sources are comprised of labor, transportation and honey marketing. This implies that beekeeping is beneficial and had vital contribution to the livelihoods of the beekeepers. The fact is endorsed by Mwakato- be *et al.* (2016) that beekeeping is providing multiple employment opportunities to the youth and women of Tanzania.

Constraints in beekeeping : Table-6 shows the majors problems and constraints faced by the sampled beekeepers in the study area. The pest attack was claimed by 23 percent beekeepers, expensive inputs were reported by 36 percent, lack of modern techniques and trainings were recorded by 13 percent, marketing problems were reported by 9 percent, poor assistance from the NTFP office was recorded by 3 percent, while scarcity of bee colonies were reported by 4 percent beekeepers. A total of 8 percent respondents reported the problem of scarci ty of flowering plants and only 4 percent complained for lack of credit facilities in the study area. The major reported constraints were expensive inputs, pest attack, lack of modern techniques and trainings and marketing problems during honey production. These findings are similar with Okpokiri et al. (2015). Due to these constraints, the maximum potential of bee- keeping enterprise cannot be explored.

Conclusions

The study concludes that beekeeping was found as an income generating and employment creating agricultural activity and with futuristic approach, it is providing multiple opportunities to the residents of the study area. Mostly family labor was involved in beekeeping. From the results of paired t-test, it is also concluded that honey bee keeping is a significant income generating with more than 5 lacs average annual income thus it can further improve the socioeconomic conditions of the people of study area in short and long run. The results also show that beekeeping provided multiple sources of employment (to 400 people) which included labour, transportation and honey marketing, thus beekeeping had vital contribution to employment generation in the study area. The major constraints during bee keeping were expensive inputs, pest attack, lack of modern techniques and trainings and marketing problems. Keeping in view the findings, the study suggests for a comprehensive program focusing on the provision of low cost inputs, pesticides/insecticides, modern techniques and trainings and market facilities to strengthen the cottage industry of honey bee keeping in the study area.

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Utilization of Information and Communication Technology in Integrated Pest Management

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Abstract

Internet has become the great potential to impact research, extension and teaching in Entomology. Scientists can communicate with their counterparts in other universities and research institutions. They can access a large database of information available on the net. Research literature is migrating very fast from paper to the web most of which can be accessed free of cost. It permits easy and efficient access of information thus saving a researcher's valuable time. Extension entomologists can access the latest information on pest control which can be disseminated to the farmers. Farmers can communicate directly with the expert for solution of their specific problem. Internet based communication is becoming more popular than making phone calls both among farmers and extension workers as it permits broader choice for the farmers and allows sufficient time for the expert to answer a query. Teachers can put their lecture notes on the institution's website to be accessed by students. Students can take practice tests on the institution's website, review and improve their performance.

Key words *: Decision support system, entomology, information technology, internet, world wide web.*

Introduction

Information and Communication Technology (ICT) commenced with the launch of World Wide Web in 1991. India had its first National e-governance plan in 2006 and the launch of 'Digital India' project in 2014. Digital India version 2.0 of 2021 aims to transform India into a digitally empowered society by facilitating wider dissemination of knowledge and technological products and processes for inclusive development of our nation in all spheres, and agriculture is not an exception. Transformation in agriculture is a continuous process and evolves with the needs of mankind and technological innovations of human minds on the sidelines of the vagaries of monsoon and climate change. While major components of crop production viz., high yielding cultivars, fertigation and irrigation directly maximize crop yields, crop protection targets to minimise yield losses due to biotic stress factors be it weeds, insects, pathogens, mites, nematodes, rodents, birds and vertebrates under pre- and post-harvest situations. Maximum yield loss to crops is estimated at 33% by weeds followed by insects (26%), diseases (20%), rodents (6%) and others (6-8%) with yield losses higher for fruits and vegetables (4.6-15.9%), followed by pulses (6.4-8.4%), cereals (4.7-6.0%) and oilseeds (3.1-10%) under Indian conditions. Paradigm shifts of pest management have gone through phases of Subsistence, Exploitation, Crisis, Disaster and Integration over decades.

Integrated pest management (IPM) has been a national policy since 1985 and encompasses array of tactics viz., genetic, cultural, mechanical, physical, legal, behavioral, biological and chemicals to be combined suitably to manage pests below the level of economic damage keeping in mind the socio economic and environmental safeguards of producers and consumers. Thus, IPM for a given crop or for a cropping and production system is knowledge intensive and variable. Under such circumstances, scope of information and communication technology (ICT) in plant protection in general and IPM in particular are multifold. India sustains IPM development and validation with crop-based institutes of Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs) providing technical back up besides the Central Integrated Pest Management Centers established across all States anchoring its implementation. Since agriculture is a State subject the respective State Department of Agriculture is also actively involved in propagating IPM along with the provisions for supply of critical pest management inputs. Considering IPM is holistic and knowledge intensive, use of ICT is a must for an overall as well as precise crop health management fitting into the social milieu of farmers and consumers alike. The current write up describes the application of ICT in various areas of IPM with focus based on the work done with the involvement of ICAR-NCIPM, in general and under National Innovations in climate Resilient Agriculture, in particular.

Areas of Applications of ICT in IPM

Pest Diagnostics : Traditionally, crop inspection and plant disorders were identified by farmers or experts. However, it is not feasible continuously for the large fields. Nowadays artificial intelligence (AI) has begun to modify the plant protection environment around us. Computer vision empowered with machine learning promise to monitor crops for occurrence and diagnosis of disease at large scale. The four phases namely image acquisition, image pre-processing, features extraction, and classification are used in computer vision-based models. PLANTIX is a platform on mobile aids crop insect-disease diagnostics including India. DNA barcoding for easy and quick identification and high-throughput molecular methods such as polymerase chain reaction (PCR), species specific primers, construction of phylogenetic tree to identify biotypes and possible origin are widely used in plant pest diagnosis. Common technologies associated with plant disease detection include fluorescence imaging, hyper spectral technique, GC-MS, enzymatic and antibody-based biosensors. Diagnosis of bacterial, fungal, and viral infections and insect damage attack in vegetables and fruits using volatile organic compounds emitted from plants is possible by electronic nose (e-nose) systems. Preparation of rapid precise diagnostic detection kits including artificial intelligence, environmental DNA (eDNA) technology coupled with isothermal nucleic acid amplification tests (iNAATs) including loop-mediated isothermal amplification (LAMP) are gaining importance. Sensor based gadgets for pest monitoring and management are feasible only through ICT. Automated trapping of insects and the data transfer to servers exist.

Real Time Pest Surveillance and Advisories for Field Level Pest Management : Pest surveillance is central to IPM and has components of survey and monitoring. Surveillance implies only observation and reporting of findings without intervention. Monitoring generally means to be aware of the state of a system and also refers to observation of change after there has been an intervention of some sort. Monitoring is the often used interchangeably with Surveillance. Pest surveillance is an official process of collecting and recording data on pest occurrence or absence by survey, abundance through monitoring or other procedures. Surveillance has components of survey and monitoring for use in: pest risk analyses, establishment of pest free areas, and the preparation of pest list.

Surveillance is the need for

Early detection of new pests esp. exotic pests for an emergency action resulting in measures of eradication or containment

For declarations of pest free areas involving detection, delimitation and monitoring of pest occurrence to select/establish pest free areas,

To compile host and commodity pest lists and distribution records for categorization of pests and

Making pest risk analysis and undertaking phytosanitary measures.

Guidelines for pest surveys/surveillance and monitoring are a must using the direct and indirect tools/devices supported by services of rapid identity of pests, developing database and retrieval systems, and processing of information for needful trade, biosecurity and pest management and all need use of ICT.

The requisites for an ICT based pest surveillance include :

1. An organized sampling plan for selection of fields,

2. Scientifically based sampling methodology for pests including the monitoring tools (GPS device, traps and lures for insects, data sheets (books),

3. IT infrastructure (server, computers, customized software for data entry cum upload and reporting, and modems for internet connectivity),

4. Fixed schedule for pest surveillance, issue and dissemination of pest management advisories (based on ETLs) and

5. Man power for pest observations, data entry and issue of advisories.

Awareness creation among farmers and skill development for pest scouts/monitors and data entry operators provide strong foundation for e-pest surveillance (Vennila, 2016). There need to be continuous co-ordination among all the stakeholders right from programme formulation to field level implementation in terms of knowing the pest's status, recommendation of pest management advisories and their dissemination to farmers during each copping season. The repository of digital data base on pest scenario and their management on long term would empower the future generations with the insights of the past to plan for future. The ICAR based National Research Centre for IPM has been facilitating ICT as a vehicle for launching area wide IPM through e-pest surveillance vide its website: https://ncipm.icar.gov.in/.

The ongoing programs viz.,

1. Crop pest surveillance and advisory project (CROPSAP) (Maharashtra) across crops of Soybean, Cotton, Rice Pigeonpea, Chickpea, Maize, Sorghum and Sugarcane (https://cropsap.maharashtra.gov.in/);

2. Horticulture pest surveillance and advisory project (HortSAP) (Maharashtra) (https://ncipm.icar.gov.in/Horticulture/Default.aspx) for the crops of Mango, Pomegranate, Banana, Nagpur mandarin, Sweet orange, Sapota, Tomato, Okra and Cashewnut stand as successful examples for large scale

area wide implementation of IPM across Maharashtra. While CROPSAP engages mobileapps for collection of data from fields, HortSAP uses collection of data using data sheets, their entry into an offline software and online upload for pest status reporting. E-pest surveillance in horticultural crops in Haryana is another ICT based project implemented covering fruit and vegetable crops. CROPSAP & HORTSAP in Maharashtra, and E-pest surveillance in horticultural crops in Haryana together cover 24 crops from categories of cereals (three), pulses (two), commercial crops (two), oilseed (one), fruits (five), plantations (two) and vegetables (nine) and are implemented at the ground level. The flow chart shown depicts the ICT (internet) based surveillance system under implementation.

Framework of ICT based surveillance and advisory : Different software components of have to be developed to acquire pest data from fields and to analyze the data for reporting of pest status in turn for issuing advisory for pest management using internet. In CROPSAP, a three tier architecture based system consisting of database for information storage; an offline application for pest data capture and data upload into database; an online application for pest reporting and advisory was developed. The different reports such as present and past pest situations can be viewed by experts. Data capture can be using data sheets and then entered into web based software, or substituting data collection with customized mobile apps developed for direct recording of field data and upload to server where reporting application exists. The state agri. universities issue advisory for different locations to the concerned state agencies for further spread it to the farmers Software development: The database was designed and developed for storage of interrelated pest information using SQL Sever 2000. The database consists of data fields to store data on various parameters. Various tables and views were created for different domain-specific information. Relationships were established among these tables for data normalization. Various stored procedures were generated in the database to execute different tasks.

Data entry & uploading module : Login details are created for data entry operators and pest monitors. The application is a standalone application for entry of details of fields, crop pests and other information. Data is uploaded after verification and subsequently transferred to centralized database through XML. Mobile apps directly transfers data to the server while in online.

Pest reporting & advisory module : The main purpose of pest reporting is to communicate immediate or potential danger. Immediate or potential danger normally arises from the occurrence, outbreak or spread of a pest. The provision of reliable and prompt pest reports confirms the operation of effective surveillance. Pest reporting allows necessary pest management requirements and actions to be taken. Pest reports contain information on the identity of the pest, location, pest status, and nature of the immediate or potential danger (near economic threshold level (ETL) or above ETL). Online application was developed using ASP.net technology as user interface which provides plant protection experts the reports for issuing advisories to different stake holders. System generates pest reports in different formats such as tabular, graphical or GIS maps. Both current as well as temporal pest reports are produced. The system has provision for producing pest reports for village(s)/taluka(s)/district(s) having pest(s) population above or equal to the pest ETL during selected dates that require/s attention of pest management experts. On the basis of pest situation of a particular location, pest experts feed the advisory (at taluk level) for state agencies to further spread it to the farmers for implement appropriate and timely decisions for pest management, if required.

Electronic Solutions against Agricultural Pests (e-SAP) is an IT solution for crop health management designed and developed by University of Agricultural Sciences, Raichur (Prabhuraj, 2021). Over 2000 officers of both agriculture and horticulture are conducting pest surveillance cum advisory through e-SAP. At present e-SAP is supporting field user with 53 agricultural and horticultural crops capable of resolving over 1000 problems. The highlight of all programs is the digital delivery of the pest management advisories to the farmers as short message service (SMS). Third party evaluations of CROPSAP had worked out the cost (including cost of infrastructure and manpower) of Rs 10 per ha on a scale of 100 lakh ha since 2015 as against from Rs 16 per ha in 2010. Avoidance crop losses to a tune of Rs 1000 Cr/annum by spending a meager Rs 10 Cr. No outbreak of any of the major pests since 2009 but for pink bollworm in 2017, however reduced by 60% in 2018 over 2017. Thus, ICT based pest surveillance and issuing digital advisories for area wide popularization and implementation of IPM is a happening activity across states of Karnataka (e-SAP), Maharashtra (Vennila *et al.*, 2016) and Haryana in India. Since Agriculture is a state subject there needs to be initiatives and importance given for real time pest surveillance-based management advisories wherein hand holding can be in collaboration central agencies.

Research Database Development and Analysis : All basic /strategic/ applied research involves the process of collecting and recording data on pest occurrence, their documentation, measurement of abundance using sampling plans and observation procedures and data analysis are all data driven and without ICT our know-hows would be limited. Since pest risks associated with climate change requires comprehensive and long-term data of crop pest-weather over space and time, ICT serves as a translational tool to assimilate data base effectively and efficiently. National Innovations in Climate Resilient Agriculture (NICRA) provided a research platform for studying changes in pest scenarios in response to climatic change across crops of rice, pigeonpea, groundnut and tomato wherein ICT was used as a tool for data base development on pests and weather through electronic networking of identified locations from different agro climatic zones of the country for the crops of rice, pigeonpea, groundnut and tomato.

Information System for e Pest Surveillance : All technical information essential for field pest surveillance (data sheets, guidelines and manuals) and the client software (set up and user manuals) constitute information system and are for ready reference all the time by anyone. Crop wise comprehensive standalone information system on 'Diagnosis and Sampling for Pest Surveillance (DSPS)' for rice, pigeonpea, groundnut and tomato have been developed as a window based application using asp.net with C# with descriptions and images of plant parts, insects, diseases and beneficial insects sampled vis a vis sampling procedures following the flow chart given below including the features of data sheets along with user manual incorporated. The application in respect of target crops is standalone (supplied through DVDs) and are also web hosted.

Data Accrual, Reporting and Analysis : An information and communication technology (ICT) (electronic-e) supported web-based pest surveillance system (e- pest surveillance) consisting centralized database, offline client data capture, admin panel, and data reporting and analysis was designed. Developed web application is working in two modules (1) Client and (2) Reporting applications integrated with each other to have user-friendly interface. Login page is created to provide authenticated user-based sessions for web application access. The credentials are system generated based on crop and study location. A separate console is developed for administrator to authenticate web application accessibility. Client software installations and problem solving are done through remote access using open source remote access software.

Software architecture : The architecture of client (for data accrual and upload) and reporting appilcations is presented hereunder.

Client application : Is XML based and installed in computer system of project co-opted centers to accrue information viz. field, crop, insect pest and disease details, weather observations, crop yields etc. All the relevant data of pest surveillance are collected by pest scouts and save/upload in client application by data entry operator. The application works in offline mode with uploads to the server database in online mode. Setup files for client software installation by RTPD centers are generated using admin panel configuring software applicable for the target surveillance center. NICRA client software user manuals were made available in addition to facilitating needful open source software such (window upgradations and team viewer for remote access between NCIPM and RTPDs for installation).

Reporting application : The reporting system has been developed to make available the details and data accrued through the pest surveillance from the fields and received at the server through uploads from the client-side application. Reporting application consisting admin panel is functional and available on website: https://ncipm.icar.gov.in . Reporting systems for 2011 and later from 2012 onwards were developed and hosted due to mid-course modification in data sheets. Reporting modules have options to retrieve data sets in the desired formats and units that could serve researchers to work on various ecological models analyzing within/ between field variations, multispecies associations, and yield loss assessment by crop pests besides crop-pest-weather/ climatic analysis across seasons or locations.

Data stored in the server database are used further for viewing and downloading different customized reports in online mode viz.,

1. Crop pest weather reporting;
2. Comparison [weather, light and pheromone traps and pest scenario across locations] and
3. Spatial [pestweather (graphical)].

The queries serve as data provider for Web applications from SQL server. Experts make queries and analyze data for intra and inter-center pest dynamics. These optimized reports can be exported to MS excel for display and printing purposes.

Sensor based and Geospatial Technologies : Recent technologies of internet of things (IoT) are all ICT based. A wireless sensor network is a system comprised of radio frequency (RF) transceivers, sensors, microcontrollers and power sources. Wireless sensor networks with self-organizing, self-configuring, self-diagnosing and self healing capabilities have been developed to solve problems or to enable applications that traditional technologies could not address. The wireless sensors are cheap enough for wide spread deployment in the form of a mesh network and also it offers robust communication through redundant propagation paths. The low-cost, low-power small devices equipped with limited sensing, data processing and wireless communication capabilities perfectly suits precision agriculture where decisions are to be made at micro-climatic level at right time/place/input crop-weather-pest/disease relations using wireless sensory and field-level surveillance data on closely related and interdependent pest (Thrips) – disease (Bud Necrosis) dynamics of groundnut (peanut) crop. Various data mining techniques were used to turn the data into useful information/ knowledge/ relations/ trends and correlation of crop-weather pest/disease continuum. These dynamics obtained from the data mining techniques and trained through mathematical models were validated with corresponding ground level surveillance data. It was found that Bud Necrosis viral disease infection is strongly influenced by Humidity, Maximum Temperature, prolonged duration of leaf wetness, age of the crop and propelled by a carrier pest. All the latest facilities relating to climate change studies on crops/pests under controlled conditions (have essentially digital components and provide understanding climate change impacts on specific pests of target crops. Open top chambers (OTP), carbon di oxide chambers, Free-Air Carbon Dioxide Enrichment (FACE), Free-Air Temperature Enrichment (FATE) and Carbon Dioxide Temperature Gradient Chamber (CTGC) are all ICT embedded tools. Results of controlled studies are useful to understand future pest status through use of process-based phenology models when combined with projected climatic scenarios.

Information and communication technology aided geo-spatial techniques such as remote sensing can be taken advantage for surveillance and quick monitoring in larger areas. The associated technological tools associated are hyper spectral imaging at ground as well as airborne devices including drones. here is an opportunity to make increased application of ICT, geo-spatial and simulation techniques, and artificial intelligence (AI) for pest surveillance, diagnostics and forewarning. GIS tools also can be applied - hot spots can be identified; and pest risk maps can be generated using models to focus our attention on pest management. Global Positioning Systems (GPS), a system of radio-emitting and receiving satellites used for determining positions on the earth is a great tool for supporting plant health programs for data visualization/query, survey data collection, management, and analysis, risk and pathway analysis and change detection, and the possibilities are endless! Geospatial technology includes typical GIS software packages such as ArcGIS, ArcExplorer, MapPoint and Google Earth. Use of remote sensing, collecting and interpreting information about the environment from a distance using satellite imagery, radar, or aerial photography has been demonstrated for insect pests. Remote sensing application for the area wide assessment of mealybug severity in Warangal (AP), and of damage at Sirsa (HR) on cotton (Prabhakar *et al*., 2012; Prasad *et al*., 2014) are recent examples in India.

Pest Forewarning : The sophisticated tools of ICT allows us to build a quality database and that various approaches from basic heuristics to application of artificial intelligence for development of pest predictions can give models for field use emphasis was laid to develop software products of pest forecasting. Forewarning is an essential component of IPM, and predicting of pest incidence based on changing climate is a challenge as its impact on pests is both direct and indirect. e-pest surveillance done under CROPSAP and NICRA has sustained and widened the scope of forewarning. Given the broad range of forecasting methods, rule-based predictions have served as simple but robust tools of forewarning of rice insect pest severity amongst seven locations viz., Ludhiana (Punjab), Chinsurah (West Bengal), Raipur (Chhattisgarh), Karjat (Maharashtra), Hyderabad (Telangana), Mandya (Karnataka) and Aduthurai (Tamil Nadu) besides maximum severity of *Spodoptera litura* for groundnut cropping system at Dharwad (Karnataka) and early blight of tomato at Bengaluru (Karnataka). Empirical models using field incidence/severity of insect pests and diseases of rice, pigeonpea, groundnut and tomato for various locations with their respective weather patterns have been validated to be effective for designated periods of crop season. Such empirical models and the rule-based models have been facilitated for validation as well as field use through web hosting as well as application for use through web and smart phones (available on Goggle play store).

IPM Dissemination : Recent advancements of digital tools are largely mobile based as mobiles have become part and parcel of daily lives of mankind. Android smart phones as a communication tools are popular and that people of different fields including pesticide dealers, extension functionaries and farmers possess and use them in their daily lives. Customised applications for need-based use in plant protection are potential value additions in the digital era. The innovations described here have been the successful application of digital technologies for facilitating scientific knowledge resources to aid in operational decision making and as tools of dissemination for pest management at farm level.

Mobile Apps on Pest Prediction : PESTPREDICT, an android mobile application for pest forewarning assists researchers, extension personnel of agriculture and farmers to get location specific forecasts of desired insect pest(s) or disease(s) for their effective management on target crops. PESTPREDICT reduces calculation efforts and provides an instant and extempore framework for use of developed prediction models. While success of predictions can be continuously improved through refinements considering the changing pest scenario and climate, immediate requirement is the need for locations of target crops to use the application on regular basis and issue 'pest alerts' at times prediction of 'high' severity levels. Web enabled/mobile application-based predictions are specific to locations and insects, creating awareness amongst potential users including extension functionaries is of utmost importance. QR codes generated to facilitate easy and instant downloads for use of the application are furnished hereunder. It is always pertinent to have a 'pest alert' backed up by direct and random field level monitoring.

Mobile Apps on Insecticide and Fungicide Calculations : Ever since the green revolution of 1960s in India, crop protection has relied largely on use of ever growing pesticides with various modes of action and the visual effects of pest management using synthetic chemicals were obvious and attractive to farmers. Over time, use of pesticides with their indiscriminate and injudicious use including the use of banned and spurious ones led to harmful effects of resistance build up by pests leading to their field control failures, pesticide poisoning of humans and natural resources, residues in food and food chains in addition to growers getting caught in debt traps leading to farmer suicides. More than 290 pesticides have been registered in India by the Central Insecticide Board and Registration Committee of the Department of Plant Protection, Quarantine and Storage of Government of India. It is imperative to use pesticides with label claims at recommended dosages using proper application technologies for effective pest management. One of the greatest limitations towards judicious use of pesticides is the lack of adequate awareness on the different groups of pesticides registered and their dosages specific to pests recommended for use on different crops in addition to their method of field application. As many chemicals are available for use against a single insect or disease and their dosages differ in respect of crops, it is difficult to remember all details by researchers, students, extension personnel, pesticide dealers and farmers. Making available mobile apps to facilitate scientific pesticide use on major crops is of potential value addition and hence mobile apps were developed for insecticide and fungicide calculations.

Considering the current status and recommendation pathways of pesticide use in India and the potential outreach of digital technology, android applications were developed for insecticide and fungicide calculations (IFC). IFCs in respect of sixteen crops viz,, Rice, Cotton, Chillies, Tomato, Brinjal, Okra, Groundnut, Cabbage, Wheat, Pigeonpea, Potato, Soybean, Chickpea, Cauliflower, Mustard and Sugarcane that have chemical and biological insecticides/ fungicides/nematicides together numbering 119, 87, 88, 83, 57, 43, 37, 39, 31, 32, 20, 44, 34, 20, 14,12 and 13 against insects, diseases & nematodes totalling 27, 17, 19, 23,16, 13, 20, 12, 31, seven, six, 21, six, 12, 10 and 13, respectively have been developed and hosted. IFC architecture includes scenarios for selecting insect pest/disease/nematode or pesticides (chemical/biological) or methods of application (seed/seedling treatment, soil application, and foliar spray) to proceed for further calculations. All IFCs have been developed using an open source software 'SQLite' on the framework of android studio. IFCs assist in calculation of pesticide quantity required to be procured for a given farm area besides facilitating dilution and method of their application. All insecticides and fungicides included have 'label claims' for use on specific crops complying with recommendations of Central Insecticide Board and Registration Committee. Feature of 'area converter' providing conversions of area to desired standard units, 'More info' displaying details on source and contact information besides and 'demo' on "how to use IFCs" are made available. 'Feedback' feature allows users to interact with developer of IFCs. Maize Pesticide Calculator (Maize-PC) is similar to IFCs in architecture but has additional features of selecting for weeds, herbicides associated and treatment methods indicating options of whorl application, poison baiting and pre or post emergence applications. Maize-PC covers 22, 11 and 14 insecticides, fungicides and herbicides for management of four insects, 11 diseases and 27 weeds, respectively. While the IFCs of Rice, Cotton, Soybean, Pigeonpea and Chickpea and Maize-PC are bilingual (English & Marathi), Groundnut, Tomato, Brinjal, Cabbage, Potato and Sugarcane, Wheat & Mustard are in English. Cauliflower and Okra IFCs are in English and Hindi. Chilli IFC (English) has been updated with two more (Kannada & Tamil) languages. All the apps are available on to Google Play Store.

Mobile Apps on IPM : Management of pests at field level is done through integration of different tactics and technologies that are compatible, altogether referred as integrated pest management (IPM) to achieve an economically profitable and environmentally safe food production system with safety of humans from occupational and food residue hazards due to pesticides. IPM is a strategy that integrates genetic, cultural, biological, mechanical, physical, and chemical methods of pest management each having a variety of options to choose from based upon considerations of space and time driven by socio cultural economic milieu of crop growers and market demands and hence holistic.

Mobile Apps on Crop based IPM : IPM mobile apps have been developed for crops of Rice, Pigeonpea, Groundnut and Tomato based on information assembled from recommended package of practices of different States and crop/pest specific reports and web portals of Agricultural Universities of different states. Architecture of IPM apps were designed after requirement analysis for clients. IPM apps used open source and lightweight database namely 'SQLite' that works on eclipse android 23.0.1 framework using .db format. Java Core Library provided most functions of the app and Dalvik virtual machine was used for specific improvements at backend. specific reports and web portals. Architecture of IPM apps were designed after requirement analysis of the clients as given in the flow diagram below. Provisions of accessing other apps viz., IFCs and forecast apps 'Pestpredict' within IPM apps in respect of crops have been made.

IPM apps allow the users to know information as per requirement in different ways as listed hereunder.

1. Selection of an independent option of pest management followed by further options relating to specific pest (insect/disease) through drop down menu.

2. Feature of 'crop calendar-based pest management' provides details of management options pertaining to stages of crop growth.

3. Details on good agricultural practices (GAP) covering essential agronomic practices including weed, fertilizer and water management besides operations at pre-sowing, harvest and post-harvest stages of crop production.

4. Additional information on 'safety on pesticide use' and 'data sheets and guidelines' for pest surveillance have been integrated.

5. External standalone apps on forewarning using empirical model and rule based model systems of insects and diseases viz., Pestpredict EMS (kharif), Pestpredict EMS (rabi) and Pestpredict RBS and insecticide and fungicide calculators that guide right selection of pesticide for a given pest at right dosage with calculations and narratives on field application methods are linked appropriately under desired features in respect of target crops. All mobile apps on crop IPM are in English, and are standalone occupying a memory size of 10-12 MB. All work in offline subsequent to initial installation through Google Play Store.

Mobile app on FAW-IPM : Development and deployment of an android mobile app for the invasive insect of fall armyworm IPM (FAW_ipm) has been a step towards nationwide knowledge creation cum dissemination of FAW management in maize. Eleven cultural, five mechanical, 16 natural bio agents (nine parasitoids, three predators & four pathogens), two monitoring methods, six applied bio control options (one botanical, an egg parasitoid & four microbials) and eight chemical insecticides (one seed treatment & seven foliar) and economic thresholds of one moth/trap/night and plant damage 5,10 and 20% constitute FAW IPM. FAW_ipm was built on the architecture as given in the flow chart below using open source SQLite database engine in android studio frame work. The app allows the user to identify four stages of FAW and damage to four parts of the plant either using keys for diagnosis or based on images along four stages of crop growth. Monitoring using pheromone traps with installation guidelines and field scouting.using sampling procedure with option FAW surveillance to register locations, fields and dates are available with reporting of calculations on moths/trap/week and per cent plant damage, respectively. All options under ETL based management have calculations on quantity of biologicals/chemicals to be procured for a given farm area based on their recommended dosages, dilutions with water, method of field application and waiting periods as applicable. Selection of management along crop growth stages offer three, 18, five and two options in respect of pre-planting, sowing to six leaf stage, seven leaf to flowering , flowering to harvest, respectively. Additional features viz., 'Feedback' allowing users to interact with developers, 'More info' furnishing details on developers and source of information and 'Precautions on pesticide use' are available. Current version of 'FAW_IPM' is in English and Marathi uploaded on Google Play Store and is also accessible for downloads at: https://ncipm.icar.gov.in/Web_cropsap/AndroidApp.htm. The android based mobile app (FAW_IPM) is a drive towards digital IPM that gives real time information access to researchers, crop protection specialists, pesticide dealers, extension functionaries and maize growing farmers of India on FAW management. FAW_IPM also propels the dissemination and adoption of scientifically proven and effective methods of FAW management at a quicker pace across maize growing areas (Vennila *et al.*, 2021).

Conclusions

IPM is an evolving system approach that accommodates all need-based innovations, concepts and policies in each area of pest management tactic right from pest resistant crops, ecological engineering, augmentative biocontrol, semiochemicals and pesticides with varied modes of action. While the role of chemical pesticides cannot be denied within IPM, their judicious use is far from satisfactory due to a variety of reasons resulting in occupational and pollution hazards in addition to pesticide residues in food and water. Enormous inventions and innovations in the area of crop protection requires integration of ICT paving way for precise methods, formulations/ materials, and technologies in crop health management. Like any other digital tools, ICT based applications for pest management needs creation of awareness on their availability with purpose to all the stakeholders related to crop protection for its wider utility. The possible convergence with department personnel, extension officials and other stakeholders of plant protection certainly would improve its applicability. While the ICT based pest surveillance for data base development and assessment of pest scenario would pay short as well as long-term dividends for crop protection research and development, available customized ICT tools on IPM are highly field oriented and farmer centric applications. All applications help to take informed and instant decisions on status and management of pests on target crops and are products for dissemination of crop protection technologies under IPM umbrella within the framework of 'Digital India'.

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Watermelon Production and Marketing Constraints in India

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Abstract

The watermelon (*Citrullus lanatus*) is a tropical fruit that is grown and consumed all over the world. India has the unique distinction of being able to grow almost any fruit or vegetable. The purpose of this research was to find out more about watermelon constraints involved in production and marketing aspects in India. A multistage sampling strategy was used in this investigation. The major cultivation of watermelon was usually seen in south India. In south India, Andhra Pradesh and Karnataka have the largest watermelon acreage and production in India, they were chosen purposefully for the study. 50 farmers were randomly chosen from each state for the study. Garrett's ranking technique was used to examine the data. The results reveled that water scarcity, severe incidence of pests and diseases, non-availability of labour during peak season, high cost of inputs, lack of timely availability of credit, and damage due to unfavourable weather conditions were the major constraints faced by the sample farmers in the production of watermelon in south India. As a result, it is vital to build research and extension apparatus to combat pests and diseases by breeding drought-tolerant, pest-resistant, and disease-resistant varieties suitable for tropical climates. The results with respect to problems faced by the sample farmers in marketing front in south India are lack of storage facility followed by lack of transportation facilities, breakage of fruits at the time of transportation, loading and unloading and lack of support price. To extend the shelf life of the fruit, cooperative cold storage infrastructure must be developed, as well as the immediate need to coordinate watermelon marketing on cooperative lines and the construction of regulated marketplaces in the research region.

Key words : *Watermelon, Production constraints, marketing constraints and garrett's ranking technique.*

Introduction

Watermelon is one of the most popular fruits grown in the tropics and eaten all over the world. In different parts of India, watermelon is called tarbuj, tarmuj, kalingad, and kalindi. Watermelon [*Citrullus vulgaris* Schrader Ecklon & Zeyher; *Citrullus lanatus* (Thunb.) Matsum. & Nakai.] and muskmelon [*Cucumis melo* L.] are two species of melons that belong to the Cucurbitaceae family and are consumed primarily during the hot season. The fruit is consumed in higher quantities worldwide than any other cucurbit. China, Iran, Turkey, Brazil, and the United States are the world's major producers of watermelon, according to FAO estimates from 2021.

In India, Uttar Pradesh produces the most watermelon (706.65 million tonnes), followed by Andhra Pradesh (628.57 million tonnes), Tamil Nadu (315.19 million tonnes), Karnataka (260.90 million tonnes), and Orissa (260.90 million tonnes). These five states account nearly 70 percent of the country's total output (NHB-2021-22). Watermelon cultivation in India has augmented from 70.6 thousand hectares in 2011-12 to 104.20 thousand hectares in 2021-22, according to data from the Ministry of Agriculture, Government of India. Production has also increased in lockstep with area, from 1727.50 thousand metric tonnes in 2011-12 to 3225.44 thousand metric tonnes in 2021-22. (APEDA, 2021-22). In 2020-21, India's watermelon exports were 31739.02 MT and Rs. 53.65 crores, respectively.

Due to its high prevalence of pests and diseases, watermelon causes more difficulties than other agricultural and horticultural commodities. Watermelon arrivals and prices are particularly difficult to forecast because it is seasonal. When there are many arrivals (peak harvest season), prices are lower; when there are few arrivals (lean season), prices are higher. In this regard, the current study was carried out with the goal of learning about the challenges experienced in the production and marketing of watermelon in India in general and south India in particular. It's vital to have a good marketing strategy in place so that producers receive adequate money for their products and consumers get a good deal. Watermelon farming in India should be paired with modern varieties that are suited to agro-climatic conditions.

Research Methodology

This study employed a multistage sampling strategy. Two states, Karnataka and Andhra Pradesh, were purposely picked for the study in the first stage because they have the most acreage and produce the most watermelon in India. Usually, tropical districts with high temperature are favorable conditions for watermelon cultivation, so that in the second stage was district selection, with two districts, Haveri in Karnataka and Anantapur in Andhra Pradesh, being chosen. The third stage involved selecting taluks from the districts of Haveri and Anantapur. At this stage, two taluks in Haveri district, Hirekerur and Savanur, and Raptahdu and Anantapur in Anantapur district, were chosen for the study because commercial watermelon production had the most potential in these two taluks. In the last stage, 25 farmers from each taluk were selected randomly for production aspects in watermelon cultivation.

The study was purely based on primary data. The primary data were collected from the farmer respondents through personal interview method, with the help of well-structured and pre-tested questionnaire exclusively designed for the study. Garrett's ranking analysis was followed for analysis of the data.

Garrett Ranking Technique : Garrett's ranking technique was employed to determine farmer acceptance and challenges in the production and sale of watermelon. It essentially converted the order of limitations or benefits into numerical scores. In comparison to a standard frequency distribution, the main advantage of this technique was that the limitations or advantages were organised according to their importance to respondents. As a result, the same number of respondents may have received different ranks for two or more limitations.

Garrett's formula for converting ranks into per cent is given by

$$\text{Per cent position for every } i^{th} \text{ factor} = \frac{100 \quad (R_{ij} \quad 0.5)}{N_j}$$

Where,

R_{ij}= rank given for i^{th} factor by j^{th} individual

N_j= number of factors ranked by j^{th} individual

The per cent position of each rank was then converted into scores referring to the Table given by Garret and Woodswordh (1996). For each factor, the scores of individual respondents were added together and divided by the total number of the respondents for whom scores were added. These mean scores for all the factors were arranged in descending order, ranks were given and most important factors were identified.

Results and Discussion

Problems encountered by watermelon growers in the study area : An informal discussion with the sample farmers revealed that as such there were problems in production and marketing of watermelon in India in general and south India in particular. The opinion survey was conducted for the sample farmers who produce watermelon, to ascertain the problems faced. The results of the opinion survey presented in Table-1 and 2 are discussed here.

Production problems faced by watermelon growers in the study area : During pre-testing phase, ten problems were identified in watermelon and the opinion survey results are presented in Table-1. Because watermelon cultivation is done under dry land areas in the district by drip irrigation technology, the biggest production challenges experienced by the sample farmers in Karnataka and Andhra Pradesh were water scarcity (with a mean score of 76.84 & 68.60). Jabir and Sanjeev found a similar key constraint in their study on farmers' perceptions of risks in fruit and vegetable production in Uttar Pradesh (2008). Farmers identified an issue of high pest and disease incidence (with a mean score of 71.26 and 78.24, respectively) that needed to be addressed. Research and extension machinery has to be geared up in this region to mitigate this problem. Dhakane *et al.* found a similar result in their study on constraints in grape production technology in Barshi tehsil of Solapur district (2009). The problem non-availability of labour during peak season (with a mean score of 61.72 & 47.72), because watermelon is highly labour intensive crop and availability of the labour is a problem especially during the peak time of harvesting and weeding, which coincides with the other agricultural operations. Farmers faced high input costs (mean score of 59.26 & 63.32), particularly in watermelon agriculture, where seeds account for the majority of costs, followed by fertilizers and PPC. These findings are in line with the study on constraints faced by banana growers of Nanded district by Hendge *et al.* (2007). Farmers faced the problem of non-availability timely credit on time (with a mean score of 50.72 and 59.00). They could not get credit from institutional agencies and maximum farmers borrowed from money lenders and others. Similar constraint was observed with the findings of Adeoye (2011), made an economic analysis of watermelon-based production system in Oyo state, Nigeria. The problem of damage due to unfavorable weather conditions (mean score of 50.60 & 53.06).

Marketing problems faced by watermelon growers in the study area : Similar to identification of constraints for production, ten marketing problems were identified in watermelon and the opinion survey results are presented in Table-2. The results revealed that the major problems faced by the Karnataka and Andhra Pradesh farmers in marketing front, farmers given first rank to problem of lack of storage facilities with a mean score of 75.52 and 77.44. Watermelon fruits occupy more space compared to other fruits. Because of high cost for storage construction,

Table-1 : Constraints involved in production of watermelon in Karnataka and Andhra Pradesh. (N=100)

Sl. No.	Problems	Karnataka Haveri district		Andhra Pradesh Anantapur district	
		Garrett mean score	Rank	Garrett mean score	Rank
1.	Water scarcity	76.84	I	68.60	II
2.	Severe incidence of pests and diseases	71.26	II	78.24	I
3.	Non-availability of labour during peak season	61.72	III	47.72	VI
4.	High cost of inputs	59.26	IV	63.32	III
5.	Lack of timely availability of credit	50.72	V	59.00	IV
6.	Damage due to unfavorable weather conditions	50.60	VI	53.06	V
7.	Maintenance problems of irrigation structures	41.78	VII	40.70	VII
8.	Lack of technical guidance	34.74	VIII	27.80	IX
9.	Non-availability of FYM	29.62	IX	36.26	VIII
10.	Breakage of fruits at the time of harvesting.	23.14	X	22.62	X

Table-2 : Constraints involved in marketing of watermelon in Karnataka and Andhra Pradesh districts. (N=100)

Sl. No	Problems	Karnataka Haveri district		Andhra Pradesh Anantapur district	
		Garrett mean score	Rank	Garrett mean score	Rank
1.	Lack of storage facility	75.52	I	77.44	I
2.	Lack of transportation facilities	65.76	II	56.70	III
3.	Breakage of fruits at the time of transportation, loading and unloading.	61.52	III	54.90	IV
4.	Lack of support price	53.22	IV	74.56	II
5.	Lack of regulated market	48.78	V	51.98	V
6.	Lack of awareness about market information	47.98	VI	44.46	VII
7.	Markets far away from farm	47.00	VII	33.52	VIII
8.	Lower prices due to seasonal gluts	36.94	VIII	47.66	VI
9.	Lack of processing industries related to watermelon	32.32	IX	28.60	IX
10.	Few purchasers available in local market	28.96	X	28.18	X

farmers were unable to have the storage structures with their own interest and cost. They dispose their produce at whatever the price prevailing in the market. Similar constraint was observed in the study on constraints in production and marketing of onion in Northern Karnataka by Vinayak *et al.* (2013). Second rank given to lack of transportation facilities with a mean score value of 65.76 and 56.70 *viz.,* poor road conditions and lower frequencies of vehicles for transportation. The factor was in line with the study on production and marketing of sapota in Northern Karnataka by Ramachandra (2006). A minimum of 8-10 tonnes was a must for the economic transportation. Farmers expressed the problem of breakage of fruits at the time of transportation, loading and unloading (with a mean score of 61.52 & 54.90). There was lack of packing structures in watermelon during transportation because fruits are bigger in size, not in uniform shape and not possible for packing. Watermelon outer green shell is tender and delicate in nature. So, breakage of fruits was observed during produce handling such as loading and unloading. Fourth rank given to, lack of support price in market (mean score of 53.22 & 74.56) due to the arrival of large quantity of fruits to the market at the same time (seasonal glut). The price would crash substantially. There is necessary to develop cold storage structures on co-operative basis to increase the shelf life of the fruit and Government should make the watermelon fruit as a notified commodity in the regulated market.

Conclusions

Watermelons growers have large number of problems in production and marketing their produce. Major production problems faced by sample farmers in the study area were water scarcity followed by severe incidence of pests and diseases and non-availability of labour during peak season. Therefore, it is necessary to develop research and extension machinery has to be geared up to overcome the pests and diseases through developing drought tolerant, pests and disease resistant varieties suitable to the tropical climatic conditions. Major problems faced by the farmers in marketing front were lack of storage facilities followed by lack of transportation facilities, breakage of fruits at the time of transportation, loading and unloading and lack of support price. There was a need for an agency to help the growers in marketing of the produce. Even-though the watermelon cultivation was profitable, there was lots of lacuna in marketing of watermelon. Hence, there was an immediate need to organize marketing of watermelon on the cooperative lines and also establishment of regulated markets in the study area.

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Marketing of Watermelon in South India-Management Approach

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Abstract

In southern India, watermelon is one of the most extensively grown and consumed fruits. The purpose of this study was to learn more about watermelon marketing by identifying channels, marketing expenditures, and margins. This study employed a multistage sampling technique. Karnataka and Andhra Pradesh were specifically chosen for the study since they have the most watermelon acreage and production in India. Primary data was collected from a diversity of stakeholders, including pre-harvest cum wholesalers, retailers, and a few mediators working at various levels of the marketing channels. It was discovered that each state has two distribution channels based on the data. In channel I, the primary participants were the producer, retailer, and consumer, whereas in channel II, the main players were the producer, pre-harvest contractor cum wholesaler, retailer, and consumer. In both states, the producer net price per tonne in channel-I was Rs. 7,430 and Rs. 6,390, respectively, while the consumer paid price was Rs. 9,577 and Rs. 8,347. The average net price received by the producer per tonne in channel I and channel II was Rs. 7180 and Rs. 6090, respectively, but the consumer purchased price was Rs. 10,755 and 9,479, suggesting that the producers' share of the consumer rupee was highest in channel I and lowest in channel II. In both states, the majority of farmers opted to sell their produce through channel II. Farmers in Karnataka (84 %) and Andhra Pradesh (76 %) preferred channel II to sell their produce. It is necessary to establish active Farmer Producer Groups / Farmer Cooperative Groups that can take advantage of remote and competitive marketplaces while paying their members a fair price. To eliminate regional disparities in watermelon prices, better transportation, storage, and processing facilities are also required.

Key words : *Pattern of sales, marketing costs, margins and price spread.*

Introduction

Watermelon (*Citrullus lanatus*) is one of the most popular fruits grown in the tropics and consumed all over the world. India has the unusual distinction of being able to grow practically every type of fruit and vegetable. After China, India is the world's second-largest producer of fruits (9%). Uttar Pradesh produces the most watermelon in India (706.65 million tonnes), followed by Andhra Pradesh (628.57 million tonnes), Tamil Nadu (315.19 million tonnes), Karnataka (260.90 million tonnes), and Orissa (260.90 million tonnes) (253.54 thousand tonnes). These five states accounted for almost 70% of the country's overall output (NHB-2021-22). According to data given by the Ministry of Agriculture, Government of India, watermelon cultivation in India has increased from 70.6 thousand hectares in 2011-12 to 104.20 thousand hectares in 2021-22, production has also increased in pace with area, from 1727.50 thousand metric tonnes in 2011-12 to 3225.44 thousand metric tonnes in 2021-22. (APEDA, 2021-22). Watermelon exports from India reached 31739.02 MT and Rs. 53.65 crores in 2020-21, respectively. Watermelon is good for human and livestock consumption because it contains most of the body's basic daily nutritional requirements as well as other essential nutrients that help to prevent human health problems such as cancer, stroke, high blood pressure, high vague, heart attack, and other cardiovascular diseases. Which is rich in an amino acid called citrulline that may help move blood through your body and can lower your blood pressure.

Watermelon occupies an area of 6.81 thousand hectares in Karnataka state and production of 260.90 thousand tonnes. Mysore district is the leading producer of watermelon in the state, and other well marked areas are Haveri, Chamarajnagar, Kolar, Mandya, Bagalkote, Kopppal, Belgavi and Chikballapur districts. The total area under watermelon in Andhra Pradesh was 11.89 thousand hectares, with a total production of 628.57 thousand tonnes. Anantapur, Chittoor, Prakasam, and Kadapa districts in Andhra Pradesh have well-defined farming zones.

It is critical to have an effective marketing system in place so that producers receive adequate returns for their products and consumers receive them at a fair price. The production of watermelon in Andhra Pradesh was year due to favoured agro-climatic conditions coupled with the advanced varieties. India grows approximately 25 commercial varieties, a few of which have delightfully interesting names: "New Hampshire Midget," "Madhuri 64," "Black Magic," and "Sugar Baby," "Arun 0035", "Hybrid Dragon", "Namdhari NS – 295". The varieties released by IIHR, Bangalore are Arka Shyama, Arka Muthu, Arka Aiswarya, Arka Akash and Arka Manik.

Research Methodology

This study employed a multistage sampling strategy. Two states, Karnataka and Andhra Pradesh, were purposely picked for the study in the first stage because they have the most acreage and produce the most watermelon in India. The second stage was district selection, with two districts, Haveri in Karnataka and Anantapur in Andhra Pradesh, being chosen. The third stage involved selecting taluks from the districts of Haveri and Anantapur. At this stage, two taluks in Haveri district, Hirekerur and Savanur, and Raptahdu and Anantapur in Anantapur district, were chosen for the study because commercial watermelon production had the most potential in these two taluks.

Primary data was collected from a range of sources, including pre-harvest cum wholesalers, retailers, and a few mediators working at various levels of the marketing channels. Five intermediaries at each level were chosen from the two districts to research the marketing characteristics of watermelon.

Results and Discussion

Marketing channels : Watermelon from the research area was transmitted from the producers to the ultimate consumers via two marketing channels and which are mentioned below.

Channel – I : Producer – Retailer – Consumer.

Channel – II : Producer – Pre-harvest contractor cum wholesaler – Retailer – Consumer.

The standing crop was traditionally sold to pre-harvest contractors, wholesalers, and merchants who came to inspect the crop at maturity. The majority of the farmers in the sample sold their crops to pre-harvest contractors and cum wholesalers. The term ‘on farm sale’ or ‘sale at farm gate’ refers to a sale that takes place on the farm itself.

The payment was made in instalments to the watermelon growers. At the time of the negotiations, a little advance was paid. Before the last truck load of fruits leaves the farm, a significant sum is paid. Pre-harvest contractor cum wholesalers would bring the produce and sell them in distant market. From this point, the produce pass through the retailer to ultimate consumers.

Pattern of sales of watermelon by farmers in the study area : Table-1 shows that the percentage of watermelon produced sold through various market channels in the research area. The table shows that the majority of farmers in both districts opted to sell their produce through channel-II. In the Haveri district, 84 percent of farmers (42 farmers) favoured channel-II, whereas 16 percent (8 farmers) selected channel-I. Similarly, in the Anantapur district, 76 percent (38 farmers) favoured channel II, whereas only 24 percent (12 farmers) preferred channel-I.

Marketing costs, margins and price spread in marketing of watermelon in the study area : Watermelon is transported from growers to end users via several intermediaries. The middlemen provided various services in the marketing process while also expecting to be compensated for their efforts.

The difference between the price paid by the consumer and the net price received by the producer for an equivalent quantity of farm produce is known as the price spread. This price spread is made up of marketing expenses and intermediary margins, and it ultimately determines the overall efficacy and efficiency of a marketing system. Table-2 shows the precise price spread per tonne of watermelon across different channels.

In Haveri district, the results revealed from the table that, in channel-I the farmers sold their produce to the retailers at the farm gate itself. Retailers paid Rs.7,430 per tonne for the produce, and the retailer’s cost was Rs.898.45 per tonne, with a profit margin of Rs.1,294.26 per tonne, which he sold to the final customer for Rs.9,578 per tonne. After deducting the producer’s costs, the net price received by the producer was Rs.7,335 per tonne. As a result, the producer received 76.58 percent of the retail price, which was greater than channel- II.

Furthermore, it can be observed from the table that in channel-II, farmers sold their produce to a pre-harvest contractor cum wholesaler on the farm. The crop was purchased by a pre-harvest contractor cum wholesaler for Rs.7,180 per tonne, while the cost to the pre-harvest contractor cum wholesaler was Rs.1,163.56 per tonne. The profit margin per tonne was Rs.834.35. The retailer bought the product from a pre-harvest contractor and sold it to the final consumer. In this process, retailer incurred a cost of Rs.174 per ton of watermelon and realized net earnings of Rs.1,402.78 per ton of watermelon. After deducting the producer’s marketing costs, the producer obtained a net price of Rs.7,085 per tonne. As a result, the producer received 65.88 percent of the retail price.

In Anantapur district, the results revealed from the table that, in channel-I, the farmers sold their produce to the retailers at the farm gate itself. Retailers purchased the produce at Rs.6,390 per ton and cost incurred by the retailer was Rs.868.81 per ton and keeping a profit margin of Rs.1,088.82 per ton and he sold to the ultimate consumer at Rs.8,348 per ton. The net price received by the producer after deducting the cost incurred by the producer was Rs.6,259 per ton. Thus, the producer received 74.98 per cent of the consumer price.

Table-1 : Pattern of sale of watermelon in different channels.

Sl. No.	Channel	Karnataka Haveri district (n=50)		Andhra Pradesh Anantapur district (n=50)	
		No. of farmers	%	No. of farmers	%
1.	Channel – I	8	16	12	24
2.	Channel – II	42	84	38	76

Table-2 : Marketing cost, margin and price spread in marketing of watermelon in different channels. (Rs./tonne)

Sl. No.	Particulars	Karnataka Haveri district		Andhra Pradesh Anantapur district	
		Channel I	Channel II	Channel I	Channel II
1.	Producer price	7,430.00	7180.00	6,390.00	6,090.00
2.	Marketing cost incurred by producer	95.00	95.00	131.00	131.00
3.	Producers net price (1-2)	7,335.00	7,085.00	6,259.00	5,959.00
4.	Purchase price of wholesaler	-	7,180.00	-	6,090.00
5.	Cost incurred by wholesaler	-	1,163.56	-	1197.20
6.	Profit margin of wholesaler	-	834.35	-	728.72
7.	Purchase price of retailer	7,430.00	9,177.91	6,390.00	8,015.92
8.	Cost incurred by retailer	898.45	174.00	868.81	226.65
9.	Profit margin of retailer	1,249.26	1,402.78	1,088.82	1,236.38
10.	Purchase price of consumer	9,577.71	10,754.69	8,347.63	9,478.95
11.	Producer's share in consumer's rupee	76.58	65.88	74.98	62.86
12.	Price spread (10-3)	2,242.71	3,669.69	2,088.63	3,519.95

Further, from the table it could also be seen that in channel-II farmers sold their produce to pre-harvest contractor cum wholesaler at the farm level itself. Pre-harvest contractor cum wholesaler purchased the produce at Rs.6,090 per ton and cost incurred by pre-harvest contractor cum wholesaler was Rs.1,197.20 per ton. The profit margin was Rs.728.72 per ton. The retailer purchased the produce from pre-harvest contractor cum wholesaler and sold to the ultimate consumer. In this process, retailer incurred a cost of Rs.226.65 per ton of watermelon and realized net earnings of Rs.1,236.38 per ton of watermelon. Producer received a net price of Rs.5,959 per ton after deducting the marketing cost incurred by the producer. The producer's share in consumer's rupee was 62.86 per cent.

Conclusions

The producers share in consumer's rupee was found to be more in channel-I of marketing in both the districts which is a local marketing channel. The superiority of channel-I over channel-II in respective districts in terms of producer share in consumer rupee and hence, the hypothesis that, fewer the intermediaries efficient would be the channel, is established in marketing of watermelon also. Price spread was more in channel-II of both the districts as the number of market intermediaries present were more and this channel operated during the glut period in the market and hence farmers received lower price per ton. The purchase price of consumer was more in channel-II of both the districts. Because, in channel-II pre-harvester contractor cum wholesalers sold their produce to distant retailers and the number of market intermediaries present were more in this channel. Hence, channel-I was considered to be the best marketing channel as the price spread was less in both the districts.

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Site-Specific Nutrient Management in Maize Based on STCR and Targeted Yield Approach

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Abstracts

Field experiments were conducted at Karimnagar, Telanagana during *rabi*-2021 to demonstrate SSNM technique on farmer field using soil test - based fertilizer application and targeted yield concept in maize crop. In this study, there are three treatment used: Treatment -1: - Fertilizer application based on eight soil sample test, Treatment- 2: - Fertilizer application based on the one soil sample test, and Treatment -3: - Farmer fertilizer practices. The study conducted that grain yield in qt ha^{-1} (79 and 74 qt ha^{-1} grain yield in treatment 1 &2 respectively) and grain yield in qt ha^{-1} over farmer fertilizer practices (12 and 7 qt ha^{-1} grain yield in treatment 1 &2 respectively) was highest in treatment-1 followed by treatment-2. Maximum gross return and gross return per ha were observed in treatment -1 (Rs. 147730.00 and Rs. 22440.00 respectively) followed by treatment-2 (Rs. 138380.00 and Rs. 13090.00 respectively).

Key words : *Gross return, maize, soil test fertilizer application, and targeted yield.*

Introduction

Maize is a significant economic crop in India, with an estimated acreage of 9.4 million hectares capable of producing 28.7 million tonnes (India stat, 2021-22). Telangana is one of India's most important maize-growing states, with maize mostly used as a commercial feed crop. Maize (Corn) is the second most important cultivated crop in Telangana, with roughly 6.3 lakh hectares producing 25.5 lakh tonnes yearly (India stat, 2021-22). Telangana's average maize production is 4057 kg ha^{-1}, greater than the national average of 3065 kg ha^{-1} (India stat 2021-22). Maize yield is determined by the variety, season, soil fertility, and crop management practices used by farmers. Maize is a demanding crop that necessitates a balanced supply of all three key nutrients (N, P, and K). Maize hybrids are very responsive to nutrient input from outside sources. The rate of fertilizer applications is determined by the soil nutrient status, which varies with soil heterogeneity. Variations in crop growth and yield per hectare basis could be due to this heterogeneity. SSNM approach has the capacity to supply key nutrients in an optimum amount to maize to get maximum grain yield and high input use efficiency. The application of SSNM to maize increases farmer revenue significantly. To archive objective yield, site-specific nutrient management is a unique fertilizer delivery strategy based on spatial and temporal soil heterogeneity, crop nutrient requirements, and cropping system. This method is part of precision farming or site-specific crop management. The core concepts of SSNM are the diagnosis of geographical variability in the soil's nutrient-providing capacity and the use of appropriate instruments and procedures to treat this variability. It's a broad notion for balancing the supply and demand of nutrients based on their spatial and temporal variations. This method establishes a scientific foundation for providing nutrients to crops as and when they are required for individual fields in a given cropping season, hence avoiding over-or under-nutrition. SSNM for Asian irrigated rice systems was developed by IRRI in collaboration with national partners across Asia in the 1990s to overcome major limits originating from generalized fertilizers recommendations for large swathes, as practiced in Asia. The existence of SSNM reflects an awareness that future gains in productivity and input use efficiency would necessitate more knowledge-intensive soil and crop management systems that are customized to the unique characteristics of particular fields. It is described as the dynamic, field-specific management of nutrients during a given cropping season in order to optimize the supply and demand of nutrients based on their differences in cycling through the soil-plant system. On account of the above facts, the present investigation was contemplated in maize crop to get maximum yield using STCR and targeted yield approach.

Table-1 : Initial soil status of selected farmer field.

Sl. No.	Physico-chemical Properties	Value	Rating	Reference's
1.	pH	8.32		Jackson, 1973
2.	EC (dS m^{-1})	0.112		Jackson, 1973
3.	Organic Carbon (%)	0.42	Low	Walky and Black,1934
4.	Available N (kg ha^{-1})	162	Low	Subbiah and Asija, 1956
5.	Available P (kg ha^{-1})	19.78	Medium	Olsen et al., 1954
6.	Available K (kg ha^{-1})	268.92	Medium	Jackson, 1973

Table-2 : Fertilizer Application rate as per treatments.

Sl. No.	Treatments	Nitrogen (kg ha^{-1})	Phosphorus P_2O_5 (kg ha^{-1})	Potassium K_2O (kg ha^{-1})
1.	Treatment–1 (Fertilizer application based on eight soil sample tested per ha)	237	53	78
2.	Treatment–2 (Fertilizer application based on one soil sample tested per ha)	256	55	83
3.	Treatment–3 (Farmer fertilizers practice)	180	60	40

Table-3 : Comparative study of grain yield, gross return and cost of fertilizer of maize.

Treatments	Grain yield (q ha^{-1})	Change in grain yield over farmer fertilizer practices (q ha^{-1})	Cost of Fertilizer (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Gross return over Farmer Fertilizer practices (Rs. ha^{-1})
Treatment-1 (Fertilizer application based on eight soil sample tested per ha)	79	12	7372.00	147730.00	22440.00
Treatment-2 (Fertilizer application based on one soil sample tested per ha)	74	7	8669.00	138380.00	13090.00
Treatment-3 (Farmer fertilizers practice)	67	-	5418.00	125290.00	-

Materials and Methods

A field experiment was conducted in farmer fields at Karimnagar district, Telangana State during *rabi,* 2021-22. The objective of the present investigation was to study the influence of STCR and the Targeted yield approach on maize grain yield and farmer income. There are three treatment used in the experiment:

T1 : Application of fertilizer using STCR Model and Targeted yield approach based on eight soil sample collection testing data per ha (Eight soil sample was collected based on soil fertility variability using Geostatistical analysis)

T2 : Application of fertilizer using STCR Model and Targeted yield approach based on one soil sample collection testing data per ha.

T3 : Farmer Fertilizer practices.

In STCR approach initial soil available nutrients N, P and K are required to compute the target yield equations at a particular field level. A target yield 65 q ha^{-1} was taken for a test variety of DHM-117. The required quantity of fertilizers to attain the target yield was calculated based on the initial soil fertility status with the equation given below.

$$FN = 4.25\ T - 0.24\ SN$$

$$FP_2O_5 = 0.9\ T - 0.3\ SP$$

$$FK_2O = 1.41T - 0.05\ SK$$

In the above equation, FN, FP_2O_5, and FK_2O represent the fertilizer of nitrogen, phosphorus, and potassium in kg ha^{-1}. T means the target yield in q ha^{-1}.SN, SP, and SK are soil available N, P, and K respectively. Initial soil sample are collected at each location and analyzed for pH of the soil in 1:2.5 soil water suspensions (Jackson, 1973), electrical conductivity of the soil in 1:2.5 soil water extract (Jackson, 1973). Available nitrogen in the soil was determined by alkaline permanganate method (Subbiah and Asija, 1956). Available phosphorus content was determined by Olsen's extractant (Olsen *et al.,* 1954). The available potassium in soil was extracted with neutral normal ammonium acetate (Jackson, 1973). The initial soil status are present in table-1. The required nitrogen was applied through three splits, one third at basal, one third at knee high, and last dose of one third at the tasseling stage while phosphorus and potassium are applied as basal.

Result and Discussion

Grain yield : Grain yield of maize varied between 67 to 79 q ha^{-1} whereas the highest grain yield was 79 q ha^{-1} observed in the treatment-1 with the application of 237:53:78 N, P_2O_5, and K_2O kg ha^{-1} respectively (Table-3). Grain yield of maize in treatment-1 was 12 and 5 q ha^{-1} higher than in treatment-3 and treatment-2 respectively. In STCR technology has recorded an additional mean yield over farmer fertilizer practice. The higher grain yield in STCR recommendation may be due to the application of fertilizers based on the needs of the crop. Fertilizers in the target yield approach consider the crop needs and nutrients present in the soil. It may be due to the coincidence fertilizers application with critical stages of crop. It might have resulted in better assimilation of photosynthates to grain. Similar results were obtained by Ray *et al.,* (2000), Meena *et al.,* (2001), Jayaprakash *et al.,* (2006), Arun Kumar *et al.,* (2007), Umesh (2008), Vikram *et al.,* (2015), Pradeep Kumar and Parmanand, (2018) and Prabhakar Reddy *et al.,* (2018).

Farmer Income : Among three treatments, Maximum gross return per ha was observed in treatment-1 followed by treatment-2 then treatment-1 (Table-3) might be due to the proper allocation of fertilizer in treatment-1. Highest gross return per ha in treatment -1 due to the highest grain yield per ha in treatment -1 and more uptake of nutrient in it. It also noticed that gross return per ha over farmer fertilizer practices (Treatment-3) was highest in treatment-1 followed by treatment-2. Gross return over farmer fertilizer practices in treatments-1 and 2 was Rs. 22440.00 and Rs. 13090.00 respectively. This may be due to higher productivity and gross returns in the STCR treatment over the farmer fertilizer practice treatment. It might be also due to nutrient balance in soil due to soil test-based fertilizer application and nutrient reserves in the soil. Similar results are reported by Pradeep Kumar and Parmanand (2018).

Conclusions

The present investigation concluded that the soil test-based fertilizer application on the basis of eight soil sample test gave the highest grain yield and better outcomes over farmers' fertilizer recommendations due to balanced nutrient management.

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Study of Drip Irrigation on Banana (*Dwarf Cavendish*) in Central Plains Agro-Climatic Zone Safedabad, Barabanki, U.P.

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Abstract

Banana (*Musa* spp.) is one of the world's major food crops grown in developing country. It provides valuable source of income through local and international trade and contribute to the live hood of many people through crop production, processing and marketing. Banana requires large quantity of water during its life cycle. Therefore, to save water and to increase production, a drip fertigation system was designed and installed on an area of 0.011025 ha (110.25 m^2). The present study was carried out to estimate the yield and economic evaluation for banana cultivation. The drip fertigation was done at three evapotranspiration (ET) based irrigation levels (E_1=0.6 ET, E_2=0.8 ET, E_3=1.0 ET and at three fertilizer levels of recommended doses of fertilizer (RDF) viz., F_1=70% RDF, F_2=80% RDF and F_3=100% RDF laid out in factorial randomized block design with three replications. The maximum yield was found to be 0.873 tonne (E_3F_3) followed by 0.816 tonne (E_2F_3) and 0.795 tonne (E_1F_3). The highest BCR was recorded for the treatment combination E_3F_3(2.18) followed by E_2F_3 (2.04) and E_3F_2(2.01). The higher BCR in the drip fertigation was the consequences of the reduction of cost on irrigation and labour. Thus, drip fertigation was observed to be the best option for optimum utilization of fertilizer nutrients and water for ensuring higher crop productivity and profitability in banana.

Key words *: Banana, crop production, yield, economic evaluation, evapotranspiration, recommended doses of fertilizer, drip fertigation*

Introduction

Banana(*Musa paradissica* L.*)* is one of the major and economically important fruit crops of India. It occupies 20% of the area among the total area under crop in India. Most the Banana is grown by planting suckers. Banana in India is known as "Instant energy provider", which is cheap, nutritious and available all round the year.It is one of the leading fruit crop of india.In India, drip fertigation is extensively used in the banana cultivation. This micro-irrigation system also allows clean and mechanized cultivation, thereby substantially reducing the cost of weeding. The potential for drip irrigation system in India is estimated to be around 21.3 M ha (Narayanamoorthy, 2008). But till the year 2010, we could achieve 1.9 m ha only under drip (4.9 M ha in micro irrigation). It has been accepted as the best solution for intensive crop production (Samuel *et al.,* 2002) and maintenance of economic viability through increased water use efficiency and water saving (Narayanamoorthy, 2006). The farmers in India generally follow conventional surface method of irrigation in banana cultivation which is quite inefficient and non-remunerative. The major portion of cost is incurred in hiring labour for irrigation (More *et al.,* 2005) and the drip fertigation system has been reported to reduce the labour costs by 30-35% (Berad *et. al.,* 1999).The water saving, increase in productivity and gross income due to drip over the conventional flood method of irrigation in banana may be 29%, 29.1% and 30.2% respectively with a BCR of 2.3 (Narayanamoorthy, 2003).Banana requires large quantity of water during its life cycle. Water is becoming increasingly scarce worldwide due to various reasons. (Rosegrant, *et.al.* 2002).

Drip irrigation refers to frequent application of small quantities of water on or below the soil surface as drops. Generally, furrow systems are more difficult to automate particularly with regard to regulating an equal discharge in each furrow and losing too much water to deep drainage or runoff (Walker, 1989).An earlier estimate made by (FAO,1993) for average irrigation water utilization showed that farm distribution losses constitute 15% of irrigation water; while field application system losses constitute 25%, irrigation system losses 15% and the water effectively usedby crops constitutes only about 45%.In India, banana is grown under diverse conditions. The selection of varieties, therefore, is based on a large number of varieties catering to various kinds of needsand situations.However, around 20 cultivars viz. Dwarf Cavendish, Robusta, Monthan, Poovan, Nendran,Red banana, Nyali, SafedVelchi, Basarai, Ardhapuri, Rasthali, Karpurvalli, Karthali, and Grandnaineetc..Grandnaine is gaining popularity and may soon be the most preferred variety due to its tolerance to biotic stresses and good quality bunches. Bunches have well-spaced hands with a

Table-1 : Fixed and operation cost of banana cultivation for 0.011025 hectare of land under drip fertigation systems (excluding fertilizer and irrigation cost).

Sl. No.	Particular	Drip fertigation
Fixed cost		
1	Installation cost including one 1.5 HP water pump (Rs. 9000)	20,000
2	Life span for drip system and water pump (year)	10
3	Depreciation @ 4% (Rs.)	800
4	Interest cost @ 10% (Rs.)	2000
Operating cost (excluding fertilizers and irrigation cost)		
5	Repair and maintenance cost including electrical and labour charge @ 2% (Rs.)	400
6	Seasonal cost of drip system (3+4+5) (Rs.)	3200
7	Cost for field preparation and planting (Rs.)	2960
8	Cost for cultural practices (Rs.)	2000
9	Cost for plant protection measures i.e., chemicals + application charges (Rs.)	2000
10	Labour cost incurred during harvesting @ Rs. 2/bunch	512
Seasonal total cost (6 + 7 + 8 +9 + 10)		Rs. 10,672

Table-2 : Details of treatment cost for fertilizers and irrigation for cultivating 0.011025 hectare of bananas.

Treatments	Amounts of Urea: DAP : MOP (g/plant/season)	Total cost of fertilizer (Rs.)*	Total volume of water (L)	Pump operation (hrs)	Consumption of Electricity (kWh)	Cost of electricity/ season (Rs.) ‡	Total cost (Rs.)
E_1F_1	290.5:15.8:472.5	670	204,480	35	39.2	313.6	983.6
E_1F_2	332:18.1:540	767	204,480	35	39.2	313.6	1080.6
E_1F_3	415:22.6:675	958	204,480	35	39.2	313.6	1271.6
E_2F_1	290.5:15.8:472.5	670	272,640	40	44.8	358.4	1028.4
E_2F_2	332:18.1:540	767	272,640	40	44.8	358.4	1125.4
E_2F_3	415:22.6:675	958	272,640	40	44.8	358.4	1316.4
E_3F_1	290.5:15.8:472.5	670	340,800	43.2	48.4	387.2	1057.2
E_3F_2	332:18.1:540	767	340,800	43.2	48.4	387.2	1154.2
E_3F_3	415:22.6:675	958	340,800	43.2	48.4	387.2	1345.2

*Cost per kg of Urea: Rs. 5.5, DAP: Rs. 24.0, MOP: Rs. 18.0/kg,
‡ Electricity consumption @ 1.12 kW per hour with discharge rate = 2 lps
‡ Cost of Electricity Rs. 8/Unit

straight orientation of figures, bigger in size. Fruit develops an attractive uniform yellow color with better shelf life & quality than other cultivars.

Materials and Methods

Location of study area : Barabanki district is one of the five districts of Ayodhya division, in the central Awadh region of Uttar Pradesh India. Total area of Barabanki district is 3891.5 sq km. Barabanki district is situated between 27°19' and 26°30' North latitudes, and 80°05' and 81°51' East longitudes.Banana, basically a tropical crop, grows well in a temperature range of 15ºC-35ºC with a relative humidity of 75-85%. It prefers tropical humid lowlands and is grown from the sea level to an elevation of 2000 m above mean sea level. In India, this crop is being cultivated in climates ranging from humid tropical to dry mild subtropics through a selection of appropriate varieties.Chilling injury occurs at a temperature below 12ºC.The high velocity of wind exceeding 80 km/hr. damages the crop. Four months of monsoon (June to September) with an average 650-750 mm. Rainfall is most important for vigorous vegetative growth of bananas. Deep, rich loamy soil with a pH between 6.5-7.5 is most preferred for banana farming. Soil for bananas should have good drainage, adequate fertility, and moisturewhich is available in the study area.

Drip irrigation : Drip irrigation refers to frequent application of small quantities of water on or below the soil surface asdrops. It embodies the philosophy of irrigating the root zone instead of entire land.Banana being a succulent, evergreen and shallow rooted crop requires large quantity of water of increasing productivity. Water requirement of banana has been worked out to be 1800-2000 mm per annum. In winter, Irrigation is provided at an interval of 7-8 days while in summer it should be given at an interval of 4-5 days. However, during rainy season irrigation is provided if required as excess irrigation will lead to root zone congestion due to removal of air from soil pores, thereby affecting plant establishment and growth. In all, about 70-75 irrigations are provided to the crop. Application of drip irrigation and mulching technology has reported to improve water us efficiency.

Table-3 : Economic analysis of different treatment combinations in banana cultivation for 0.011025 hectare of land.

Treat-ments	Fixed and operating cost of cultivation		Fertilizers and irrigation cost		Seasonal total cost of Cultivation		Yield		Gross returns		Net returns		Benefit cost ratio (BCR)
	(Rs. for 0.011025 ha	(Rs. /ha)	Rs. for 0.011025 ha	Rs. / ha	Rs. for 0.011025 ha	Rs. / ha	t for 0.011025 ha	t / ha	Rs. for 0.011025 ha	Rs. / ha	Rs. for 0.011025 ha	Rs. / ha	
E_1F_1	10,672	967982	983.6	89215	11,656	1057197	0.735	66.7	22050	2001000	10,394	943803	1.891
E_1F_2	10,672	967982	1080.6	98014	11,753	1065996	0.754	68.4	22620	2052000	10,867	986004	1.924
E_1F_3	10,672	967982	1271.6	115338	11,944	1083320	0.795	72.1	23850	2163000	11,906	1079680	1.996
E_2F_1	10,672	967982	1028.4	93297	11,700	1061279	0.745	67.6	22350	2028000	10,650	966721	1.910
E_2F_2	10,672	967982	1125.4	102077	11,797	1070059	0.768	69.7	23040	2091000	11,243	1020941	1.953
E_2F_3	10,672	967982	1316.4	119401	11,988	1087383	0.816	74.0	24480	2220000	12,492	1132617	2.042
E_3F_1	10,672	967982	1057.2	95891	11,729	1063873	0.778	70.6	23340	2118000	11,611	1054127	1.989
E_3F_2	10,672	967982	1154.2	104689	11,826	1072671	0.794	72.0	23820	2160000	11,994	1087329	2.014
E_3F_3	10,672	967982	1345.2	122013	12,017	1089995	0.873	79.2	26190	2376000	14,173	1286005	2.179

†Excluding the fertilizers and irrigation cost
*Market price of banana: Rs. 30/kg during March 2018 and March 2019 (average)

There is saving of 58% of water and increase yield by 23-32% under drip. Raw bunch gets matured earlier by 30-45 days and yield is increased by 15-30% and 58-60% of water is saved on irrigation. Water use efficiency of drip was higher and the system saved 50 % of irrigation water. Yield of drip irrigated plants was also higher (B. Cevik, 1988).

The field experiment was conducted during the year 2018 and 2019 at the awadh region of Safedabad, Barabanki, U.P. Healthy sword suckers (2-3 leaf) weighing around 1.5-2 kg each (2.0-2.5 month old) of dwarf cavendishwere planted (spacing = 1.5m × 1.5m) in the square pattern and total study area is 110.25 m2which accommodate 64 plants of banana. The irrigation was provided to the on banana plant by drip method in which first four months from planting water was given @ 15 litre/plant/day, next four month up to developments of shooting water was given @ 20 liter/plant/day from shooting stage to 15 days before harvesting water was given @ 25 liter/plant/day. The ratoon was maintained by retaining only one sucker per plant. The reference crop evapotranspiration (ETo) was taken as the basis to calculate of crop water requirement (Doorenbos and Pruitt, 1977). The volume of water required per plot was computed based on the equation given byVermeiren and Jobling (1980). The drip fertigation was done at three evapotranspiration (ET) based irrigation levels (E_1=0.7 ET, E_2=0.8 ET, E_3=1.0 ET for drip and at three fertilizer levels of recommended doses of fertilizer (RDF) viz., F_1=70% RDF, F_2=80% RDF and F_3=100% RDF laid out in factorial randomized block design with three replications. The water soluble and cheaply available conventional fertilizers were used for the fertigation.

Economic analysis : The economic analysis was carried out to determine the economic feasibility of the crop under standard drip fertigation. For the economic analysis (0.011025 hectare basis), total cost of cultivation, gross returns and net returns were calculated from the yield of banana (64 plants/0.011025 ha). The seasonal cost of drip irrigation system and 1.5 Horse Power water pump includes 4% depreciation, prevailing 10% interest rate, 2% interest for repair and maintenance cost calculated from the fixed cost. The life span of the drip irrigation system was considered to be 10 years. The total cost of cultivation for drip was calculated by considering the cost incurred in land preparation, intercultural operation, fertilizer, crop protection measures, irrigation water and harvesting during the period of experimentation. Gross return from each treatment was calculated from the yield of banana by accounting the prevailing market price during the harvesting periods. Net returns were calculated by subtracting the total cost of cultivation from the gross return. The benefit cost ratio (BCR) was calculated by

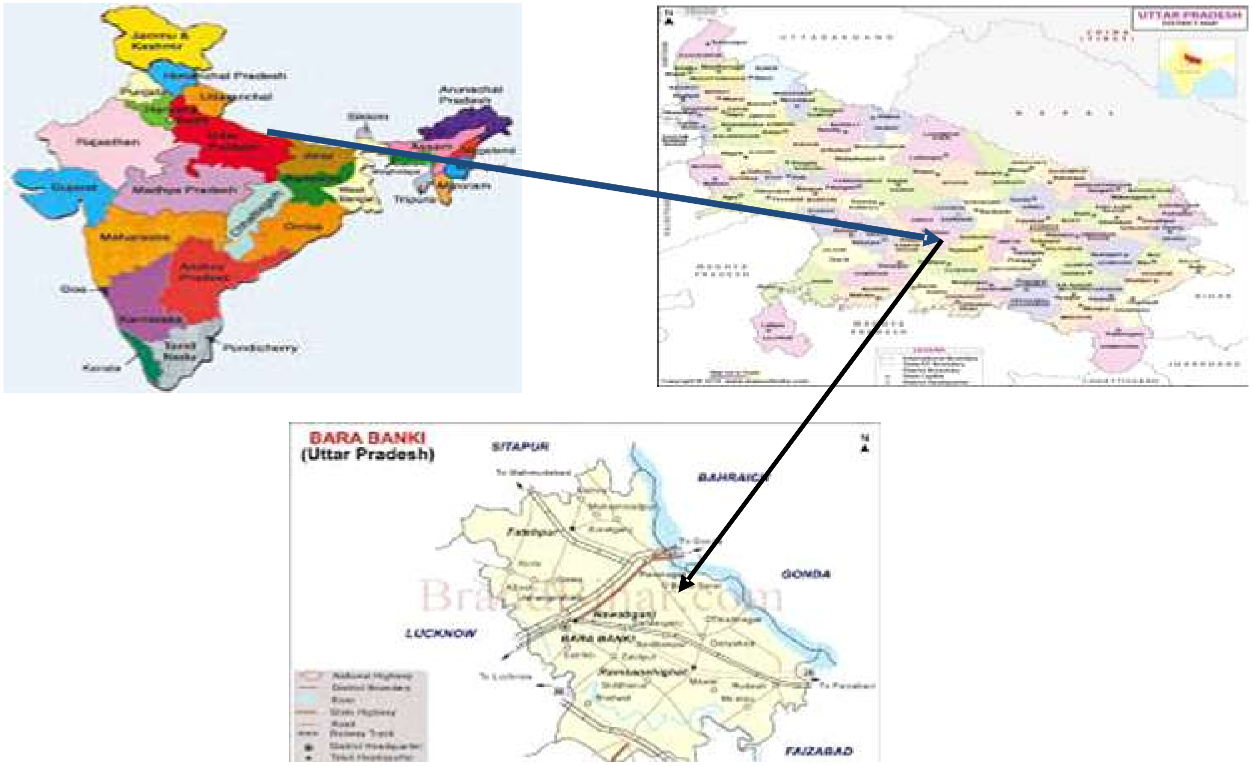

Fig.-1: location of the study area map safedabad barabanki U.P.

dividing the gross returns of each treatment with their respective cost of cultivations.

Results and Discussion

The economics of the drip fertigation systems was worked out to determine the economic feasibility and benefit-cost ratio of the system by considering the cost of standard drip fertigation. The usual life span of the drip system was considered to be 10 years. The operating cost of cultivation accommodated expenses incurred in land preparation and planting, intercultural operation, fertilizers, crop protection measures, irrigation water and harvesting with labour charges. The total cost of banana cultivation was determined by adding the fixed cost and operating cost of cultivation including the different treatments cost. The estimated seasonal cost of cultivation excluding the variable cost of fertilizers and irrigation was found to be Rs. 10672 for the drip irrigation system (Table-1).

The total average volume of water required to irrigate 0.011025 ha of banana field constituting 64 plants (1.5m x 1.5 m) through drip irrigation system was found to be 204.480 m3 for 0.6ETo, 272.640 m^3 for 0.8 ETo and 340.800 m^3 for 1.0 ETo considering 90 percent irrigation efficiency. The treatment costs of irrigation and fertilizer for drip fertigation was found to be highest for E_3F_3 (Rs. 1345.2) and lowest for E_1F_1 (Rs. 983.6) (Table-2).

The gross return of each treatment was calculated by multiplying the yield of banana with the prevailing market price @ Rs. 30/kg during the harvesting periods i.e., March and April of 2018 and 2019 (Table-3). Gross return was observed to be the highest for the treatment combination E_3F_3 (Rs. 26190), followed by the treatment combination E_2F_3 (Rs. 24480) and E_1F_3 (Rs.23850). However, the lowest gross return of Rs. 22050 was obtained from drip irrigation supplemented with 70% of RDF (E_1F_1) (Table 3) which is shown in fig.4. Out of the different drip fertigation treatments, drip irrigation at 1.0 ETo with 100% RDF (E_3F_3) recorded the highest net profit of Rs. 14173, immediately followed by that of drip irrigation at 0.80 ETo with 100% RDF (E_2F_3) exhibiting net profit of Rs. 12492 and drip irrigation at 0.80 ETo with 80% RDF (E_3F_2) showing a net profit of Rs. 11994 (Table 3) which is shown in fig.4.The highest BCR was recorded for the treatment combination E3F3 (2.18) followed by E_2F_3 (2.04) and E_3F_3 (2.014) (Table-3). The higher BCR in the drip fertigation was the consequences of the reduction of cost on irrigation and labour. The maximum yield was found to be 0.873 tonne (E_3F_3) followed by 0.816 tonne (E_2F3) and 0.795 tonne (E1F3) and the lowest yield was found to be 0.735 tonne (E_1 F_2) which are shown in fig.-3.

Similar findings have been reported by Chandrakumar *et al.,* (2001) who recorded the highest

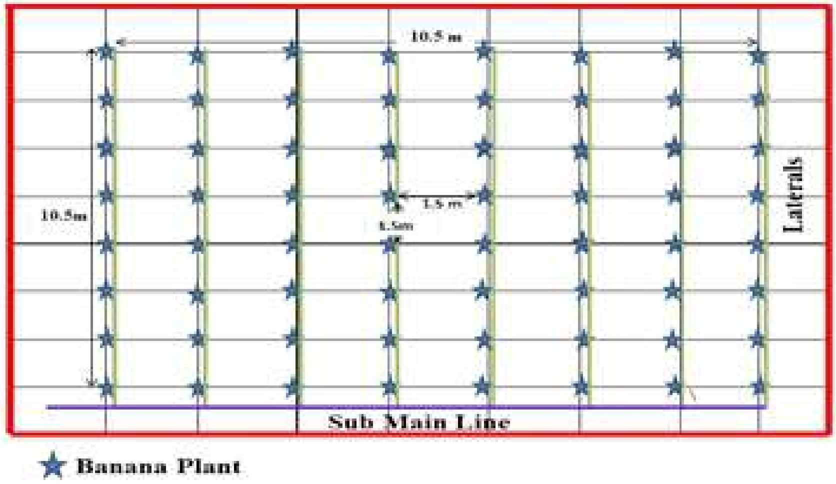

Fig.-2 : Layoutof drip irrigation system for banana cultivation in study area Safedabad, Barabanki.

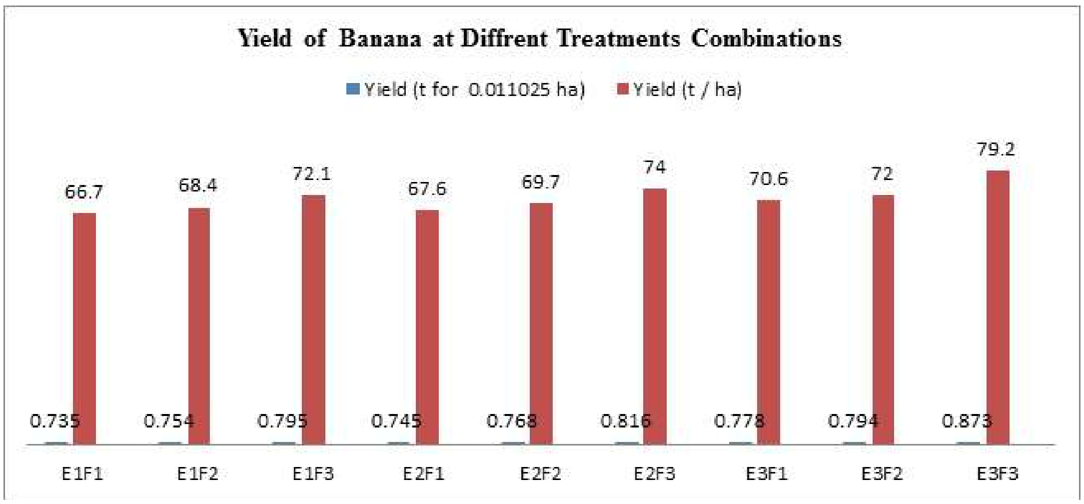

Fig.-3 : Yield of Banana Plant at different Treatments Combinations (t/h, t for 0.011025) in year 2018-19.

BCR was with 150 g/plant/year of N and K fertigation in banana. The BCR of 5.26 has been demonstrated from drip fertigation of banana in Bhawansinagar, Gujarat (AICRP-WM, 2010). More *et al.,* (2005) demonstrated that the major portion of human labour was chiefly used for irrigating the crop leading to the reduction of BCR which was drastically curtailed in drip irrigation system. Increased income in banana crop through drip irrigation has also been reported earlier (Agrawal and Agrawal, 2005; Shashidhara *et.al.,* 2007). Based on the higher average WUE (55.7 kg/ha-mm), average water saving (49.8%) and a higher estimated BCR (4.42), the drip irrigation at 80% evapotranspiration replenishment (0.8 ETo) equivalent to 3181.5 m3/ha/year or 1272.6 litre/plant/year supplemented with 80% RDF (N:P:K =160:40:200 g/plant/year) can be advocated to the farmers of Gangetic plain of India. From the results of the study, it can be concluded that, drip irrigation is by far the most advantageous over conventional surface irrigation in economizing water use in terms of higher water use efficiency and considerable water savings with higher yield of banana. Though the initial investment for laying the drip fertigation system is high and an impediment for resource poor farmers, however, its long-term benefits can be accrued by increasing the monetary returns and hence improving the better economy of small and marginal farmers. Farmers can opt for low cost and easily available fertilizers like Urea, DAP, and MOP. The future of the banana cultivation practice in 21st century lies in the use of fertigation method through drip irrigation.

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Management of Sesame (*Sesamum indicum* L.) Phyllody Caused by Phytoplasma

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Abstract

Phyllody caused by phloem limiting phytoplasma is a very serious disease in sesame. Effect of different date of sowing, use of intercrops showed that both leaf hopper population and per cent disease incidence were found minimum at early sowing *i.e.* before 30th July (6.03 per cent) and intercropping with cowpea in 1:1 ratio having least mean disease incidence (10.33 per cent) followed by 10th August (9.40 per cent) and intercropping with cowpea in 2:1 ratio, respectively.

Key words : *Diseases, incidence, leaf hopper, treatment, phyllody, phytoplasma.*

Introduction

Sesame (*Sesamum indicum* L.) belongs to family pedaliaceae, which have basic chromosome number 2n =26 and originated in India. It is also Known as *til* (Hindi), *tal* (Gujarati), *till* (Panjabi), *nuvvulu* (Telugu), *ellu* (Tamil) and *ragi* (oriya) in different til growing parts of India. Sesame crops suffers from many fungal, viral, bacterial and phytoplasma diseases. The diseases such as Phytopthora blight (Butler,1918), Root rot (Mehta,1951), Bacterial blight (Rao,1962; kolte,1985; Vyas *et al.* 1984), Bacterial leaf spot (Vyas *et al.*1984; kolte,1985), Cercospora leaf spot (kolte,1985), Alternaria leaf spot (Kolte, 1985), Powdery mildew (Rajpurohit,1993), Phyllody (Gibbon MC,1924; Kashiram, 1930) etc.

Among all the above mentioned diseases phyllody is a severe disease of sesame which cause a major loss in crop yield in most of the crop growing region, chiefly in warm areas (Manjunath, 2012).

Sesame phyllody was first reported in Burma (Myanmar) and was nominate as "*Green flowering disease/ Pothe*" (Gibbon MC, 1924). Later, it was reported in India as plant appear phyllody such as symptoms and was called filamentous Phytoplasma diseases reported in many crops like cereals, oilseeds, ornamentals, fruits, vegetables, plantations, weeds and spices crops also. In phytoplasma diseases phyllody is important disease which is observed on many host plant in which sesame, chickpea, brinjal, mungbean, pigeon pea, parthenium and black paper are commonly remark host plant which is infected by phytoplasma phyllody disease. First report of phytolasma as plant pathogens responsible for yellows disease (Doi *et al.* 1967). Phytoplasma are covered by single unit membrane, lacking rigid cell wall, pleomorphic in shape with average diameter of 0.2 – 0.8 ìm and transmitted is mainly occur by sap sucking insect vectors belonging to families Cicadellidae (Leaf hopper) and Fulgoridae (Plant hopper). Transmission of sesame phyllody disease is occured by leaf hopper (*Orosius albicinctus*), grafting and dodder. There is no transmission by sap.

Insect vectors plays an important role in the transmission of MLOs. Ghauri (1966) identified the same vector as *Orosius albicinctus Dist.*. Sesame phyllody could be managed either by using resistant cultivars or by using insecticides against leaf hopper vectors. Crop hygiene practices which help to decrease phyllody incidence in sesame are early rouging of symptomatic plants, reduction on growing susceptible varieties and control of host plants of the leaf hopper vectors. Some of the cultural methods, particularly rotation management, sowing dates could also be abundant applied (Beech, 1981).

Materials and Methods

Effect of sowing dates on sesame phyllody

Experiment details

Season	:	*Kharif* - 2019
Plot size	:	Gross : 2.1 x 2.0 m^2
Spacing	:	30 x 15 cm
Design	:	Randomized block design (RBD)
Variety	:	Local
Replications	:	Four
Treatments	:	Five

Table-1 : Effect of different dates of sowing on leaf hopper population and disease incidence of phyllody in sesame.

Date of sowing	Number of leaf hopper/leaf*	*Per cent Disease Incidence
30th June	0.82	16.52 (23.98)
10th July	0.72	14.92 (22.72)
20th July	0.84	21.40 (27.56)
30th July	0.42	6.83 (15.15)
10th August	0.54	9.40 (17.85)
SEm ±	0.03	0.50
CD (p= 0.05)	0.12	1.62

* = Mean values of four replications (Angular transformed value given in parenthesis).

Table-2 : Effect of Intercrops on leaf hopper population and disease incidence of phyllody in sesame.

Tr. No.	Treatments	Number of leaf hopper/leaf*	*Disease incidence (%)
T_1	Sesame + Mung bean (2:1)	2.15	27.02 (31.32)
T_2	Sesame + Mung bean (1:1)	1.98	23.65 (29.10)
T_3	Sesame + Moth bean (2:1)	1.40	15.14 (22.90)
T4	Sesame + Moth bean (1:1)	1.09	13.64 (21.64)
T_5	Sesame + Mung bean mix (1:1)	2.03	24.24 (29.49)
T_6	Sesame + Moth bean mix (1:1)	1.69	15.38 (23.09)
T_7	Sesame + cowpea (2:1)	0.98	12.39 (20.61)
T_8	Sesame + cowpea (1:1)	0.86	10.33 (18.75)
T_9	Sole crop	2.37	28.30 (32.14)
	SEm ±	0.08	0.69
	CD (P=0.05)	0.23	2.08

Treatment details

D1 - 30th Jun

D2 - 10th July

D3 - 20th July

D4 - 30th July

D5 - 10th August

Observations : Leaf hoppers were recorded early in the morning on top, middle and bottom leaves of randomly selected plants. Leaf hopper count were recorded from 7 days after germination with an weekly interval. Regular observations on phyllody were recorded from appearance of the disease and subsequent at 15 days interval up to the harvest of crop. Disease incidence was calculated by using the formula as mentioned below.

$$\text{Per cent disease incidence (PDI)} = \frac{\text{No. of plants infected}}{\text{No. of plants observed}} \quad 100$$

Effect of Inter cropping on sesame phyllody

Experiment details

Season : *Kharif* - 2019

Plot size : Gross : 2.1 x 2.0 m^2

Spacing : 30 x 15 cm

Design : Randomized block design (RBD)

Variety : Local

Replications : Three

Treatments : Nine

Treatments

Observations : Leaf hoppers were recorded early in the morning on top, middle and bottom leaves of randomly selected plants. Leaf hopper count was recorded from 7 days after germination with a weekly interval. Regular observations on phyllody were done from appearance of the disease and subsequent at 15 days interval up to the harvest of crop. Observations of disease incidence as well as insect populations was recorded near maturity all the intercropped sesame plants. Percent disease Incidence was calculated by using the formula as mentioned below.

$$\text{Per cent disease incidence (PDI)} = \frac{\text{No. of plants infected}}{\text{No. of plants observed}} \quad 100$$

Results and Discussion

Phyllody of sesame is one of the major disease causing considerable yield loss. Date of sowing, Intercropping, management through different chemicals and bio pesticides on the incidence of sesame phyllody was investigated with an objective to find out the suitable package of efficient management of the disease.

Effect of different dates of sowing on leaf hopper population and disease incidence of phyllody in sesame : The effect of different dates of sowing on leaf hopper population, disease incidence was studied and

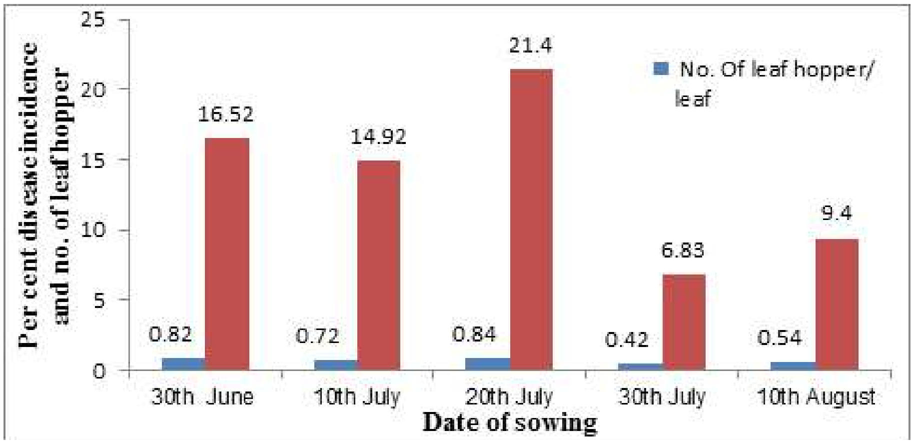

Fig.-1 : Effect of different dates of sowing on leaf hopper population and disease incidence of phyllody in sesam.

Plate-1 : Field representing different dates of sowing.

Plate-2 : Field showing effect of Intercrops.

presented in Table-1, Fig.-1 and Plate-1. The maximum number of leaf hopper was observed in 20th July sown crop (0.84) followed by 30thJune sown crop (0.82). The minimum leaf hopper population was observed 30th July sown crop (0.42) followed by 10th August sown crop (0.54). Among all the sowing dates, significantly superior disease incidence was observed in 20th July sown crop *i.e* (21.40 per cent) followed by 30th June sown crop. Result indicated that, treatment 20th July recorded highest disease incidence (21.40 per cent) where as minimum disease incidence (6.83 per cent) was reported in 30th July sowing followed by 10th August (19.40 per cent). It also indicates that, early sowing favours the disease development whereas late sowing after 30th July or in August month was most suitable dates for sowing sesame crop for management of sesame phyllody.

From the results obtained on the sesame phyllody incidence, vector population per leaf. It can be concluded that 30th June and August 10th are the best sowing dates for the sesame crop as the appropriate period in which sowing can be done to minimize the disease incidence.

Similarly Choudhari and Prasad (2007) studied effect of weather parameter and vector population on incidence and development of phyllody disease study reported that, sesame crop sown on June 5th recorded highest incidence of phyllody 28.6% and 26.5% during *Kharif*-2002 and 2004, a low disease incidence was recorded with late date of sowing and low leaf hopper vector population in crop sown on July 15 and July 25.

Dehghani *et al.* (2009) reported that the effect of sowing date on sesame phyllody disease, among the five date of sowing (June 8, 22 and July 6, 16, 28) highest yield and lowest disease incidence were obtained with late date of sowing July 28.

Hosseini *et al.* (2015) studied the status of sesame phyllody and its control methods and reported that, sowing date and spraying have significant effect on infection of phyllody. Delay in sowing date reduce sesame phyllody up to 31% also reported that, sowing of sesame in July 5 reduce diseases incidence.

Effect of Intercrops on leaf hopper population and disease incidence of phyllody in sesame : Effect of inter crops on leaf hopper population and incidence of phyllody disease in sesame at maturity stage of crop was studied and results are presented in Table 2, Fig.2 and Plate 2. The per cent disease incidence and vector populations varied significantly among the different inter crops. The maximum number of leaf hopper was recorded when inter crop mung bean used as inter crop (Sesame + Mung bean 2:1) with 2.15 vector population per leaf. The minimum leaf hopper population was recorded when inter crop cowpea used as inter crop (Sesame + cowpea 1:1) with vector populations 0.86 per leaf.

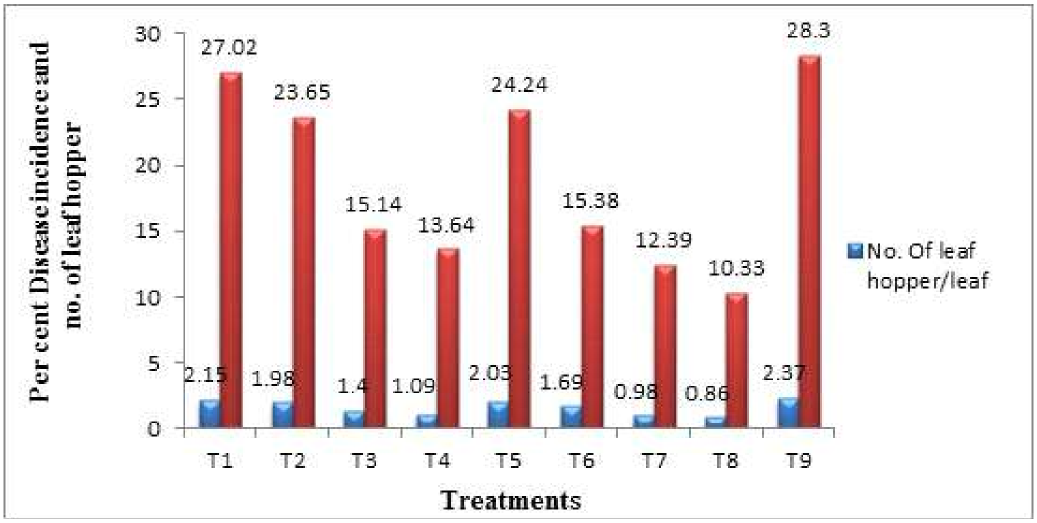

Fig.-2 : Effect of Intercrops on leaf hoppers populations and disease incidence of phyllody in sesame.

All the treatments were found more effective in reducing disease incidence over control. Result revealed that, in maturity stage of crop minimum disease incidence was recorded when inter crop cowpea used as inter crop (Sesame + cowpea 1:1) followed by cowpea (Sesame + cowpea 2:1). The next best treatment was recorded when inter crop moth bean used as inter crop (Sesame + Moth bean 2:1). The disease incidence recorded varied ranged from 10.33 to 27.02 per cent as against 28.30 per cent in sole crop. However among all the treatments cowpea used as inter crop (Sesame + cowpea 1:1) recorded least mean disease incidence (10.33%) and this was followed by cowpea (Sesame + cowpea 2:1) 12.39 per cent, moth bean (Sesame + Moth bean 1:1) 13.64 per cent, moth bean (Sesame + Moth bean mix 1:1) 15.14 per cent, moth bean (Sesame + Moth bean mix 1:1) 15.38 per cent, Mung bean (Sesame + Mung bean 1:1) 23.65 per cent, Mung bean (Sesame + Mung bean mix 1:1) 24.24 percent, Mung bean (Sesame + Mung bean 2:1) 27.02 per cent, and sesame used as sole crop 28.30 per cent.

From the result obtained (Table 4.8 and Fig. 4.4) on the sesame phyllody incidence and vector population, it can be concluded that cow pea and Moth bean sown as inter crop are the best for sesame crop for reducing the incidence of phyllody disease.

Conclusions

The effect of dates of sowing on leaf hopper population and disease incidence were revealed that, leaf hopper population was minimum when crop sown on 30th July, with disease incidence 6.83 per cent with respect to other hand maximum leaf hopper population recorded on when crop sown on dated 20th July, with disease incidence 21.40 per cent.

Effect of inter crops on leaf hopper population and incidence of phyllody disease in sesame at maturity stage of crop was studied and results indicate that the per cent disease incidence and vector populations varied significantly among the different inter crops. The maximum number of leaf hopper was recorded when mung bean used as inter crop (Sesame + Mung bean 2:1) with 2.15 vector population per leaf with 27.02 per cent disease incidence, where as the minimum. The minimum leaf hopper population was recorded when cowpea used as inter crop (Sesame + cowpea 1:1) with vector populations 0.86 per leaf showed minimum disease incidence *i.e* 10.33 per cent, respectively. It was also observed that the sesame phyllody incidence and vector population can be minimize with cow pea sown as inter crop.

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Evaluation of Frontline Demonstration of Green Gram (*Vigna radiata* L.) in Haveri District of Northern Karnataka

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Abstract

Green gram or Mungdal (*Vigna radiata* L.) is an important pulse crop in India, plays a major role in augmenting the income of small and marginal farmers of Northern Karnataka. The low production of traditional varieties of green gram was a cause of concern for the farmers at large. To overcome this problem of low yield, ICAR-Krishi Vigyan Kendra in Haveri district has conducted frontline demonstration in field of adopted villages. The present study was conducted by KVK, Haveri during 2016-17 and 2017-18 during *kharif* season with twenty frontline demonstrations in Itagi, Balambeeda and Lakumapura villages of Haveri district. The results of demonstrations showed that cultivation of high yielding variety DGGV-2 of green gram has given yield increase of 28.73 and 20.25 percent during 2016-17 and 2017-18, respectively over local check. The technology gap ranges from 8.49 and 1.50 during 2016-17 and 2017-18, respectively. The highest extension gap of 1.60 was recorded during 2017-18. This high extension gap requires urgent attention from planners, scientists, extension personnel and development departments. The technology index varies from 60.64 and 10.71 during 2016-17 and 2017-18, respectively. The changes will accelerate the adoption of newer technologies to increase the productivity of green gram in this area. There is a need to adopt multi-pronged strategy which involves enhancing green gram production through horizontal and vertical expansion and productivity improvements through better adoption of improved technology.

Key words : *Extension gap, farmers practice, frontline demonstration, green gram, technology gap, technology index.*

Introduction

Pulses have great importance in Indian agriculture as they are rich source of protein (17 to 25 per cent) as compared to that of cereals (6 to 10 per cent), their ability to fix atmospheric nitrogen and improve the soil fertility. Among pulses, green gram is one of the most important crop. Protein malnutrition is prevalent among men, women and children in India. Pulses contribute 11 per cent of the total intake of proteins in India (Reddy, 2010). In India, frequency of pulses consumption is much higher than any other source of protein, which indicates the importance of pulses in their daily food habits. Keeping the cheapest source of protein, it is important to increase pulses production to increase balanced diet among the socially and economically backward classes. With 35 per cent of world area and 27 per cent of production, India is the largest pulse producing nation.

Green gram crop is one of the important pulse crops in Northern Karnataka. Green gram contains 25 per cent of high digestible proteins and consumed both as whole grain as well as dal. It is a soil building crop which fixes atmospheric nitrogen through symbiotic action and can also be used as green manure crop adding 34 kg N ha^{-1}. The improved technology packages were also found to be financially attractive. Yet, adoption levels for several components of the improved technology were low, emphasizing the need for better dissemination (Kiresur *et al.,* 2001). Several biotic, abiotic and socio-economic constraints inhibit exploitation of the yield potential and these needs to be addressed. Crop growth and yield are limited through poor plant nutrition and uncertain water availability during the growth cycle. Inappropriate management may further reduce the fertility of soil (Rabbinge, 1995). The green gram crop is mainly cultivated in *kharif* season. Frontline demonstration on green gram using new crop production technology was initiated with the objectives of showing the productive potentials of the new production technologies under real farm situation over the locally adopted production technologies.

Materials and Methods

Frontline Demonstration is the new concept of field demonstration evolved by ICAR with the inception of technology mission on oilseeds and pulses. The main objective of frontline demonstrations is to demonstrate newly released crop production technologies and its management practices in the farmer's field. The present investigation was carried out at adopted villages (Itagi,

Table-1 : Details of green gram growing under Existing Farmer's Practices and Improved Practices adopted in Frontline demonstrations at farmer's field in Haveri district of Northern Karnataka.

Sl. No.	Operations	Existing farmer practices	Improved/recommended practices adopted in Demonstrated plot (FLDs)
1.	Variety	Local	DGGV-2
2.	Time of Sowing	June-July	June-July
3.	Seed Treatment	Not done	Rhizobium @ 500 g/ha^{-1} of seed material
4.	Nutrition	Lower dose of Nutrition	RDF (25:50:20 kg ha^{-1})
5.	Method of sowing	Broadcasting	Line sowing
6.	Plant Protection Measures	Non-adoption of recommended package of practices	Spraying of Imidacloprid @ 250 ml ha^{-1}
7.	Weed management	Not done	Spraying of Pendimethalin 30 EC @ 3.25 lt ha^{-1}

Table-2 : Performance of Front-Line Demonstrations (FLD) of Green gram in Haveri district of Northern Karnataka.

Sl. No.	Year	Area (ha)	No. of farmers	Seed yield (q/ha)			% increase over control	Technology gap	Extension gap	Technology index (%)
				Potential	Demonstration	Control				
1.	2016-17	4	10	14	5.51	4.28	28.73	8.49	1.23	60.64
2.	2017-18	4	10	14	12.5	10.9	20.25	1.50	1.60	10.71
		Average			9.00	7.59	24.49	5.00	1.42	35.68

Table-3 : Economics of improved technologies and farmers practice in green gram.

Year	Total cost of cultivation (Rs. ha^{-1})		Gross returns (Rs. ha^{-1})		Net returns (Rs. ha^{-1})		B:C ratio	
	Demo	Farmers practice	Demo	Farmers practice	Demo	Farmers practice	Demo	Farmers practice
2016-17	5800	5500	23163	17094	17363	11514	3.99	3.10
2017-18	19380	19215	62500	54500	43120	35285	3.22	2.84
Average	12590	123575	42832	35797	30242	23400	3.61	2.97

Balambeeda and Lakumapura) of ICAR-KVK, Haveri district, Karnataka state. The materials for the present study comprised high yielding genotype of green gram (DGGV-2). Locally cultivated variety were used as local check. The soil type was medium to low in fertility status. The objective of evaluation was to study the gaps between the potential yield and demonstration yield, extension gaps and the technology index. In the present study the data on output of green gram crop were collected from FLD plots, besides the data on local practices commonly adopted by the farmers of this region to estimate the technology gap, extension gap and the technology index. The following formulae have been used for calculating the different indices (Samui *et al.*, 2000 and; Sagar and Chandra Ganesh, 2004).

Technology gap = Potential yield - Demonstration yield

Extension gap = Demonstration yield - Farmers yield

Technology index=((Potential yield - Demonstration yield) / Potential yield) 100

Results and Discussion

Frontline demonstration was conducted on 08 hectares of land on 20 demonstration plots. The high yielding genotype of green gram DGGV-2 was used for study. On an average the yield increase was 24.49 q ha^{-1} during the study period. The result indicates that the frontline demonstration has given a good impact over the farming community of Haveri as they were motivated by the new agricultural technologies applied in the FLD plots. Yield of green gram was, however varied in different years, which might be due to the soil moisture availability and rainfall condition, climatic aberrations, disease and pest attacks as well as the change in the location of trials every year. The DGGV-2 had performed well when compared to local check. The per centage increase in the yield over local check was 28.73 and 20.25 during two subsequent years (2016-17 & 2017-18). The technology gap, gap in the demonstration yield over potential yield ranges from 8.49 and 1.50 per cent during 2016-17 and 2017-18, respectively. The technology gap observed may be attributed to dissimilarity in the soil fertility status and weather conditions as well as the soil moisture availability. Hence, location specific recommendation appears to be necessary to bridge the gap between the yields of different technologies. The highest extension gap of 1.60 was recorded during 2017-18. This emphasized the need to educate the farmers through various means for more adoption of newly improved agricultural technologies to bridge the wide extension gap. More and more use of new high yielding varieties by the farmers will subsequently change this alarming trend of galloping extension gap. The new technologies will eventually lead to the farmers to discontinuance of old varieties with the new technology. This high extension gap in all these varieties requires urgent attention from planners, scientists, extension personnel and development departments. The technology index shows the feasibility of the evolved technology at the farmers' field. The lower the value of technology index, more is the feasibility of the technology. The highest technology index were 60.64 percent for the year 2016-17 and lowest in 2017-18 with 10.71 per cent in Haveri district, only a small chunk of farmers has access to irrigation or affordable chemical inputs and where growth and yield reducing losses, farmers' actual yields are less than its genetic potential. Sustainable intensification strategies for Haveri district requires improved soil, water and nutrient management innovations. Green gram cultivation has also ensured sustainable natural resource management objectives. Vulnerability to natural disasters can substantially be reduced through the adoption of green gram cultivation because of the improvement in productivity, increase in cash income and acquired assets that families can fall back on when disasters occurs. Direct involvement of beneficiaries in adopting green gram cultivation technology suitable to their condition has given high payoffs in terms of enthusiasms and interest and also in ensuring that the technology addresses the priority needs that have been identified by the beneficiaries.

Despite the low soil moisture availability, climatic and natural aberrations faced in the region, DGGV-2 had given a very good result in comparison to local check. These technologies may be popularized in this area by the state agriculture departments and extension agencies to mitigate the large extension gap. Mainly small and marginal farmers are associated with the cultivation of arhar in the region and the use of new production technologies will substantially increase the income as well as the livelihood of the farming community. There is a need to adopt multi-pronged strategy which involves enhancing green gram production through horizontal and vertical expansion and productivity improvements through better adoption of improved technology. In the fragile environments and poor farm resource base, green gram is the best choice for farmers. Cultivation of green gram also helps in protecting the environment from the risk of high input agriculture.

Economic return : The input and output prices of commodities prevailed during the demonstrations were taken for calculating cost of cultivation, gross return, net return and benefit/cost ratio. Data in table 3 reveals that the cost involved in the adoption of improved technology in green gram ICM varied and was more profitable. The cultivation of green gram under improved technologies gave higher net return of Rs. 17363 and 43120 ha^{-1} respectively, as compared to farmers practices (Rs. 11514 and 35285 ha^{-1} during 2016-17 and 2017-18, respectively). An average net return and B:C ratio of demonstration field is Rs. 30242 ha^{-1} and 3.61, respectively as compared to farmers practice (Rs 23400 ha^{-1} and 2.97). The benefit cost ratio of ICM of green gram under improved cultivation practices was higher than farmer's practices in both the years and this may be due to higher yield obtained under improved technologies compared to local check (farmer's practice). This finding is in corroboration with the findings of Mokidue *et al.* (2011).

Reasons for low yield of green gram at farmers' fields : Optimum sowing time was not followed due to non-availability of quality seed. More than 90 per cent of the farmers had been sowing seed as improper method due to which the plant population was sometimes 2-3 times more than the recommended one. Farmers were cultivating the local variety of green gram, which is low yielding, susceptible to mung bean Yellow Mosaic Virus (YMV), leaf crinkling and powdery mildew diseases. For control of these pests and diseases farmers were using pesticides indiscriminately which has led to increased cost of cultivation.

Conclusions

In the frontline demonstrations there was an average increase of 24.49 per cent in grain yield over the local check. Such increase was recorded with average net returns of Rs.30242 ha^{-1}. As found in the results the BCR (3.61) was sufficiently high to motivate the farmers for adoption of the technologies. These demonstration trials also enhance the relationship and confidence between farmers and KVK scientists. The recipient farmers of FLDs also play an important role as source of information and quality seeds for wider dissemination of the improved varieties of green gram for other nearby farmers. It is concluded that the FLD programme was a successful tool in enhancing the production and productivity of green gram crop through changing the knowledge, attitude and skill of farmers.

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Review of Soybean Breeding for Disease and Insect Resistance

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Abstract

Soybean (*Glycine max* [L.] Merr.) is a significant commercial annual legume crop, but several abiotic and biotic restrictions threaten its production. Pests of soybean are a key biotic limitation to soybean productivity and quality. Soybean crop losses due to animal pests, diseases, and weeds average 26–29% globally. More than 135 crop diseases have been found, with about 30 species estimated to be capable of inflicting significant economic damage. There are already 35 diseases found in India, 14 of which are deemed significant due to yield loss severity. This review examines the damage and yield losses in soybean caused by plant diseases such as Charcoal Rot, Soybean Rust, Mungbean Yellow Mosaic Virus, and insect pests such as Girdle Beetle, Armyworm, and Whitefly, as well as the breeding strategies used to develop resistant varieties and the latest developments in resistance breeding programs and practices to alleviate these constraints.

Key words : *Soybean, charcoal rot, soybean rust, mungbean yellow mosaic virus, girdle beetle, armyworm, whitefly.*

Introduction

Soybean (*Glycine max* [L.] Merr.) is indeed an important economic annual grain legume, accounting for more than half of worldwide oilseed output. Soybean is a good source of edible oil (18–22%), protein (40–42%), minerals, and vitamins (1). Diseases and insects are major stumbling blocks to yields. Phytopathogenic microorganisms parasitize soybean (*Glycine max* (L.) Merr.) and induce a variety of degenerative changes in the plant. In India, 35 diseases have indeed been discovered, 14 of which are considered serious due to the severity of yield loss. Viruses, sclerotium blight, anthracnose, rust charcoal rot, and rhizoctonia aerial blight caused the greatest yield reduction in 2006. (2). The variety of diseases afflicting soybean has increased dramatically, according to the fifth edition of the Compendium of Soybean Diseases and Pests (3). Fungi, viruses, and bacteria are the three types of pathogens that directly impact soybean crops. Fungi are the most dangerous, followed by bacteria, viruses, and phytoplasmas. According to (4) and (5), disease losses averaged about 9%. Although fungi are the most common pathogens that impact seed, viruses and bacteria can cause significant soybean seed infections. Similar losses are caused by insect damage. Despite the fact that there are over 700 plant-feeding insect species in soybean (6), just a few are responsible for the majority of the damage. Girdle beetle, stem fly, tobacco caterpillar, green semi looper, and whitefly are the most common insect pests infecting soybean in India. *Aphis glycines* and *Bemisia tabaci*, for example, spread various viruses in several key crops, including soybean (7), (8) and (9). The majority of insect pests are treated chemically (10); however, the chemicals used have a detrimental influence on the ecosystem and several other beneficial creatures. Off-target effects of insecticides on non-target species are also a significant concern, and certain pesticides are quite persistent in the environment (11, 12). The losses are caused by a decrease in yield and grain quality and a reduction in seed quality in soybean produced for seed. To develop economically viable, environmentally sound, and socially acceptable pest control techniques, complete information on the disease and insect pest complex, their status, and chronology of emergence over the crop season, losses, and kind of damage is critical. The study focuses on the impact of diseases and insects on seed quality. Only a small amount of study has been conducted on the influence of infections and insects on these features, but this will change as humanity establishes markets for these and other quality attributes and develops speedy, reliable evaluation systems for these traits. In India, roughly 20 major insect species attack soybean crops, and the damage potential of specific big insect-pests ranges from 20 to 80 percent depending on the insect and crop stage (13). If the insect-pest load is appropriately managed, an average additional yield of 27 percent can be obtained (14). This review looks at the existing context in which plant breeders work and the steps that must be taken to improve the soybean crop for higher food production.

Major Diseases

Charcoal Rot (*Macrophomina phaseolina*) : *M. phaseolina* is a polyphagous fungus found in soil and seeds that causes charcoal rot and summer wilt in soybean. The disease is known as charcoal rot because the excessive formation of miniature black microsclerotia causes the affected plant tissue to blacken (15). This thermophilic fungus prefers dryness and warm temperatures. It promotes seedling deterioration in the tropical and subtropical zones, drastically lowering the crop canopy (16). The infection begins on the root and then spreads to the lower part of the stem and higher root region. During the dry and hot summer, 40-50 percent of plants may be affected, resulting in a 20-25 percent reduction in production (17). The fungus was discovered to have a detrimental impact on all key elements of soybean yield. Drought tolerance is intimately linked to *M. phaseolina* resistance breeding. Soybean drought tolerance is frequently associated with resistance to charcoal rot. In the afflicted locations, it is thus suggested to cultivate genotypes whose generative phase of growth does not overlap with the dry period (18). Because of unpredictable rainfall and longer periods of drought, charcoal rot has resulted in more yield loss in India since 2004. On some farms, yield loss has reached 77 percent. *M. phaselolina* and Rhizoctonia solani are inhibited by the soybean phytoalexin gyceollin (19). Charcoal rot is found throughout the world in the tropical and subtropical regions and the north-central and southern regions of the United States (20). It infects over 500 economically important species, including maize, sorghum (21), and sunflower (22). Cultural approaches, seed-applied fungicides, and biocontrol are examples of CR management options in soybean; however, they have not been effective or generally adopted, and they have given limited control (23). Host resistance may be the best option for preventive measures because it is less expensive and more environmentally friendly. (24, 25 and 26) examined the roles of mycelia and microsclerotia units within soybean tissues in providing disease resistance. Complete immunity has not been recorded in any species; however, partial resistance has been identified in soybean, such as DT-97-4290, which is used as a disease check standard (22). GWAS are used to uncover genetic variants of key characteristics such as disease resistance by associating variance throughout the whole genome with phenotypes (27). Many studies have noticed differences in *M. phaseolina* colonization of root tissue across soybean varieties (28). The identification of genetic markers linked to the charcoal resistance gene might greatly simplify breeding material screening and accelerate the development of new resistant cultivars (29). There has been progressing in the development of mapping populations to map QTL for charcoal rot resistance in soybean, and the discovery of associated molecular markers is ongoing (29). Genome-wide association studies have been recognized as a highly effective method for exploring SNP-disease relationships and interpreting trait inheritance patterns. It is better adapted to genomic selection procedures than marker-assisted selection (MAS) due to its quantitative character. MAS is insufficient for enhancing quantitatively inherited, i.e., polygenic attributes (30). Although soybean genotypes with adequate resistance exist, little work has been done to incorporate resistance into cultivated varieties.

Soybean rust (*Phakopsora pachyrhizi*) : The fungus *P. pachyrhizi* causes Asian soybean rust (ASR), among the most destructive plant diseases. The disease has emerged as the most serious possible danger to key soybean growing areas in Brazil, Paraguay, Bolivia, and Northern Argentina (31). The pathogen infects soybean plants at any growth stage (32). Soybean rust is one of India's most serious soybean diseases, reducing yields by up to 100% depending on the period of infection, variety sown, and environment. It generally appears in India between the third and fourth weeks of July and the final week of September. This virus thrives on volunteer and winter planted soybean in southern India during the rainy season and then spreads to soybean in more northern locations. Many management measures have been attempted to avoid and reduce the effect of soybean rust. The most successful technique for reducing the effects of soybean rust has been thought to be chemical treatment using fungicides. The limited number of acceptable fungicides, precise application needs, increased cost of production, environmental harm and the establishment of fungicide resistant races are the primary drawbacks of employing fungicides, despite the enormous advantages (33). As a result, disease resistance may be used to produce an environmentally friendly, cost-effective, and long-term management of the illness (3, 34). Six dominant resistance genes to P. pachyrhizi (Rpp1-Rpp6) have been identified. Depending on the *P. pachyrhizi* isolates, these genes may also be recessive (35, 36, and 37). All the Rpp genes have been mapped to particular chromosomes or linkage groups (LGs): Rpp 1 on LG-G chromosome 18; (37), Rpp 2 on LG-J chromosome 16; (38), Rpp3 on LG-C2 chromosome 6; (39), Rpp4 on LG-G (38), and Rpp6 on LG-G (40). Furthermore, even though the rust fungus lacks sexual reproduction, there is significant pathogenic heterogeneity in rust populations. As a result, there are no soybean cultivars resistant to all known races of *P. pachyrhizi*. Backcrossing Rpp1, Rpp1-b, (Hyuuga), and Rpp5 into MG II and MG IV elite backgrounds were used to produce the NILs released by the University of Illinois (41). Additional NILs with Rpp1, Rpp2, Rpp3, and Rpp4 backcrossed into an MG VII superior background have been generated by the University of Georgia (42). Furthermore, the Georgia Agricultural Experiment Stations produced a breeding line in 2007 that introduced the Rpp(Hyuuga) gene into the background of "Dillon" (MG VI) (43). Yamanaka (44) recommended using Rpp-pyramided lines carrying Rpp2, Rpp4, and Rpp5, which are potential resistance breeding materials due to their strong and generally persistent resistance to all tested ASR inocula and in all genetic environments evaluated.

Mungbean Yellow Mosaic Virus : Yellow mosaic virus (YMV), caused by the mungbean yellow mosaic virus, is one of India's most frequent soybean diseases. Usharani (45) speculated that at least three different viruses were involved and also identified the virus isolated from YMD-affected soybean plants in northern and central India as soybean isolate of MYMIV-(Sb) due to its 89 percent resemblance to Mungbean yellow mosaic India virus (2004). Because MYMIV has a limited number of natural resistant sources, traditional breeding efforts to generate resistant cultivars are restricted. The soybean accession PH71443/UPSM534 is commonly employed as a group of natural MYMIV resistance in breeding operations. According to inheritance studies, resistance in UPSM534 is governed by two recessive loci, rym1 and rym2. Researchers previously explored that a field-resistant cultivar PK416, derived from UPSM534, when administered by agro-inoculation, was also resistant to MYMIV. After infection with MYMIV by whitefly or agro-inoculation, PK416 did not exhibit yellow mosaic symptoms. B-23J (coded as NRC-94, derived from Ankur x PK 1024) was developed as a YMV-tolerant, high-yielding line with various disease resistance demonstrated in AICRP trials. (46) Discovered 21 genotypes with full resistance in-field testing. Gill et al. (47) created SL 958 of soybean by pedigree approach from a hybrid of two yellow mosaic resistant varieties, SL 525 x SL 706 from NPZ in 2014. It was first reported that a double recessive gene governs the trait inheritance in PI171443 (48).

In contrast, (48) identified a monogenic recessive gene in PI 171443 and SL 525 for the trait. In two resistant cultivars, DS9712 and DS9814, (50) showed the trait's dominant and monogenic genetic inheritance. Because the genealogy of these two kinds could not be connected to a known source of YMV resistance, the results reported in their study might be attributed to the escapes of susceptible plants due to low disease pressure on a completely another gene. According to (49), the MYMIV resistance gene was found on chromosome 6 (LG C2) near two SSR markers, Satt 322 and GMAC7L Resistance to YMV was shown to be dominant and regulated by a single main gene in F1 and F2 populations of four crossings involving two highly resistant varieties UPSM-534 and PK-416 and two highly susceptible genotypes JS-335 and AMS-353 (51). (*Vigna mungo* L. Hepper). Ma et al. (52) discovered and mapped markers connected to the SMV resistance gene. Using composite interval mapping, one significant quantitative trait locus (QTL) on chromosome 6 accompanied by the markers Satt281, Sat 076, and one on chromosome 2 surrounded by markers BARCSOYSSR 02 0423 and BARCSOYSSR 02 0425 were found. Furthermore, gene annotation using these QTLs on the soybean genome identified two candidate genes, RDRP1 and SGS3, that have a role in begomovirus resistance. This study's markers will be useful in marker-assisted breeding for YMD resistance in soybean (53).

Major Insect Pests

Girdle beetle (*Oberiopsis brevis*) : The girdle beetle is a significant pest that reduces soybean yields by 14 to 42 percent (54). Girdle beetles are prevalent in the country's central region, accounting for more than 80% of the total area and output. Girdle beetles attack crops from pre-bloom through seed fill, with a damage potential of up to 58 percent. The weather conditions determine the frequency of this insect nuisance. Other procedures must be used if insect-resistant sources must be discovered (55). NRC-12 and NRC-7 are examples of tolerant genotypes. Multiple insect resistance was discovered in the breeding lines B14P58-59, D2P11, D2P23, D2P25, D3P6, D3P8, D3P23, D4P20, D6P18, D6P22, releasing a variety JS 93-05. (56). The relative field resistance of eight germplasms to stem girdler is investigated. Five germplasms were extremely resistant to stem girdler, with percentage damage ranging from 11.77 to 17.36 percent. Three germplasms were very vulnerable to stem girdler, with percentage damage ranging from 20.49 to 27.96 percent. The stem girdler plant infested among different germplasms ranged from 2.47 (Basara) to 5.65 (MACS 1046) per meter row length based on the classification. Basara, JS-335, JS-9305, DSB-2803, and KDS-756 were highly resistant (HR). KDS-869, MACS-1460, and RSC-1046 were all incredibly susceptible (57).

Tobacco Caterpillar (*Spodoptera litura*) : When compared to other insect pests such as soybean looper (*Chrysodeixis chalcites*), pod worm (*Helicoverpa armigera*), and the leaf roller, *Spodoptera litura* (*Fabricius*) (Lepidoptera: *Noctuidae*) is regarded to be an important economic leaf-feeding insect pest of soybean in Indonesia

(*Lamprosema indicata*). The armyworm invasion might result in yield reductions of up to 80%. (58). According to (59), the uncontrolled condition reduced soybean output by 68 percent compared to the cyhalothrin-controlled condition. The intensity of leaf defoliation and the larval population density (greater larval density) impact the amount of yield loss (59). During the previous decade, *Spodoptera litura* has caused significant damage to blooms and immature pods in India's northern and central regions. In some places of India, the tobacco caterpillar has become a severe soybean pest in recent decades, causing outbreaks of the insect (5). The greatest appearance occurred in September and October, coinciding with the highest activity of egg masses and larval populations in soybean, contributing to the pest epidemic during the reproductive stage of the crop. Insecticides have traditionally been used to protect the plant against insect infestations. However, improper pesticide usage has negative consequences for human health and the environment. As a result, using resistant cultivars as an option to prevent crop losses due to insect pests is critical. Based on antibiosis and anti-xenosis tests, the G511H/Anj-1-4 soybean line was identified as resistant to the armyworm *S. litura* (60).

Additionally, (61) found that nine soybean genotypes possessed anti-xenosis resistance to the armyworm after assessing the tolerance of 18 soybean genotypes to the *S. litura.* Based on reproduction and population growth criteria, Farahani et al. (62) analyzed the resistance of five soybean genotypes to *S. exigua*. They determined that the L17 and BP genotypes were more resistant than the Williams genotype. Whenever a soybean genotype was less favored for feeding than another, it was termed resistant to *S. litura* (61). The Brazilian soybean genotype IAC100 exhibited a high level of non-preference for feeding *Spodoptera* larvae (63). The features of pubescence were associated with anti-xenosis resistance, according to (64), who conducted a genetic study of anti-xenosis resistance in *S. litura*. Resistant cultivars have become an essential management approach for herbivorous insect groups such as *S. litura* (65, 66). The benefits of resistant varieties include being environmentally friendly, reducing pesticide input, lowering farmer costs, and being compatible with alternative control measures such as natural enemies (67). Because the armyworm's great damage potential resulted in soybean production losses, selecting more insect-resistant varieties became extremely desirable.

White Fly *(Bemisia tabaci) :* Whitefly, which transmits the virus that causes yellow mosaic disease in soybeans, has grown important in northern regions. Whitefly infestations can diminish soybean yields and potentially cause crop loss, directly or indirectly. Whitefly nymphs and imago puncture and suck the host plant's foliage fluid, creating chlorosis in the leaves (68). Anti-xenosis, antibiosis and tolerance might be mechanisms the host plant uses to combat pests (69). Planting resistant cultivars is one of the alternative ways of controlling whiteflies based on integrated pest management concepts. Studies showed that genotypes created whitefly-resistant high-yielding soybean cultivars revealed restricted genetic variability. The heredity of broad sense varies between 5% and 81 percent. Days to flowering, leaf damage intensity, and seed weight per plant all demonstrated strong heritability in the broad sense (81 percent, 80 percent, and 52 percent, respectively. The biggest genetic advance will be achieved by selecting leaf damage intensity and seed weight per plant, respectively, by 41.62 percent and 20.15 percent. On the degree of leaf damage and seed weight per plant, high heritability paired with strong genetic progress showed successful selection for these characteristics in this population (70). Whitefly-resistant soybean cultivars can be developed through a soybean breeding program. The selection of resistant plants is a critical step in obtaining resistant cultivars. Several factors should be considered while planting whitefly-resistant soybean cultivars. One of the morphological characteristics that are frequently connected with resistance qualities is the density of leaf trichomes (71, 72). The number of leaf trichomes linked with whitefly resistance in soybean genotypes. The quantity of leaf trichomes has a negative connection with leaf damage ($r = -0.29$, $p = 0.24$), showing that whitefly resistant genotypes have a weak anti-xenosis mechanism (73). According to Silva et al. (74), the anti-xenosis mechanism was demonstrated by the least number of eggs deposited on resistant soybean leaves with thick trichomes. The glabrous soybean isolines were extremely resistant, but the isolines with profuse pubescence were extremely vulnerable (75). Between 1976 and 1986, (76) tested 109 soybean cultivars for whitefly resistance, finding 42 cultivars to be extremely resistant, 25 cultivars to be resistant, 16 cultivars to be moderately resistant, 14 cultivars to be susceptible, and 12 cultivars to be severely sensitive.

In multi-year and multi-site experiments, the quantitative trait loci (QTL) of whitefly resistance in soybean revealed a great deal for soybean breeding. Furthermore, the thickness of the leaves influences the antixenosis process in soybeans (77). The total population of egg, larva, pupa, and imago per leaf area can be used to estimate soybean resistance to whitefly attacks when it is connected to the existence of pests (78). Moreover, because the juvenile stage of the whitefly produces the most leaf damage, its prevalence affects the extent of soybean genotype resilience (79; 80; 81 and 82). In 1993 and 1994, (83) tested 14 soybean genotypes in maturity groups VII VIII for resistance to *Bemisia argentifolii*. The 14 soybean genotypes showed substantial variations in mean whitefly numbers. The 170 plants in the JRB1F2 population (Huapidou Qihuang 26) were utilized to create a genetic linkage map using SSR markers to determine the QTLs linked to whitefly resistance. Using both Win QTL Cartographer Version 2.5 composite interval mappings, eight QTLs directly linked with whitefly resistance were discovered in the JRB1F2:3 population generated from the JRB1F2 population in Jinan and Guanxian from 2008 to 2010. In Jinan, six QTLs were found, with the maximum accounting for 37.3 percent on chromosome 17 between sat 326 and sat 172, and the minimal accounting for 9.2 percent on chromosome 5 between satt236 and sat 271. In Guanxian, two QTLs were discovered, accounting for 36.9% and 16.1% on chromosomes 1 and 2, respectively. High-level resistance genotypes can be utilized as an IPM tool against B. tabaci or as a source of resistance in plant breeding initiatives (84).

Conclusions

The conclusions that may be derived based on the findings of long-term national and international research on soybean resistance to insects and disease-causing agents are soybean resistance breeding, which involves the generation and dissemination of disease-resistant and less prone cultivars, one of the most effective disease management approaches.

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Problems and Constraints Faced by Khasi Mandarin Growers : A Study in East Siang District of Arunachal Pradesh

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Abstract

The present study was conducted to study the various problems faced by khasi mandarin growers of east siang district of Arunachal Pradesh. A total 120 farmer were selected for the present study. The study of problems are under the following sub-heads. Those are personal problem, social problem, Technical problem, capacity problem, managerial problems, availing of inputs problem, economic and marketing problem. Under personal problem the major study finding revealed that lack of self improvement was ranked 1 (81.67%), labour scarcity and high labour charges was ranked 1 (91.67%),less exposure to training programmed was ranked 1(85.83%) ,lack or no credit facility for khasi mandarin cultivations was ranked 1 (91.67%),untimely supply of seedling/fertilizer (100%),high cost of input was ranked 1 (85.83%), procedure for obtaining loan is complicated was ranked 1 (97.50%) and no processing centre for value addition was ranked 1 (100%) respectively.

Key words : *Problems; Khasi mandarin grower,*

Introduction

Khasi mandarin is one of the most important commercial variety of north eastern region and occupied an important place among the other varieties of mandarin orange. It is loose skinned oranges belonging to species citrus reticulata Blanco. The most commercial citrus cultivars in India are the mandarin followed by sweet orange and acid lime with a total production 20.84,38 and 26.29 lakh tonnes, respectively (Bhandare *et al.* 2014).

Mandarin orange cultivation plays a very important role in socio-economic upliftment of the farmers in North-Eastern Himalayan region is one of the leading regions in mandarin production over the years due to its congenial environment, already existing genetic resources and plantations. The region is considered as one of the natural home or primary gene centre (Gosh, 1977 and Ray and Deka, 2000) and reservoir of various citrus species including mandarin orange (Hazarika, 2012).

The east siang district of Arunachal Pradesh is favoured by nature with mostly hilly terrians and gentle slope which is suitable for growing horticulture crops like citrus. Among the citrus crops, Khasi mandarin is one of the most widely cultivated commercial fruit crop and plays a vital role in the socio economic development of the people in this region. Most of the orchards were established generation back and some orchards have already crossed their economic life and leaving the orchards without going for any rejuvenation process which very important for old age plant and the development of growing technique, production and marketing system are still far below the standard which can say due to negligence by farmers most of the orchards have started declining in few years.In view of this, the present study was conducted to study various problem faced by khasi mandarin growers in east siang district of arunachal Pradesh.

Materials and Methods

The present study was conducted in east siang district of Arunachal Pradesh. Purposive sampling method was followed in selecting the district. There are four subdivision and blocks viz.., pasighat, Mebo,Ruksin,Nari. Total 12 villages from each blocks were selected through purposive cum proportionate random method. From each selected villages 120 respondents were selected thus consisting of who had Khasi mandarin orchard of 5-10 years were selected randomly.

Primary data were collected by personal interview method with the help of well- structured schedule, which was followed by group discussion with to collect relevant data/information from respondents. As many as 44 major items in different areas were finally identified which may be considered as the most important problems of khasi mandarin growers of east siang district of Arunachal Pradesh. These identified problems were grouped in eight categories such as personal problem, social problem, technical problem, capacity problem, managerial problem, Availing of inputs problem, economic problem and marketing problem. In order to ascertain the degree of seriousness of the problems and for taking up different extension efforts, the items were ranked based on the percentage intensity of responses against each item.

A pretested research schedule was used for collection of data. Appropriate statistical tools such as frequency, percentage, were used for analysis of data.

Results and Discussion

Personal problem : The first and foremost personal problem expressed by 81.67 per cent of the respondents was "Lack of self-improvement" The probable reason may be due to unawareness of scientific knowledge of technology. Hence, the AEA, KVK and various other extension agencies can provide training and demonstration time to time regarding the farm mechanization and encourage information sharing by the way of farming group that can motivate the respondents to self improvement.

Many of the respondents (63.33%) revealed that "Lack of self confidence" as the problem. Most of the respondents did not know the actual potential of scientific knowledge of cultivation practices on Khasi Mandarin. It might be less confidence towards scientific cultivation. Therefore, the extension agents could motivate and boost the confidence of the respondents by organizing personal development programmed.

"Feeling of insecurity" was expressed as a problem by 60.00 per cent of the respondents. The probable reason might be less contact with extension agents as well as agriculture scientist. Hence, extension agents should embrace the need and problem of the farmers by providing need based training.

"Less enhancement of self-esteem or respect" was mentioned as a problem by 35.83 per cent of the respondents. The probable reason might be due to self inferior feeling towards own decision making. Therefore, extension agencies like AEO and the government officials should pay regular visit to check their progress and problem of the farmers.

Social problem : "Labour scarcity and high labour charges" was reported as problem by 91.67 per cent of the respondents. This might be due to the fact that as most of them were financially very weak, they could not affords to give them wages as it was very high and sometimes they faced problems as their wages were not fixed due to which they couldn't keep a fixed amount of wage save for them. Also at times when they needed labors they were unavailable which lead to loss of the Khasi Mandarin growers.

"Lack of support from family" identified as a problem by 74.17 per cent of the respondents. The probable reason might be due to untrained some of the farmers family. This could be overcome by engaging all family members in farming and trained up in scientific modern technology.

"Less enhancement of the farmers towards mandarin cultivation" was mentioned as a problem by 35.83 per cent of the respondents. This may be due to fact that less training exposure and less extension contact. Therefore, more extension and training exposure need to provided aware and inspired them towards scientific cultivation.

"Lack of influences from peers groups" 16.67 per cent was one of the problem which respondents.

Technical problem : "Less exposure to training programmes" was mentioned as a problem by 85.83 per cent of the respondents. The probable reason might be the place where training was organized inconvenience time.

"Lack of suitable technology" was reported as a constraint by 81.67 per cent of the respondents in their Khasi Mandarin. The recommended Khasi Mandarin production technologies may not be suitable to all the regions. The recommendations of state Department of Horticulture for obtaining higher yields may not be relevant to the existing field conditions. Moreover, the soil and climate factors also vary from region to region. So, the farmers might stick to traditional varieties. Therefore, area specific technology should be develop for this.

"Lack of knowledge about cultivation practices of Khasi Mandarin" was expressed as a problem by 63.33 per cent of the respondents. The probable reason might be the Khasi Mandarin orchards were established generation back and also crossed their economic life. Therefore, the extension agencies should emphasize on the scientific training and modern technology for higher productivity.

"Less linkage between College of Horticulture and Forestry" was reported as a problem by 52.50 per cent of the respondents.

"Less contact between KVKs and farmer" was the problem reported by 46.67 per cent of the respondents. The possible reason might be the most of the respondents were located at a distant place from their resident. Another reason may be due to sometimes training were organized untimely when they busy in their farms. Therefore, training organizer should be know their suitable and efficient time then fixed the training.

"Lack of interest and non-availability of ADO/AEA in time" was revealed as a problem by 43.33 per cent of the respondents. The possible reason might be the farmers were busy in their farms they couldn't went to meet

Table-1 : Problems faced by khasi mandarin growers in East Siang.

Sl. No.	Problems	Frequency	Percentage	Rank
A	**Personal problem**			
1	Lack of self-improvement	98	81.67	I
2	Lack of self confidence	76	63.33	II
3	Feeling of insecurity	72	60.00	III
4	Less enhancement of self-esteem or respect	43	35.83	IV
B	**Social problem**			
1	Labour scarcity and high labour charges	110	91.67	I
2	Lack of support from family	89	74.17	II
3	Less enhancement of the farmer towards mandarin cultivation	43	35.83	III
4	Lack of influences from peers groups	20	16.67	IV
C	**Technical problem**			
1	Less exposure to training programmes	103	85.83	I
2	Lack of suitable technology	98	81.67	II
3	Lack of knowledge about cultivation practices of Khasi Mandarin	76	63.33	III
4	Less linkage between College of Horticulture and Forestry	63	52.50	IV
5	Less contact between KVKS and farmer	56	46.67	V
6	Lack of interest and non-availability of ADO/AEA in time	52	43.33	VI
C	**Capacity problem**			
1	Lack or no credit facility for Khasi Mandarin cultivations	110	91.67	I
2	Poor marketing infrastructures	112	93.33	II
3	Lack of credit facilities in the area	98	81.67	III
4	Only some part of the growers have good access to Govt. support	89	74.17	IV
D	**Managerial problem**			
1	Untimely supply of seedling/fertilizer	120	100	I
2	Lack of transport facilities to be brought from distant place	110	91.67	II
3	Lack of adequate knowledge about plant protection equipment	106	88.33	III
4	Lack of information about scientific cultivation of Khasi Mandarin	98	81.67	IV
E	**Availing of inputs problems**			
1	High cost of input	103	85.83	I
2	Inputs are not available at right time	110	91.67	II
3	Low purchasing power/ poor affordability	98	81.67	III
4	Lack of subsidy for input	57	47.50	IV
H	**Economic problem**			
1	Procedure for obtaining loan is complicated	117	97.50	I
2	Inadequate loan from financial agencies	115	95.83	II
3	Untimely release of loan by bank authority	113	94.17	III
4	Repayment of loan installment is not convenient	110	91.67	IV
5	Delay in getting loan	109	90.83	V
6	Lack of own capital	103	85.83	VI
7	High interest rate of loan	98	81.67	VII
F	**Marketing problem**			
1	No processing centre for value addition	120	100.00	I
2	High fluctuation in market price	118	98.33	II
3	No proper storage facilities	113	94.17	III
4	Poor marketing infrastructures and storage capacity	111	92.50	IV
5	Lack of knowledge about maintaining standard quality	103	85.83	V
6	Unavailable/reluctant to carry the produce to distant market	98	81.67	VI
7	Lack of proper market facilities	92	76.67	VII
8	Lack of knowledge about proper techniques of marketing	91	75.83	VIII
9	Involvement of middle man	89	74.17	IX
10	Lack of export marketing in the area	88	73.33	X
11	Farmer are not aware/encourage about commercialization of orange	87	72.50	XI

ADO/AEA daily. Another reason may be due to visit is not regular in village due to high ratio.

Capacity problem : "Lack or no credit facility for Khasi Mandarin cultivations" was mentioned as a problem by 91.67 per cent of the respondents. It may be attribute to the fact that most of the respondents faced problems as they don't get credit from credit organization when they needed it the most. Sometimes bank officials hesitate to give loan to the Khasi Mandarin crops growers as they don't trust them which were another problem face by the respondents.

"Poor marketing infrastructures" was reported as a problem by 93.33 per cent of the respondents. The government should emphasize and provide the basic market infrastructure facility cold storage, processing unit to get some extra earning from this crop.

"Lack of credit facilities in the area" was revealed as a problem 81.67 per cent of the respondents. As input were costly in terms of fertilizer, pesticide, weedicide, etc the farmers had to faced difficulties in obtaining the inputs. Therefore proper credit linkage may be availed so that the farmers could obtain loan for farming at the time of need.

"Only some part of the growers have good access to Govt. support" was revealed as a problem by 74.17 per cent of the respondents. According to them they didn't give any interest to the poor famers.

Managerial problem : "Untimely supply of seedling/fertilizer" was mentioned as a problem by 100 per cent of the respondents. The concerned authorities were not taking adequate efforts to create awareness supply of seedling untimely the benefit offered by government to boost agricultural production to the farmers.

"Lack of transport facilities to be brought from distant place" was reported as a problem by 91.67 per cent of the respondents. This created a lot of tensions for them as farmers found it difficult to transport produce to different paces.

Many respondents 88.33 per cent revealed that "Lack of adequate knowledge about plant protection equipment" as the problem. Most of the respondents did not know the actual knowledge about plant protection due to lack of training. Therefore, suitable measure should be taken to develop the skills of the farmers in performing operation as regards to plant protection.

"Lack of information about scientific cultivation of Khasi Mandarin" was reported as a problem by 81.67 per cent of the respondents. Therefore, various extension agents especially those at village level should provide proper and timely information regarding scientific training and demonstration.

Availing of inputs problem

"High cost of input" was reported as a problem by 85.83 per cent of the respondents. This might be due to the rise in price of seedling, fungicide, pesticides, chemical fertilizer every year. But at the same time, price of agricultural produce had not increased proportionately. In addition, due to the shortage of inputs, the traders sold the inputs at high cost.

"Inputs are not available at right time" was mentioned as problem by 91.67 per cent of the respondents. Most of the farmers could not afford to buy at the right time.

"Low purchasing power/ poor affordability" was revealed as a problem by 81.67 per cent of the respondents. This mainly due to the fact that most of the farmers belonged to poor groups of families hence they could not raise their living condition.

"Lack of subsidy for input" was one of the major problem faced by the Khasi Mandarin growers (47.50%). Therefore, the concerned authorities may try to solve the matter by ensuring subsidy to the farmers so, that more number of scientific cultivation practices were adopted by them.

Economic problem : The first and foremost economic problem expressed by 97.50 per cent of the respondents was unable to procedure for obtaining loan is complicated. The possible reason may be rural people are not much educated and unawareness about the authentic procedure to obtaining loan for Agriculture, farm machinery, orchard management etc.

"Inadequate loan from financial agencies" was a problem mentioned by 95.83 per cent of the respondents. This might due to unawareness of any banking information related to agriculture financial agencies.

"Untimely release of loan by bank authority" was reported as the problem by 94.17 per cent under the economic problem by the respondents. The respondents revealed that the concerned authorizes were not taking adequate effort to create awareness released of loan regarding Agriculture loans.

"Repayment of loan installment is not convenient" was revealed that majority 90.83 per cent as a problem of the respondents.

"Delay in getting loan" was expressed as a problem by 90.83 per cent of the respondents. The probable reason may be due to respondents have no patient and emergent needs to get loan. Therefore, official they allow to aware the respondents.

"Lack of own capital" was revealed that 85.83 per cent as a problem of the respondents. The probably reason might be due to most of the respondents were less saving, no proper budget enough money with them. Another reason may be they depend only khasi mandarin crop for their main source

"High interest rate of loan" was reported as the problem 85.83 per cent of the respondents. As result farmer had suffer when inflation in produce.

Marketing problem : The first important marketing problem expressed by majority of the respondents (100.00%) was no proper processing centre for value addition. Most of the respondents demanding processing due to Khasi Mandarin is perishable fruit crop. Its causes many lost and cost production of the yields. This might be another reason behind that not adopted modern technologies.

"High fluctuation in market price" was reported to be one of the major problem that the respondents (98.33%) faced after harvest the Khasi Mandarin in market place. Its may leads to lower return if price drops. The government should strongly emphasize on the fixation and its follow up by the various wholesalers and other agencies processing commodity at village level. So, that farmers are not exploited and get remunerative price for their product.

"No proper storage facilities" was revealed as a problem by 94.17 per cent of the respondents. In the study area there is lacking of storage facilities because of that farmers suffered huge losses as they were unable to store their produce after harvest the Khasi Mandarin. As result the produce are subjected to sale at a lower prices. This could be overcome by giving awareness about the storage facilities.

"Poor marketing infrastructures and storage" was a problem mention by 92.50 per cent of the respondents. Therefore, the concerned authorities may try to build the efficient marketing infrastructure and storages facilities.

"Lack of knowledge about maintaining standard quality" was expressed as a problem by 85.83 per cent of the respondents. According to them they are less knowledge about standard quality.

"Unavailable/reluctant to carry the produce to distant market" was reported as a problem by 81.67 per cent of the respondents. According them market place far away from their orchard and difficulties in transportation. The hiring vehicle cost high prices that can't be afford by others farmers.

"Lack of proper marketing facilities" was a problem mention by 76.67 per cent of the respondents. Therefore, government should set up market at village level and open up new opportunities for the farmers by way of linkage or tie ups with the companies and various industries.

"Lack of knowledge about proper techniques of marketing" was reported as a problem by 75.83 per cent of the respondents. Therefore, the farmers sold out their produce at a very low price which is undesirable. Proper techniques of marketing help the farmers to disburse their produce at desirable price.

"Involvement of middle man" was a problem mention by 74.17 per cent of the respondents. According to them the farmers receive fewer prices for their produce due to existence of middleman. Another probable reason might be the farmers were not getting good prices for crops as price were manipulated by middleman who worked their way through so they could earn profits for themselves.

Many respondents (73.33%) revealed that "Lack of export marketing in the area" revealed as the problem. Most of the respondents did not know the actual export marketing area to sell the produce.

"Farmer were not aware/encourage about commercialization of orange" was reported as problem by 72.50 per cent of the respondents. Therefore, sometimes surplus production of the Khas Mandarin might give huge losses to farmers. Hence, the concerned authority should emphasize on commercialization of orange.

Conclusion

It is evident from the study, that there existed a wide gap between development of technologies and their transfer to the actual farming situations. Undoubtedly, Khasi mandarin has enormous potential for its commercialization in the district. Even though commercialization of this particular crop has been started, it is still at a budding stage due to various constraints faced by the growers. Therefore, these problems perceived by the farmers could be overcome by following proper strategies like intensified training and awareness programme involving transfer of skill and knowledge in related technologies of khasi mandarin among the farmer of the district.

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Management of Stored Grain Pest : A Review

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Abstract

In the current review article many botanicals are discussed for control of stored grain pest. Stored grain infestation is a very serious problem, because pests cause high economic losses, deteriorates the quality of food grains and endanger the public health by adulteration of food by allergens. A huge variety of insect pests have been linked to grains that have been kept. Almost all species have a high rate of reproduction, which can kill 10-15% of the grain while contaminating the rest with unpleasant odours and flavours. A number of methods used to control stored grains pest such as physical control by change in temperature, chemical control through use of insecticides and use of environment friendly botanicals for pest control. Botanicals have no side effect, they are less toxic, non-residual and biodegradable in the environment. Plant-derived chemicals influence insect growth, act as repellents, kill insects, and hinder oviposition.

Key words : *Pest, allergen, flavours, botanicals, toxic.*

Introduction

Food grains are an essential component of the vegetarian Indian diet. Grain output has been constantly increasing as production technology has improved, yet incorrect storage leads in substantial grain losses.

Acaridae mites are among the most common pests that target agricultural and stored goods systems. Storage mites are commonly underestimated because of their small size, which makes it difficult to detect an infestation (Palyvos and Emmanouel, 2006). Mites cause direct damage to stored grains by contaminating and penetrating seeds/embryos, eating the grain germ (Zachvatkin, 1941), and to a lesser extent the endosperm (Parkinson, 1990). Mites are the ones who distribute fungal spores in stores (Lacey, 1988; Hubert *et al*., 2004). They can also trigger allergic reactions such as asthma, eczema and rhinitis and particularly in the workplace (Marx *et al.,* 1993; Kondreddi *et al.,* 2006; Yadav *et al.,* 2006). Contaminated grains, dried fruits, and vegetables are no longer edible for humans or animals. The mites in grain stores prefer to stay in high-moisture areas like the corners and the centre of the storage chambers (Athanassiou *et al.,* 2003). A total of 147 grain stores in the Czech Republic's Bohemia were inspected. Both types of stores were discovered to be infested by arthropods belonging to three major taxonomic groups: mites (25 species, 120 000 individuals), psocids (8 species, 5 600 individuals), and beetles (23 species, 4 500 individuals). Grain pests such as Acarus siro, Lepidoglyphus destructor, Tyrophagus putrescentiae, Lachesilla pedicularia, , Rhyzopertha dominica, Oryzaephilus surinamensis, Sitophilus oryzae and Cryptolestes ferrugineus were found in both types of stores. A number of methods used to control stored grains pest such as physical control by change in temperature and humidity, chemical control through use of insecticides which is cost-effective and provide quick results and use of environment friendly botanicals for pest control. Botanicals are plant-derived products that contain active compounds for storage pest management. Spices and medicinal and other plants are among them. Botanical extracts offer antifeedant and arrestant properties, as well as the ability to kill and repel pests.

Chemical Control : Chemical control is the use of insecticides and other chemicals to control the infestation by the insect. chemicals is usually preferred for grain protection because they are simple to use, cost-effective and provide quick results as compared to organic methods of pest control (Hidalgo *et al*., 1998). So, residues of chemicals are also harmful for human health, along with resistance development in the target pest. Acaricides should be evaded during storage because they have serious problems such as toxic residues and deadly effects on non-target organisms, food residues, worker safety, the risk of users becoming contaminated, environmental pollution disrupting the natural ecosystem, the development of resilient strains, pest revival, and resistance. (Tapondjou *et al*., 2002; Asha *et al*., 2014; Poonia *et al*., 2015). Diatomaceous earth, a silicon-based, naturally occurring substance that can desiccate insect and mite pests, acts by removal of water-proofing waxes found in the cuticle. Cook et al. 2004 used diatomaceous earth against adult grain weevil (*Sitophilus granarius*), stored mite (*Lepidoglyphus destructor*) and larvae of the flour moth (*Ephestia kuehniella*), with doses of 10-20 g/m2 against the grain weevil/ flour moth and 1-3 g/m2 (dry dust) or 20 g/m2 (slurry) against the stored mite.With all three doses of the Diatomaceous earth against *A. siro* and *L. destructor,* complete mortality was achieved in *A. siro* and 93-97% mortalities recorded in *L. destructor.* Pulse beetle infestations were reduced when inert diatomaceous earth, activated clay, and fly ash were combined with pulse grains (Mendki et al., 2001). Wilkin, 1975 used Lindane dust (2 ppm) for effective control of *A. siro*, malathion dust (8.9 ppm) for *G. destructor* or pirimiphosmethyl dust (4 ppm) for *T. longior,* provided effective control for three months in stored barley. Chisaka *et al*. (1985) noted that higher doses of Phenothrin, fenopropathrin and permethrin were effective against mite *T. putrescentiae.* Nayak (2006) observed that spinosad and Phosphine effectively controlled all life stages of *T. putrescentiae* . Bakr and Selim (2019) accomplished complete control of *T. putrescentiae and A. ovatus* by the application of spinosad. Golob et al., 1985, was employed Cypermethrin against cowpea insect pests and offered 45 to 66 percent pest control. Actellic (2%) and Actellic super, as well as Phostoxin gas, were found to be effective in suppressing C. maculatus and other cowpea insect pests (Ilesanmi and Gungula, 2010). The reproductive rate of C. maculatus was significantly reduced under laboratory circumstances using a concentration of 5% cyromazine (insect growth regulator) and dipping treatment at 30 °C. They also discovered that when the concentration of cyromazine grew, food consumption decreased and generation lifetime increased (Al-Mekhlafi *et al*.,2012). Chemicals in storage systems have many disadvantages, including the ability to harm humans and animals , residual toxicity and insect resistance (Ntoukam et al., 2000 ; Ilesanmi and Gungula, 2010).

Physical Control : Temperature and humidity is used widely to control stored grain pest. Insects develop within a narrow temperature range, and changing this range causes insects to perish quickly. The temperature of 25-33 ^{o}C is ideal for most stored grain insects development. Grain insects will die if the temperature is below 13 degrees Celsius or above 35 degrees Celsius. The ideal temperature for mite pest reproduction and growth is 25-28°C. To prevent infestations in the bulk, cool grain (below 5 ^{o}C) and dry cereals and rapeseed (below 14.5 and 7.5 percent moisture content) to levels below which mites cannot complete their development (Armitage and Wildey 2003). Insects exposed to high temperature through dry heat, exposure to sun, superheating and steaming. Refrigerated ventilation, hot air, microwaves, high frequency irradiations and infrared are effective against stored insect and mite (Fezlds, 1992). Kohli and Mathur (1993) proved that with increase in light exposure, prolificacy, egg viability of *T. putrescentiae* was significantly reduced and hatching period, life cycle was prolonged significantly.Insect pests are harmed when the moisture content of food and other materials is increased or decreased. Because the majority of stored mites require 65-70 percent relative humidity for growth (Cunnington, 1984), they can be managed by lowering relative humidity below 60 percent, which can be accomplished by drying the grains (Kohli and Mathur, 1993). Mite development is limited by temperatures below 5°C and moisture content below 14.5 percent (Armitage and Wildey, 2003). Internal seed pests such as the cowpea weevil are disinfested by radio frequency (RF) treatments. Microwave (MW) frequencies used are 2450 MHz or 915 MHz, while radio frequencies used are 13, 27 or 40 MHz (Wang *et al.,* 2001).

Biological Control : Secondary metabolites are the biochemical, produced by tissue of higher plants. These are phenolics, alkaloids, saponins, resins and essential oils. Many plant allelochemicals (azadirachtin, nicotine, pyrethrins and rotenoids) have been developed as commercial insecticides (Talukder, 2006).

Spices as a stored grain protectant : Spices have been used from ancient times to protect stored products from pests. Most common spices used in strored grain protection are Ginger (*Zingiber officinale* Roscoe) effect on *C. chinensis*, *T. castaneum* (Ho, 1995), Turmeric (*Curcuma longa) against T. castaneum* and *S. Zeamais* (Jilani and Su, 1983; Jilani and Saxena, 1990; Unjitwatana *et al*.,1997) Clove (*Syzygium aromaticum) act on S. zeamais* and eggs of *T. castaneum S. oryzae* and *T. castaneum* (Grainge and Ahmed, 1988; Ho, 1995), Garlic (*Allium sativum) act on T. castaneum* and *S. zeamais* (Ho, 1995), Black Pepper (*Piper nigrum) act on C. chinensis* (Morallo-Rejesus *et al*., 1990). Garlic performed better in reducing number of holes per seed, damaged seeds, percentage damaged seeds and weight loss than no pesticide application treatment (Mulungu, 2007). Tomato leaf extract, mustard seed extract, black pepper powder, garlic clove powder, tulsi leaf, powder and turmeric rhizome powder, affecting the normal physiology of the insects (Singh, 2011). *Allium cepa* (onion) Bulb extract(crude), 0.02%@20ml/ 100g found toxic to *C.cephalonica and Allium sativum (garlic)* bulb extract 0.02%@20ml/ 100g act as grain protectant up to 180 days while *Curcuma longa root* powder Showed 73% grain protection (Prakash and Rao, 1997). Kim *et al.* (2003) examined the acaricidal activity of clove bud oil compounds (isoeugenol, methyleugenol) against adult *T. putrescentiae* and found methyleugenol was most toxic to

T. putrescentiae adults than isoeugenol. *Amomum villosum* fruits had repellent activity against *serricorne, Lasioderm* and *Tribolium castaneum* (Chen *et al*., 2018). In addition to spices, many other botanicals have also been used to control/kill stored grain pests.

Botanicals as a stored grain protectant : The important pests of stored grains are the rice weevil, granary weevil, lesser grain borer, Khapra beetle, pulse beetle and mites. The toxicity of plant extracts and plant powders Nerium indicum, Azadirachta indica(neem), Prosopis cineraria (khejri), Eucalyptus globulus (safeda) leaf extract reduced the fertility of *Callosobruchus maculatus* and volatile oil of Citrus reticulate resulted in 100.00 percent mortality of Sitophilus oryzae after 24 hours of exposure, followed by Curcuma long (90.00 percent), *Psidium guajava* (52.50 percent) and *Pogostemon cablin* (20.00 percent). Muhammad *et al.* (2005) indicate that neem oil has a strong insecticidal effect on stored grain beetles when used in proportions ranging from 5 to 20 percent applied on packing bags. Labiatae oil was found to be a highly effective seed fumigant, with 94 to 100 percent mortality obtained after seven days for *T. castaneum*, *S. oryzae*, *R. dominica* and *Oryzaephilus surinamensis* (Shaaya *et al*., 1997). Jilani and Malik (1973) found that neem seed extract had more repellancy than leaf and flower extract against *T. castaneum* and *Trogoderma granarium.* The adults of the former insect failed to reproduce when fed with our treated with neem seed extract. Idrees, 2016 used 0.5%, 1%, 2%, 4% and 8% concentration of ether extracts from *Azadirachta indica*, *Eucalyptus* sp., *Citrullus colocynthis*, *Allium sativum*, *Curcuma longa*, *Nicotiana tabacum*, *Nerium indicum*, *Ocimum tenuiflorum, Syzygium aromaticum* and *Cassia fistula* against the *Rhizoglyphus tritici* and observed after 7, 14, 21 and 28 days of exposure. All the plant extracts exhibited significant acaricidal potential for adult mite as compared to control. Raheja, 1996 was found neem, castor, mustard, groundnut and sesame oils reduce the number of egg lay by females in *S. nesbitti.* Seema, 2020 observed the effect of aqueous extract of Aonla fruits, lemon and orange peels against *S. nesbitti* in peral millet grains, lemon peel (8%) extract caused 100 percent mortality in *S. nesbitti* within 3 hours of treatment and orange peel extract and Aonla fruit extract at 4, 8 percent concentrations caused 100 percent mortality in *S. nesbitti* 1d after the spray. Poonam 2021, used the aqueous and Methanolic extract of Mentha pipertica S. nesbitti control and found amongst the two extracts, methanolic extract of *M. pipertica* was more effective because of lower LC50 value (1.15%) than aqueous extract of *M. pipertica* (1.74%) under direct spray bioassay.

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Influence of Potassium Silicate on paddy (*Oryza sativa* L.) Stem Borer, Sheath Mite, Lodging and Yield Attributes

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Abstract

Despite silicon not considered an essential nutrient, it is typically abundant in soils and is known to have beneficial effects when added to rice crops and several other plants. These beneficial effects include disease and pest resistance. Field experiment was conducted at Navsari Agricultural University, Navsari, Gujarat, India during *Kharif* 2015-16, 2016-17and 2017-18 to study the effect of potassium silicon on stem borer, sheath mite, lodging and yield attributes on paddy. The treatments comprised of T1 : control, 0.T2 : 0.5 % potassium silicate at tillering and PI, T3 : 0.5 % potassium silicate at tillering, PI and grain formation stage, T4 : 1.0% potassium silicate at tillering and PI, T5 : 1.0% potassium silicate at tillering, PI and grain formation stage, T6 : 1.5 % potassium silicate at tillering and PI and T7 : 1.5 % potassium silicate at tillering, PI and grain formation stage. Among the different treatment imposed, 1.0% potassium silicate at tillering, PI and grain formation stage recorded 1.37 % dead heart (DH), 2.40 % sheath mite infestation and lodging 0.85 %. Higher grain yield (47.13 q/ha) was recorded from the same treatment as compared to 39.92 q/ha in untreated check.

Key words : *Potassium silicate, stem borer, sheath mite, lodging, rice.*

Introduction

Silicon (Si) is the second most abundant element of the earth s surface and plays a significant role in imparting biotic, abiotic stress resistance and enhancing crop productivity (15,6,4). Silicon plays a crucial in preventing or minimizing lodging in cereal crops, a matter of great importance in agricultural productivity. Silicon is the only element known that does not damage plants with excess accumulation. It has been has been demonstrated to be necessary for healthy growth and stable production. Rice is a high Si accumulator plant and absorbs high amount of silicon, an average of 150-300 Kg of Si per hectare (21). For this reason, Si has been recognized as an agronomically essential element in Japan and silicate fertilizers have since then been applied to paddy soils (7). Si is required for the development of strong leaves, stems and roots. The formation of a thick silicated epidermal cell layer reduces the susceptibility of rice plants to insects *viz*., stem borers, plant hoppers and mite pests etc., According to (2), the Si content of rice varies with plant age. Application of silixol granules @ 37.5 kg ha- 1 along with 100 % recommended dose of fertilizers reduced the infestation of stem borer and leaf folder in rice (5. 9,111) found that the infestations of rice stem borer were markedly reduced by adding silicon to soil. (19) concluded that the application of silica at 1t/ha reduced the density of stem borer (*Scirpophaga incertulas*). (18) reported that addition of silicate materials significantly reduced the incidence of *Cnaphalocrocis medinalis* and *Orseolia oryzae* in rice at tillering stage. Over reliance on highly toxic, hazardous pesticides has created higher magnitude of environmental pollution leading to imbalance in natural ecosystem. Development of resistance in insects becomes a major problem due to indiscriminate use of pesticides. Hence the use of less toxic compounds of natural plant origin, host resistance, bioagent, and adoption of cultural practices and inclusion of non rice crops in cropping system are given priority as important components for implementation of IPM programme. In the absence of natural heritable resistance in rice varieties, resistance could be induced by alternate strategies to suppress certain insect pests. One such strategy is enrichment of silicon in plants. Hence the present experiment was conducted to study effect of silicon on stem borer, sheath mite, lodging and yield attributes on paddy.

Materials and Methods

The Field experiment was conducted at Krishi Vigyan Kendra Farm, Navsari Agricultural University, Navsari the south Gujarat region during *kharif* season of three consecutive year viz., 2015-16, 2016-17 and 2017-18. The experimental site is located at 20. 94-76^{o} N latitude and 72. 95-20^{o} E longitudes with an altitude of 9 m mean sea level. The soil of the experiential plots was clay in texture having medium to poor drainage, alkaline in reaction (pH=7.86), low in available nitrogen (512 kg//ha) and medium in available phosphorus (49 kg/ha) and potash (268 kg/ha). Total seven treatments consisting of

T_1: control, T_2: 0.5 % potassium silicate at tillering and panicle initiation stage (PI), T_3: 0.5 % potassium silicate at tillering, PI and grain formation stage, T_4 : 1.0% potassium silicate at tillering and PI, T_5 : 1.0% potassium silicate at tillering, PI and grain formation stage, T_6: 1.5 % potassium silicate at tillering and PI and T_7: 1.5 % potassium silicate at tillering, PI and grain formation stage were tested in complete randomize design with four replication. Paddy variety "GNR-3" seeds were used for the raising the nursery. Foliar spray of silicon was applied through the potassium silicate as per the treatments.

Observation on insect pest

Assessment of rice stem borer per cent incidence : Counts were taken on number of dead heart/white ears and total number of tillers/panicle from 10 randomly selected hills. The percent incidence (dead heart/white ears) was calculated as follows :

$$\text{Per cent incidence} = \frac{\text{No. of dead hearts white / ears}}{\text{Total number of tillers / panicle}} \quad 100$$

Mite

Based on damage symptom of panicle mite on leaf midrib : Observations were recorded from randomly selected 5 hills as follows

No incidence - 0, < 1 % - 1, 1.1 – 5 % - 3, 5.1 – 25 % - 5, 25.1 – 50 % - 7 and 50.1 – 100 % - 9

Per cent lodging : Lodging severity was scored visually as a percentage of plants that lodged at maturity. These was assessed on a 1–9 point scale where 1 was totally upright and 9 was totally lodged (lodging score: 1 = no lodging, 3 = 0%–10% lodging, 5 = 11%–25% lodging, 7 = 26%–50% lodging, 9 = >50% lodging) (TTSM 2003). Plant height was measured from the plant base to the tip of the panicle (or leaf, whichever was longer) in each plot (3).

Statistical analysis : The data on various characters studied during the investigation were statistically analyzed and wherever the treatment differences were found significant (F test), critical differences were worked out at five per cent probability level and the values were furnished. Treatment differences which were not significant are denoted as NS.

Results and Discussion

Incidence of dead heart : The data presented in Table-1 revealed that there was no significant difference between the year and treatments during three years of experimental period; so far the incidence of dead heart was concerned. However, significant difference among the treatments in relation to dead heart was observed over control treatment registered 10.59% dead heart while T5: 1.0% potassium silicate at tillering, PI and grain formation stage was the best treatment and recorded only 1.37% dead heart, followed by T6: 1.5 % potassium silicate at tillering and PI observed 3.35 %, and T7: 1.5 % potassium silicate at tillering, PI and grain formation stage (5.0 %) . The results are in conformity with 16) and (5)

Sheath mite infestation : There is a significant difference among the different treatments over sheath mite infestation. Effect of potassium silicate on the sheath mite infestation observed that the treatment 1.0% potassium silicate at tillering, PI and grain formation stage (T5) found to be superior over all the treatments recorded 2.40 per cent sheath infestation. Followed by T6: 1.5 % potassium silicate at tillering and PI stage recorded 3.23 % and was on par with T7: 1.5 % potassium silicate at tillering, PI and grain formation stage observed 3.57 per cent sheath mite infestation. And remaining treatments were established superior over control. Results are in agreement with (13).

Lodging per centage : The least lodging per centage is recorded lowest 0.85% in T5: 1.0% potassium silicate at tillering, PI and grain formation stage followed by T6: 1.5 % potassium silicate at tillering and PI stage recorded 1.68 % .

Effect on growth and yield attributes : The data show in Table-2 clearly indicated that there was no significant difference in plant height as well as effective tillers/m^2 Similar findings were also reported by (17), (1). However Yield attributing characters *viz.*, panicle length, panicle weight, number of grain per panicle and weight of grain per panicle were significantly influenced by different levels of foliar spray potassium silicon. Foliar spray of potassium silicon @ 1.5 percent at tillering, PI and grain formation stages was recorded remarkably higher panicle length (24.03 cm) and number of grain per panicle (154.42) over the control and T_2 (0.5% potassium silicate at tillering and PI stages). These finding are in accordance with (14) and (10).

Effects on Yield : Significantly higher grain yield (4713 kg/ha) were produced due to foliar spray of potassium silicate @ 1.0 percent at tillering, PI and grain formation stage (Table-3) over control and it was remain at par with the foliar spray of potassium silicate at 1.5% at tillering and PI stand as well as potassium silicate @1.5 at tillering, PI and grain formation stages. These results confirmed the findings reported by (10), (8) and (12)

Economics : Maximum gross income (Rs. 90124/ha), net income (Rs. 46514/ha) and B: C ratio (2.07) was incurred under the foliar spray of potassium silicate 1.0 % at tillering, PI and grain formation stage, which was followed by treatments T_6 and T_7.

Table-1: Pest incidence and lodging percentage of kharif rice as influenced by foliar spray of silicon (pooled data of three year).

Treatments	Stem bore infestation (%)	Sheath mite infestation (%)	Lodging percentage (%)
T_1 : Control	10.59 (19.04)	5.68 (13.77)	5.97 (14.12)
T_2 : 0.5 % potassium silicate at Tillering and PI stage	8.87 (17.52)	4.93 (12.80)	3.00 (9.92)
T_3 : 0.5 % potassium silicate at Tillering, PI and grain formation stage	7.13 (15.46)	4.50 (12.22)	2.53 (9.12)
T_4 : 1.0 % potassium silicate at Tillering and PI stage	6.38 (14.56)	4.03 (11.56)	2.77 (9.49)
T_5 : 1.0 % potassium silicate at Tillering, PI and grain formation stage	1.37 (5.99)	2.40 (8.86)	0.85 (5.23)
T_6: 1.5 % potassium silicate at Tillering and PI stage	3.35 (10.15)	3.23 (10.32)	1.68 (7.43)
T_7 : 1.5 % potassium silicate at Tillering, PI and grain formation stage	5.00 (12.29)	3.57 (10.86)	2.43 (8.94)
S. Em. ±	0.39 (0.42)	0.13 (0.11)	0.14 (0.17)
C. D. at 5%	1.10 (1.20)	0.37 (0.30)	0.40 (0.48)
C.V. %	22.11 (11.67)	11.19 (6.64)	18.01 (6.86)
YxT	NS	NS	NS

Table-2 : Effect of foliar spray of silicon on growth and yields attributes of kharif rice (pooled data of three year).

Treatments	Plant height (cm)	Effective tillers/m^2	Panicle length (cm)	Panicle weight (g)	No. of grain / panicle	Wt. of grain/ panicle(g)
T_1 : Control (No spray)	120.22	169.51	21.49	4.80	127.50	4.17
T_2 : 0.5 % potassium silicate at Tillering and PI stage	121.71	178.06	22.21	5.00	132.25	4.30
T_3 : 0.5 % potassium silicate at Tillering, PI and grain formation stage	123.69	179.17	22.80	5.22	132.17	4.48
T_4 : 1.0 % potassium silicate at Tillering and PI stage	124.02	181.83	23.62	5.43	135.75	4.75
T_5 : 1.0 % potassium silicate at Tillering, PI and grain formation stage	126.42	184.55	24.03	5.86	154.42	5.09
T_6: 1.5 % potassium silicate at Tillering and PI stage	125.63	180.82	23.60	5.87	153.42	5.17
T_7 : 1.5 % potassium silicate at Tillering, PI and grain formation stage	126.27	185.86	23.85	5.84	150.92	5.26
S. Em. ±	2.24	4.47	0.45	0.14	3.81	0.14
C. D. at 5%	NS	NS	1.28	0.40	10.77	0.39
C.V. %	6.26	8.60	6.81	9.07	9.37	9.98
YxT	NS	NS	NS	NS	NS	NS

Table-3 : Effect of foliar spray of silicon on grain yield, straw yield and economics (Avg. of three year)

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Total cost of cultivation (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha)	BCR
T_1 : Control	3992	5449	40700	76220	35520	1.87
T_2 : 0.5 % potassium silicate at Tillering and PI stage	4173	5805	41990	80011	38021	1.91
T_3 : 0.5 % potassium silicate at Tillering, PI and grain formation stage	4286	6013	42635	82326	39691	1.93
T_4 : 1.0 % potassium silicate at Tillering and PI stage	4391	6152	42640	84315	41675	1.98
T_5 : 1.0 % potassium silicate at tillering, PI and grain formation stage	4713	6475	43610	90124	46514	2.07
T_6: 1.5 % potassium silicate at Tillering and PI stage	4626	6454	43290	88751	45461	2.05
T_7 : 1.5 % potassium silicate at Tillering, PI and grain formation stage	4667	6495	44585	89495	44910	2.01

Selling price : Rice grain : 15 Rs./kg, Rice straw: 3 Rs./kg

Conclusions

From the above study it can be concluded that foliar application of potassium silicate 1.0 percent at tillering, panicle initiation and grain formation stage was recorded maximum panicle length, panicle weight, number of grain per panicle and weight of grain per panicle, grain yield and straw yield, as well as gross and net income. The pest incidence percentage, lodging percentage and sheath mite infestation were also found to be lower under the same treatment.

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Knowledge of the Rural Women Regarding Integrated Farming System

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Introduction

Indian agriculture is characterized by inter and intra linking crop production activities with one or more agricultural and allied enterprises like cattle, sheep, goat, pigs, sericulture, poultry, fishery, bee keeping and vermicomposting. Under the given situation, Indian farming is not commercialized to a large extent on one hand and on the other hand farmer has to make decisions regarding his business of farming with a view to attain sustainability. Unsustainable farming leads to environmental pollution and threatens the livelihood of millions of small farm holders. Strengthening agricultural production systems for greater sustainability and higher economic returns is a vital process for increasing income and food and nutrition security in developing countries (Ravallion and Chen, 2009).

The Integrated Farming Systems (IFS) therefore assumes greater importance for sound management of farm resources to enhance the farm productivity and reduce the environmental degradation, improve the quality of life of resource poor farmers and maintain sustainability. It utilizes wastes as resources, we not only eliminate wastes but we also ensure overall increase in productivity for the whole agricultural systems (CARDI, 2010). In order to sustain a positive growth rate in agriculture, a holistic approach is the need of the hour. This involves the adoption of scientific agronomic practices and technologies which promise an augmentation of the productive capacity of traditional agricultural systems.

The “All India Coordinated Research Project on Home Science” carried the project on “Scoping IFS Models from Gender Perspective with Focus on Enhancing Farm Income” in year 2017-20 with the objectives to document region specific tested IFS models for enhancing farm income, to screen the selected models from gender perspective and to diffuse the learnings/lessons from identified models in the adopted village. Under the project the information was collected about suitable IFS models for Rajasthan state from AICRP on IFS, Rajasthan College of Agriculture, MPUAT. According to their study four models are suitable for Rajasthan. Out of four models, two models were established at farmer’s field in the adopted villages of AICRP on Home Science before establishing the models, technological interventions were given to the farm women related to Crop + Horticulture model and Crop + Poultry models. Since the project has completed three years of its implementation therefore, it is apt time to frame a systematic study on knowledge of the rural women regarding technologies promoted under IFS models.

Research Methodology

(i) Locale of the study : The present study was conducted purposively in *Gudli* village of *Mavli* panchayat samiti of Udaipur district in Rajasthan state as the researcher was well acquainted with the socio-economic conditions of the place which facilitated and smoothened the data collection process. Another reason was that AICRP – Home Science has adopted the village and promoted various IFS models in the village.

(ii) Selection of the sample : The AICRP on Home Science has promoted two IFS model viz. crop+horticulture and crop+poultry in the adopted villages of MPUAT, Udaipur. For selection of sample, IFS model wise list of women was procured from AICRP on Home Science. From the list, it was observed that crop+horticulture and crop+poultry IFS models were promoted among 50 and 60 respondents, respectively. Thus there were total 110 rural women and all were included in the study.

(iii) Construction of tool : For accomplishing the present investigation, interview technique was used to collect information from the rural women beneficiaries. For this purpose, interview schedule was developed by the investigator by consulting review of literature. The schedule included questions related to knowledge of the rural women regarding technologies promoted under IFS models such as improved varieties of maize and wheat, seed selection, application of fertilizer and manure, types of irrigation system, major pests and diseases of maize and wheat, verities of fruits and vegetables seeds, plant selection criteria, site selection, nursery, transplanting, plant to plant distance, general cultural practices, construction of poultry house, feeding material and quantity, different health checkup, major poultry diseases, vaccination, collection of eggs, feeding of birds, bird breeds, heating during winters and marketing.

(iv) Procedure of data Collection : The Interview technique was used for data collection after establishing rapport and explaining the purpose of the study. Probing was done to get the desired information from the respondents. The respondents were contacted individually and interviewed at their homes and farms. The questions were asked in local dialect (*Mewari*), which helped them to understand the questions more clearly.

Results and Discussion

(i) Knowledge of the rural women regarding technologies promoted under crop+ horticulture IFS model : Promotion of horticulture can, not only lead to livelihood security and high economic returns but also secure nutritional security. The southern Rajasthan region is ideally suited for arid and sub-tropical Horticulture. Many fruits, vegetables, flowers, ornamental and medicinal plants are grown by farm women at their own land with the assistance or training provided by All India Coordinated Research Projects of Maharana Pratap University of Agriculture and Technology, Udaipur.

In this regard, Table-1 depicts that most of the rural women (92%) had knowledge of organic farming and they generally apply cow dung/vermicompost manure in their main cropland. Farm women explained that organic manure is sustainable to environment and does not affect the fertility of soil whereas application of modern manures and fertilizers harm the crop field and its fertility, further more 90 per cent rural women had knowledge regarding important points to be kept in mind while selection of crops. Women explained that knowledge of different factors should be necessary before selecting a crop such as, how traditional and scientific knowledge could be blended, which Horticulture crops should be grown according to suitable temperature and climatic conditions, condition of soil suited to a particular crop, availability of water to drain the crop, multiple cropping systems options, past and present experience of rural women in selection of a particular crop, profit and risk they are expecting from the current crop selection, financial resources required for the purchasing of raw material, availability of machinery and labour needed in transplanting, facility of market to sale the product and government policies for rural women to promote their own enterprise. Dave *et al.* (2014) assessed knowledge about vegetable cultivation technologies promoted under NAIP for tribal women and reported that knowledge of participants about okra, tomato and chilli cultivation technologies were significantly (0.01) higher than the non-participant tribal women.

Further Table-1 reveals that 82 per cent of the respondents had knowledge of appropriate climate required for growing fruits and vegetables. Respondents explained that as the temperature of Udaipur region is semi-arid, and the pattern of rainfall is unpredictable, so they generally choose that kind of crop which require less water and maintenance. More than three fourth of the respondents (78%) reported that they give importance while selection of proper place and site for growing of crop, availability of raw material and labour, requirement of irrigation and drainage facility and proper marketing and transport facility so that they could run it smoothly. Respondents had knowledge about signs of fruit maturity and right time to pluck the fruits and vegetables, application of fertilizer and manure in maize and wheat crops and appropriate irrigation system for maize and wheat crop (70%). Rural women also had knowledge of benefits of multiple farming as it gets maximum benefit and profit (68%). About 62 per cent of the respondents had knowledge of getting soil testing and whom they contact for it wheareas 60 per cent respondents had knowledge of selection of improved verities of maize and wheat. It was further clear from Table, that 22 to 30 per cent of the respondents had knowledge regarding different kind of insects/pest and post-harvest management of horticultural crops, respectively. Only 20 per cent respondents had knowledge regarding appropriate spacing between two horticulture crops as they had given inappropriate answers.

The study is also in line with Shaikh and Shinde (2019), they stated that knowledge of farm women regarding various agricultural activities was higher namely bird watching, seed bed preparation, intercultural operations, land preparation, harvesting and medium in marketing, post-harvest operations and processing activities.

(ii) Knowledge of the rural women regarding technologies promoted under crop+poultry IFS model : It is important to note that in the present study many villagers gave up their poultry activity due to current pandemic situation and spreading of bird flu/avian influenza in the year 2021 which had hampered their Poultry activity as there was scarcity of raw material for chicks, layers and broilers in the local market and consumer showed negative attitude towards consumption of Poultry items during the pandemic. Hence very few respondents were available at the time of field survey who had poultry activity.

Perusal of Table-2 shows knowledge of the respondents about fodder. All the respondents had knowledge that the ideal green fodder given to poultry chicks is maize, *chari*, *bazara, jowhar,* and sorghum, 75

Table-1 : Knowledge of the respondents regarding technologies promoted under crop+horticulture IFS model. n=50

S. No.	Components	Total	
		f	%
1.	Selection of site for carrying out horticulture operations	39	78
2.	Selection of crop	45	90
3.	Selection of improved varieties of maize and wheat	30	60
4.	Application of fertilizer and manure in maize and wheat crops	35	70
5.	Appropriate irrigation system for maize and wheat crop	35	70
6.	Suitable climate for growing fruits and vegetable	41	82
7.	Appropriate distance between two crops	10	20
8.	Indicators/sign of maturity/ripening of fruits and vegetables	35	70
9.	Postharvest management practices	15	30
10.	Insect-pest management	11	22
11.	Benefits of soil testing	32	62
12.	Benefits of organic farming	46	92
13.	Benefits of multiple farming	34	68

Table-2 : Knowledge of the respondents regarding technologies promoted under crop+poultry IFS mode. n = 60

S. No.	Components	Total	
		f	%
1.	Selection of improved varieties of maize and wheat	35	58.33
2.	Application of fertilizer and manure in maize and wheat crops	40	66.66
3.	Appropriate irrigation system for maize and wheat crop	38	63.33
4.	Requirement of floor space for one layer	33	55
5.	Requirement of area for a layer	25	41.66
6.	Temperature of Poultry house	21	35
7.	Requirement of lights by layers per day	15	25
8.	Requirement of ceiling height in the centre	18	30
9.	Requirement of fodder	33	55
10.	Average body temperature	21	35
11.	Ideal fodder for Poultry farm	60	100
12.	Cage Poultry farming system	45	75
13.	Requirement of space for one hen in a cage system	18	30
14.	Distance between brooder house and layer house	25	41.66
15.	Keeping chickens can be in a unit measuring of 20’ x 5’	15	25
16.	Requirement of one male hen in a cage	28	46.66

per cent respondents reported that the cage poultry farming system was ideal is layers. In cage, the birds are kept in one, two or three per cage should arranged in single or double or triple rows, 63.33 to 66.66 per cent respondents had knowledge of appropriate irrigation system for maize and wheat crop and application of fertilizer and manure in maize and wheat crops. More than half of the respondents (58.33%) had knowledge about the selection of improved verities of maize and wheat, 55 per cent of the respondents had knowledge about the floor space which is required for one layer and fodder requirement, as they reported that in layer house, birds over 18-20 weeks of the age are reared. Experts from MPUAT explained that each broiler require one square foot of floor space while a layer requires two square feet of floor space under deep-litter system of rearing. About 46.66 per cent respondents reported that normally one rooster is recommend for every ten hens for reproduction of chicks. They explained that in a large flock, there is often more than one rooster, with no problems but in smaller flocks, it could be a greater risk. In a study by Yadav and Pareek (2016) majority (45.71%) of the on-campus trainee’s had high level of knowledge followed by medium level of knowledge (41.43%) and low level of knowledge (12.86%) about use of animal husbandry practices. Whereas 55.71 per cent of trainees had good knowledge about use of improved farm implements followed by 34.29 per cent had medium level of knowledge and 10 per cent had low level knowledge.

Regarding area required for a layer, 41.66 per cent respondents had knowledge of area required for each bird to lay eggs and the distance between brooder house and layer house i.e. it should be at least of 100 meters. It is further suggested that the egg collection room, office room and the feed storeroom should be located near entrance to minimize the movement of people around the poultry sheds.

Table-3 : Distribution of the respondents by their knowledge regarding promoting technologies. n=110

Category	f	%
Good (Above 66.66%)	44	40
Average (33.33% - 66.66%)	50	45.45
Poor (Less than 33.33%)	16	14.54

Table-2 indicates that equal number of the respondents (35%) had knowledge regarding the maintenance of average body temperature of hen and poultry house. Experts suggested that normal chicken body temperature ranges from 105 to 107 degrees Fahrenheit and the temperature of the poultry house should be optimal that lies between 65° and 75°F. Anything above 75°F can cause an unhealthy amount of stress on the chickens which could affect their organs and reduces their life expectancy also.

About 30 per cent of the respondents reported that the height of the ceiling in the center should be 10 to 12 feet above the ground floor, 2 square feet space required per hen in the cage, 2.5 to 3 square feet area is required for each bird to lay eggs whereas 25 per cent of the respondent reported that the layers requires 14-16 hours of light of each day for the better production of eggs. They also stressed that light should be provided at 7-8 feet above the ground level and must be hanged from ceiling. Kurbetta (2016) showed that 80 per cent rural women had low level of knowledge in integrated pest management followed by integrated farming system (56.70%), seed treatment (70%) and organic farming (63.33%). Only in case of dairy management, majority (63.30%) of the untrained women possessed medium level of knowledge.

(iii) Overall knowledge of the respondents regarding promoted technologies : Data in Table 3 reveal that 40 per cent of the respondents exhibited good knowledge, 45.45 exhibited average knowledge and 16 per cent of the respondents had poor knowledge about technologies promoted under IFS model.

Conclusions

It can be concluded from the findings that, 45.45 per cent pf the respondents were found in average knowledge category whereas, 40 per cent had good knowledge about both IFS model. Only 14.54 per cent of the respondents were found in poor knowledge category. Hence, there is a need to pay more emphasis on Integrated Farming System aspects during the trainings. For exposure to new technologies, regular visitis of women should be organized at KVK and ATIC center, etc.

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Evaluation of Botanicals against Phomopsis Blight in Brinjal

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Abstract

The present research was carried out with an objective to develop an effective, economic and environmentally sound management practice for control of disease Phomopsis blight. Some commonly available plant extracts were being used for the evaluation against the pathogen *Phomopsis vexans* in *In-vitro* and *In-vivo* condition. To evaluate the antifungal activity of botanicals. Seven different botanicals/plant extracts were tested on different concentration like 5%, 10%, 15% for their antimicrobial behavior against the test pathogen *Phomopsis vexans* by Poisoned Food Technique ((Nene and Thapliyal, 1993) under *in-vitro* condition. In *in-vivo* condition The experiment conducted was with design Randomized Complete Block Design. The time of spraying botanical was scheduled at disease appearance stage and three sprays were sprayed at 10 days interval.In the present investigation has been undertaken with a view to study *in-vitro* and *in-vivo* efficacy of some antifungal plant extracts. In *in-vitro* evaluation botanicals The minimum mycelial growth was observed in T_4 *Allium sativum* (16.77 mm) at 5% concentration and (0.00 mm) at 10, 15% which was statistically at par with T_7 *Curcuma longa* (0.00) at 10 and 15 % and next effective botanical was T_8*Zingiber officinale* (17.27 mm), T_3*Ocimum sanctum* (24.07 mm), T_2 *Azadiractin indica* (32.17 mm), T_5 *Lantana camara* (36.00 mm), T_6*Aeglemarmelos* (37.79 mm) at 15% concentration. In *in-vivo* conditions among all the treatments applied *Allium sativum* shows minimum percent disease index(12.00%), (24.00%) (36.66%) after 82, 92 and 102 days after planting.

Key words : *Brinjal Phomopsis blight, Phomopsis vexans, botanicals/plant extracts, management.*

Introduction

Brinjal (*Solanum melongena* L.) is an important vegetable crop cultivated in the tropics and sub-tropics, and grown extensively in China, India, Bangladesh, Pakistan and Philippines. It is one of the most important vegetable crops of India (Zeven & Zhukovsky 1975, Rashid 1976, Sekara *et al*., 2007) and its name is derived from Arabic and Sanskrit whereas, the name egg plant has been derived from its shape resemblance to the egg. It is also known as 'Guinea squash' (Thompson and Kelly, 1957).The centre of origin of brinjal is Indo-Burma region (Vavilov1928). Brinjal is known to have many medicinal properties and good for diabetic patients. It has also been recommended for patients suffering from liver complaints (Shukla and Naik 1993).Brinjal is described as the 'King of vegetables' due to it's versatility use in Indian food (Choudhary and Gaur, 2009).This crop affected by various diseases which causes damage in all growth stage limiting production. Among those diseases Phomopsis blight and fruit rot caused by *Phomopsis vexans* has been treated as one of the major constraints to eggplant cultivation in the country (Khan, 1999; Das, 1998).It is also said that most destructive and important disease on brinjal are Brinjal leaf blight and fruit rot incited by the fungus, *Phomopsis vexans* (Sacc. & Syd.)Harter (Edgerton and Moreland, 1921).Phomopsis blight was first reported India from the Gujarat state in 1914 and then from almost all the states wherever brinjal is grown (Rangaswamy and Mahadevan, 2002) and since then from many regions of India and crop loss due to this disease ranging from 15-20%.It has been reported that pathogen *Phomopsis vexans* reduces yield and marketable value of the crop nearby 20-30% (Jain and Bhatnagar 1985; Kaur *et al*., 1985). *Phomopsis vexans* associated with brinjal has been reported from many areas in tropical parts except few African countries (Smith *et al*., 1998) the pathogen is believed to be originated from South Asia (Prance and Nebbit 2005). This disease appears as damping off, tip over and seedling blight in the nursery and fruit rot in the harvesting crop (Singh, 1992; Ashrafuzzaman, 2006). It is readily transmitted through seeds internally as well as externally (Porter 1943, Vishunavat & Kumar 1993). This disease transmits through the spores produced by the fruiting body pycnidia. It survives in or on eggplant crop debris soil and seed. It spread through the fungal spore that dispersed by rain splashes, contaminated equipment and insects (Howard *et al*., 2007). It has been reported that pathogen *Phomopsis vexans* reduces yield and marketable value of the crop nearby 20-30 % (Hossain *et al*., 2013).In India losses to the extent of 10-20 per cent have been reported (Panwar *et al*., 1970).It not only affects the market value of fruits but, also adversely affect the nutritive value (Bhale *et al*. 2001).Seed is also one of the infection source of *P. vexans* and may serve as a substrate for pathogen survival. The pathogens remain on the seed coat and the cotyledons causing various degrees of seed discoloration (Chaudhary and Hasija 1979).

Harter in 1914 reported this pathogen as host specific on brinjal, but is also reported on other hosts including Acacia, Capsicum, Sorghum and Prunus. *Phomopsis vexans*is a pycnidia fungus with an apparent sexual form in genus *Diaporthe*, easily seed born and producing large numbers of conidia. It causes disease in *Solanum melongena.* Its only significant host, ranging from poor seed germination and damping off seedling to leaf and stem lesion and to fruit rot, both in the field and after harvest. The temperature required for *Phomopsis vexans* for growth and pycnidia formation are 25ºC. The pH required is 4.0 to 9.0 favoured growth and pycnidia formation. The pathogen was internally as well as externally seed born and was transmitted to the seedlings. The inoculum on stem and fruit survived for 24 months while inoculumon leaves survived only for two months in field. Brinjal is being a nutritious vegetable crop with short duration but requires more chemical fertilizer and pesticides. Exclusive dependence of chemical methods of management of diseases is not always advisable (Campbell, 1989). The inappropriate use of pesticides especially fungicides were found to poses adverse effect on ecosystem and possible carcinogenic risk than herbicides and insecticides together. Excess amount of fertilizer causes severe health hazard and effect soil fertility. A report found that about 3,55,000 people die globally every year for the poisoning of different agrochemicals especially pesticides and two third of the global death is due to chemical farming from the developing countries like India (Shoron and Nishanthlalu, 2014). Fertilizers exclusive dependence of chemical methods of management of disease is not always advisable. Certain protective fungicides although hazardous to environment are still used for the control of fungal diseases (Nwankiti 1990).

Due to the aforementioned considerations, there is a need to develop new management strategies to reduce the dependence on the synthetic agrochemicals in management of plant diseases. The present research was carried out with an objective to develop an effective, economic and environmentally sound management practice for control of disease. Many higher plants and their constituents have been successful in plant disease management and have proved to be non-phytotoxic and harmless. Thus, in this study some commonly available plant extracts were being considered for the evaluation against the pathogen *Phomopsis vexans*. Onion contains chemicals that seem to reduce swelling (inflammation), reduce lung tightness in people with asthma, and reduce levels of cholesterol and sugar in the blood. Onion contains chemicals that seem to reduce swelling (inflammation), reduce lung tightness in people with asthma, and reduce levels of cholesterol and sugar in the blood. Onion contains chemicals that seem to reduce swelling (inflammation), reduce lung tightness in people with asthma, and reduce levels of cholesterol and sugConsidering the importance of the management of this disease. The present investigation was carried out with fallowing material and methods.

Materials and Methods

The pathogen *Phomopsis vexans* isolated from the infected leaves and fruit of brinjal which was collected from Organic Research and Demonstration Block at College of Horticulture VCSG Uttarakhand University of Horticulture and Forestry following tissue segmentation method. The infected leaves were thoroughly washed with running tap water and then, immediately examined under compound microscope for preliminary identification of the pathogen. After this the samples are used for pathogen isolation. The infected leaf collected from the research field were cut into 2-4 mm bit with a margin of infected portion and surface sterilized with 1:1000 mercuric chloride ($HgCl_2$) solution for 30 seconds. The pieces were thoroughly rinsed 3 times in sterilized distilled water to remove the residue of mercuric chloride. The cut pieces were placed in between two layers of blotting sheet to remove moisture and then aseptically transfer to sterile potato dextrose agar slants with the help of sterilized inoculation needle and incubated in BOD incubator at 27±1ºC temperature and observed periodically for mycelia growth of fungus. Colonies developed from the inoculated sample pieces were identified by taking mycelial character as means for identifying the pathogen.After isolation culture obtained was purified by single spore isolation technique (Johnston and Booth, 1983).10 ml of two per cent water agar media was poured into sterile Petri Plates and left for few minutes to solidify. Dilute spore suspension was prepared by adding seven days old fungal culture in a sterilized distilled water. One ml of suspension prepared was spread uniformly on agar and these plated were incubated at 27±1ºC for 12 hours. The plates then observed under microscope to locate single isolated and germinated conidium. The areas having the spore are marked on the surface of the plates. The growing hyphal tip portion of the isolate was cut with the help of cork borer. Using an inoculation needle under aseptic condition it was carefully transferred into potato dextrose agar plates and incubated at 27±1ºC to get pure

Table-1 : Description of botanicals / plant extracts.

Common name	Botanical name	Family	Plant part used
Neem	*Azadiractin indica*	*Meliaceae*	Leaves
Tulsi	*Ocimum sanctum*	*Lamiaceae*	Leaves
Garlic	*Allium sativum*	*Amaryllidaceae*	Clove
Lantana	*Lantana camara*	*Verbenaceae*	Leaves
Bael	*Aeglemarmelos*	*Rutaceae*	Leaves
Turmeric	*Curcuma longa*	*Zingiberaceae*	Rhizome
Ginger	*Zingiber officinale*	*Zingiberaceae*	Rhizome

Table-2 : Rating scale used to record disease intensity on leaves for Phomopsis blight

Degree of infection of leaves	Category	Grade/numerical value
No infection	I	0
1-7% infection on leaves	II	1
8-14% infection on leaves	III	2
15-30% infection on leaves	IV	3
31-40% infection on leaves	V	4
41-100% infection on leaves	VI	5

Table-3 : Effect of different botanicals on mycelial growth (mm) of at 5, 10, 15 per cent concentration.

T. No.	Treatments	Radial growth (mm) Does (%)		
		5	10	15
T_1	Control (no botanical applied)	71.97±0.67	71.97±0.67	71.97±0.67
T_2	*Azadiracti nindica*	57.82*±0.56	42.07*±0.80	32.17*±0.86
T_3	*Ocimum sanctum*	44.62*±0.83	31.32*±0.86	24.07*±0.62
T_4	*Allium sativum*	16.77*±0.59	00.00*±0.00	0.00*±0.00
T_5	*Lantana camara*	58.87*±0.57	43.92*±0.67	36.00*±0.45
T_6	*Aeglemarmelos*	52.35*±0.57	40.50*±1.07	37.97*±0.79
T_7	*Curcuma longa*	20.57*±0.84	00.00*±0.00	00.00*±0.00
T_8	*Zingiber officinale*	34.67*±0.60	22.17*±0.84	17.27*±0.71
	SE(D)	0.96	1.02	0.85
	C.D(0.05)	2.00	2.11	1.77

culture. The pure culture obtained was maintained in laboratory refrigerator for further studies.

***In-vitro* bioassay of Botanicals :** To evaluate the antifungal activity of botanicals. Seven different botanicals/plant extracts namely *Azadirachta indica, Ocimum sanctum, Allium sativum, Lantana camara, Aeglemarmelos, Curcuma longa* and *Zingiber officinale* were tested on different concentration like 5 %, 10 %, 15 % for their antimicrobial behavior against the test pathogen *Phomopsis vexans*by Poisoned Food Technique (Nene and Thapliyal, 1993) under *in-vitro* condition. Procedure followed for the preparation of plant extracts are explained detailed in below.

Preparation of crude extract of Botanicals : 100 grams of fresh plant materials such as leaves, cloves and rhizome were collected from each plant and fresh samples were washed in tap water and finally washed thrice using sterilized distilled waterand chopped and crushed in a sterilized mortar and pestle by adding the distilled water (1:1 w/v). The macerate obtained was filtered through two layered muslin cloth. Again, filtered through Whatman No. 42 filter paper. Finally the filtrates obtained from the leaves, rhizome and cloves were used as stock solution (Begum and Bhuiyan, 2006).From the stock solution different concentration of aqueous extracts5, 10 and 15 ml was added to 95, 90 and 85 ml of sterilized molten potato dextrose agar medium respectively so as to get 5,10 and 15 per cent concentrations. The flask was shaken gently to ensure proper From the stock solution different concentration of aqueous extracts5, 10 and 15 ml was added to 95, 90 and 85 ml of sterilized molten potato dextrose agar medium respectively so as to get 5,10 and 15 per cent concentrations. The flask was shaken gently to ensure proper mixing of were placed in middle of the plate with the help of cork borer or inoculation needle and incubated at 27±1 °C. Petri plates contain only pathogen on PDA media served as control.3 replications were maintained for each treatment. The colony growth was measured after 7 days botanicals in PDA. About 20 ml of molten PDA was poured into each of the 90 mm sterilized Petri plates. After solidification of media each plate was seeded with 5 mmmycelial growth over control, calculated by using the formula as given by Vincent (1947).

Observations recorded Size of colony in millimeter(mm) : The size of fungal colony was observed by measuring the radial growth of the fungal colony with

Table-4 : Effect of different botancals on per cent mycelial inhibition of pathogen at 5, 10, 15 per cent concentration.

T. No.	Treatments	Percent inhibition over control Does (%)		
		5	10	15
T_1	Control (no botanical applied)	0.00±0.00	0.00±0.00	0.00±0.00
T_2	*Azadiractin indica*	19.62*±1.42	41.50*±1.48	55.89*±1.09
T_3	*Ocimum sanctum*	37.95*±1.61	56.45*±1.37	66.55*±0.68
T_4	*Allium sativum*	76.66*±0.68	100.00*±0.00	100.00*±0.00
T_5	*Lantana camara*	18.16*±1.30	38.96*±0.83	49.93*±0.72
T_6	*Aeglemarmelos*	27.41*±0.70	43.67*±1.96	47.23*±0.88
T_7	*Curcuma longa*	71.38*±1.33	100.00*±0.00	100.00*±0.00
T_8	*Zingiberofficinale*	51.80*±1.00	69.10*±1.31	75.95*±1.23
	SE(D)	1.59	1.61	1.06
	C.D (0.05)	3.30	3.34	2.20

Table-5 : Effect of different Botanicals on per cent disease index (PDI) 82, 92 and 102 days after transplanting (DAT).

T. No.	Treatments	Does ml/liter	PDI 82 days	PDI 92 Days	PDI 102 Days
T_1	Control	-	34.66±1.33	44.00±2.30	54.66±1.76
T_2	*Azadiractin indica*	10	22.66*±1.33	30.66*±1.33	40.66*±1.33
T_3	*Ocimum sanctum*	10	21.33*±1.33	31.33*±1.76	41.33*±1.76
T_4	*Allium sativum*	10	12.00*±2.30	24.00*±2.30	36.66*±1.33
T_5	*Lantana camara*	10	22.66*±2.66	34.66*±1.33	44.66*±0.66
T_6	*Aegle marmelos*	10	24.00*±2.30	32.00*±2.30	42.66*±1.33
T_7	*Curcuma longa*	10	13.33*±1.33	25.33*±1.33	38.00*±1.15
T8	*Zingiber officinale*	10	17.33*±1.33	26.66*±1.33	38.66*±1.13
	C.D.		5.26	5.80	4.44
	S.E.(d)		2.43	2.68	2.05

the help of measuring scale from two different direction and the mean of observation considered as radial growth of colony.

Per cent inhibition of mycelium : Per cent inhibition of mycelial growth was calculated in relation to growth in control by using the formula of Vincent (1947).

$$I = \frac{C - T}{C} \quad 100$$

Where,

I = per cent growth inhibition

C = Radial growth of fungus in control

T = Radial growth of fungus in Treatment

***In-vivo* management of *Phomopsis vexans* :** The field experiment was conducted during *kharif* season 2019 at Organic Research and Demonstration Block, College of Horticulture, VCSG UUHF, Bharsar with 7 Botanicals against *Phomopsis vexans*. The experiment conducted was with design Randomized Complete Block Design. Seven different botanicals/plant extracts are *Azadirachta indica, Ocimum sanctum, Allium sativum, Lantana camara, Aeglemarmelos, Curcuma longa* and *Zingiberofficinale* were tested on concentration 10 %. The time of spraying botanical was scheduled at disease appearance stage and three sprays were sprayed at 10 days interval. The first spray was applied as soon as the first symptom of the disease on leaves was observed in the experimental field. The spraying was done by hand sprayer to cover whole surface of plant fruit, flower and leaves. Per cent disease index (PDI) was recorded by five leaves on plants are selected randomly and rating of each leaves is done by using a 0-5 rating scale given by Pandey *et al*. (2002).

Per cent disease index was calculated by following formula (Patil *et al*., 2003) :

$$PDI = \frac{(n \quad V) \quad 100}{N \quad S}$$

Where, = Summation

n = Number of leaves in each category

V = Numerical value of leaves observed

S = Maximum numerical value/grade

N = Total no. of leaves observed

Results and Discussion

Botanicals (Plant extracts) might be a better alternative of chemical pesticides in management of plant diseases. Seven botanicals *viz*., *Azadirachta indica, Ocimum sanctum, Allium sativum, Lantana camara, Aeglemarmelos, Curcuma longa, Zingiber officinale* at three different concentrations (5, 10 and 15 %) were evaluated in the laboratory for their efficacy against *Phomopsis vexans* through poisoned food technique.

All the botanicals tested on this experiment were significant over control. The minimum mycelial growth was observed in T_4 *Allium sativum* (16.77 mm) at 5% concentration and (0.00 mm) at 10, 15 % which was statistically at par with T_7 *Curcuma longa* (0.00) at 10 and 15 % and next effective botanical was T_8*Zingiber officinale* (17.27 mm), T_3*Ocimum sanctum* (24.07 mm), T_2 *Azadiractin indica* (32.17 mm), T_5 *Lantana camara* (36.00 mm), T_6*Aeglemarmelos* (37.79 mm) at 15% concentration. While maximum mycelial growth of pathogen was observed with T_1 Control (71.79 mm) at each concentration. T_4 *Allium sativum* inhibited 100% growth of fungus at 10 and 15% concentration which statistically at par with T_7 *Curcuma longa* inhibited 100% radial growth @ 10 and 15 % concentration.

Evaluation of seven botanicals under laboratory (*in vitro*) condition at three different concentrations i.e., 5, 10, and 15% was tested against pathogen (*Phomopsis vexans*) by poisoned food technique (Akthar and chaube, 2006). This experiment revealed that *Allium sativum*99concentration maximum inhibition of radial growth was recorded in garlic and turmeric extract 100% (Das *et al*.,2018) reported that bulb extracts of *Allium sativum* was found most effective (100%) inhibition at 10% concentration.applied *Allium sativum* shows minimum percent disease index(12.00%), (24.00%) (36.66%) after 82, 92 and 102 days after planting followed by *Curcuma longa* (13.33%), (25.33%), (38.00%), *Zingiberofficinale* (17.33%), (26.66%), (38.66%), *Ocimum sanctum* (21.33%), (24.00%), (36.66%) and the maximum PDI was observed in *Lantana camara* (22.66%), (32.66%), (44.66%). Observations in the present investigation are similar with findings of (Lakshmi 2011) that tulsi extract used for field was moderately effective.

Were placed in middle of the plate with the help of cork borer or inoculation needle and incubated at 27±1 °C. Petri plates contain only pathogen on PDA media served as control.3 replications were maintained for each treatment. The colony growth was measured after 7 days incubation. The efficacy of the botanicals was expressed as per cent inhibition of mycelial growth over control, calculated by using the formula as given by Vincent (1947).

Observations recorded Size of colony (in mm) : The size of fungal colony was observed by measuring the radial growth of the fungal colony with the help of measuring scale from two different direction and the mean of observation considered as radial growth of colony.

Per cent inhibition of mycelium : Per cent inhibition of mycelial growth was calculated in relation to growth in control by using the formula of Vincent (1947).

$$I = \frac{C - T}{C} \quad 100$$

Where,

I = per cent growth inhibition

C = Radial growth of fungus in control

T = Radial growth of fungus in treatment

***In-vivo* management of *Phomopsis vexans* :** The field experiment was conducted during *kharif* season 2019 at Organic Research and Demonstration Block, College of Horticulture, VCSG UUHF, Bharsar with 7 Botanicals against *Phomopsis vexans*. The experiment conducted was with design Randomized Complete Block Design. Seven different botanicals/plant extracts are *Azadirachta indica, Ocimum sanctum, Allium sativum, Lantana camara, Aeglemarmelos, Curcuma longa* and *Zingiberofficinale* were tested on concentration 10 %. The time of spraying botanical was scheduled at disease appearance stage and three sprays were sprayed at 10 days interval. The first spray was applied as soon as the first symptom of the disease on leaves was observed in the experimental field. The spraying was done by hand sprayer to cover whole surface of plant fruit, flower and leaves. Per cent disease index (PDI) was recorded by five leaves on plants are selected randomly and rating of each leaves is done by using a 0-5 rating scale given by Pandey*et al*. (2002).

Per cent disease index was calculated by following formula (Patil *et al*., 2003):

$$PDI = \frac{(n \quad V) \quad 100}{N \quad S}$$

Where, = Summation

n = Number of leaves in each category

V = Numerical value of leaves observed

S = Maximum numerical value/grade

N = Total no. of leaves observed

The percentage disease index (PDI) was calculated based on the damage caused by pathogen *Phomopsis vexans* on the leaves of brinjal. Among all the treatments applied *Allium sativum* shows minimum percent disease index (12.00%), (24.00%) (36.66%) after 82, 92 and 102 days after planting followed by *Curcuma longa* (13.33%), (25.33%), (38.00%), *Zingiber officinale* (17.33%), (26.66%), (38.66%), *Ocimum sanctum* (21.33%), (24.00%), (36.66%) and the maximum PDI was observed in *Lantana camara* (22.66%), (32.66%), (44.66%). Observations in the present investigation are similar with findings of (Lakshmi 2011) that tulsi extract used for field was moderately.

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Principles and Strategies of Pest Management in Organic Farming System

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Introduction

Organic agriculture is a holistic production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Holistic means near-closed nutrient and energy cycle system considering the whole farm as one organism. Organic agriculture relies on a number of farming practices based on ecological cycles and aims at minimizing the environmental impact of the food industry, preserving the long-term sustainability of soil and reducing to a minimum use of nonrenewable resources. Organic agriculture is both a philosophy and a system of farming aiming to produce food that is nutritious and uncontaminated with substances that could harm human health. Organic farming benefits to the ecosystem include conservation of soil fertility, carbon dioxide storage, fossil fuel reduction, preserving landscape, and preservation of biodiversity.

Pest management in organic farming is achieved by using appropriate cropping techniques, biological control, and natural pesticides (mainly extracted from plant or animal origins). Organic farming is characterized by higher diversity of arthropod fauna and conservation of natural enemies than conventional agriculture.

According to the IFOAM, organic agriculture is guided by four principles :

Health (soil, plant, animal, and human),

Ecology (living ecological systems and cycles),

Fairness (environment and life opportunities), and

Care (protect the health and well-being of current and future generations as well as the environment).

Pest management in organic farming is a holistic (whole-farm) approach that largely depends on the ecological processes and biodiversity in the agroecosystem. Accordingly, most IPM tactics, principles, and components match with organic farming systems. The goal of this strategy is to prevent pests from reaching economically damaging levels without causing risk to the environment. Successful IPM programs in organic farming may have the following components: (1) monitoring crops for pests, (2) accurately identifying pests, (3) developing economic thresholds, (4) implementing integrated pest control tactics, and (5) record keeping and evaluation.

The factors that render crop habitat unsuitable for pests and diseases include limitation of resources, competition, parasitism, and predation. These factors play an important role in maintaining equilibrium of the agro-ecosystem and suppression of harmful pests. Faunal and floral diversities play a substantial role in pest and disease management in organic farming system. The four principles of pest management in organic farming system, namely, prevention, avoidance, monitoring, and suppression.

Differences between organic and conventional farming with respect to plant protection : Few options of plant protection substances are available for certified organic growers compared to conventional ones. Thus, they should capitalize on the natural processes and management of the ecosystem to control harmful organisms. Organic farms had a more diverse arthropod fauna, on average, than conventional farms. Additionally, natural enemies (parasitoids and predators) were more abundant on organic farms. Arthropod biodiversity, as measured by species richness, on average one-third greater on organic farms than on conventional farms.

Under organic farming systems, the fundamental components and natural processes of ecosystems, such as soil organism activities, nutrient cycling, and species distribution and competition, are used directly and indirectly as farm management tools to prevent pest populations from reaching economically damaging levels. Soil fertility and crop nutrients are managed through tillage and cultivation practices, crop rotations and cover crops and supplemented with manure, composts, crop waste material and other allowed substances.

Soil-borne and root pathogens are usually found in low levels in organic farming as compared to conventional farming. Insect pests such as aphids and whiteflies (sucking insects) are less serious in organic farming than in conventional farming due to lower nitrogen concentrations in foliar tissues or phloem of plants in the former compared with the latter. Almost all pesticides available for organic farming have short residual effects and work through direct contact mode of action as compared to the persistent systemic pesticides used in conventional farming. Table 1 gives the main differences between organic and conventional farming with respect to soil fertility, biodiversity and other criteria.

Crop protection practices in organic farming : Practices and tactics used in organic farming are based on the three management strategies, which include prevention, monitoring and suppression. These practices will be intensively discussed in the following paragraphs:

Identification and monitoring of crop pests : Crop pests include insects, weed, plant pathogens, invertebrate, and vertebrate animals. Identification of insect pests and their natural enemies is an important step in any pest management program. Insect pests and natural enemies could be identified using keys and field guides or otherwise consulting an official identification bodies. Unlike insect pests, plant pathogens including fungi, bacteria, virus, and nematodes are difficult to identify in the field and may need laboratory diagnosis. However, signs of insect damage and symptoms of plant diseases may be easily distinguished in the field. Weeds could be easily identified using key and field guides.

Monitoring is the regular inspection or scouting of field crops for pests including insects, pathogens, nematodes, and weeds, to determine their abundance and level of damage. It serves as an early warning system for the presence of pests and diseases providing information for decision-making regarding management action and evaluation of control methods. Insect pests can be monitored through visual observation, pheromone and light traps, sticky traps, water traps, yellow traps, sweep nets, beating trays and pitfall traps. Scouting data are used to develop economic thresholds, a useful decision-making tool to start control action when a pest population reaches or exceeds the specified economic threshold.

Tactics used for pest prevention and suppression in organic farming : A successful integrated pest management (IPM) program in organic farming incorporates a variety of pest management tactics such as cultural, mechanical/physical, biological and biopesticide (allowed for organic use) tactics individually or in combination. Each control tactic, discussed below employs a different set of mechanisms for preventing and suppressing pest populations.

Cultural pest control : The goal of cultural control is to alter the environment, the condition of the host, or the behavior of the pest to prevent or suppress an infestation. It disrupts the normal relationship between the pest and the host and makes the pest less likely to survive, grow or reproduce.

In agricultural crops, crop rotation, selection of crop plant varieties, timing of planting and harvesting, irrigation management, crop rotation, and use of trap crops help reduce populations of weeds, microorganisms, insects, mites, and other pests. These cultural practices are more preventive than curative and thus may require planning in advance.

The diversified habitat provides these parasites and predators with alternative food sources, shelter and breeding sites.

Tillage can cause destruction of the insect or its overwintering chamber, removal of the protective cover, elimination of food plants and disruption of the insect life cycle generally killing many of the insects through direct contact, starvation or exposure to predators and weather.

The use of trap strip crops can control insect damage at the field edges and at the same time avail refuge and food for beneficial insects.

Insect resistance is an important component of pest and disease management. Quality-based resistance can be induced in plants through management of nutrients and irrigation. Intercropping and biodiversity play an important role in pest management in organic farming.

Mechanical and physical pest control : One of the simplest methods of physical or mechanical pest control is handpicking insects or hand-pulling weeds. This method works best in those situations where the pests are visible and easily accessible.

Physical or mechanical disruption of pests also includes such methods as mowing, hoeing, flaming, soil solarization, tilling or cultivation, and washing. Animals such as kangaroos cause damage by eating yellow dates; hence, fruit bunches are covered to protect them from such damage.

Devices that can be used to exclude insect pests from reaching crops in organic farming include, but not limited to, row covers, protective nets with varying mesh size according to the pest in question, and sticky paper collars that prevent crawling insects from climbing the trunks of trees.

Water pressure sprays can be employed to dislodge insect pests such as aphids and mites from the plant surface.

Insect vacuums, on the other hand, could be used to remove insects from plant surface and collect them into a collection box.

Table-1 : Fundamental differences between organic and conventional farming.

Organic farming (OF)	Conventional farming (CF)
Synthetic fertilizers and synthetic pesticides are not permitted	Synthetic fertilizers and synthetic pesticides are allowed
Genetically modified organisms (GMOs) are not allowed	GMOs can be used
Soils have higher water holding capacity than Organic farming	Soils have less water holding capacity than Organic farming
Organic farming has larger floral and faunal biodiversity than CF (complex crop pattern)	Conventional farming has smaller biodiversity than Organic farming (simple crop pattern)
The agricultural landscape is characterized by heterogeneity (multicultural system)	The agricultural landscape is characterized by homogeneity (monocultural system)
Minimizing the use of nonrenewable resources by recycling plant and animal waste into the soils (on-farm inputs)	Depends largely on nonrenewable resources (off-farm inputs)
Organic farming is more sustainable than CF	Conventional farming is less sustainable compared to Organic farming
Strictly regulated by international and national institutional bodies such as Codex Alimentarius and IFOAM	Not strictly regulated
Crop protection depends mainly on natural processes such as soil fertility, crop cycle, and biodiversity (more preventive)	Crop protection relies mainly on human intervention with synthetic chemicals (more curative)

Table-2 : Plant protection products for use in organic farming.

Name of product	Purpose and specifications of use
Azadirachtin from the neem tree (*Azadirachta indica*)	Used as insecticide
Beeswax	Used as protectant for treatment of cuts and wounds after pruning or in grafting
Plant oils	Used for control of small-bodied insects such as thrips, aphids, and whiteflies
Laminarin (from *Laminaria digitata*) or kelp or brown algae seaweed	A polysaccharide from the group of the glucans, used to protect plants against fungi and bacteria. Kelp should be grown according to the organic standards
Pheromones	Used only in traps and dispensers
Pyrethrins from the leaves of *Chrysanthemum cinerariaefolium*	Used as insecticide
Pyrethroids (only deltamethrin or lambda cyhalothrin)	Used only in traps with attractants or pheromones
Quassia from the plant *Quassia amara*	Only insecticide and repellent
Microorganisms, e.g., *Bacillus thuringiensis, Beauveria bassiana*, and *Metarhizium anisopliae*	Origin should not be GMOs
Spinosad from the soil bacterium *Saccharopolyspora spinosa*	Used as insecticide
Ethylene	Insecticidal fumigant against fruit flies
Paraffin oil	Used as insecticide against small-bodied insects
ntblFatty acids (soft soaps)	Insecticide against mite, thrips, and aphids
Lime sulfur (mixture of calcium hydroxide and sulfur)	Used as fungicide
Kieselgur (diatomaceous earth) from the hard-shelled diatom protist (chrysophytes)	Used as mechanical insecticide
Naturally occurring aluminum silicate (kaolin)	As insect repellent against a wide range of insects at a rate of 50 kg/ha
Calcium hydroxide	Used as fungicide
Sodium hypochlorite (bleach or as javel water). It is a disinfectant with numerous uses, and its effect is due to the chlorine	Used in seed treatment as viricide and bactericide
Sulfur	Used as broad-spectrum inorganic contact fungicide and acaricide
Copper compounds such as: copper hydroxide, copper oxychloride, copper oxide, tribasic copper sulfate, and Bordeaux mixture (copper sulfate and calcium hydroxide)	Used as fungicide and bactericide maximum of 6 kg copper per ha annually
Sheep fat (obtained from fatty sheep tissues by heat extraction and mixed with water to obtain an oily water emulsion)	A triglyceride consisting predominantly of glycerine esters of palmitic acid, stearic acid and oleic acid.
A repellent by smell against vertebrate pests such as deer and other game animals.	It should not be applied to the edible parts of the crop
Quartz sand	Used as repellent against vertebrate pests

Biological pest control : Biological methods are the use of beneficial organisms that can be used in the field to reduce insect pest populations. Biological control is grouped into three categories: importation or classical biological control, which introduces pest's natural enemies to the locations where they do not occur naturally, augmentation involves the supplemental release of natural enemies, boosting the naturally occurring population, and conservation, which involves the conservation of existing natural enemies in the environment. The role of beneficial species on pests is of relatively greater importance in organic agriculture than in conventional agriculture, because organic growers do not have recourse to highly potent insecticides (such as synthetic pyrethroids) with which to tackle major pest problems.

Bio-pesticide control : Bio-pesticides are characterized by having minimal or no risk to the environment, natural enemies, and nontarget organisms due to their mode of action, rapid degradation, and the small amounts applied to control pests. They are slow acting, have a relatively critical application times, and suppress rather than eliminate a pest population. Biopesticides have limited field persistence and shorter shelf life and present no residue problems. Thus, they are approved for pest management in organic crops.

Plant protection products (PPPs) authorized in organic farming : The crop protection in organic farming is holistic, and hence, it is extremely difficult to separate inputs as plant protectants (pesticides). Plant protection products authorized for use in organic farming differ among countries depending on the differences in crops, pests and cropping systems, as well as regulations and standards adopted by these countries. Organically approved pesticides fall into the following groups: biorational, inorganics, botanicals, microbial, oils and soaps. The most widely used as insecticides are microorganisms, natural pyrethrins, rapeseed oil and paraffin; the most widely used as fungicides are copper compounds, sulfur and microorganisms. The rules of organic agriculture allow the use of unregistered products such as nettle slurry, which is used against aphids. It can be prepared on the farm or shared among farmers.

Natural Enemies in Organic Farming Systems : Virtually all arthropods (insects and their close relatives) serve as food (prey or host) for some other organism, such as predatory or parasitic insects, disease-causing microorganisms, birds, fish, and insect-eating mammals and plants. Insects and other organisms that use arthropods as a resource—resulting in their death, weakening, or reduced reproductive potential—are called natural enemies, biological control agents, biocontrols, or beneficials. In agricultural systems, the most common natural enemies are other insects and spiders. Natural enemies can help keep plant-feeding insects from attaining damaging population levels. It is important to understand how to manage agroecosystems to take advantage of the services of natural enemies. The intentional manipulation of natural enemies (either directly or indirectly) through manipulation of the environment to reduce pest populations or their damage is called biological control or biocontrol. Natural enemies can be generalists, consuming many types of prey, or specialists, with a much narrower host range. There are two general types of arthropods that are natural enemies: predators and parasitoids.

Predators : Predators consume one or more living prey insects. Predatory behavior is widespread among arthropods (insects, spiders and mites). Some common predators in vegetable production systems are spiders, predatory mites, ground beetles, rove beetles, ladybird beetles, predatory bugs, lacewings, mantids, robber flies and syrphid fly larvae.

Fig.-1 : Predatory stink bug, *Tethida barda,* and prey.

Parasitoids : Parasitoids live in or on the body of their host insect during at least part of their life cycle. Parasitoid is the term used to describe an insect that parasitizes and kills its insect host. Parasitoids that insert their eggs into a host's body are called endoparasitoids. Those that lay their eggs outside of the host's body, and whose larvae develop on the outside of the host's body, are called ectoparasitoids. Parasitoids that attack pest insects are called primary parasitoids. Parasitoids that attack other species of parasitoids are called hyperparasitoids. Usually the larval stage of the parasitoid is the parasitic life stage. The adult stage is typically free-living (not parasitic), and needs resources such as water, nectar, or pollen for survival. A typical female parasitoid searches for a host insect and, depending on the species, deposits one or more egg in or on the host. The eggs hatch and develop inside the host insect. When parasitoid development is complete, the parasitic larvae emerge and pupate outside the host, or, in the case of many parasitoids, pupate inside the host insect and emerge as adults. Most parasitoids are in the wasp (Hymenoptera) and fly (Diptera) orders. There are a few species of beetles (Coleoptera) that parasitize other insects. The small group of twisted-wing parasites (order Strepsiptera), consists entirely of parasitoids.

Figure-2 : A whitefly parasitoid, *Encarsia formosa*.

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Effect of PROM and Biodynamic Manure on Nutrient Content, Uptake, Soil Biological Properties, Yield and Economics of Blackgram (*Vigna mungo* L.) under Organic Farming

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Abstract

A field experiment titled "Effect of PROM & Biodynamic Manure on Growth, Yield and Quality of Organic Blackgram {*Vigna mungo* (L.) Hepper}" was conducted at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, MPUAT, Udaipur during *kharif* season of the year 2020 (June-September). The study was conducted with an objective to study the effect of organic sources of nutrients (PROM, BD-500 and BD-501) on the growth, productivity and profitability of the blackgram along with its effect on the physical, chemical and biological properties of the soil. The soil texture of the experimentation site was clay loam and slightly alkaline in nature. PU-1 variety of the crop was used for the research using randomized block design replicated thrice with 11 treatments namely, T1: Control, T_2: 100 per cent RDP, T_3: 75 per cent RDP, T_4: BD-500 (75 g ha^{-1}), T_5: BD-501 (2.5 g ha^{-1}), T_6: 100 per cent RDP + BD-500 (75 g ha^{-1}), T_7: 75 per cent RDP + BD-500 (75 g ha^{-1}), T_8: 100 per cent RDP + BD-501 (2.5 g ha^{-1}), T_9: 75 per cent RDP + BD-501 (2.5 g ha^{-1}), T_{10}: 100 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}) and T_{11}: 75 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}). The results indicated that nutrient content and uptake in seed and haulm and yield, soil biological properties [bacterial, fungal and actinomycetes count (cfu/gram) and dehydrogenase activity] and net return of organic blackgram were found to be significantly higher with the application of 100 per cent RDP through PROM + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}) (T_{10}) invariably followed by T_{11}: 75 per cent RDP through PROM + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}) in comparison to rest of the treatments.

Key words : *Biodynamic, blackgram, BD-500, BD-501, nutrient, organic, PROM, yield.*

Introduction

Pulses are one of the important and inevitable constituent of a balanced diet and its production is an important arm of food grain production of a country. India is the largest pulse producing country in the world with more than 34 per cent share in area and 26 per cent share in production (MoA & FW, GOI, 2017-2018). In India, organic farming is being practiced as traditional agricultural practices since long but to meet the scientific standards, it needs to follow the basic organic farming principles, namely principle of fairness, care, ecology and health. Area under Organic cultivation is increasing every year globally as well as in India. At the global level in the end of 2018, a total of 71.5 million ha was organically managed, representing a growth of 2.9 per cent over the year of 2017 (Willer, FiBL-IFOAM, 2020).

Phosphate Rich Organic Manure (PROM) is a type of nutrient input used as an alternative to aforesaid well-known phosphatic fertilizers like diammonium phosphate and single super phosphate. It is also known as "Green Chemistry Fertilizer". Ministry of Agriculture and Cooperation, Government of India has also approved PROM and has included it under Fertilizer Control Order (Ministry of Agriculture and Cooperation, Annual Report 2014-2015). Biodynamic farming mainly focuses on producing a living soil with revitalized natural forces. It basically works with the cosmic cycles undergoing in the universe (Biodynamics Association of India). There are two major groups of biodynamic preparations, the first group is numbered as BD-502 to BD-507 and the second group includes two preparations as BD-500 and BD-501. BD Preparations are known to increase the growth of the plants by influencing physical, chemical and biological properties of soil and plant.

Inspite of this fact, India still lags on the productivity front of pulses including blackgram. Blackgram is one of the major pulse crops, cultivated in India and adding a considerable contribution in total pulse production. The most prominent reason being the low productivity of blackgram includes its cultivation with very low inputs by the marginal farmers of rainfed areas. Organic cultivation can be a tool to utilise on-farm produced inputs for harvesting synthetic chemical free produce and also enrich the soil system simultaneously.

Materials and Methods

The present investigation was carried out during the *Kharif* 2020 at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur, situated in the southern part of Rajasthan at the latitude of 24° 35' North and longitude of 74° 42' East, situated at an altitude of 580.70 meters above the mean sea level. The soil of the experimental field was clay loam in texture with pH value of 7.9, medium in available nitrogen (285 kg N ha^{-1}), available phosphorus (16 kg P_2O_5 ha^{-1}) and high in potassium (368 kg K_2O ha^{-1}). During the crop growing season, the maximum and minimum temperatures were ranged between 28.5 to 33.1°C and 20.1 to 23.4°C, respectively and with 747.9 mm of total amount of rainfall. The experiment was carried out in the randomized block design (RBD). Random number table (Fisher, 1950) was used as an aid to randomization for the allocation of 11 treatments that comprises namely as T_1: Control, T_2: 100 per cent RDP, T_3: 75 per cent RDP, T_4: BD-500 (75 g ha^{-1}), T_5: BD-501 (2.5 g ha^{-1}), T_6: 100 per cent RDP + BD-500 (75 g ha^{-1}), T_7: 75 per cent RDP + BD-500 (75 g ha^{-1}), T_8: 100 per cent RDP + BD-501 (2.5 g ha^{-1}), T_9: 75 per cent RDP + BD-501 (2.5 g ha^{-1}), T_{10}: 100 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}) and T_{11}: 75 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}).

Seeds 15 kg ha^{-1} of organic blackgram variety 'Pratap Urd-1' was used for the study after treating as per recommendation of organic farming package at the time of sowing. Crop were sown by 'kera' method at 5 cm depth in rows 30 cm apart behind the plough. Nutrient management of the crop was done according to the treatments and phosphate rich organic manure (PROM) was applied to the soil as per the dose of different treatments and the required dose of BD-500 according to treatment was sprayed to soil one day before sowing. Another component of treatment, BD-501 was also applied to the crop at 2-4 leaf stage. The crop was raised as rainfed but light irrigation was arranged 5 days after sowing for better germination. Five plants were selected and tagged in the field at random at harvest. These plants were collected and kept for carrying out post-harvest analysis. To calculate the dry matter, collected samples were oven dried at 65°C till constant weight is obtained. After taking the dry weight, samples were ground to convert it into fine powder and passed through 60 mesh sieves to obtain final sample for the nutrient analysis. Seed samples were also ground to make fine powder as a process of sample preparation for analysis. Although, seeds were not needed to be oven dried as the moisture content in them was already less.

All the chemical analysis were performed in the laboratory with utmost care with the methods that were adopted to carry out the analysis. After calculating the nutrient content by above mentioned methods, the nutrient uptake was calculated by using the mathematical formula as Nutrient uptake (kg ha^{-1}) by multiplying nutrient content (%) in seed or haulm with Seed or haulm yield and then divided by 100. Total nutrient uptake was also calculated by summing the uptake of individual nutrients by seed and haulm. After threshing and winnowing, the weight of clean seeds obtained from each plot was measured. Similarly, haulm yield of the crop was obtained by weighing the harvested produce from each plot.

Results and Discussion

Nutrient content in seed and haulm : The data in Table-1 represents the nutrients present in seed and haulm of the harvested produce. The values presented here depicts that maximum nitrogen, phosphorus, potash, and sulphur, iron and zinc content as 3.99, 0.419, 1.338, 0.294 per cent and 48.3 and 9.64 ppm, respectively was present in the seeds obtained from the plots having the treatment T_{10}: 100 per cent RDP through PROM + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}) which was found statistically at par with T_{11}: 75 per cent RDP through PROM + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}). All the treatments positively influenced the nutrient content in seed.

The same table also exhibits the potassium content in haulm of blackgram. It states that, in similarity to seed, maximum nitrogen, phosphorus, potash, and sulphur, iron and zinc content 2.34, 0.257, 2.298, and 0.141 per cent and 202.15 and 21.11 ppm, respectively in haulm were recorded with T_{10}: 100 per cent RDP through PROM + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}) followed by T_{11}: 75 per cent RDP through PROM + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}). These two treatments were indifferent to each other but significantly superior over control and rest of the treatments.

Nutrient uptake in seed and haulm : Total nutrient uptake in terms of N, P, K, S, Zn and Fe were calculated from the data (Table-2) of nutrient uptake of the respective nutrients by seed and haulm. The data clearly depicts that the maximum nutrient uptake was recorded in T_{10} which were 82.00 kg ha^{-1}, 8.83 kg ha^{-1}, 57.64 kg ha^{-1}, 5.4 kg ha^{-1}, 50.62 g ha^{-1} and 421.93 ha^{-1}, N, P, K, S, Zn and Fe, respectively and it was closely followed by T_{11}. The enhancement in the nutrient uptake by the crop was attributed to better nutrient availability and absorption of nutrients by the crop. The observed results were in close association with the results presented by Raut *et al.* (2018), Malsawmkimi *et al.* (2018), Jat *et al.* (2018) and Bairwa *et al.* (2019), during their respective researches.

Soil Biological Properties : Organics inputs are known to improve the soil biota. To assess the influence of applied inputs to the soil, colony forming units of bacteria, fungi and actinomycetes per gram of soil were assessed. Table-3 indicates that T_{10}: 100 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}) recorded 44.60, 29.13 and 24.96 cfu $gram^{-1}$ of soil of bacteria, fungi and actinomycetes, respectively. This was highest amongst all

Table-1 : Effect of PROM & biodynamic manure on N, P, K, S, Fe and Zn content in seed and haulm of organic blackgram.

Treatments	N content (%)		P content (%)		K content (%)		S content (%)		Fe content (ppm)		Zn content (ppm)	
	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm
T_1 : Control	3.13	1.48	0.308	0.209	1.217	1.769	0.180	0.102	40.04	197.24	8.72	17.02
T_2 : 100 per cent RDP	3.55	1.83	0.379	0.228	1.240	2.056	0.241	0.122	43.43	199.42	9.20	18.44
T_3 : 75 per cent RDP	3.54	1.80	0.375	0.227	1.238	2.053	0.235	0.121	43.27	199.35	9.19	18.35
T_4 : BD-500 (75 g ha^{-1})	3.28	1.59	0.322	0.217	1.222	1.884	0.201	0.109	40.62	198.12	8.80	17.35
T_5 : BD-501 (2.5 g ha^{-1})	3.41	1.69	0.351	0.221	1.233	1.964	0.219	0.115	41.92	198.93	9.08	17.59
T_6 : 100 per cent RDP + BD-500 (75 g ha^{-1})	3.69	1.97	0.394	0.239	1.247	2.151	0.258	0.128	44.89	200.57	9.35	19.03
T_7 : 75 per cent RDP + BD-500 (75 g ha^{-1})	3.65	1.96	0.395	0.237	1.245	2.146	0.256	0.127	44.68	200.26	9.32	18.88
T_8 : 100 per cent RDP + BD-501 (2.5 g ha^{-1})	3.84	2.12	0.409	0.248	1.257	2.255	0.275	0.135	46.49	201.03	9.49	20.05
T_9 : 75 per cent RDP + BD-501 (2.5 g ha^{-1})	3.83	2.08	0.407	0.247	1.254	2.250	0.273	0.132	46.34	200.80	9.46	19.84
T_{10} : 100 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1})	3.97	2.34	0.419	0.257	1.338	2.298	0.294	0.141	48.30	202.15	9.64	21.11
T_{11} : 75 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1})	3.99	2.26	0.418	0.255	1.336	2.272	0.289	0.140	48.08	202.06	9.60	21.02
SEm ±	0.04	0.02	0.003	0.002	0.005	0.021	0.004	0.001	0.09	0.11	0.03	0.10
CD (at 5%)	0.12	0.06	0.008	0.005	0.014	1.698	0.010	0.003	0.26	0.32	0.09	0.30

Table-2 : Effect of PROM & biodynamic manure on NPKS (kg ha^{-1}) and Fe & Zn (g ha^{-1}) uptake in seed and haulm of organic blackgram.

Treatments	N uptake		P uptake		K uptake		S uptake		Fe uptake		Zn uptake	
	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm	Seed	Haulm
T_1 : Control	17.87	20.00	1.76	2.83	6.94	23.91	1.03	1.38	9.72	266.60	4.98	23.01
T_2 : 100 per cent RDP	27.66	31.94	2.95	3.98	9.90	35.89	1.88	2.13	14.37	348.12	7.17	32.18
T_3 : 75 per cent RDP	27.35	30.66	2.90	3.88	9.78	35.04	1.81	2.06	14.19	340.16	7.11	31.32
T_4 : BD-500 (75 g ha^{-1})	19.17	22.94	1.88	3.11	7.21	27.22	1.18	1.57	10.14	286.35	5.14	25.07
T_5 : BD-501 (2.5 g ha^{-1})	20.51	26.58	2.11	3.49	7.50	30.95	1.32	1.81	10.57	313.52	5.45	27.73
T_6 : 100 per cent RDP + BD-500 (75 g ha^{-1})	29.64	36.44	3.16	4.41	10.38	39.72	2.07	2.36	15.30	370.32	7.51	35.14
T_7 : 75 per cent RDP + BD-500 (75 g ha^{-1})	29.13	36.51	3.16	4.41	10.30	39.97	2.05	2.37	15.08	373.09	7.44	35.19
T_8 : 100 per cent RDP + BD-501 (2.5 g ha^{-1})	32.48	40.79	3.46	4.79	11.08	43.44	2.33	2.59	16.96	387.39	8.03	38.64
T_9 : 75 per cent RDP + BD-501 (2.5 g ha^{-1})	31.87	39.96	3.38	4.72	10.87	43.18	2.27	2.54	16.50	385.33	7.87	38.08
T_{10} : 100 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1})	35.30	46.71	3.70	5.13	11.82	45.81	2.60	2.81	18.66	403.27	8.52	42.11
T_{11} : 75 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1})	34.46	45.00	3.63	5.08	11.57	45.26	2.51	2.79	18.25	402.31	8.34	41.84
SEm ±	0.39	0.65	0.03	0.08	0.08	0.88	0.03	0.05	0.12	6.54	0.06	0.65
CD (at 5%)	1.16	1.91	0.09	0.24	0.22	2.62	0.09	0.15	0.34	19.29	0.17	1.91

RDP: Recommended dose of phosphorus through Phosphate Rich Organic Manure

Table-3 : Effect of PROM and biodynamic manure on microbial population, yield and net returns.

Treatments	Bacterial population (X 10^6 cfu/g soil)	Fungi population (X 10^4 cfu/g soil)	Actinomycetes population (X 10^5 cfu/g soil)	Dehydrogenase activity (µg TPF/g soil/h)	Seed yield (kg/ha)	Haulm yield (kg/ha)	Net return (ha^{-1})
T_1 : Control	30.68	19.25	17.21	11.81	571	1352	33319
T_2 : 100 per cent RDP	36.93	25.14	19.77	21.97	779	1746	48945
T_3 : 75 per cent RDP	35.53	24.57	19.66	21.15	773	1706	49157
T_4 : BD-500 (75 g ha^{-1})	33.87	23.17	18.81	16.97	584	1445	34145
T_5 : BD-501 (2.5 g ha^{-1})	31.21	21.14	17.84	16.05	601	1576	36352
T_6 : 100 per cent RDP + BD-500 (75 g ha^{-1})	43.40	27.83	23.53	30.09	804	1846	50829
T_7 : 75 per cent RDP + BD-500 (75 g ha^{-1})	42.03	27.51	23.33	29.70	799	1863	51419
T_8 : 100 per cent RDP + BD-501 (2.5 g ha^{-1})	38.60	26.45	22.03	26.16	846	1927	55050
T_9 : 75 per cent RDP + BD-501 (2.5 g ha^{-1})	38.13	26.06	21.03	25.41	831	1919	54678
T_{10} : 100 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1})	44.60	29.13	24.96	33.59	884	1995	57987
T_{11} : 75 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1})	43.76	28.77	24.25	32.70	869	1991	57547
SEm ±	0.51	0.38	0.27	0.34	6.0	33	632
CD (at 5 %)	1.51	1.12	0.78	1.01	17	97	1863

RDP: Recommended dose of phosphorus through Phosphate Rich Organic Manure

other treatments and were at par with T_{11}: 75 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}) in which 43.76, 28.77 and 24.25 cfu $gram^{-1}$ of soil of bacteria, fungi and actinomycetes, respectively were recorded. Among the sole application of treatments T_2: 100 per cent RDP recorded the best result which was indifferently followed by T_3: 75 per cent RDP. These treatments were followed by T_4: BD-500 (75 g ha^{-1}) and these three treatments were significantly superior over control. The probable reason behind this might be the addition of microbes through organic inputs and improving its activity by influencing the micro-environment in the direction suitable for microbial activity. The results presented by Reeve *et al.* (2010) and Oliveira and Ferreira (2014) are also augmenting in the same direction.

Dehydrogenase activities explain the oxidation reaction and activity of microorganisms in soil. To evaluate the effect of applied organic inputs on the dehydrogenase activity, fresh soil samples were used. The results of the analysis presented in Table 3 indicates that highest dehydrogenase activity of 33.59 µg TPF g^{-1} soil h^{-1} was recorded in T_{10}: 100 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}), which was insignificantly followed by 32.70 µg TPF g^{-1} soil h^{-1} T_{11}: 75 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}). Amongst the sole application of treatments, highest dehydrogenase activity was recorded in two significantly at par treatments, namely T_2: 100 per cent RDP (21.97 µg TPF g^{-1} soil h^{-1}) and T_3: 75 per cent RDP (21.15 µg TPF g^{-1} soil h^{-1}). Dehydrogenase activity recorded in T_4: BD-500 (75 g ha^{-1}) and T_5: BD-501 (2.5 g ha^{-1}) were 16.97 and 16.05 µg TPF g^{-1} soil h^{-1}, respectively.

Yield : Seed and haulm yield obtained per unit area is considered as the productivity of the crop. The data analysed from the experimentation highlighted that the inclusion of PROM and biodynamic manures in the organic cultivation of blackgram has shown clear positive influence on the productivity. The control plot recorded seed yield of 571 kg ha^{-1} and haulm yield of 1352 kg ha^{-1}. The sole application of BD-500 and BD-501 could not bring much variation in the seed and haulm yield as compared to the PROM application. Sole application of PROM at the rate of 75 and 100% RDP recorded seed yield of 773 and 779 kg ha^{-1} and haulm yield of 1706 and

1746 kg ha^{-1}. But the improvement in the productivity was notable when these inputs were applied in combination. The maximum seed yield (884 kg ha^{-1}) and haulm yield (1995 kg ha^{-1}) were recorded in T_{10}, which was statistically at par with the seed yield (869 kg ha^{-1}) and haulm yield (1991 kg ha^{-1}) obtained in $T_{11.}$

Better assimilation and mobilisation of translocate to the important parts by the application of PROM is one of the major reasons of wonderful results obtained during the experimentation. Protection of crops from stresses, increased photosynthetic ability and improvement in soil biota by biodynamic manures were reason behind the positive effect of BD-500 and BD-501. The results recorded in the experiment was also being supported by the findings of Ali *et al*. (2014) and Nandeha *et al.* (2018).

Economics : Applicability of any agronomic input directly depends on the profitability of applied treatments. To assess the profitability, net returns were calculated (Table 3.0) as per the prevailing market rate, and T_{10}: 100% RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}) recorded maximum net return of 57987.00 ? ha^{-1}. This was statistically at par with the treatment, T_{11}: 75% RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}), which recorded 57547.00 ? ha^{-1} net returns. If the effects caused by individual treatments were analysed, it was recorded that PROM showed the best results followed by BD-501 and BD-500, respectively. The improvement in profitability of the crop by the application of these inputs were mainly due to the influence of these inputs on the crop.

Conclusions

From the above representation of results and their discussion, it can be concluded that the application of PROM, BD-500 and BD-501 has resulted in improvement in the nutrient content and uptake by seed and haulm, yield, economics and soil biological properties. Best combination for nutrient content and uptake, microbial population, yield and economics was T_{10}: 100 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}), which was statistically at par with T_{11}**:** 75 per cent RDP + BD-500 (75 g ha^{-1}) + BD-501 (2.5 g ha^{-1}). But after the complete analysis, T_{11} was suggested due to the fact that it gives equally superior result with lesser application of PROM.

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Line X Tester Analysis for Seed Yield and its Traits in Sesame (*Sesamum indicum* L.)

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Abstract

The present investigation carried out by Line x Tester analysis on sesame *(sesamum indicum* L.*)* at the Agricultural Research Station, J.A.U., Amreli, Gujarat. These forty crosses along with a two checks, G.Til-2 and G.Til-3 were evaluated in Amreli during summer 2016-17. Heterobeltiosis crosses for high seed yield per plant and its components in the crosses *viz.,* AT-319 x AT-285, AT-253 x R-T-54, BHUVA-2 x AT-285, AT-319 x G.Til-10 and AT-341 x G.Til-10 and also exhibited significant standard heterosis (G.Til-2 and G.Til-3) for seed yield per plant. For number of seeds per capsule Maximum, significant and positive heterosis over G.Til-2 and G.Til-3 was observed in, AT-253 x G.Til-10.Heterotic effects for seed yield per plant could be a result of combinational heterosis. Hence, to obtain maximum heterotic effects for seed yield per plant, desired level of heterosis for each component character should be worked-out to identify superior hybrids.

Key words: *Sesame, heterobeltiosis, L x T analysis and seed yield per plant.*

Introduction

Sesame (*Sesamum indicum* L.) is a very ancient oilseed crop of the tropic and warm sub-tropics regions with is a member of the order Tubiflorae and family Pedaliaceae. Sesame is predominantly annual self-pollinated (85-95%) diploid (2n=2x=26) crop. It is referred as 'Queen of Oilseeds' due to its regard by the users and owing to its oil quality (Bedigian and Harlan 1986). Sesame contains about 45 - 52% oil, 20 - 27% protein, 6 - 7% moisture, 16% carbohydrate and 6 - 8% crude fiber in its small oblong seeds. Corolla is campanulate having lower corolla lobe longer than the upper one with one sterile and four functional epipetalous stamens (Najeeb 2012). Important sesame growing countries are India, Sudan, Myanmar, China, Uganda, Nigeria, Pakistan, Mexico and Tanzania. However, it is also cultivated in Bangladesh, Somalia, Turkey, Thialand, Venezuela, Ethiopia and Egypt. Worldwide, it is cultivated in an area of 117 lakh ha with production of 60.16 lakh MT and productivity of 512 kg/ha (Myint *et al*., 2020). India is the world leader with the biggest area (1858 thousand ha), production (815 thousand MT) and productivity (438 kg/ha). Being the fourth important oilseed crop in Indian agriculture after groundnut, rape seed and mustard, it is widely cultivated in the states of Uttar Pradesh, Rajasthan, Orissa, Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, West Bengal, Bihar and Assam. In Gujarat, during 2016-17, sesame is cultivated in an area of 2.56 lakh ha with a production of 1.52 lakh tones and productivity of 530 kg/ha (Anon., 2016-17). The average productivity is very low as compare to other growing countries China, Japan and Korea. Hence, there is an urgent need to increase the productivity by breaking the present yield barrier and developing hybrids with high yield potential. However, little is thought about the morphological, growth and biochemical characters that appear highly promising in improving performance of this crop (Suganthi, 2017)

The first important step in the exploitation of heterosis is to know its magnitude and direction. The theory of dominant linked gene hypothesis put forward by Jones (1917) and advocated and discussed in Singh and Singh (1984) appears to be the most acceptable, both in concept and utilization of hybrid vigour in self-pollinated crops. According to them one can select a pure breeding line equally good or even better than F_1 hybrid. For breaking the present yield barrier and evolving varieties with high yield potential, it is desirable to combine the genes from genetically diverse parents (Wadikar *et al.,* 2019).The computation of relative heterosis has no genetic basis and hence not estimated. Hence, heterosis over better parent (heterobeltiosis) and heterosis over standard check G.Til-2 and G.Til-3 (standard heterosis) with significance in the desirable direction have taken into consideration for comparing the different crosses in the present investigation. The aim of heterosis estimation in the present study has to spot out the best combination of parents giving high degree of useful heterosis and characterization of parents for their genotypic worth for future use in breeding programme.

Materials and Methods

The experimental material comprised of four females as testers and ten males as lines and their 40 hybrids derived from line x tester mating design. These 40 hybrids along with a two checks, G.Til-2 and G.Til-3 were evaluated in a ARS, Amreli environments during summer 2016-17. The parents and F_1's with checks were sown in single row (plot) of 2.25 m length with spacing 45 cm x 15 cm. All the agronomical practices and plant protection measures were followed as and when required to raise a good crop of sesame. The observations were recorded on five randomly selected plants from parents and crosses for all characters *viz.,* days to flowering, days to maturity, plant height (cm), height to first capsule (cm), number of branches per plant, length of capsule (cm), width of capsule (cm), number of capsules per plant, number of capsules per leaf axil, number of seeds per capsule, 100-seed weight (g) and seed yield per plant (g). Agricultural Research Station, J.A.U., Amreli is located in North Saurashtra Agro-climatic zone-VI of Gujarat state. Geographically, Amreli is situated at 21.35 N latitude and 71.12 E longitudes with an elevation of 130 meters above the mean sea level. The soil of the experimental site was medium black with pH is 7.5 to 8.3. Standard procedures for analysis of variance were followed. Data were first subjected to the analysis followed for randomized block design as per Panse and Sukhatme (1967). The magnitude of heterosis for all the twelve traits and expressed as percentage superiority or inferiority of the F_1 hybrids over better parent (BP) and standard check G.Til-2 and G.Til-3 (SC) was calculated as per standard method suggested by Fonseca and Patterson (1968).

Results and Discussion

The analysis of variance for Amreli (Table-1.) revealed the significant differences among the genotypes for all the characters except width of capsule indicating the existence of sufficient variability in the material studied. Parents and hybrids mean squares were significant for all the characters under all indicating the presence of sufficient diversity among the parents and hybrids for all the characters. The mean squares due to parents vs. hybrids contrast also revealed significant differences for all the characters except P vs H for number of branch per plant, length of capsule, width of capsule, number of capsules per leaf axil, seed weight and seed yield per plant which indicated differences among parents and hybrids as a group and the presence of mean heterosis for all the traits.

In analysis range of days to flowering heterosis over better parent was -6.50% (AT-306 x RT-54) to 8.50.46% (Khadkala-S x G.Til-10). The earliest hybrid over better parent was AT-306 x RT-54 (-6.50%) followed by AT-307 x RT-54 (-5.69%), AT-253 x RT-54 (-4.96%), AT-307 x G.Til-10 (-4.72%) and AT-319 x G.Til-10 (-4.35 %). Significant and negative heterobeltiosis a cross was recorded in nine. The range of earliest standard heterosis (H_2C_1) over G.Til-2 and (H_2C_2) over G.Til-3 ranged from -8.33 to 6.67 % and -4.35 to 11.30%. Significant and negative standard heterosis (H_2C_1) and (H_2C_2) crosses was recorded in 19 and one.

For days to Maturity, analysis the magnitude varied from -4.91 to 10.89%, while minimum significant and negative heterobeltiosis (H_1) was exhibited by the cross AT-319 x G.Til-1(-4.91%). Maximum heterobeltiosis was observed in the cross Khadkala-S x G.Til-10 (10.89%). Out of 40 crosses, fourteen crosses recorded (significant and positive) heterobeltiosis and five crosses recorded desirable (significant and negative) heterobeltiosis. The cross combination AT-341 x AT-285 recorded the highest desirable standard heterosis (H_2C_1) over G.Til-2 (-5.73%) followed by Khadkala–S x AT-285 (-4.96%), AT-322 x RT-54(-4.58%), AT-322 x AT-285 (-4.20%) and Bhuva-2 x G. Til-1(-4.20%). The cross combination AT-341 x AT-285 recorded the highest desirable standard heterosis (H_2C_2) over G.Til-3 (-4.26%) followed by Khadkala–S x AT-285 (-3.49%), AT-322 x RT-54(-3.10%), AT-322 x AT-285 (-2.71%) and Bhuva-2 x G. Til-1(-2.71%) (Table-4). Positive heterosis for plant height is good for developing cross with tall plant type with high seed yield per plant. The tall parent was considered as better parent to estimate the heterobeltiosis for plant height. The heterobeltiosis ranged from -25.37 (AT-319 x RT-54) to 53.92% (IS-209 x G.Til-10). Out of forty significant cross, combinations the magnitude of standard heterosis over H_2C_1 and H_2C_2 ranged from -37.46 (AT-319 x RT-54) to 13.89 % (AT-341x G.Til-10) and -32.66 (AT-319 x RT-54) to 22.62% (AT-341x G.Til-10), respectively. Further, twenty seven over H_2C_1 and nineteen over H_2C_2 manifested significant and positive standard heterosis, signifying that performance of crosses over standard check was consistent and superior for plant height (Table-4). Lowest height to first capsule over better parent was AT-341 x AT-285 (-47.71%) followed by AT-322 x RT-54 (-43.24%), Khadkala-S x G.Til-10 (-42.25%), AT-319 x G.Til-1(-38.63%) and AT-253 x AT-285 (-36.02%). Significant and negative heterobeltiosis crosses were recorded in 15. Four crosses over G.Til-2 and 17 crosses over G.Til-3 exhibited significant and desirable (negative) standard heterosis. The range of standard heterosis in pooled over H_2C_1 and H_2C_2 was -59.98 to 18.83 % and -51.66 to 43.52%, respectively. The cross, Bhuva-2 x G.Til-1exhibited highest, negative and significance standard heterosis for H_2C_1 and H_2C_2 (Table-5).

Table-1 : Analysis of variance (mean squares) for Amreli.

Source	d.f.	Days to flowering	Days to maturity	Plant height (cm)	Height to first capsule	Number of branches /plant	Length of capsule (cm)	Width of capsule (cm)	Number of capsule/ plant	Number of capsules/ leaf axil	Number of seeds per capsule	1000-seed weight (g)	Seed yield/ plant (g)
Replication	2	43.81**	48.25*	93.12**	22.15	0.072	0.09	0.01	48.05*	0.073	44.20*	0.06	3.42
Parents	13	162.78**	415.90**	4,429.27**	2,990.60**	30.14**	1.01**	0.03	2,944.68**	1.78*	931.76**	1.59**	86.46**
Line	9	106.70**	335.20**	4,131.70**	2,746.45**	25.28**	0.92**	0.02	2,401.03**	1.51*	798.62**	0.81*	72.95**
Tester	3	30.33*	80.66**	47.14*	5.79	0.16	0.07	0.00	101.97**	0.03	116.74*	0.44	9.57*
Hybrids (F1)	39	210.1**	778.45**	11,670.9**	4,407.50**	80.00**	4.46**	0.26**	13,387.60**	7.05**	2,687.50**	6.36**	501.9**
Parents vs. Crosses	1	75.08**	10.80*	207.15**	349.45**	0.26	0.11	0.03	48.02*	0.25	40.99*	0.64	4.75
Error	106	200.18	533.07	555.46	297.62	4.42	0.71	0.05	933.79	1.98	549.32	0.26	33.01

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

Table-2 : Heterobeltiosis (H1) and standard heterosis (H2C1 and H2C2) in Amreli for different characters in sesame

Sr. No.	Characters	Range of heterosis (%)			Number of crosses with significant heterosis					
		H_1	H_2C_1	H_2C_2	H_1		H_2C_1		H_2C_2	
					+ve	-ve	+ve	-ve	+ve	-ve
1.	Days to flowering	-6.50 to 8.85	-8.33 to 6.67	-4.35 to 11.30	13	9	2	19	7	1
2.	Days to maturity	-4.91 to 10.89	-5.73 to 6.11	-4.26 to 7.75	14	5	7	20	8	9
3.	Plant height (cm)	-25.37 to 53.92	-37.46 to 13.89	-32.66 to 22.62	20	17	6	27	14	19
4.	Height to first capsule (cm)	-47.71 to 114.33	-59.98 to 18.83	-51.66 to 43.52	18	16	4	27	17	18
5.	Number of branches per plant	-59.73 to 31.15	-37.66 to 107.79	-42.17 to 92.77	2	19	10	5	9	8
6.	Length of capsule (cm)	-17.21 to 19.43	0.31 to 37.42	-24.80 to 3.03	3	4	18	0	0	23
7.	Width of capsule (cm)	-17.96 to 6.99	-6.28 to18.36	-16.02 to6.06	0	0	0	0	0	0
8.	Number of capsules per plant	-49.87 to 32.78	-36.99 to 89.95	-35.36 to 94.85	4	32	18	18	19	18
9.	Number of capsules per leaf axil	-22.22 to 70.59	-11.76 to 70.59	-28.57 to 38.10	2	0	6	0	1	0
10.	Number of seeds per capsule	-20.07 to 27.33	-8.28 to 36.85	-16.01 to 25.31	8	19	26	3	13	15
11.	100-seed weight (g)	-26.39 to 11.06	-18.79 to 11.06	-22.12 to 6.51	1	17	1	15	0	19
12.	Seed yield per plant (g)	-60.11 to 46.15	-59.20 to 65.52	-65.20 to 41.18	5	24	10	23	7	29

Table-3 : Five most heterobeltiotic (H_1) crosses alongwith standard heterosis (H_2) and per se performance for seed yield and its component traits Amreli in sesame.

Sr. No.	Crosses	Mean seed yield/plant (g)	Seed yield per plant (g)			Day to flowering			Days to maturity			Plant height (cm)		
			H_1	H_2C_1	H_2C_2	H_1	H_2C_1	H_2C_2	H_1	H_2C_1	H_2C_2	H_1	H_2C_1	H_2C_2
1.	AT-319 x AT-285	6.97	46.15**	20.11*	2.45	-0.87	-5.00**	-0.87	-0.78	-3.44**	-1.94	10.13**	-7.71**	-0.63
2.	AT-253 x R-T-54	8.33	36.61**	43.68**	22.25**	-4.96**	-4.17**	0.00	0.79	-0.76	-1.55	-4.36**	-21.31**	-15.27**
3.	BHUVA-2 x AT-285	6.20	19.23*	6.90	-8.82	-3.45	-6.67**	-2.81	-0.39	-3.05**	-1.55	51.48**	2.70	10.57**
4.	AT-319 x G-TIL-10	9.53	14.40**	64.37**	40.20**	4.35*	0.00	4.35*	-1.46	3.05**	4.65**	17.16**	-1.82	5.71**
5.	AT-341 xG-TIL-10	9.60	11.20*	65.52**	41.18**	0.85	-0.83	3.48	4.86**	-1.15	0.39	-2.93*	13.89**	22.62**

Sr. No.	Crosses	Mean seed yield/plant (g)	Height to first capsule			Number of branch per plant			Length of capsule (cm)			Width of capsule (cm)		
			H_1	H_2C_1	H_2C_2	H_1	H_2C_1	H_2C_2	H_1	H_2C_1	H_2C_2	H_1	H_2C_1	H_2C_2
1.	AT-319 x AT-285	6.97	24.64**	-4.11	15.81**	-8.33	11.69	3.61	-5.64	22.20**	-8.38	-16.67	-3.38	-13.42
2.	AT-253 x R-T-54	8.33	-7.89	-33.04**	-19.13**	-41.61**	12.99	4.82	19.43**	37.42**	3.03	-3.46	7.73	-3.46
3.	BHUVA-2 x AT-285	6.20	98.60**	-11.85**	6.48	-38.52**	-2.60	-9.64	-13.06	0.31	-24.80**	-15.92	-0.48	-10.82
4.	AT-319 x G-TIL-10	9.53	30.63**	0.50	21.39**	19.67**	89.61**	75.90**	-14.27**	11.02	-16.76**	-14.10	-5.80	-13.42
5.	AT-341 xG-TIL-10	9.60	-20.21**	13.22**	36.75**	-11.48	40.26**	30.12**	-9.85	12.27	-15.83**	-12.33	-3.86	-13.85

Sr. No.	Crosses	Mean seed yield/plant (g)	Number of capsules per plant			Number of capsules per leaf axil			Number of seeds per capsule			100-seed weight (g)		
			H_1	H_2C_1	H_2C_2	H_1	H_2C_1	H_2C_2	H_1	H_2C_1	H_2C_2	H_1	H_2C_1	H_2C_2
1.	AT-319 x AT-285	6.97	23.49**	35.05**	38.52**	-15.79	-5.88	-23.81	-8.29**	15.22**	5.50**	-5.02	0.73	-3.40
2.	AT-253 x R-T-54	8.33	20.09**	58.33**	62.41**	-20.00	-5.88	-23.81	5.47**	21.03**	10.82**	-8.16**	-1.25	-5.31
3.	BHUVA-2 x AT-285	6.20	32.78**	45.66**	49.41**	36.84**	52.94**	23.81	-3.48**	7.48**	-1.59	-6.90	-9.92*	-13.61**
4.	AT-319 x G-TIL-10	9.53	-2.30	69.75**	74.12**	-6.25	-11.76	-28.57	-13.02**	25.10**	14.55**	-3.54	2.30	-1.90
5.	AT-341 xG-TIL-10	9.60	3.09	79.11**	83.72**	0.00	-5.88	-23.81	1.98	17.09**	7.21**	-0.59	5.53	1.20

*, **Significant at 5 and 1 per cent levels, respectively.

Table-4 : Heterobeltiosis (H_1) and standard heterosis over G.Til-2 (H_2C_1) and G.Til-3 (H_2C_2) under Amreli for days to flowering, days to maturity, plant height (cm) and number of branches/plant.

Sr. No.	Crosses	days to flowering			days to maturity			plant height (cm)			number of branches/plant		
		(H_1)	H_2C_1	H_2C_2	(H_1)	H_2C_1	H_2C_2	(H_1)	H_2C_1	H_2C_2	(H_1)	H_2C_1	H_2C_2
1.	AT-253 x AT-285	0.86	-2.5	1.74	1.57	-1.53	0	-3.82*	-20.86**	-14.8**	-2.63	-3.9	-10.84
2.	AT-253 x G.Til-1	0	-2.5	1.74	0.39	-2.67*	-1.16	7.28**	-11.73**	-4.97**	-44.19**	-37.66**	-42.17**
3.	AT-253 x G.Til-10	-3.31	-2.5	1.74	2.36*	-0.76	0.78	12.95**	-7.07**	0.05	31.15**	107.79**	92.77**
4.	AT-253 x RT-54	-4.96**	-4.17*	0	0.79	-3.05**	-1.55	-4.36**	-21.31**	-15.27**	-41.61**	12.99	4.82
5.	AT-265 x AT-285	-0.86	-4.17*	0	0.4	-3.82**	-2.33*	-6.55**	-19.49**	-13.32**	5.56	-1.3	-8.43
6.	AT-265 x G.Til-1	-4.27*	-6.67**	-2.61	0.8	-3.44**	-1.94	0.52	-14.24**	-7.66**	-18.6	-9.09	-15.66
7.	AT-265 x G.Til-10	-1.68	-2.5	1.74	2.79*	-1.53	0	13.73**	-2.01	5.5**	-16.39*	32.47**	22.89*
8.	AT-265 x RT-54	-4.2*	-5**	-0.87	0.8	-3.44**	-1.94	29.69**	11.73**	20.3**	-57.05**	-16.88	-22.89*
9.	AT-306 x AT-285	-3.45	-6.67**	-2.61	-1.57	-4.2**	-2.71*	-5.5**	-14.83**	-8.3**	-8.33	-14.29	-20.48*
10.	AT-306 x G.Til-1	-3.42	-5.83**	-1.74	-2.26*	-1.15	0.39	1.09	-13.75**	-7.14**	-20.93*	-11.69	-18.07
11.	AT-306 x G.Til-10	-3.1	4.17*	8.7**	0.37	3.44**	5.04**	17.7**	6.09**	14.22**	13.11	79.22**	66.27**
12.	AT-306 x RT-54	-6.5**	-4.17*	0	1.19	-2.67*	-1.16	14.43**	3.14*	11.05**	-59.73**	-22.08*	-27.71**
13.	AT-307 x AT-285	-4.31*	-7.5**	-3.48	-1.57	-4.2**	-2.71*	6.12**	-6.33**	0.85	9.72	2.6	-4.82
14.	AT-307 x G.Til-1	0	-2.5	1.74	-3.4**	-2.29*	-0.78	10.87**	-5.4**	1.85	-11.63	-1.3	-8.43
15.	AT-307 x G.Til-10	-4.72**	0.83	5.22**	1.89	3.05**	4.65**	2.45	-9.57**	-2.64	-20.49**	25.97*	16.87
16.	AT-307 x RT-54	-5.69**	-3.33	0.87	2.38*	-1.53	0	13.52**	0.2	7.88**	-42.95**	10.39	2.41
17.	AT-319 x AT-285	-0.87	-5**	-0.87	-0.78	-3.44**	-1.94	10.13**	-7.71**	-0.63	19.44	11.69	3.61
18.	AT-319 x G.Til-1	-3.48	-7.5**	-3.48	-4.91**	-3.82**	-2.33*	-21.5**	-34.22**	-29.18**	0	11.69	3.61
19.	AT-319 x G.Til-10	4.35*	0	4.35*	-1.46	3.05**	4.65**	17.16**	-1.82	5.71**	19.67**	89.61**	75.9**
20.	AT-319 x RT-54	-2.61	-6.67**	-2.61	1.19	-2.67*	-1.16	-25.37**	-37.46**	-32.66**	-59.73**	-22.08*	-27.71**
21.	AT-322 x AT-285	-1.72	-5**	-0.87	-1.57	-4.2**	-2.71*	-19.81**	-25.28**	-19.56**	-8.33	-14.29	-20.48*
22.	AT-322 x G.Til-1	-1.71	-4.17*	0	-2.64*	-1.53	0	-13.29**	-26.02**	-20.35**	-30.23**	-22.08*	-27.71**
23.	AT-322 x G.Til-10	-0.78	6.67**	11.3**	2.96**	6.11**	7.75**	-7.8**	-14.09**	-7.51**	-12.3	38.96**	28.92**
24.	AT-322 x RT-54	-3.25	-0.83	3.48	-0.79	-4.58**	-3.1**	-24.93**	-31.12**	-25.85**	-51.68**	-6.49	-13.25
25.	AT-341 x AT-285	-4.31*	-7.5**	-3.48	0	-5.73**	-4.26**	12.37**	9.67**	18.08**	-16.67	-22.08*	-27.71**
26.	AT-341 x G.Til-1	-0.85	-3.33	0.87	4.86**	-1.15	0.39	9.9**	-6.23**	0.95	-15.12	-5.19	-12.05
27.	AT-341 x G.Til-10	0.85	-0.83	3.48	4.86**	-1.15	0.39	-2.93*	13.89**	22.62**	-11.48	40.26**	30.12**
28.	AT-341 x RT-54	-2.54	-4.17*	0	5.26**	-0.76	0.78	10.01**	0.93	8.67**	-51.68**	-6.49	-13.25
29.	Bhuva-2 x AT-285	-3.45	-6.67**	-2.61	-0.39	-3.05**	-1.55	51.48**	2.7	10.57**	-38.52**	-2.6	-9.64
30.	Bhuva-2 x G.Til-1	0	-3.33	0.87	-4.56**	-4.2**	-2.71*	-7.68**	-37.41**	-32.61**	-34.43**	3.9	-3.61
31.	Bhuva-2 x G.Til-10	4.31*	0.83	5.22**	2.28*	2.67*	4.26**	51.19**	2.5	10.36**	1.64	61.04**	49.4**
32.	Bhuva-2 x RT-54	-0.86	-4.17*	0	1.59	-2.29*	-0.78	6.37**	-27.88**	-22.36**	-48.99**	-1.3	-8.43
33.	Khadkala-S x AT-285	-2.65	-8.33**	-4.35*	0.4	-4.96**	-3.49**	-6.54**	-8.79**	-1.8	-27.55**	-7.79	-14.46
34.	Khadkala-S x G.Til-1	2.65	-3.33	0.87	3.63**	-1.91	-0.39	-10.41**	-23.56**	-17.71**	-31.63**	-12.99	-19.28
35.	Khadkala-S x G.Til-10	8.85**	2.5	6.96**	10.89**	4.96**	6.59**	-17.78**	-3.53*	3.86**	-9.84	42.86**	32.53**
36.	Khadkala-S x RT-54	4.42*	-1.67	2.61	6.85**	1.15	2.71*	7.92**	-0.98	6.61**	-53.02**	-9.09	-15.66
37.	IS-209 x AT-285	0.86	-2.5	1.74	3.56**	0	1.55	9.84**	-18.9**	-12.68**	9.59	3.9	-3.61
38.	IS-209 x G.Til-1	-4.31*	-7.5**	-3.48	3.56**	0	1.55	-13.36**	-36.03**	-31.13**	-17.44	-7.79	-14.46
39.	IS-209 x G.Til-10	5.17**	1.67	6.09**	8.7**	4.96**	6.59**	53.92**	13.65**	22.36**	-12.3	38.96**	28.92**
40.	IS-209 x RT-54	0	-3.33	0.87	0.79	-3.05**	-1.55	-9.51**	-33.19**	-28.07**	-55.03**	-12.99	-19.28
	Min.	-6.50	-8.33	-4.35	-4.91	-5.73	-4.26	-25.37	-37.46	-32.66	-59.73	-37.66	-42.17
	Max.	8.85	6.67	11.30	10.89	6.11	7.75	53.92	13.89	22.62	31.15	107.79	92.77
No. of crosses with desirable heterosis		9	19	1	5	20	9	17	27	19	2	10	9

Table-5 : Heterobeltiosis (H_1) and standard heterosis over G.Til-2 (H_2C_1) and G.Til-3 (H_2C_2) under Amreli for height to first capsule, length of capsule, width of capsule and number of capsule/plant.

Sr. No.	Crosses	height to first capsule			length of capsule (cm)			width of capsule (cm)			number of capsule/plant		
		(H_1)	H_2C_1	H_2C_2	(H_1)	H_2C_1	H_2C_2	(H_1)	H_2C_1	H_2C_2	(H_1)	H_2C_1	H_2C_2
1.	AT-253 x AT-285	-36.02**	-53.49**	-43.83**	8.57	23.91**	-7.1	-1.25	14.49	2.6	-14.09**	-6.05	-3.63
2.	AT-253 x G.Til-1	1.54	-26.18**	-10.84**	10.61	26.24**	-5.36	3.46	15.46	3.46	-39.02**	-29**	-27.17**
3.	AT-253 x G.Til-10	6.17	-22.82**	-6.78	-6.11	16.93*	-12.34*	-5.63	5.31	-5.63	-16.43**	45.21**	48.95**
4.	AT-253 x RT-54	-7.89	-33.04**	-19.13**	19.43**	37.42**	3.03	-3.46	7.73	-3.46	20.09**	58.33**	62.41**
5.	AT-265 x AT-285	-15.97**	-35.04**	-21.54**	-3.87	15.68	-13.27*	-2.08	13.53	1.73	-26.51**	-19.63**	-17.56**
6.	AT-265 x G.Til-1	4.68	-21.95**	-5.72	11.74	34.47**	0.81	6.99	18.36	6.06	-24.85**	-12.5**	-10.25**
7.	AT-265 x G.Til-10	15.81**	-10.47**	8.13*	4.49	30.12**	-2.44	-2.18	8.21	-3.03	-8.54**	58.9**	63**
8.	AT-265 x RT-54	53.71**	18.83**	43.52**	2.19	22.98**	-7.8	2.18	13.04	1.3	-41.73**	-23.17**	-21.19**
9.	AT-306 x AT-285	-19.22**	-35.54**	-22.14**	2.33	15.99	-13.04*	-2.5	13.04	1.3	-8.56*	0	2.58
10.	AT-306 x G.Til-1	37.29**	2.37	23.64**	-2.72	10.87	-16.88**	-1.29	11.11	-0.43	-43.73**	-34.47**	-32.79**
11.	AT-306 x G.Til-10	11.88**	-10.72**	7.83*	-14.09*	6.99	-19.79**	-4.72	7.25	-3.9	9.33**	89.95**	94.85**
12.	AT-306 x RT-54	44.38**	15.21**	39.16**	3.1	18.63*	-11.06	-0.43	12.08	0.43	-49.87**	-33.9**	-32.2**
13.	AT-307 x AT-285	27.93**	-3.49	16.57**	-5.79	3.57	-22.35**	-4.58	10.63	-0.87	-5.89	5.71	8.43*
14.	AT-307 x G.Til-1	23.24**	-8.1**	10.99**	5.59	20.34*	-9.78	-12.23	-2.9	-12.99	-32.84**	-21.8**	-19.79**
15.	AT-307 x G.Til-10	19.67**	-9.73**	9.04*	-17.21**	3.11	-22.7**	-15.28	-6.28	-16.02	-42.64**	-0.34	2.22
16.	AT-307 x RT-54	43.47**	8.23**	30.72**	-2.43	12.27	-15.83*	-3.49	6.76	-4.33	-10.3**	18.26**	21.31**
17.	AT-319 x AT-285	24.64**	-4.11	15.81**	-5.64	22.2**	-8.38	-16.67	-3.38	-13.42	23.49**	35.05**	38.52**
18.	AT-319 x G.Til-1	-38.63**	-54.24**	-44.73**	-5.76	22.05**	-8.5	5.78	14.98	3.03	-42.94**	-33.56**	-31.85**
19.	AT-319 x G.Til-10	30.63**	0.5	21.39**	-14.27*	11.02	-16.76**	-14.1	-5.8	-15.58	-2.3	69.75**	74.12**
20.	AT-319 x RT-54	-36.3**	-51**	-40.81**	-14.63*	10.56	-17.11**	4.09	10.63	-0.87	-49.35**	-33.22**	-31.5**
21.	AT-322 x AT-285	-29.87**	-41.15**	-28.92**	5.22	12.73	-15.48*	-7.08	7.73	-3.46	-24.63**	-17.58**	-15.46**
22.	AT-322 x G.Til-1	-27.93**	-46.26**	-35.09**	0.68	14.75	-13.97*	2.21	11.59	0	-45.88**	-36.99**	-35.36**
23.	AT-322 x G.Til-10	-15.45**	-29.05**	-14.31**	-10.97	10.87	-16.88**	-3.52	5.8	-5.19	-9.72**	56.85**	60.89**
24.	AT-322 x RT-54	-43.24**	-52.37**	-42.47**	-9.72	3.88	-22.12**	-12.39	-4.35	-14.29	-41.3**	-22.6**	-20.61**
25.	AT-341 x AT-285	-47.71**	-50.25**	-39.91**	4.77	12.58	-15.6*	-17.08	-3.86	-13.85	-19.84**	35.62**	39.11**
26.	AT-341 x G.Til-1	28.09**	-4.49	15.36**	-0.27	13.66	-14.78*	-0.44	8.21	-3.03	-20.18**	35.05**	38.52**
27.	AT-341 x G.Til-10	-20.21**	13.22**	36.75**	-9.85	12.27	-15.83*	-12.33	-3.86	-13.85	3.09	79.11**	83.72**
28.	AT-341 x RT-54	10.84**	2	23.19**	0.13	15.22	-13.62*	-9.05	-2.9	-12.99	-33.94**	11.76**	14.64**
29.	Bhuva-2 x AT-285	98.6**	-11.85**	6.48	-13.06	0.31	-24.8**	-15.92	-0.48	-10.82	32.78**	45.66**	49.41**
30.	Bhuva-2 x G.Til-1	-9.83	-59.98**	-51.66**	-10.63	3.11	-22.7**	-13.47	2.42	-8.23	-5.39	10.16**	13**
31.	Bhuva-2 x G.Til-10	114.33**	-4.86	14.91**	-8.6	13.82	-14.67*	-17.96	-2.9	-12.99	-18.13**	42.24**	45.9**
32.	Bhuva-2 x RT-54	24.16**	-44.89**	-33.43**	-3.23	11.65	-16.3**	-11.43	4.83	-6.06	-38.1**	-18.38**	-16.28**
33.	Khadkala-S x AT-285	-8.13*	-12.59**	5.57	-4.78	5.28	-21.07**	-15.83	-2.42	-12.55	-37.59**	-20.21**	-18.15**
34.	Khadkala-S x G.Til-1	-21.57**	-41.52**	-29.37**	16.62*	32.92**	-0.35	0	11.59	0	-11.16**	13.58**	16.51**
35.	Khadkala-S x G.Til-10	-42.25**	-21.45**	-5.12	-4.11	19.41*	-10.48	-6.93	3.86	-6.93	-31.87**	18.38**	21.43**
36.	Khadkala-S x RT-54	9.89**	1.12	22.14**	2.29	17.7*	-11.76	-6.06	4.83	-6.06	-48.83**	-32.53**	-30.8**
37.	IS-209 x AT-285	8.77	-38.15**	-25.3**	17.39*	29.97**	-2.56	-6.67	8.21	-3.03	-29.12**	-22.49**	-20.49**
38.	IS-209 x G.Til-1	-23.68**	-56.61**	-47.59**	3.95	18.48*	-11.18	3.11	12.08	0.43	-22.84**	-10.16**	-7.85*
39.	IS-209 x G.Til-10	72.81**	-1.75	18.67**	-3.37	20.34*	-9.78	-2.64	6.76	-4.33	-9.46**	57.31**	61.36**
40.	IS-209 x RT-54	-11.84*	-49.88**	-39.46**	10.93	27.64**	-4.31	1.36	8.21	-3.03	-36.88**	-16.78**	-14.64**
	Min.	-47.71	-59.98	-51.66	-17.21	0.31	-24.80	-17.96	-6.28	-16.02	-49.87	-36.99	-35.36
	Max.	114.33	18.83	43.52	19.43	37.42	3.03	6.99	18.36	6.06	32.78	89.95	94.85
No. of crosses with desirable heterosis		18	4	17	3	18	0	0	0	0	4	18	19

Table-6 : Heterobeltiosis (H_1) and standard heterosis over G.Til-2 (H_2C_1) and G.Til-3 (H_2C_2) under Amreli for number capsule/ leaf axils, number of seeds/ capsule, 1000 seed weight and seed yield per plant

Sr. No.	Crosses	number capsule/ leaf axils			number of seeds/ capsule			1000 seed weight (g)			seed yield per plant (g)		
		(H_1)	H_2C_1	H_2C_2	(H_1)	H_2C_1	H_2C_2	(H_1)	H_2C_1	H_2C_2	(H_1)	H_2C_1	H_2C_2
1.	AT-253 x AT-285	-15.79	-5.88	-23.81	-20.07**	-8.28**	-16.01**	-7.86	-0.94	-5.01	-22.92*	-36.21**	-45.59**
2.	AT-253 x G.Til-1	35.29	35.29	9.52	-17.04**	-4.81*	-12.84**	-7.96*	-1.04	-5.11	-44.37**	-51.72**	-58.82**
3.	AT-253 x G.Til-10	11.76	11.76	-9.52	19.19**	36.85**	25.31**	-16.5**	-10.23*	-13.91**	-1.6	41.38**	20.59**
4.	AT-253 x RT-54	-20	-5.88	-23.81	5.47**	21.03**	10.82**	-8.16*	-1.25	-5.31	36.61**	43.68**	22.55**
5.	AT-265 x AT-285	21.05	35.29	9.52	-3.64*	11.21**	1.83	1.59	0.1	-4	-19.58*	-33.91**	-43.63**
6.	AT-265 x G.Til-1	70.59**	70.59**	38.1*	-6.13**	8.34**	-0.79	2.92	2.92	-1.3	-15.89	-27.01**	-37.75**
7.	AT-265 x G.Til-10	18.75	11.76	-9.52	1.91	17.62**	7.7**	0.64	-0.84	-4.9	-0.8	42.53**	21.57**
8.	AT-265 x RT-54	-10	5.88	-14.29	-11.1**	2.6	-6.05**	0.95	-0.52	-4.6	-42.08**	-39.08**	-48.04**
9.	AT-306 x AT-285	-5.26	5.88	-14.29	27.33**	28.77**	17.91**	0.42	-0.73	-4.8	18.88	-2.3	-16.67*
10.	AT-306 x G.Til-1	-11.76	-11.76	-28.57	15.51**	16.82**	6.97**	6.05	6.05	1.7	-33.77**	-42.53**	-50.98**
11.	AT-306 x G.Til-10	0	-5.88	-23.81	-5.93**	8.01**	-1.1	-8.55	-9.6*	-13.31**	-3.2	39.08**	18.63**
12.	AT-306 x RT-54	-20	-5.88	-23.81	-2.98	6.48**	-2.51	-16.37**	-17.33**	-20.72**	-60.11**	-58.05**	-64.22**
13.	AT-307 x AT-285	-15.79	-5.88	-23.81	-5.68**	-1.4	-9.72**	-15.28**	-4.49	-8.41*	-32.29**	-25.29**	-36.27**
14.	AT-307 x G.Til-1	0	0	-19.05	3.7*	8.41**	-0.73	-11.2**	0.1	-4	-41.15**	-35.06**	-44.61**
15.	AT-307 x G.Til-10	-6.25	-11.76	-28.57	2.09	17.22**	7.33**	-26.39**	-17.01**	-20.42**	-50.4**	-28.74**	-39.22**
16.	AT-307 x RT-54	0	17.65	-4.76	-2.19	7.34**	-1.71	-12.41**	-1.25	-5.31	-15.1*	-6.32	-20.1**
17.	AT-319 x AT-285	-15.79	-5.88	-23.81	-8.29**	15.22**	5.5**	-5.02	0.73	-3.4	46.15**	20.11*	2.45
18.	AT-319 x G.Til-1	5.88	5.88	-14.29	-3.72*	20.96**	10.76**	-13.88**	-8.66*	-12.41**	-37.09**	-45.4**	-53.43**
19.	AT-319 x G.Til-10	-6.25	-11.76	-28.57	-0.43	25.1**	14.55**	-3.54	2.3	-1.9	14.4**	64.37**	40.2**
20.	AT-319 x RT-54	-15	0	-19.05	-13.02**	9.28**	0.06	-4.04	1.77	-2.4	-45.9**	-43.1**	-51.47**
21.	AT-322 x AT-285	-21.05	-11.76	-28.57	4.19*	1.2	-7.33**	7.3	7.41	3	-18.88	-33.33**	-43.14**
22.	AT-322 x G.Til-1	17.65	17.65	-4.76	1.42	0.4	-8.07**	-17.21**	-17.12**	-20.52**	-52.98**	-59.2**	-65.2**
23.	AT-322 x G.Til-10	18.75	11.76	-9.52	3.66*	19.03**	8.99**	-1.46	-1.36	-5.41	-2	40.8**	20.1**
24.	AT-322 x RT-54	-20	-5.88	-23.81	-9**	-0.13	-8.56**	-18.87**	-18.79**	-22.12**	-55.19**	-52.87**	-59.8**
25.	AT-341 x AT-285	-10.53	0	-19.05	-5.51**	3	-5.68**	-16.13**	-10.96*	-14.61**	-35.14**	-3.45	-17.65**
26.	AT-341 x G.Til-1	-5.88	-5.88	-23.81	-8.08**	0.2	-8.25**	-13.77**	-8.46	-12.21**	-36.68**	-5.75	-19.61**
27.	AT-341 x G.Til-10	0	-5.88	-23.81	1.98	17.09**	7.21**	-0.59	5.53	1.2	11.2*	65.52**	41.18**
28.	AT-341 x RT-54	-20	-5.88	-23.81	-1.09	8.54**	-0.61	-17.01**	-11.9**	-15.52**	-47.88**	-22.41**	-33.82**
29.	Bhuva-2 x AT-285	36.84*	52.94**	23.81	-3.48*	7.48**	-1.59	-6.9	-9.92*	-13.61**	19.23*	6.9	-8.82
30.	Bhuva-2 x G.Til-1	31.58	47.06*	19.05	-2.34	8.74**	-0.43	-9.71*	-9.71*	-13.41**	-9.62	-18.97*	-30.88**
31.	Bhuva-2 x G.Til-10	0	11.76	-9.52	2.38	17.56**	7.64**	-5.18	-8.25	-12.01**	-18.8**	16.67*	-0.49
32.	Bhuva-2 x RT-54	0	17.65	-4.76	-3.06	7.94**	-1.16	-7.12	-10.13*	-13.81**	-43.17**	-40.23**	-49.02**
33.	Khadkala-S x AT-285	-3.7	52.94**	23.81	16.49**	13.15**	3.61*	-3.07	-4.49	-8.41*	-30.63**	-36.21**	-45.59**
34.	Khadkala-S x G.Til-1	-11.11	41.18*	14.29	2.23	1.2	-7.33**	-0.21	-0.21	-4.3	-3.75	-11.49	-24.51**
35.	Khadkala-S x G.Til-10	-22.22	23.53	0	-8.43**	5.14**	-3.73*	-8.47	-9.81*	-13.51**	-39.6**	-13.22	-25.98**
36.	Khadkala-S x RT-54	-14.81	35.29	9.52	-13.26**	-4.81*	-12.84**	3.28	1.77	-2.4	-52.46**	-50**	-57.35**
37.	IS-209 x AT-285	-15.79	-5.88	-23.81	-8.05**	2.14	-6.48**	-9.47*	-12.21**	-15.82**	-36.3**	-46.55**	-54.41**
38.	IS-209 x G.Til-1	-11.11	-5.88	-23.81	-7.33**	2.94	-5.75**	11.06*	11.06*	6.51	-11.92	-23.56**	-34.8**
39.	IS-209 x G.Til-10	-5.56	0	-19.05	-3.14	11.21**	1.83	0.22	-2.82	-6.81	-8.8	31.03**	11.76
40.	IS-209 x RT-54	20	41.18*	14.29	-7.57**	2.67	-5.99**	-8.93*	-11.69**	-15.32**	-45.36**	-42.53**	-50.98**
	Min.	-22.22	-11.76	-28.57	-20.07	-8.28	-16.01	-26.39	-18.79	-22.12	-60.11	-59.20	-65.20
	Max.	70.59	70.59	38.10	27.33	36.85	25.31	11.06	11.06	6.51	46.15	65.52	41.18
No. of crosses with desirable heterosis		2	6	1	8	26	13	1	1	0	5	10	7

In number of branches per plant AT-319 x RT-54 and AT-253 x G.Til-10 were the crosses exhibiting lowest and highest heterobeltiosis. 10 and 7 crosses exhibited significant and positive heterosis over H_2C_1 and H_2C_2, respectively. The magnitude of standard heterosis ranged from -37.66 to 107.79 % for H_2C_1 and -42.17 to 92.77 % for H_2C_2. The cross AT-253 x G.Til-10 exhibited highest standard heterosis (108.55% and 73.70%) in environments, while the cross AT-253 x G.Til-1 recorded minimum standard heterosis (Table-4). The magnitude for length of capsule (cm) in heterobeltiosis ranged from -17.21% (AT-307 x G.Til-10) to 19.43% (AT-253 x RT-54) in cross. The magnitude of standard heterosis for H_2C_1 ranged from 0.31 to 37.42%. While, the values for H_2C_2 were -24.80 to 3.03%. The cross AT-253 x RT-54 recorded maximum, significant and positive heterosis of 19.43%, 37.42% and 3.03. The cross Bhuva-2 x G.Til-1 expressed minimum values of standard heterosis (0.31 and -24.80 %) for H_2C_1 and H_2C_2 in cross. In width of capsule the crosses AT-265 x G.Til-1 and Bhuva-2 x G.Til-10 recorded highest, significant and positive as well as lowest significance negative heterobeltiosis, respectively. Depicted none of crosses with significant and positive heterosis over better parent and none of crosses with significant and negative heterosis over better parent recurred. The highest magnitude of positive standard heterosis for H_2C_1 and H_2C_2 was manifested by the cross AT-265 x G.Til-1 (18.36% and 6.06%). Further, none of crosses over H_2C_1 and none of cross over H_2C_2 exhibited significant and positive standard heterosis. Highest value for number of capsules per plant in heterosis over better parent was recorded Bhuva-2 x AT-285 (32.78%) followed by AT-319 x AT-285 (23.49%), AT-253 x RT-54 (20.09%), AT-306 x G.Til-10 (9.33%) and AT-341 x G.Til-10 (3.09%). Maximum significant and positive heterosis over G.Til-2 and G.Til-3 was observed in the cross, AT-306 x G.Til-10 (89.95% and 94.85%). Standard heterosis ranging from -36.99 to 89.95% for H_2C_1. For H_2C_2 the ranges -35.36 to 94.85%. The crosses exhibiting significant and positive heterosis for H_2C_1 and H_2C_2 were 18 and 19 crosses, respectively (Table-5).

With number of capsules per leaf axil for crosses, AT-265 x G.Til-1 (70.59%) and Khadkala-S x G.Til-10 (-22.22%) exhibited maximum and minimum heterosis over respective better parent. Significant and positive heterobeltiosis was manifested by two cross. Likewise, significant and negative heterobeltiosis was manifested by none of cross. The total 40 F_{1S}, the cross combination AT-265 x G.Til-1 (70.59%) recorded the highest number of capsules per leaf axil in desirable standard heterosis (H_2C_1) over G.Til-2 followed by Bhuva-2 x AT-285(52.94%), Khadkala-S x AT-285 (52.94%), Khadkala-S x G.Til-1 (41.18%) and IS-209 x RT-54 (41.18%). In case of the cross combination AT-265 x G.Til-1 recorded the highest desirable standard heterosis (H_2C_2) over G.Til-3 (38.10%) followed by Bhuva-2 x AT-285(23.81%), Khadkala-S x AT-285 (23.81%), Khadkala-S x G.Til-1 (14.29%) and IS-209 x RT-54 (14.29%).The crosses exhibiting significant and positive heterosis over H_2C_1 and H_2C_2 were six and one crosses, respectively. (Table-6).

For number of seeds per capsule in heterosis over better parent for -20.07 (AT-253 x AT-285) to 27.33% (AT-306 x AT-285).Out of 40 crosses for number of seeds per capsule, the range found in standard heterosis for H_2C_1 and H_2C_2 across the environments was -8.28 to 36.85% and -16.01 to 25.31%, respectively. Maximum, significant and positive heterosis over G.Til-2 and G.Til-3 was observed in, AT-253 x G.Til-10 (36.85% and 25.31%).The magnitude of heterobeltiosis ranged from--26.39% (AT-307 x G.Til-10) to 11.06% (IS-209 x G.Til-1) in 1000-seed weight (g). Hybrids exhibiting significant and positive heterobeltiosis was observed one cross. The magnitude of standard heterosis for H_2C_1 ranged from -18.79 to 11.06%. While, the values for H_2C_2 -22.12 to 6.51%. The cross IS-209 x G.Til-1 recorded maximum, significant and positive heterosis of 11.06% and 6.51% over both checks. The cross combination AT-322 x RT-54 expressed minimum standard heterosis (-18.79 and -22.12%) for H_2C_1 and H_2C_2 (Table-6).

For seed yield per plant (g) heterobeltiosis ranged from -60.11% (AT-306 x RT-54) to 46.15% (AT-319 x AT-285) in this cross. Significant and positive heterobeltiosis was expressed in five crosses and Whereas, significant and negative heterobeltiosis was expressed 23 crosses in analysis. Further, based in this analysis, best three crosses were AT-319 x AT-285 (46.15%), AT-253 x RT-54 (36.61%) and Bhuva-2 x AT-285 (19.23%). Out of 40 F_{1S}, standard heterosis for H_2C_1 in seed yield per plant (g) ranged from -59.20% (AT-322 x G.Til-1) to 65.52% (AT-341 x G.Til-1) While, the values for H_2C_2 in seed yield per plant (g) ranged from -65.20% (AT-322 x G.Til-1) to 41.18% (AT-341 x G.Til-1). The cross AT-341 x G.Til-1 recorded maximum, significant and positive heterosis of 65.52% and 41.18% over both the checks in the environments. Crosses exhibiting significant and positive standard heterosis over G.Til-2 were ten as well as seven crosses recorded significant and positive heterosis over G.Til-3 (Table-6).

Wide range of heterosis usually indicates amount of variability for the heterosis. Most of characters expressed either wide or moderate range of heterosis over the environments. It is of profound interest to know the cause of heterosis for seed yield. Whitehouse *et al.* (1958) and Grafius (1959) have suggested that there may not be any gene system for yield *per se*, as yield is an end product of the multiplicative interaction between the yield components. This would indicate that the heterosis for seed yield should be through heterosis for the individual yield components or alternatively due to the multiplicative effect of partial dominance of component characters. Williams and Gilbert (1960) have reported that even simple dominance in respect of yield components may lead to expression of heterosis for yield. Hagberg (1952) observed similar effects and termed it "combinational heterosis". In general, it would be deduce that magnitude of heterotic effects were high for seed yield/ plant and number of capsules per plant; moderate for plant height, height to first capsule, number of branches per plant, number of capsules per leaf axil, and lower days to flowering, days to maturity, length of capsule, width of capsule, number of seeds per capsule and1000-seed weight (Table-2).

In order to see whether similar situation exist in sesame or not, a comparison of five most heterotic crosses for seed yield was made with other yield related characters along with average mean seed yield per plant (Table-3). The crosses AT-253 x RT-54 which manifested significant and desirable heterobeltiosis and standard heterosis for seed yield per plant also recorded significant and positive heterosis for days to flowering, length of capsule, number of capsules per plant and number of seeds per capsule. Therefore, heterotic effects for seed yield per plant could be a result of combinational heterosis. Hence, to obtain maximum heterotic effects for seed yield per plant, desired level of heterosis of each component character should be worked-out to identify superior hybrids. Highly significant and positive heterobeltiosis was exhibited for plant height by Bhuva-2 x AT-285 and AT-319 x G.Til-10; for height to first capsule by AT-341 x G.Til-10; for number of branch per plant by AT-307 x AT-285 and AT-319 x G.Til-10; for length of capsule by Khadkala x G.Til-1 and AT-306 x AT-285; for number of capsules per plant by AT-322 x AT-285, AT-319 x AT-285, AT-307 x AT-285, AT-253 x AT-285, AT-306 x G.Til-10 and AT-322 x G.Til-10; for number of seeds per capsule by AT-306 x AT-285; for 1000-seed weight by AT-322 x AT-285. The results indicated that in different crosses, pathway for releasing heterotic effects varied from cross to cross. It also revealed that plant height, height to first capsule, number of branch per plant, length of capsule, number of capsules per plant, number of seeds per capsule, 1000-seed weight were the main contributors towards increased seed yield. High association of heterosis between these characters and seed yield per plant in sesame has also been earlier reported by Banerjee and Kole (2010), Prajapati *et al*. (2010a), Jadhav and Mohrir (2013), Vavdiya *et al.* (2013), Azeez *et al.* (2014), Joshi *et al.* (2014), Chaudhari *et al.* (2015a), Monpara and Pawar (2016), Patel *et al*. (2016), Ghule *et al*. (2017), Meenakumari and Ganesamurthy (2017); and Karande *et al*. (2018).

The foregoing discussion and information given clearly on the crosses AT-319 x G.Til-10, AT-253 x RT-54 and AT-341 x G.Til-10 which manifested significant and desirable heterobeltiosis and standard heterosis for seed yield per plant also recorded significant and positive heterosis for days to flowering, length of capsule, number of capsules per plant and number of seeds per capsule. Therefore, heterotic effects for seed yield per plant could be a result of combinational heterosis. Hence, to obtain maximum heterotic effects for seed yield per plant, desired level of heterosis of each component character should be worked-out to identify superior hybrids. The crosses *viz.,* AT-319 x AT-285, AT-253 x RT-285, Bhuva-2 x AT-285, AT-319 x G.Til-10 and AT-341 x AT-285 exhibited significant and positive heterobeltiosis for seed yield per plant and its components. Such crosses could be exploited further for seed yield advancement in sesame. It could profitably be exploited through heterosis breeding for general cultivation in order to increase the yield potentiality in sesame.

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Heterosis Study for Seed Yield and its Components in Black Sesame (*Sesamum indicum* L.)

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Abstract

The present investigation on "Heterosis for seed yield and its components in black sesame (*Sesamum indicum* L.)" was undertaken to study heterosis for seed yield and its components by using line x tester analysis. Ten lines, four testers and the resulting forty crosses were evaluated in a randomized block design with three replications at the Agricultural Research Station, Junagadh Agricultural University, Amreli during *Kharif* - 2019. Among four crosses Vijapdi 1 x ABT 33, Nana Bhamodara 6 x G.Til 10, NIC 8476 x ABT 33 and Keriya 10 x ABT 33 found most promising for seed yield and its component traits, hence these hybrids could be used to exploit heterosis after identifying suitable hybrid seed production technology and in future breeding programme by utilizing biparental mating or recurrent selection breeding approaches to obtain desirable segregants for development of superior genotypes for seed yield and its component traits.

Key words : *Black, sesame, line x tester, heterosis.*

Introduction

Sesame (*Sesamum indicum* L.) is one of the most ancient and important oilseed crops grown next to groundnut and mustard in India. The oilseed crops play an important role in agriculture and industrial economy of India. India occupies a very prominent place in the oilseed map of the world as it produces a large variety of oilseed crops and ranks first in respect of total hectare and production. Sesame can grow well in many ecological regions of tropical and sub-tropical climates. At present, Sudan is the largest producer of sesame seed in the world followed by Myanmar, India, Tanzania, Nigeria, Chinaand Ethiopia. In India, sesame is cultivated in 14.20 lakh hectare area which produces 6.89 lakh tones of sesame annually with productivity of 485 kg/ha (Anon., 2019a).. Sesame it is widely cultivated in the states of Madhya Pradesh, Uttar Pradesh, Rajasthan, Gujarat, Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, West Bengal, Bihar and Assam. In Gujarat, sesame is cultivated in an area of 1.66 lakh ha with a production of 1.08 lakh tones and productivity of 650 kg/ha (Anon., 2019b). This crop is generally cultivated as sole or inter crop during *Kharif* and summer seasons. The productivity of sesame is very low as compared to other oilseeds hence, it is necessary to raise the productivity and thereby total oilseeds production in order to meet edible oil requirement of the country.

Black Sesame seeds, also known as kala til, is one of oldest condiments known to man. They are highly valued for their oil. It may be a small seed but no doubt a very powerful one, used for many health promoting and anti-ageing benefits. 1. Anti-ageing properties, 2. Decreases the risk of cancer, 3.Relief for constipation and indigestion, 4.Stabilizes your blood pressure (Anon., 2018).

Materials and Methods

The material for the present study consisted of ten females, *viz*., Khadkala 3, Nana Bhamodra 6, Hathigadh 1-1, Hathigadh 1-2, Ingorala 5, Panch Talavada, Vijapadi 1, Keriya 7, Keriya 10, NIC 8476 and four males *viz*., G.Til 10, ABT 33, AT 324, GRT 8376-1. The experimental material used in the present studyconsisted of 54 test entries comprising of 40 hybrids developed from ten lines and four testers and 14 parents. Among parents G.Til10 was used as a standard check. The crosses were made during summer 2019 at Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh through line x tester mating design. Ten lines, four testers and the resulting 40 crosses were evaluated in a Randomized Block Design with three replications at the Agricultural Research Station, Junagadh Agricultural University, Amreli during *Kharif*-2019. Each entry was accommodated in single row plot of 4.2 meter length with row to row and plant to plant distances of 60 cm and 10-15 cm, respectively. All the recommended agronomical practices and plant protection measures were followed for raising a normal crop. Observations were recorded on five randomly selected plants in each genotype and from each replication except days to 50 per cent flowering and days to maturity which were calculated on plot basis and their mean values were used for statistical analysis. The characters studied were days to 50% flowering, days to maturity, plant height (cm), height to first capsule (cm), number of branches per plant, capsule length (cm), number of capsules per plant, number of seeds per capsule, 1000 seed weight (g), seed yield per plant (g) and oil content (%).

Results and Discussion

The analysis of variance was performed to test the differences among the genotypes, parents, hybrids and parents *vs.* hybrids for all the eleven characters studied and are presented in Table 1. All the character showed significant differences among the genotypes indicating the presence of sufficient variability in the experimental materials. The differences among the parents and hybrids were found highly significant for days to 50 % flowering, height to first capsule, number of seeds per capsule,1000 seed weight and oil content suggesting the presence of sufficient diversity among parents and hybrids themselves for these characters. The mean squares due to parents *vs.* hybrids were found highly significant for days to maturity, number of capsules per plant, number of seeds per capsule, 1000 seed weight and seed yield per plant indicating that, heterosis could be exploited for most of the characters under study. Results on heterosis are presented in table 2 to 6.

Days to 50 % flowering : In sesame, earliness in flowering is a desirable trait with regard to days to 50% flowering (Table-3), 11 crosses exhibited significant and desirable (negative) relative heterosis. The significant heterobeltiosis in desired way was recorded in six crosses. The spectrum of heterobeltiosis was -9.30 % (Hathigadh 1-2 x GRT 8376-1) to 15.70 % (Khadkala 3 x ABT 33). The highest, significant and negative heterobeltiosis was recorded in the cross Hathigadh 1-2 x GRT 8376-1 (-9.30 %) followed by Ingorala 5 x AT 324 (-8.46 %) and Ingorala 5 x GRT 8376-1 (-7.69 %). Early flowering in hybrids has been also reported by Kumaresan and Nadarajan (2003) and Sumathi and Muralidharan (2008).

The range of standard heterosis for days to 50 % flowering was recorded from -4.88 % (Hathigadh 1-2 x GRT 8376-1 and Keriya 10 x GRT 8376-1) to 15.45 % (Panch Talavada x AT 324). The highest but non-significant magnitude of standard heterosis in desired direction was found in cross Keriya 10 x GRT 8376-1 and Hathigadh 1-2 x GRT 8376-1 (-4.88 %) followed by Nana Bhamodara 6 x ABT 33, Ingorala 5 x AT 324,

Ingorala 5 x ABT 33, Keriya 7 x G.Til 10 (-3.25 %) and Ingorala 5 x GRT 8376-1, Vijapdi 1 x ABT 33, Keriya 7 x AT 324 (-2.44 %). In the study of Dela and Sharma (2019) also none of the crosses reported significant standard heterosis for days to 50% flowering in negative direction.

Days to maturity : The significant heterosis over mid-parent in desired direction recorded in six crosses evaluated. Two hybrids exhibited significant heterobeltiosis in negative way. The value of heterobeltiosis varied from -3.47 % (Keriya 7 x ABT 33) to 3.97 % (Khadkala 3 x GRT 8376-1). The highest magnitude of significant heterobeltiosis in desired direction was recorded in cross Keriya 7 x ABT 33 (-3.47 %) followed by Panch Talavada x GRT 8376-1 (-3.45 %). These crosses can be utilized for development of short duration sesame variety. Significant negative heterosis for days to maturity has been reported by Solanki and Gupta (2000), Singh (2002), Sundari and Kamala (2012) and Imaran *et al.* (2017).

Plant height : Out of 40 crosses, five crosses exhibited significant and desirable (positive) relative heterosis. The relative heterosis ranged from -11.63 % (NIC 8476 x ABT 33) to 23.75 % (Hathigadh 1-1 x G.Til 10). The spectrum of heterobeltiosis varied from -19.15 % (NIC 8476 x ABT 33) to 17.85 % (Hathigadh 1-1 x G.Til 10). Out of 40 crosses evaluated, four crosses exhibited significant heterobeltiosis in positive direction. The highest significant heterobeltiosis in desired direction recorded in the cross Hathigadh 1-1 x G.Til 10 (17.85%) followed by Keriya 7 x AT 324 (16.91 %), Keriya 10 x G.Til 10 (15.74 %) and Keriya 10 x ABT 33 (15.16 %).

Nine crosses displayed significant standard heterosis in positive direction for plant height. The magnitude of standard heterosis recorded from -7.69 % (Khadkala 3 x GRT 8376-1, Keriya 7 x G.Til 10) to

33.23 % (Keriya 10 x ABT 33). The highest magnitude of standard heterosis in expected direction was exhibited by cross Keriya 10 x ABT 33 (33.23 %) followed by Keriya 7 x AT 324 (23.38 %) and Keriya 10 x G.Til 10 (22.15 %). Solanki and Gupta (2000), Singh (2002), Rao (2011) and Parimala *et al.* (2013) also observed significant positive heterosis for plant height in sesame.

Height to first capsule : The range of relative heterosis for height to first capsule recorded from -41.88 % (Khadkala 3 x GRT 8376-1) to 55.13 % (Ingorala 5 x G.Til 10). Two exhibited significant heterobeltiosis in negative way. The value of heterobeltiosis varied from -36.65 % (Khadkala 3 x GRT 8376-1) to 80.53 % (Ingorala 5 x G.Til 10). The highest magnitude of significant heterobeltiosis in desired direction was recorded in cross Khadkala 3 x GRT 8376-1 (-36.65 %) followed by Hathigadh 1-1 x AT 324 (-19.73 %). Significant negative heterosis for height to first capsule has also been reported by Durga and Raghunadham (2001).

Table-1 : Analysis of variance (mean squar) for seed yield and its contributing characters in sesame.

Sources	Df	Mean square for					
		Days to 50% flowering	Days to maturity	Plant height	Height to first capsule	Number of branches per plant	Capsule length
Replications	2	3.85	0.96	83.41	45.93	0.01	0.04
Genotypes	53	16.18**	6.56**	272.31**	161.31**	0.30*	0.09**
(a) Parents	13	10.74**	5.47	134.50	176.84**	0.53**	0.02
(b) Hybrids	39	18.35**	6.37**	318.60**	158.70**	0.20	0.11**
(c) Parents vs. Hybrids	1	2.11	28.14**	258.64	61.39	1.15*	0.01
Error	106	2.61	3.37	85.00	17.43	0.18	0.02

Table-1 : Continue…

Sources	Df	Number of capsules per plant	Number of seeds per capsule	Mean square for 1000 seed weight	Seed yield per plant	Oil content
Replications	2	19.52	8.92	0.05	0.78	0.12
Genotypes	53	76.81**	107.32**	0.22**	4.94**	1.83**
(a) Parents	13	74.84*	174.28**	0.07**	1.01*	0.83**
(b) Hybrids	39	49.60	77.65**	0.22**	5.87**	2.20**
(c) Parents vs. Hybrids	1	116.79**	394.42**	2.11**	19.97**	0.22
Error	106	39.13	3.63	0.02	0.45	0.07

*and ** indicate significant at 5% and 1% levels of probability, respectively.

The standard heterosis ranged from -9.73 % (Khadkala 3 x GRT 8376-1) to 80.53 % (Ingorala 5 x G.Til 10). Only one cross Khadkala 3 x GRT 8376-1 (-9.73 %) recorded negative standard heterosis for height to first capsule.

Number of branches per plant : The significant heterosis over mid parent in desired way recorded in two crosses. It's magnitude ranged from -22.63 % (Keriya 10 x G.Til 10) to 28.97 % (Vijapdi 1 x AT 324). The significant and positive heterobeltiosis for this character exhibited in two crosses. The values of it varied from -24.64 % (NIC 8476 x GRT 8376-1) to 25.45 % (Vijapdi 1 x AT 324). The highest, significant and positive heterobeltiosis recorded in cross Vijapdi 1 x AT 324 (25.45 %) followed by Panch Talavada x AT 324 (22.64 %). The spectrum of heterosis over standard check varied from -23.53 % (Panch Talavada x G.Til 10 and NIC 8476 x GRT 8376-1) to 1.47 % (Vijapdi 1 x AT 324). Significant positive heterosis for number of branches per plant in sesame has been reported by Dikshit and Swain (2000), Singh (2002), Kim *et al.* (2006), Misra *et al*. (2008), Rao (2011), Sundari and Kamala (2012) and Parimala *et al*. (2013).

Capsule length : Among 40 hybrids evaluated, seven hybrids noticed significant relative heterosis in desired direction. It was ranged from -14.93 % (Khadkala 3 x G.Til 10) to 14.11 % (Khadkala 3 x GRT 8376-1). Only one hybrid showed significant and positive heterobeltiosis for capsule length. The standard heterosis for this trait varied from -12.27 % (Khadkala 3 x G.Til 10) to 20.73 % (Khadkala 3 x GRT 8376-1). The positive and significant standard heterosis was reported by eight crosses. The highest magnitude of heterosis over standard check was recorded in Khadkala 3 x GRT 8376-1 (20.73 %) followed by Nana Bhamodara 6 x ABT 33, Hathigadh 1-1 x AT 324 (14.13 %) and Keriya 7 x ABT 33 (11.80 %). Heterosis observed in most of the crosses for this character was in low magnitude. This indicates that simple additive genetic effect might be acting in expression of heterosis for capsule length. Kumar and Ganesan (2004) also reported significant positive heterosis for capsule length in sesame.

Number of capsules per plant : Number of capsules per plant is an important yield attribute in sesame. The relative heterosis was significant and positive in 12 out of 40 crosses evaluated. Two crosses exerted significant heterobeltiosis in desired direction. The magnitude of heterobeltiosis varied from -13.20 % (NIC 8476 x GRT 8376-1) to 33.30 % (NIC 8476 x ABT 33). The highest magnitude of significant heterobeltiosis for this trait recorded in cross NIC 8476 x ABT 33 (33.30 %) followed by Vijapdi 1 x ABT 33 (21.38 %). Only one cross NIC 8476 x ABT 33 (17.38 %) had significant and positive standard heterosis. The results for this character indicted that standard heterosis ranged from -8.56 % (NIC 8476 x GRT 8376-1) to 17.38 % (NIC 8476 x ABT 33). Significant positive heterosis for number of capsules per plant in sesame has been reported by Dikshit and Swain (2000),

Table-2 : Estimation of heterosis (%) in F_1 over mid parent (MP), better parent (BP) and standard check (SC) for days to 50 % flowering, days to maturity, plant height and height to first capsule in sesame.

Sr. No.	Cross Combinations	Days to 50% flowering			Days to maturity			Plant height			Height to first capsule		
		MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
1.	Khadkala 3 x AT 324	-4.58	0.00	1.63	1.76	3.17	0.78	-8.55	-11.08	-6.15	-7.69	-3.11	38.05**
2.	Khadkala 3 x GRT 8376-1	8.53**	12.00**	13.82**	1.35	3.97*	1.55	-7.98	-8.54	-7.69	-41.88**	-36.65**	-9.73
3.	Khadkala 3 x ABT 33	13.82**	15.70**	13.82**	2.15	3.57*	1.16	1.43	-5.59	9.23	-11.31*	-7.45	31.86**
4.	Khadkala 3 x G.Til 10	0.00	0.81	0.81	0.39	1.59	-0.78	-4.47	-4.62	-4.62	-16.06*	1.77	1.77
5.	Nana Bhamodara 6 x AT 324	-6.09*	-4.38	6.50*	-0.96	-0.77	-0.39	3.96	3.21	8.92	-5.88	11.63	27.43**
6.	Nana Bhamodara 6 x GRT 8376-1	-1.09	2.26	10.57**	-2.10	-1.15	-0.39	-3.30	-4.73	-0.92	-7.21	14.73	30.97**
7.	Nana Bhamodara 6 x ABT 33	-9.51**	-1.65	-3.25	0.58	0.77	1.16	-9.80	-14.36*	-0.92	-13.82*	1.55	15.93
8.	Nana Bhamodara 6 x G.Til 10	-6.42*	0.81	0.81	-1.93	-1.55	-1.55	-1.06	-2.96	0.92	22.31**	30.97**	30.97**
9.	Hathigadh 1-1 x AT 324	1.12	3.03	10.57**	0.01	0.00	0.39	-1.41	-8.45	-3.38	-27.16**	-19.73**	4.42
10.	Hathigadh 1-1 x GRT 8376-1	-7.17**	-6.82*	0.00	-1.91	-0.77	-0.39	5.79	0.30	1.23	-5.04	8.84	41.59**
11.	Hathigadh 1-1 x ABT 33	4.35	9.09**	7.32*	1.93	1.93	2.33	-3.88	-14.36*	-0.92	-6.83	2.04	32.74**
12.	Hathigadh 1-1 x G.Til 10	2.75	6.50*	6.50*	-0.58	-0.39	-0.39	23.75**	17.85*	17.85*	40.77**	61.95**	61.95**
13.	Hathigadh 1-2 x AT 324	-3.76	-0.78	4.07	-4.35**	-2.32	-1.94	-4.13	-6.39	3.69	-4.32	5.44	37.17**
14.	Hathigadh 1-2 x GRT 8376-1	-10.69**	-9.30**	-4.88	-2.43	-1.51	1.16	-6.98	-11.11	-1.54	-22.85**	-11.56	15.04
15.	Hathigadh 1-2 x ABT 33	8.00**	11.57**	9.76**	-4.35**	-2.32	-1.94	7.07	4.79	21.23**	-8.70	0.00	30.09**
16.	Hathigadh 1-2 x G.Til 10	9.52**	12.20**	12.20**	-4.17**	-1.94	-1.94	-9.20	-13.61*	-4.31	16.92*	34.51**	34.51**
17.	Ingorala 5 x AT 324	-10.86**	-8.46**	-3.25	-0.96	-0.77	-0.39	7.80	6.88	14.77*	-7.65	0.67	33.63**
18.	Ingorala 5 x GRT 8376-1	-8.75**	-7.69*	-2.44	0.19	1.15	1.94	0.15	-2.87	4.31	0.59	14.00*	51.33**
19.	Ingorala 5 x ABT 33	-5.18	-1.65	-3.25	-3.28*	-3.09	-2.71	-3.45	-6.91	7.69	4.00	12.67	49.56**
20.	Ingorala 5 x G.Til 10	1.19	4.07	4.07	-2.32	-1.94	-1.94	4.15	0.57	8.00	55.13**	80.53**	80.53**
21.	PanchTalavada x AT 324	5.19*	6.77*	15.45**	-2.31	-1.93	-1.55	5.81	5.51	12.00	17.15**	37.12**	60.18**
22.	PanchTalavada x GRT 8376-1	-6.77**	-6.77*	0.81	-4.18**	-3.45*	-2.33	6.39	3.77	10.15	0.62	22.73**	43.36**
23.	PanchTalavada x ABT 33	7.87**	13.22**	11.38**	3.46*	3.86*	4.26*	-0.14	-4.26	10.77	14.66*	33.33**	55.75**
24.	PanchTalavada x G.Til 10	-5.47*	-1.63	-1.63	-2.12	-1.55	-1.55	9.25	6.09	12.62	10.20	19.47**	19.47*
25.	Vijapdi 1 x AT 324	1.89	5.47	9.76**	-2.87	-1.93	-1.55	1.61	1.46	7.08	9.09	17.65**	59.29**
26.	Vijapdi 1 x GRT 8376-1	-1.15	0.78	4.88	-2.84	-2.65	-0.39	3.58	1.46	6.77	-2.62	9.15	47.79**
27.	Vijapdi 1 x ABT 33	-3.61	-0.83	-2.44	-2.49	-1.54	-1.16	4.18	-0.53	15.08*	-10.98*	-4.58	29.20**
28.	Vijapdi 1 x G.Til 10	3.59	5.69	5.69	0.77	1.94	1.94	-0.75	-3.22	1.85	20.30**	41.59**	41.59**
29.	Keriya 7 x AT 324	-9.09**	-5.51	-2.44	1.54	1.93	2.33	18.81**	16.91*	23.38**	9.97	27.61**	51.33**
30.	Keriya 7 x GRT 8376-1	1.54	3.94	7.32*	-2.66	-1.92	-0.78	-5.15	-5.72	-3.69	-23.46**	-7.46	9.73
31.	Keriya 7 x ABT 33	12.10**	14.88**	13.01**	-3.85*	-3.47*	-3.10	-3.67	-9.31	4.92	-12.62*	0.75	19.47**
32.	Keriya 7 x G.Til 10	-4.80	-3.25	-3.25	-0.19	0.39	0.39	-8.68	-9.64	-7.69	14.98*	25.66**	25.66**
33.	Keriya 10 x AT 324	1.90	6.35*	8.94**	2.32	2.32	2.71	9.62	9.62	15.69*	-22.18**	-1.72	0.88
34.	Keriya 10 x GRT 8376-1	-9.65**	-7.14*	-4.88	-0.76	0.39	0.78	0.45	-1.75	3.69	14.38*	50.86**	54.87**
35.	Keriya 10 x ABT 33	1.21	3.31	1.63	0.77	0.77	1.16	20.45**	15.16*	33.23**	21.65**	52.59**	56.64**
36.	Keriya 10 x G.Til 10	7.63**	8.94**	8.94**	-2.90	-2.71	-2.71	18.86**	15.74*	22.15**	49.34**	51.33**	51.33**
37.	NIC 8476 x AT 324	1.53	6.40*	8.13*	0.39	0.39	0.78	0.76	-3.79	1.54	-7.87	-4.82	39.82**
38.	NIC 8476 x GRT 8376-1	-3.10	0.00	1.63	-1.53	-0.39	0.00	15.94**	13.11	14.15*	-1.12	6.02	55.75**
39.	NIC 8476 x ABT 33	11.38**	13.22**	11.38**	-1.54	-1.54	-1.16	-11.63*	-19.15**	-6.46	-4.99	-2.41	43.36**
40.	NIC 8476 x G.Til 10	0.81	1.63	1.63	-0.58	-0.39	-0.39	5.49	3.38	3.38	3.94	28.32**	28.32**
	S.E. (d) ±	1.12	1.30	1.30	1.33	1.53	1.53	6.48	7.48	7.48	2.98	3.44	3.44
	C.D. at 5%	2.24	2.58	2.58	2.65	3.06	3.06	12.91	14.91	14.91	5.93	6.85	6.85
	C.D. at 1%	2.97	3.43	3.43	3.51	4.06	4.06	17.12	19.77	19.77	7.87	9.08	9.08
	Range	-10.86 to 13.82	-9.30 to 15.70	-4.88 to 15.45	-4.35 to 3.46	-3.47 to 3.97	-3.10 to 4.26	-11.63 to 23.75	-19.15 to 17.85	-7.69 to 33.23	-41.88 to 55.13	-36.65 to 80.53	-9.73 to 80.53

*and ** indicate significant at 5% and 1% levels of probability, respectively.

Table-3 : Estimation of heterosis (%) in F_1 over mid parent (MP), better parent (BP) and standard check (SC) for number of branches per plant, capsule length, number of capsules per plant and number of seeds per capsule in sesame.

Sr. No.	Cross Combinations	Number of branches per plant			Capsule length			Number of capsules per plant			Number of seeds per capsule		
		MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
1.	Khadkala 3 x AT 324	-0.88	-8.20	-17.65*	2.84	1.56	7.92	5.43	5.23	0.36	-3.67	-4.23	-30.62**
2.	Khadkala 3 x GRT 8376-1	-13.85*	-18.84*	-17.65*	14.11**	13.61**	20.73**	0.09	-4.65	0.45	11.80**	5.06	-14.47**
3.	Khadkala 3 x ABT 33	-14.96*	-18.18*	-20.59**	-11.84**	-15.61**	-10.33*	9.23	3.36	-1.43	2.00	-11.66**	-13.62**
4.	Khadkala 3 x G.Til 10	-10.08	-14.71	-14.71	-14.93**	-17.44**	-12.27**	0.64	-1.69	-1.69	-11.14**	-23.76**	-23.76**
5.	Nana Bhamodara 6 x AT 324	4.50	-1.69	-14.71	-3.79	-6.99	3.26	-2.31	-3.82	-5.70	4.92	-5.59*	-14.47**
6.	Nana Bhamodara 6 x GRT 8376-1	-17.19*	-23.19**	-22.06**	2.03	-0.58	10.38*	5.61	1.95	7.40	-14.06**	-18.41**	-26.08**
7.	Nana Bhamodara 6 x ABT 33	-10.40	-15.15	-17.65*	9.63*	2.80	14.13**	13.09*	5.64	3.57	-15.36**	-18.47**	-20.27**
8.	Nana Bhamodara 6 x G.Til 10	-13.39	-19.12*	-19.12*	-4.71	-9.44*	0.54	8.01	6.95	6.95	-8.03**	-12.35**	-12.35**
9.	Hathigadh 1-1 x AT 324	2.70	-3.39	-16.18*	7.43*	4.85	14.13**	4.12	1.88	-3.21	-21.37**	-28.19**	-37.06**
10.	Hathigadh 1-1 x GRT 8376-1	-10.94	-17.39*	-16.18*	1.14	-0.50	8.31	0.18	-6.68	-1.69	2.56	-1.08	-13.31**
11.	Hathigadh 1-1 x ABT 33	-7.20	-12.12	-14.71	-8.81*	-13.69**	-6.06	9.57	6.08	-3.57	-9.91**	-14.58**	-16.47**
12.	Hathigadh 1-1 x G.Til 10	-13.39	-19.12*	-19.12*	-11.90**	-15.48**	-8.00	4.58	-0.18	-0.18	-9.40**	-14.99**	-14.99**
13.	Hathigadh 1-2 x AT 324	4.85	3.85	-20.59**	-8.44*	-9.75*	-3.73	5.37	4.83	0.62	-12.49**	-16.91**	-33.05**
14.	Hathigadh 1-2 x GRT 8376-1	-1.67	-14.49	-13.24	-9.91**	-10.48*	-4.50	-0.58	-4.99	0.09	-6.52*	-7.00*	-24.29**
15.	Hathigadh 1-2 x ABT 33	-5.98	-16.67*	-19.12*	4.35	-0.29	6.37	15.55*	9.01	4.63	-4.20	-12.63**	-14.57**
16.	Hathigadh 1-2 x G.Til 10	-9.24	-20.59**	-20.59**	4.18	0.92	7.66	-0.73	-2.72	-2.72	-5.96*	-15.10**	-15.10**
17.	Ingorala 5 x AT 324	-0.92	-5.26	-20.59**	-1.83	-2.60	0.93	14.90*	8.16	2.76	-0.93	-8.62*	-21.65**
18.	Ingorala 5 x GRT 8376-1	-7.94	-15.94*	-14.71	-2.26	-3.81	1.32	11.73	0.34	5.70	-0.82	-3.33	-17.11**
19.	Ingorala 5 x ABT 33	-4.07	-10.61	-13.24	-7.61	-9.79*	-8.00	8.86	8.06	-8.02	-8.98**	-14.58**	-16.47**
20.	Ingorala 5 x G.Til 10	-10.40	-17.65*	-17.65*	4.55	3.53	5.59	14.35*	5.12	5.12	-13.93**	-20.06**	-20.06**
21.	PanchTalavada x AT 324	23.81**	22.64*	-4.41	-7.42	-8.22	-4.89	6.39	1.09	6.68	4.70	0.95	-21.22**
22.	PanchTalavada x GRT 8376-1	3.28	-8.70	-7.35	2.69	0.98	6.37	-3.56	-3.64	1.69	-8.48**	-10.38**	-27.03**
23.	PanchTalavada x ABT 33	-5.88	-15.15	-17.65*	8.19*	5.72	7.66	1.44	-8.37	-3.30	-18.56**	-26.78**	-28.41**

*and ** indicate significant at 5% and 1% levels of probability, respectively.

Table-3 : Contd...

Sr. No.	Cross Combinations	Number of branches per plant			Capsule length			Number of capsules per plant			Number of seeds per capsule		
		MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
24.	PanchTalavada x G.Til 10	-14.05	-23.53**	-23.53**	2.32	1.40	3.26	1.38	-1.28	4.19	-17.56**	-26.61**	-26.61**
25.	Vijapdi 1 x AT 324	28.97**	25.45**	1.47	-3.35	-4.85	-1.40	12.45	9.76	4.28	-1.13	-9.16**	-21.44**
26.	Vijapdi 1 x GRT 8376-1	6.45	-4.35	-2.94	6.42	3.93	9.47*	9.51	1.78	7.22	-7.42**	-10.13**	-22.28**
27.	Vijapdi 1 x ABT 33	-5.79	-13.64	-16.18*	8.32*	6.57	7.01	25.08**	21.38**	9.80	-14.15**	-19.11**	-20.91**
28.	Vijapdi 1 x G.Til 10	-4.07	-13.24	-13.24	3.82	3.61	4.04	11.46	6.15	6.15	-17.67**	-23.23**	-23.23**
29.	Keriya 7 x AT 324	-3.51	-11.29	-19.12*	6.51	6.39	10.25*	7.90	5.72	0.45	-13.35**	-26.01**	-24.29**
30.	Keriya 7 x GRT 8376-1	-12.98	-17.39*	-16.18*	6.76	5.77	11.41*	11.93*	4.40	9.98	-34.71**	-41.38**	-40.02**
31.	Keriya 7 x ABT 33	-17.19*	-19.70*	-22.06**	11.48**	8.14	11.80**	15.77*	11.93	2.05	-26.75**	-28.38**	-26.72**
32.	Keriya 7 x G.Til 10	-16.92*	-20.59**	-20.59**	6.12	4.38	7.92	6.76	2.05	2.05	-27.97**	-28.79**	-27.14**
33.	Keriya 10 x AT 324	-10.74	-21.74**	-20.59**	2.65	1.02	4.68	9.70	8.11	5.79	3.50	-3.06	-29.78**
34.	Keriya 10 x GRT 8376-1	-14.49*	-14.49	-13.24	2.98	0.54	5.90	-2.54	-6.01	-0.98	7.01*	-4.93	-22.60**
35.	Keriya 10 x ABT 33	-3.70	-5.80	-4.41	8.86*	7.14	7.51	16.12*	8.56	6.24	7.74**	-11.29**	-13.25**
36.	Keriya 10 x G.Til 10	-22.63**	-23.19**	-22.06**	7.61	7.43	7.79	14.41*	13.19	13.19	-29.50**	-42.45**	-42.45**
37.	NIC 8476 x AT 324	-1.85	-5.36	-22.06**	-3.45	-3.62	-0.13	14.31*	10.13	4.63	23.60**	19.10**	-13.73**
38.	NIC 8476 x GRT 8376-1	-16.80*	-24.64**	-23.53**	6.53	5.48	11.10*	-5.44	-13.20*	-8.56	10.73**	1.04	-17.74**
39.	NIC 8476 x ABT 33	-8.20	-15.15	-17.65*	5.56	2.46	5.80	35.56**	33.30**	17.38**	8.58**	-8.42**	-10.45**
40.	NIC 8476 x G.Til 10	-9.68	-17.65*	-17.65*	-4.58	-6.09	-3.03	14.79*	7.93	7.93	-25.58**	-37.80**	-37.80**
	S.E. (d) ±	0.31	0.36	0.36	0.09	0.10	0.10	4.48	5.17	5.17	1.33	1.54	1.54
	C.D. at 5%	0.62	0.72	0.72	0.18	0.21	0.21	8.92	10.30	10.30	2.65	3.07	3.07
	C.D. at 1%	0.83	0.96	0.96	0.24	0.28	0.28	11.83	13.67	13.67	3.52	4.07	4.07
	Range	-22.63 to 28.97	-24.64 to 25.45	-23.53 to 1.47	-14.93 to 14.11	-17.44 to 13.61	-12.27 to 20.73	-5.44 to 35.56	-13.20 to 33.30	-8.56 to 17.38	-34.71 to 23.60	-42.45 to 19.10	-42.45 to -10.45
Number of crosses having significant heterosis in desirable direction		2	2	0	7	1	8	12	2	1	6	1	0

*and ** indicate significant at 5% and 1% levels of probability, respectively.

Table-4 : Estimation of heterosis (%) in F_1 over mid parent (MP), better parent (BP) and standard check (SC) for 1000 seed weight, Seed yield per plant and Oil content in sesame.

Sr. No.	Cross Combinations	1000 Seed weight			Seed yield per plant			Oil content		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1.	Khadkala 3 x AT 324	25.59**	23.77**	26.74**	29.66**	28.43**	22.26**	-3.09**	-3.13**	-3.20**
2.	Khadkala 3 x GRT 8376-1	12.19**	9.38*	12.00**	-1.59	-8.12	0.86	4.24**	4.10**	3.95**
3.	Khadkala 3 x ABT 33	8.60**	7.94*	11.89**	-6.86	-7.18	-11.03	-5.92**	-5.94**	-6.07**
4.	Khadkala 3 x G.Til 10	-0.40	-1.56	0.80	7.84	5.25	5.25	-1.87**	-1.94**	-1.94**
5.	Nana Bhamodara 6 x AT 324	18.80**	12.95**	24.57**	30.23**	28.82**	22.99**	1.62**	0.68	0.61
6.	Nana Bhamodara 6 x GRT 8376-1	-3.30	-9.02*	0.34	-4.04	-10.30	-1.52	1.00*	0.23	-0.19
7.	Nana Bhamodara 6 x ABT 33	-2.24	-5.18	4.57	-12.34*	-12.51*	-16.14**	-2.73**	-3.58**	-3.76**
8.	Nana Bhamodara 6 x G.Til 10	8.59**	3.52	14.17**	39.66**	36.50**	36.50**	-1.00*	-1.95**	-1.95**
9.	Hathigadh 1-1 x AT 324	17.15**	10.37**	24.11**	-14.30**	-17.50**	-16.73**	0.66	-0.06	-0.14
10.	Hathigadh 1-1 x GRT 8376-1	-1.04	-7.72*	3.77	-12.76**	-16.28**	-8.09	3.14**	2.57**	2.15**
11.	Hathigadh 1-1 x ABT 33	-3.54	-7.32*	4.23	7.36	4.66	5.63	-0.92*	-1.58**	-1.76**
12.	Hathigadh 1-1 x G.Til 10	17.48**	10.98**	24.80**	23.10**	22.53**	23.68**	1.49**	0.72	0.72
13.	Hathigadh 1-2 x AT 324	3.54	-0.32	7.09	8.46	5.53	4.18	3.41**	2.54**	2.46**
14.	Hathigadh 1-2 x GRT 8376-1	25.29**	19.36**	28.23**	-3.25	-8.12	0.86	1.79**	1.10*	0.68
15.	Hathigadh 1-2 x ABT 33	-3.74	-5.43	1.60	6.59	5.04	3.70	0.35	-0.45	-0.62
16.	Hathigadh 1-2 x G.Til 10	-0.39	-3.83	3.31	-1.30	-1.94	-1.94	1.06*	0.17	0.17
17.	Ingorala 5 x AT 324	15.40**	10.65**	19.89**	9.68	7.33	4.74	2.44**	2.04**	2.76**
18.	Ingorala 5 x GRT 8376-1	23.29**	16.98**	26.74**	-13.85**	-18.64**	-10.68	-0.06	-0.62	0.09
19.	Ingorala 5 x ABT 33	6.52*	4.22	12.91**	-6.61	-7.44	-9.68	-0.77	-1.20*	-0.50
20.	Ingorala 5 x G.Til 10	28.25**	23.31**	33.60**	26.14**	24.61**	24.61**	-0.46	-0.81	-0.11
21.	PanchTalavada x AT 324	14.41**	12.57**	15.66**	7.05	0.62	6.81	-2.61**	-3.63**	-1.64**
22.	PanchTalavada x GRT 8376-1	10.97**	8.01	10.97**	14.68**	12.78**	23.82**	-3.28**	-4.45**	-2.48**
23.	PanchTalavada x ABT 33	12.62**	12.13**	16.23**	-3.49	-8.17	-2.52	-1.05*	-2.14**	-0.11

*and ** indicate significant at 5% and 1% levels of probability, respectively.

Table-4 : continue…

Sr. No.	Cross Combinations	1000 Seed weight			Seed yield per plant			Oil content		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
24.	PanchTalavada x G.Til 10	10.26**	8.79	11.77**	1.41	-1.53	4.53	-3.42**	-4.40**	-2.42**
25.	Vijapdi 1 x AT 324	26.80**	24.28**	28.69**	8.66	4.07	-2.80	-0.35	-0.67	-0.10
26.	Vijapdi 1 x GRT 8376-1	6.77*	3.53	7.20	2.27	-9.04	-0.14	0.10	-0.39	0.18
27.	Vijapdi 1 x ABT 33	-2.92	-2.98	0.57	46.45**	38.55**	32.80**	0.33	-0.04	0.53
28.	Vijapdi 1 x G.Til 10	12.52**	10.60**	14.51**	7.73	-0.07	-0.07	-0.66	-0.94	-0.37
29.	Keriya 7 x AT 324	16.28**	14.78**	17.14**	21.08**	20.76**	12.79*	1.00*	0.75	0.68
30.	Keriya 7 x GRT 8376-1	23.74**	20.83**	23.31**	21.01**	11.71*	22.64**	-1.22**	-1.28*	-1.69**
31.	Keriya 7 x ABT 33	19.00**	18.08**	22.40**	-11.01*	-12.37*	-16.00**	0.37	0.19	0.01
32.	Keriya 7 x G.Til 10	8.60*	7.50	9.71*	4.82	1.11	1.11	0.48	0.20	0.20
33.	Keriya 10 x AT 324	6.29	0.62	12.00**	-6.75	-7.53	-12.17*	-1.42**	-1.51	-1.58**
34.	Keriya 10 x GRT 8376-1	12.88**	5.75	17.71**	-9.22	-15.33**	-7.05	0.18	0.10	-0.16
35.	Keriya 10 x ABT 33	6.86*	3.18	14.86**	31.57**	30.98**	25.54**	-0.21	-0.25	-0.43
36.	Keriya 10 x G.Til 10	5.90	0.51	11.89**	13.85**	10.99	10.99	-1.45**	-1.57**	-1.57**
37.	NIC 8476 x AT 324	-4.02	-10.05**	2.29	7.70	2.76	5.67	-0.30	-1.28*	-1.35**
38.	NIC 8476 x GRT 8376-1	2.28	-5.13	7.89*	9.87*	6.39	16.80**	0.77	-0.05	-0.47
39.	NIC 8476 x ABT 33	18.19**	12.96**	28.46**	34.10**	29.55**	33.22**	1.07*	0.14	-0.04
40.	NIC 8476 x G.Til 10	4.60	-1.71	11.77**	7.81	6.32	9.33	-2.54**	-3.53**	-3.53**
	S.E. (d) ±	0.11	0.12	0.12	0.45	0.52	0.52	0.19	0.22	0.22
	C.D. at 5%	0.22	0.25	0.25	0.91	1.05	1.05	0.38	0.44	0.44
	C.D. at 1%	0.29	0.34	0.34	1.21	1.39	1.39	0.51	0.59	0.59
	Range	-4.02 to 28.25	-10.05 to 24.28	0.34 to 33.60	-14.30 to 46.45	-18.64 to 38.55	-16.73 to 36.50	-5.92 to 4.24	-5.94 to 4.10	-6.07 to 3.95
Number of crosses having significant heterosis in desirable direction		26	18	29	12	11	12	10	5	4

*and ** indicate significant at 5% and 1% levels of probability, respectively.

Table-6 : Range of heterosis as well as number of crosses with response to heterotic effects for various traits in sesame.

Characters	Range of Heterosis (%)			Number of crosses with significant heterosis					
	Relative Heterosis	Heterobeltiosis	Standard heterosis	Relative Heterosis		Heterobeltiosis		Standard heterosis	
				+Ve	-Ve	+Ve	-Ve	+Ve	-Ve
1. Days to 50% flowering	-10.86 to 13.82	-9.30 to 15.70	-4.88 to 15.45	09	11	13	06	14	00
2. Days to maturity	-4.35 to 3.46	-3.47 to 3.97	-3.10 to 4.46	01	06	03	02	01	00
3. Plant height (cm)	-11.63 to 23.75	-19.15 to 17.85	-7.69 to 33.23	05	01	04	05	09	00
4. Height to first capsule (cm)	-41.88 to 55.13	-36.65 to 80.53	-9.73 to 80.53	11	10	17	02	33	00
5. Number of branches per plant	-22.63 to 28.97	-24.64 to 25.45	-23.52 to 1.47	02	08	02	18	00	27
6. Capsule length (cm)	-14.93 to 14.11	-17.44 to 13.61	-12.27 to 20.73	07	05	01	08	08	02
7. Number of capsules per plant	-5.44 to 35.56	-13.20 to 33.30	-8.56 to 17.38	12	00	02	01	01	00
8. Number of seeds per capsule	-34.71 to 23.60	-42.45 to 19.10	-42.45 to 10.45	06	23	01	31	00	40
9. 1000 seed weight (g)	-4.02 to 28.25	-10.05 to 24.28	0.34 to 33.60	26	00	18	04	29	00
10. Seed yield per plant (g)	-14.30 to 46.45	-18.64 to 38.55	-16.73 to 36.50	13	05	11	06	12	04
11. Oil content (%)	-5.92 to 4.24	-5.94 to 4.10	-6.07 to 3.95	10	13	05	15	04	13

Solanki and Gupta (2000), Singh (2002), Kumaresan and Nadarajan (2003), Kim *et al.* (2006), Misra *et al.* (2008), Sumathi and Muralidharan (2008), Parimala *et al.* (2013) and Imaran *et al.* (2017).

Number of seeds per capsule : The results for this character depicted that six crosses recorded significant and positive relative heterosis. The spectrum of heterosis over better parent recorded from -42.45 % (Keriya 10 x G.Til 10) to 19.10 % (NIC 8476 x AT 324). The significant and positive heterosis over better parent for this trait was found only in one cross NIC 8476 x AT 324 (19.10 %). Higher estimates of heterosis for number of seeds per capsule in sesame have been reported earlier by Misra *et al.* (2008) and Sumathi and Muralidharan (2008).

1000 seed weight : The observed range for heterosis over mid parent recorded -4.02 % (NIC 8476 x AT 324) to 28.25 % (Ingorala 5 x G.Til 10). The heterosis over better parent varied from -10.05 % (NIC 8476 x AT 324) to 24.28 % (Vijapdi 1 x AT 324). The significant and positive heterosis over better parent was found in 18 crosses. The highest, significant and positive heterobeltiosis for 1000 seed weight recorded in cross Vijapdi 1 x AT 324 (24.28 %) followed by Khadkala 3 x AT 324 (23.77 %) and Ingorala 5 x G.Til 10 (23.31 %). The standard heterosis ranged from 0.34 % (Nana Bhamodara 6 x GRT 8376-1) to 33.60 % (Ingorala 5 x G.Til 10). The significant and positive standard heterosis was found in 29 crosses. The highest magnitude of significant and positive standard heterosis for 1000 seed weight was recorded in cross Ingorala 5 x G.Til 10 (33.60 %) followed by Vijapdi 1 x AT 324 (28.69 %) and Hathigadh 1-2 x GRT 8376-1 (28.23 %). Significant estimates of positive heterosis for l000 seed weight in sesame have been reported by Solanki and Gupta (2000), Durga and Raghunadham (2001), Singh

(2002), Misra *et al.* (2008), Sundari and Kamala (2012) and Imaran *et al.* (2017).

Seed yield per plant : The range of relative heterosis observed from -14.30% (Hathigadh 1-1 x AT 324) to 46.45 % (Vijapdi 1 x ABT 33). The significant and positive heterosis over better parent recorded in 11 crosses. The recorded range for heterobeltiosis was -18.64 % (Ingorala 5 x GRT 8376-1) to 38.55 % (Vijapdi 1 x ABT 33). The highest magnitude of significant and positive heterosis over better parent was recorded in cross Vijapdi 1 x ABT 33 (38.55%) followed by Nana Bhamodara 6 x G.Til 10 (36.50 %) and Keriya 10 x ABT 33 (30.98 %).

The standard heterosis for seed yield per plant fluctuated form -16.73 (Hathigadh 1-1 x AT 324) to 36.50 % (Nana Bhamodara 6 x G.Til 10). Twelve crosses registered significant and positive standard heterosis. The maximum significant and positive standard heterosis for seed yield per plant was recorded in cross Nana Bhamodara 6 x G.Til 10 (36.50 %) followed by NIC 8476 x ABT 33 (33.22%) and Vijapdi 1 x ABT 33 (32.80%).

The hybrid Vijapdi 1 x ABT 33 ranked first with respect to relative heterosis (46.45%) and heterobeltiosis (38.55%) while it ranked third with respect standard heterosis (32.80 %). Nana Bhamodara 6 x G.Til 10 ranked second in relative heterosis (39.66 %) and heterobeltiosis (36.50 %) while it ranked first in standard heterosis (36.50 %). The cross NIC 8476 x ABT 33 ranked second in standard heterosis (33.22 %), third in relative heterosis (34.10 %) and fourth in heterobeltiosis (29.55 %). These three crosses *viz*., Nana Bhamodara 6 x G.Til 10, NIC 8476 x ABT 33 and Vijapdi 1 x ABT 33 also depicted significant standard heterosis over G. Til 10 for important yield contributing traits. Nana Bhamodara 6 x G.Til 10 manifested significant standard heterosis in desirable direction for 1000 seed weight; NIC 8476 x ABT 33 for number of capsule per plant and 1000 seed weight; Vijapdi 1 x ABT 33 for plant height. This emphasized that high degree of heterosis for seed yield might be attributed to the heterosis observed for these component characters. Similar findings were also reported by Solanki and Gupta (2000), Durga and Raghunadham (2001), Singh (2002), Kumar and Ganesan (2004), Singh *et al.* (2005), Kim *et al.* (2006), Misra *et al.* (2008), Sumathi and Muralidharan (2008), Banerjee and Kole (2010), Prajapati *et al*. (2010), Sundari and Kamala (2012), Parimala *et al.* (2013), Pawar *et al*. (2016), Imaran *et al.* (2017), Chaudhary *et al.* (2018), Daba *et al.* (2019) and Dela and Sharma (2019).

Oil content : In case of oil content, five and four crosses exhibited significant positive heterobeltiosis and standard heterosis, respectively. Significant positive standard heterosis was exhibited by the cross Khadkala 3 x GRT 8376-1 followed by Ingorala 5 x AT 324, Hathigadh 1-2 x AT 324 and Hathigadh 1-1 x GRT 8376-1. Significant positive heterosis for oil content in sesame has been reported by Kumaresan and Nadarajan (2003), Sumathi and Muralidharan (2008) and Daba *et al*. (2019).

Conclusions

The hybrids Vijapdi 1 x ABT 33, Nana Bhamodara 6 x G.Til 10, NIC 8476 x ABT 33 and Keriya 10 x ABT 33 were found to be most promising for seed yield in concern to heterosis study as these four crosses ranked between one to four with respect to relative heterosis, heterobeltiosis and standard heterosis hence these hybrids could be used to exploit the heterosis after identifying suitable hybrid seed production technology and in future breeding programme by utilizing biparental mating or recurrent selection breeding approaches to obtain desirable segregants for development of superior genotypes for seed yield and its component traits.

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Effect of Available Nutrient Resources on Productivity and Economics of Coriander (*Coriandrum sativum* L.)

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Abstract

A field experiment was conducted during *rabi* season of 2018-19 at Research Farm, College of Agriculture, Gwalior (M.P.).The experiment consisted of twelve treatments *viz.,* T_1 (Control) , T_2 (100% RDF), T_3 (50% RDF + 5 tonnes FYM/ha) ,T_4 (50% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage) , T_5 (75% RDF + 5 tonnes FYM/ha)), T_6 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage), T_7 (50% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage), T_8 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage), T_9 (50% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage), T_{10} (75% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage), T_{11} (50% RDF + 5 tonnes FYM kg/ha + Azotobacter + PSB) and T_{12} (75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB) were laid out in randomized block design with three replications. The results revealed that all growth parameters (like, plant height, dry matter per plant, CGR and RGR) and all yield attributing parameters (like, no. of umbelles/plant, no. of seeds/umbelletes and seed yield) were recorded significantly higher values in the treatment T_{12} (75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB) over other treatments followed by treatment T_6 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage) and T_8 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage). Similarly the highest values of harvest index were observed with treatment T_{12} (75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB) followed by T_6 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage) and T_8 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage). The all qualitative parameters like, protein content, NPK content in seed were significantly influenced with different treatments, the treatment T_{12} (75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB) was recorded highest protein content, NP content, which was significantly superior over other treatments followed by T_6 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage); whereas the highest K content in seed was observed under treatment T_6 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage) which was significantly superior over control followed by T_{12} (75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB). The highest net returns and benefit: cost ratio was secured with the treatment T_{12} (75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB), which was highly superior over absolute control and followed by treatment T_6 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage).

Key words : *B:C ratio, FYM, harvest index, nutrient resources, RDF.*

Introduction

India is the world's largest producer, consumer and exporter of seed spices. There are many seed spices grown in India, coriander is among them. Madhya Pradesh (55%) and Rajasthan (20%) are the two largest coriander producing states contributing about 76 per cent of total production. Coriander is an annual herbaceous plant locally known as *Dhania* belongs to the family Apiaceae, used as common flavoring substance. Coriander is being cultivated as a commercial crop mainly used as spices and medicine. Coriander is an annual herb with several branches and lacy leaves with jagged edges. It is a thin-stemmed, small bushy herb, much branched, grows about 25 to 50 cm tall with alternate and compound leaves become highly segmented and linear as they reach upper extremities. It grows best in dry climates; however it can grow in any type of soil like light, well drained, moist, loamy soil and light to heavy black soil (Verma *et al*., 2011).

All parts of this herb are in use as flavoring agent and/or as traditional remedies for the treatment of different dis-orders in the folk medicine systems of different civili-zations (Sahib *et al*., 2012). Inflorescence is a compound "umbel" and usually comprises about seven smaller umbellets. The fruits consist of two halves, the single seeded mericarps. The fruits have a fragrant odour and pleasant aromatic taste. The odour and taste are due to the compound containing d-linalool or coriandrol (Nadeem *et al*., 2013). Dry seeds have 6.3 per cent moisture, 1.3 per cent protein, 0.3-0.4 per cent volatile oil, 19.6 per cent non-volatile oil, 31.5 per cent total ether extract, 24.6 per cent carbohydrates, 5.3 per cent mineral matter and vitamin A (175 I.U. per 100 g). Indian coriander is poor in oil content (0.3 to 0.4%). The low oil content in Indian coriander is stated to be due to the loss of a protein of the volatile oil during drying of fruits, too much splitting and faulty harvesting procedure.

Materials and Methods

The present investigation was conducted during *rabi* season of 2018-19 at Research Farm, Department of Agronomy, College of Agriculture, Gwalior (M.P.). The topography of the field was uniform with proper drainage. The soil of the experimental field was sandy-clay-loam in texture, having neutral in reaction (pH 7.58), EC 0.42 dS/m, organic carbon 0.38% with available N (235.42 kg/ha), P (19.10 kg/ha) and K (276.95 kg/ha). The experiment consisted of twelve treatments *viz.,* T_1 (Control) , T_2 (100% RDF), T_3 (50% RDF + 5 tonnes FYM/ha) ,T_4 (50% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage) , T_5 (75% RDF + 5 tonnes FYM/ha)), T_6 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage), T_7 (50% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage), T_8 (75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage), T_9 (50% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage), T_{10} (75% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage), T_{11} (50% RDF + 5 tonnes FYM kg/ha + Azotobactor + PSB) and T_{12} (75% RDF + 5 tonnes FYM kg/ha + *Azotobactor* + PSB) in randomized block design with three replications. The recommended dose of fertilizers (60:30:20 kg NPK/ha) was applied in the form of urea, SSP and muriate of potash; respectively as per treatments. Coriander seed was sown 16 kg/ha by manually with a uniform distance of 30 cm between rows and 10 cm distance between plant to plant in *rabi*. Gujrat-2 variety was used for experimentation in coriander. Two inter culture operations were done at 30 and 45 days after seed sowing. Five coriander plants were randomly sampled from the inner rows of the each plot leaving the border rows. All data related to pre and post-harvest study of crop were collected and statistically analyzed by using the analysis of variance technique (Fisher, 1958). Data so computed was subjected to Fisher's analysis of variance for judging the effect of various treatments.

Results and Discussion

The growth parameters viz.; plant height, dry matter/plant, CGR and RGR of coriander were significantly influenced by various INM treatments. Application of 75% RDF + 5 tonnes FYM kg/ha + *Azotobactor* + PSB gave highest value of growth parameters followed by 75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage and 75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative. Application of 50% or 75% RDF with 5 tonnes FYM + biofertilizer (*Azotobacter* + PSB) or 5 tonnnes FYM + foliar spray of nutrients (NPK, zinc and thiourea) gave notably greater value of growth parameters over control (Table-1).

These results in line with Aishwath *et al.* (2012), who found that biofertilizers produce metabolites such as; plant growth regulators that directly promote growth and facilitate nutrient uptake by plants. This could be due to greater supply of multi-nutrients, PGR and beneficial microflora left by and in addition to most favourable conditions improved with respect to physico-chemical and biological properties of the soil.

Seed production factors *viz.*; number of seeds/umbellets and umbels/plant were directly responsible for yield of crop. All yield attributing characters (Table-2), of coriander significantly improved by INM treatments over control. The maximum values of number of seeds/umbellets (5.33) and umbels/plant (21.73) were recorded under application of 75% RDF + 5 tonnes FYM kg/ha + *Azotobactor* + PSB and it is found statistically at par with treatments 75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) and 75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage. These result in line with Singh (2013), who obtained higher values of yield attributing characters of coriander with integration of RDF + biofertilizers + FYM over control. Higher values of yield attributes under INM over control could be due to developed physiological and growth parameters as a result of higher supply of all necessary plant nutrients. This result in line with Tripathi *et al.* (2013), who observed that seed yield of coriander were increased by application of FYM @ 5 tonnes/ha along with *Azotobactor* and PSB.

Yield-attributes play an important role for increasing yield of crop. The integration of 75% RDF + FYM 5 t/ha along with biofertilizers or foliar spray of nutrients gave significantly higher yield over remaining INM treatments including control. Amongst all INM treatments, significantly higher seed yield of coriander (1927 kg/ha) was recorded under application of 75% RDF + 5 tonnes FYM kg/ha + *Azotobactor* + PSB followed by 75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18), 75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ and 75% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea and proved to be significantly superior to the remaining fertility treatments. The greater seed yield registered owing to these treatments was totally suitable for the alike rises in the yield-attributes as well as increased vegetative growth parameters. The rises in yield-attributing character and in consequence the seed yield of coriander as outcome of INM have also been described by Mishra *et al.* (2019), Mounika *et al.* (2017) and Shanu *et al.* (2013). The beneficial effect of FYM, biofertilizers and foliar spray with

Table-1 : Growth parameters of coriander influenced by integrated nutrient management practices.

Treatments	Plant height (cm)	Dry matter g/plant	CGR ($g/m^2/day$)	RGR (g/g/day)
Control	66.57	9.20	0.44	1.50
100% RDF	88.13	15.57	0.86	1.72
50% RDF + 5 tonnes FYM/ha	85.40	15.00	1.02	2.10
50% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage	90.33	15.60	1.08	2.16
75% RDF + 5 tonnes FYM/ha	91.10	16.00	0.70	1.35
75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage	97.23	17.67	0.79	1.39
50% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage	88.70	15.35	1.23	2.50
75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage	95.30	16.93	1.01	1.84
50% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage	87.67	15.42	0.32	0.63
75% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage	94.23	16.79	1.19	2.23
50% RDF + 5 tonnes FYM /ha + *Azotobacter* + PSB	92.80	16.33	0.32	0.58
75% RDF + 5 tonnes FYM /ha + *Azotobacter* + PSB	100.67	18.53	0.25	0.42
S.E.(m)±	2.23	0.22	0.30	0.68
C.D. (at 5%)	6.58	0.64	NS	NS

Table-2 : Effect of integrated nutrient management practices on yield attributing characters and yield of coriander.

Treatments	No. of umbels/plant	No. of seeds/umbellets	Seed yield (kg/ha)	Harvest index (%)
Control	13.13	3.73	3558	24.85
100% RDF	19.93	4.81	4723	26.32
50% RDF + 5 tonnes FYM/ha	18.07	4.55	4504	26.46
50% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK(18:18:18) at vegetative stage	19.53	4.61	4775	26.59
75% RDF + 5 tonnes FYM/ha	19.66	4.75	4815	26.48
75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK(18:18:18) at vegetative stage	20.74	5.10	5190	27.02
50% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage	19.74	4.81	4675	26.73
75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage	20.69	4.94	5114	26.70
50% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage	19.50	4.68	4704	26.60
75% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage	20.06	4.65	5086	26.57
50% RDF + 5 tonnes FYM/ha + *Azotobacter* + PSB	19.94	4.82	4741	26.59
75% RDF + 5 tonnes FYM/ha + *Azotobacter* + PSB	21.73	5.33	5195	27.06
S.E.(m)±	0.43	0.16	90.21	0.19
C.D. (at 5%)	1.26	0.46	265.88	0.56

RDF on coriander and other crops were also described by Aishwath *et al.*(2012) and Darzi *et al.* (2012).

All INM treatments significantly increased protein content in coriander over control. The highest protein content (12.24%) in coriander was registered with 75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB followed by 75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18), 75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage, 75% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage and all these treatments were remarkably equal in value to one another and found notably higher over other treatments. The higher protein content in coriander may be due to better availability of N and Zn which have positive relationship with protein content. Further, zinc has a role in the protein metabolism in plants and nitrogen is an essential constituent of proteins. This has been supported by Mounika *et al.* (2017).

N, P and K content in seed (Table-3) significantly influenced by INM treatments. Amongst all INM treatments, highest N and P content in seed (1.96% and 0.365%; respectively) was recorded under application of 75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB. However, maximum value of K content in seed was observed with 75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18). All INM treatments gave positive

Table-3 : Effect of integrated nutrient management practices on protein content (%) and N,P,K content (%) in Coriander seed.

Treatments	Protein content (%)	N (%)	P (%)	K (%)
Control	9.92	1.59	0.273	0.409
100% RDF	11.50	1.84	0.328	0.462
50% RDF + 5 tonnes FYM/ha	11.50	1.84	0.305	0.472
50% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage	11.58	1.85	0.330	0.477
75% RDF+ 5 tonnes FYM/ha	11.65	1.86	0.345	0.497
75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage	12.20	1.95	0.355	0.515
50% RDF+ 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage	11.57	1.85	0.327	0.473
75% RDF+ 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage	12.14	1.94	0.349	0.507
50% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage	11.57	1.85	0.322	0.467
75% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage	12.12	1.94	0.346	0.501
50% RDF+ 5 tonnes FYM/ha + *Azotobacter* + PSB	11.85	1.90	0.344	0.475
75% RDF+ 5 tonnes FYM/ha + *Azotobacter* + PSB	12.24	1.96	0.365	0.506
S.E.(m) ±	0.04	0.01	0.005	0.006
C.D. (at 5%)	0.12	0.02	0.014	0.017

Table-4 : Net income and B:C ratio under different treatments of INM in coriander.

Treatments	Net income (Rs./ha)	B:C Ratio
Control	71508	3.75
100% RDF	110972	4.87
50% RDF + 5 tonnes FYM/ha	104723	4.56
50% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK(18:18:18) at vegetative stage	112614	4.69
75% RDF + 5 tonnes FYM/ha	113569	4.78
75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK(18:18:18) at vegetative stage	127804	5.10
50% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage	111014	4.69
75% RDF + 5 tonnes FYM/ha + 0.5% spray of $ZnSO_4$ at vegetative stage	123348	5.01
50% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage	110577	4.63
75% RDF + 5 tonnes FYM/ha + 500 ppm spray of thiourea at vegetative stage	121174	4.89
50% RDF + 5 tonnes FYM/ha + *Azotobacter* + PSB	112670	4.83
75% RDF + 5 tonnes FYM/ha + *Azotobacter* + PSB	129259	5.29

impact to increase NPK content in seed over control. It may possible due to *Azotobacter* application fixes nitrogen, whereas PSB solubilize native P rendering more phosphorus to solution. While, the higher content of nitrogen in coriander may be due to the application of Zn which exerts a synergistic relationship with N. Further, zinc has a role in the protein metabolism in plants and nitrogen is an essential constituent of proteins. The present result of the experiment agrees with the findings of Jadhav *et al.* (2017).

Amongst the INM treatments, maximum net income (Rs.129259/hac) and B:C ratio (5.29) was recorded under application of 75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB. This was closely followed by 75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18), which received net income Rs.127804/ha with B:C ratio (5.10). These findings are supported by Khoja (2004) and Tripathi *et al.* (2013).

Conclusions

Application of 75% RDF + 5 tonnes FYM kg/ha + *Azotobacter* + PSB and 75% RDF + 5 tonnes FYM/ha + 0.5% spray of NPK (18:18:18) at vegetative stage are the best for increasing coriander productivity with maximum net income and B:C ratio.

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Variability and Growth Rate in Production of Sorghum in Madhya Pradesh

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Abstract

The present study has been made for the relative change, variability and growth rate in area, production and productivity of sorghum in different districts of Madhya Pradesh. The time series data on area, production and productivity of sorghum were collected for last 20 years from 1999-2000 to 2018-19. The relative change in area of sorghum was observed negative in all districts, whereas Barwani, Dhâr, Jhabua, Rewa and Sidhi districts showed positive relative change in production. The highest variability in area (94.16%) and production (99.22%) were found in Guna, whereas highest variability in productivity was recorded in Khandwa (99.22%). The growth rate in area was found negative and highly significant in all districts in the state of Madhya Pradesh except Barwani, Jhabua, Shajapur and Sidhi. The growth rate in production was noticed positive and significant in Barwani and Sidhi. The positive and highly significant growth rate in productivity was observed in Barwani, Betul, Chhatarpur, Chhindwara, Dhar, Jhabua, Khargone and Sidhi. The positive and highly significant growth rate in productivity was noticed in Madhya Pradesh with growth rate of 5.64 percent per annum during entire period of study.

Key words : *Growth rate, relative change, variability, area, production and productivity.*

Introduction

Sorghum is also known as jowar is mostly cultivated for grain which is used for food, animal and birds feed. It is rank fifth among cereals after rice, wheat, maize and barley in the world. The state of Maharashtra ranked first in production of sorghum followed by Karnakata, Tamilnadu, Rajasthan, Andhra Pradesh, Uttar Pradesh and Madhya Pradesh which produced more than 90 percent of India (2018-19). The area, production and productivity of sorghum were 0.08 million hectare and 0.16 million tonnes in Madhya Pradesh which accounted for 1.83 percent area, 4.72 percent production of India with productivity was 2189 Kg/ha in which highest among other states of India. Beside grain and stover of sorghum is an important feed in the livestock sector in India for draft and dairy animals particularly in the dry seasons when other feed resources are in short supply. Hence, dual purpose types that produce both grain and stover are the preferred types. (Kelley *et*. al 1993, Kelley and Parthasarathi Rao 1994, Hall 2000). Looking to the importance of sorghum the present study has been made with following objectives :

To analyse the change and variability in area, production and productivity of sorghum in different districts of Madhya Pradesh.

To determine the pace of growth in area, production and productivity of sorghum in different districts of Madhya Pradesh.

Materials and Methods

The study confined to state of Madhya Pradesh in which 13 major producing districts of sorghum viz. Barwani, Betul, Chhatarpur, Chhindwara, Dewas, Dhar, Guna (Guna and Ashok Nagar), Jhabua (Jhabua and Alirajpur), Khandwa (Khanawa and Burhanpur), Khargone, Rewa, Shajapur (Shajapur and Agar) and Sidhi (Sidhi and Singroli) were selected randomly. The time series secondary data on area, production and productivity of sorghum were collected for last 20 years from 1999-2000 to 2018-19 from website of Department of Farmer Welfare and Agriculture Development, Madhya Pradesh, Bhopal. The data of new districts related to area, production and productivity of sorghum have been added in their parent districts. The average of first three years was taken as base year and last average of three years were taken as current year for the analysis in view of economics accuracy. The statistical tools were used for estimation of relative change, mean, coefficient of variability and growth rate.

(1) Arithmetic mean

Arithmetic mean = x/N

Where:

x = Total value of area/production/productivity

N = Number of years

(2) The Relative Change

Relative change (%) = (Pn – Po/Po) x 100

Whereas :

Pn = Current year

Po = Base year

Base year = Triennium average (1999-2000 to 2001-02) in area, production and productivity

Current year = Triennium average (2016-17 to 2018-19) in area, production and productivity.

(3) The Coefficient of Variability

The Coefficient of variation (variability) in area, production and productivity of sorghum was estimated by using following formula

C.V. (%) = (S.D./Mean) x100

Whereas

C.V. = Coefficient of variation in area, production and productivity

S. D. = Standard deviation in area, production and productivity

Mean = Average in area, production and productivity

(4) The Linear Growth Rate :

The linear growth rate in area, production and productivity of sorghum was estimated for period from 1999-2000 to 2018-19 by using following formula

$$\text{LGR } (\%) = \frac{b}{y} \quad 100$$

Whereas

LGR = Linear Growth Rate

b = Regression coefficient

$\bar{y}$ = Average of area, production, productivity

Results and Discussion

The relative change, variability and growth rate in area, production and productivity of sorghum were discussed for the state of Madhya Pradesh.

Relative change : The relative change in terms of area, production and productivity of sorghum in different districts of Madhya Pradesh is presented in table revealed that the relative change of sorghum was observed in selected districts of Madhya Pradesh.

The highest negative relative change in area of sorghum was 95.62 percent in Guna district followed by Shajapur (-90.55%), Khargone (-87.04%), Dewas (-86.26%), Chhindwara (-81.63%), Betul (-81.14%), Chhatarpur (-70.02%), Khandwa (-63.85%), Dhar (-43.92%), Jhabua (-36.31%), Barwani (-24.85%) and Sidhi (-14.51%). The negative relative change in area of sorghum has been decreased from 1999-2000 to 2018-19. The relative change in production of sorghum was found positive in Barwani (150.60%), Rewa (129.80%), Jhabua (120.45%), Dhar (108.25%), and Sidhi (116.36%). The highest relative change in productivity of sorghum in Barwani (357.93%), Dhar (320.23%), Jhabua (271.73%), Khargone (180.30%), Betul (139.59%), Chhindwara (137.04%), Sidhi (122.30%), Dewas (114.47%), Chhatarpur (137.04%), Rewa (92.63%), Guna (82.86%) and Shajapur (6.15%). Only Khandwa district showed negative relative change in productivity of sorghum during in this period. The relative change in area, production and productivity of sorghum in state of Madhya Pradesh were negative during entire period of study.

Variability : The variability in area, production and productivity of sorghum were presented in table-2 revealed that the highest variability in area was observed in Guna (94.16%) followed by Dewas (70.93%),Shajapur (66.31%), Jhabua (59.13%),Barwani (51.59%),Khargone (51.64%), Khandwa (50.40%), Betul (49.90%), Chhindwara (49.19%), Chhatarpur (47.72%), Dhar (31.91%), Rewa (29.39%) and Sidhi (24.73%).

The variability in case of production of sorghum was observed highest in Guna (99.22%), Jhabua (89.21%), Rewa (77.23%), Shajapur (75.84%), Dewas (72.99%), Khargone (57.82%), Sidhi (56.40%), Barwani (55.56%), Chhatarpur (47.54%), Betul (47.23%), Dhar (42.24%), Chhindwara (39.64%) and Khandwa (39.64%), whereas variability in productivity was found highest in Khandwa (99.84%), Khargone (62.27%), Barwani (58.38%), Jhabua (52.63%), Dhar (47.75%), Rewa (42.08%), Chhatarpur (41.36%), Shajapur (40.47%), Sidhi (40.32%), Guna (36.60%), Dewas (35.61%), Betul (35.09%) and Chhindwara (30.93%). The variability in area, production and productivity of sorghum in Madhya Pradesh were 43.26, 27.29 and 35.71 percent, respectively during entire period of study.

Growth Rate : The growth rate in area, production and productivity of sorghum are presented in table 3 revealed that the growth rate in area of sorghum was negative and highly significant in Betul, Chhatarpur, Chhindwara, Dewas, Dhar, Guna, Khandwa, Khargone, Rewa, and whole state of Madhya Pradesh. The Barwani and Jhabua showed negative and significant growth rate in area of

Table-1 : Relative change in area, production and productivity of sorghum in Madhya Pradesh.

Districts	Absolute change			Relative change %		
	Area	Production	Productivity	Area	Production	Productivity
Barwani	-9.13	49.00	2339.66	-24.85	150.60	357.93
Betul	-40.30	-18.70	982.24	-81.14	-53.24	139.59
Chhatarpur	-11.02	-6.21	883.57	-70.02	-42.36	112.70
Chhindwara	-52.33	-27.57	1102.73	-81.63	-53.39	137.04
Dewas	-11.99	-12.76	1183.97	-86.26	-73.91	114.47
Dhar	-8.93	10.07	1301.19	-43.92	108.25	320.23
Guna (Guna and Ashok Nagar	-37.80	-29.40	661.46	-95.62	-93.24	82.86
Jhabua (Jhabua and Alirajpur)	-5.12	8.91	1324.23	-36.31	120.45	271.73
Khandwa (Khandawa and Burhanpur)	-23.62	-7.54	-1371.18	-63.85	-15.32	-32.73
Khargone	-71.40	-41.90	1494.09	-87.04	-61.70	180.30
Rewa	-0.10	16.61	726.53	-0.63	129.80	92.63
Shajapur (Shajapur and Agar)	-19.86	-23.26	72.95	-90.55	-87.77	6.15
Sidhi (Sidhi and Singaroli)	-2.33	14.35	938.85	-14.51	116.36	122.30
Selected districts	-293.94	-68.40	1371.58	-68.78	-18.58	157.85
Other districts	-116.06	-12.64	1342.88	-67.93	-9.59	174.79
Madhya Pradesh	-410.00	-81.04	1364.87	-68.54	-16.21	162.88

Table-2 : Variability in area, production and productivity of sorghum in Madhya Pradesh.

Districts	Coefficient of Variability %		
	Area	Production	Productivity
Barwani	51.59	55.56	58.38
Betul	49.90	47.23	35.09
Chhatarpur	47.72	47.54	41.26
Chhindwara	49.19	39.64	30.93
Dewas	70.93	72.99	35.61
Dhar	31.91	42.24	47.75
Guna (Guna and Ashok Nagar)	94.16	99.22	36.60
Jhabua (Jhabua and Alirajpur)	59.13	89.21	52.63
Khandwa (Khandawa and Burhanpur)	50.40	39.64	99.84
Khargone	51.64	57.82	62.27
Rewa	29.39	77.23	42.08
Shajapur (Shajapur and Agar)	66.31	75.84	40.47
Sidhi(Sidhi and Singaroli)	24.73	56.40	40.32
Selected districts	40.23	20.65	36.38
Other districts	55.33	53.59	49.34
Madhya Pradesh	43.26	27.29	35.71

sorghum. The growth rate in production of sorghum was noticed positive and significant in Barwani (4. 73%), and Sidhi (4.79%) while, remaining districts showed negative growth rate in case of production of sorghum during entire period under study.

The positive and highly significant growth rate in productivity of sorghum was found highest in Barwani (8.93%) followed by Jhabua (7.49%), Dhar (7.30%), Khargone (6.02%), Sidhi (5.35%), Chhindwara (4.34%), Betul (4.22%), Chhatarpur (3.94%), whereas Dewas, Khandwa and Shajapur were found positive but non-significant growth rate in case of productivity of sorghum. The Guna and Rewa districts showed positive and significant growth rate in case of productivity with rate of 2.97 and 3.49 percent per annum, respectively. The growth rate in area and production of sorghum in Madhya Pradesh were noticed negative, whereas positive and highly significant growth rate in case of productivity in entire period of study.

Conclusions

The area of sorghum has decreased during the entire period of study; it means cropping pattern has been changed in the state of Madhya Pradesh. According to the findings of this study, it is concluded that the relative change in area of sorghum was observed negative in all districts, whereas Badwani, Dhar, Jhabua, Rewa and Sidhi showed positive relative change in case of production beside relative change in productivity was positive in all districts of Madhya Pradesh except Khandwa. The productivity is being increased due to improved varieties, adoption of new technology and recommended package of practices etc. The highest variability in area and production was 94.16 and 99.22 percent respectively in Guna. The lowest variability in

Table-3 : Growth rate in area, production and productivity of sorghum in Madhya Pradesh.

Districts	Linear Growth Rate %		
	Area	Production	Productivity
Barwani	-3.38*	4.73*	8.93**
Betul	-7.64**	-4.74**	4.22**
Chhatarpur	-5.69**	-3.57*	3.97**
Chhindwara	-8.25**	-4.77**	4.34**
Dewas	-10.62**	-9.95**	2.60
Dhar	-4.36**	2.89	7.30**
Guna (Guna and Ashok Nagar)	-14.98**	-14.16**	2.97*
Jhabua (Jhabua and Alirajpur)	-1.05*	5.74*	7.49**
Khandwa (Khandawa and Burhanpur)	-5.49**	-0.30	0.51
Khargone	-8.50**	-2.34	6.02**
Rewa	-0.39**	4.19	3.49*
Shajapur (Shajapur and Agar)	-9.69	-8.84**	0.33
Sidhi (Sidhi+ Singaroli)	-0.12	4.79*	5.35**
Selected districts	-6.44**	-1.54*	5.70**
Other districts	-7.70**	-3.52	5.44**
Madhya Pradesh	-6.81**	-2.10	5.64**

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

area was noticed in Sidhi (24.73%), while lowest variability in case of production was observed in Khandwa (39.64%). The variability of productivity was highest in Khandwa (99.84%) and lowest in Chhindwara during entire period of study. The negative growth rate in area was noticed in all districts throughout the entire period. The positive and highly significant growth rate in production was observed only in Barwani and Sidhi, while the positive and highly significant growth rate in productivity was noticed in Barwani, Betul, Chhatarpur, Chhindwara, Dhar, Jhabua, Khargone and Sidhi in entire period of study. The productivity of this crop has been enhanced due to new technology and high yielding varieties adopted by farmers.

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Soil Seed Bank Dynamics of Blood Grass (*Isachnemiliacea* Roth ex Roemet Schult) and Associated Weed Flora on Tillage, Water regimes and Herbicides in Wet Land Rice Ecocystem

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Abstract

Changes in the weed seed bank due to crop production practices are an important determinant of subsequent weed problems. Considering the vital functions of the soil seed bank, the influence of tillage, water regimes and weed management practices on the weed seed bank in the wetland soil was studied during *Kharif* and *Rabi* seasons at the State seed farm, Kottarakkara, Kerala in a wetland field heavily infested with blood grass (*Isachnemilacea* Roth ex Roem et Schult). The experiment was laid out in a split plot design with combinations of tillage and water regimes as main plot treatments and weed management practices as subplot treatments. The species composition of the soil seed bank in the selected wetland field prior to the experiment revealed that there were 13 weed species which belonged to 12 genera and 10 families. During the first crop season the seed bankof weed spectrum included 16 species while the second season there were 16 weed species present in the soil bank and blood grass dominance continued with a slightly lower Rd value (82 per cent). The soil seed bank was found significantly influenced by the tillage intensity, higher water regimes and weed management treatments. The total density of blood grass recorded initially from the soil seed bank was 672 m^{-2}.After the first and second crop seasons, the density was found to be considerably less than that of the initial status. The density declined steadily from the first crop to the second crop under all treatments including the weedy check. The total density of the associated weeds in the soil seed bank after both first and second crop seasons was considerably less than that of the initial status under all the treated plots while under the weedy check it was more than the initial.

Key words : *Soil seed bank,Tillage, water regime, weed management, blood grass.*

Introduction

Blood grass*(Isahcnemiliacea)*, locally known as v*alari/ changalipullu/naringa,* is a very troublesome wetland weed belonging to poaceae family which has infested vast tracts of rice fields in Kerala state. The relative density of blood grass was > 65 per cent in many of the wetland fields in Kerala [1]. The highly competitive nature of the weed potentially reduce rice yield when significant populations of the weed exist and can cause up to 61 per cent reduction in rice production. The weed is resistant to the prevalent farmers' practice of tillage and hand pulling and it's mat forming roots interfere with the movement of simple implements like rotary weeder restricting their efficient use. Though herbicides areconsidered as the most practical, effective and economical means of weed management in rice, most of the conventional herbicides fail to manage grass.

Soil seed bank includes weed seeds recently shed as well as older seeds that have persisted in the soil for several years. It is the sum of viable weed seeds and vegetative propagules that are present in the soil and thus contribute to weed pressure in future crops [2]. The ability to produce a large number of seeds is one of the main features developed by weeds that occur in rice fields to escape the stress imposed by the control methods and ensure the species survival. Differences in the number of seeds or weed seedling density in the seedbank can be explained by several factors including climate, relief position, soil moisture content, depth of sampling, history of the areas and management practices followed by rice farmers [3].The weed seed bank is the major source of weeds, especially annual weed species in most tilled agricultural sites. The seed bank was as important as the aboveground vegetation when assessing weed abundance. If potential weed populations could be predicted before crops are sown, it might be possible to reduce the impact of weeds by altering crop selection or changing sowing times to avoid major weed problems [4].

Unlike the aboveground weed seedling composition, weed seed bank composition in rice field soils was not greatly affected by water regime treatments [5].Differences in water regime treatments did not show significant variation in the viability of weed seeds in the soils, since there were a large number of seedlings compared to dead seeds in the soil in both planting seasons. Studies from the tropical regions on possible effects of tillage and water control on weed emergence and growth in the presence and absence of herbicides have yielded conflicting results due to site specificity.

Interactions among water, tillage and weed management practices are complex, and are furthercomplicated by soil and climatic variability and heterogeneities. The present study was therefore undertaken to investigate the effect of tillage, water regimes and some safer herbicide molecules onsoil seed bank dynamics of blood grass infestation and associated weed flora.

Materials and Methods

The field experiments were conducted during *Kharif* and *Rabi* seasons at the State seed farm, Kottarakkara, Kollam district, Kerala in a wetland field heavily infested with blood grass. An initial observation on the infestation intensity of the weed in the selected site indicated that the relative density was about 83 per cent. The soil was sandy clay loam in texture with acidic pH (4.52), high organic carbon (1.69%), available N (303.34 kg ha $^{-1}$), available P (13.52 kg ha $^{-1}$) and available K (153.42 kg ha $^{-1}$). The experiment was laid out in a split plot design with three replications and the crop variety used was *Sreyas* released from Rice Research station Moncombu, Kerala. Combinations of tillage (P) and water regimes (W) were the main plot treatments and weed management practices (M) were the subplot treatments. The tillage practices included were : P_1-intensive tillage (three ploughings *fb* puddling) and P_2 - farmers' practice (two ploughings *fb* puddling). The water regimes tried were W_1-continuous deep water ponding *i.e.*, > 7.5cm from 7 days after transplanting (DAT) till grain filling stage, W_2- >7.5cm water from 7 DAT till panicle initiation stage and W_3- maintaining about 5cm water level with intermittent drainage. The weed management practices in the subplots were M_1 - oxyflourfen @ 0.15 kg ha^{-1} *fb* one hand weeding(HW) at 20 DAT, M_2 - azimsulfuron @ 35 g ha^{-1}, M_3-(bispyribac sodium + metamifop) 70 g ha^{-1}, M_4- Fenoxaprop- *p*-ethyl @60 g ha^{-1}, M_5- HW twiceat 20 and 40 DAT and M_6 -unweeded control. The *Kharif* and the *Rabi* crop was taken immediately without disturbing the field layout. Application of manures and fertilizers as well as all the other management practices were done as per the Package of practices recommendations. Among the herbicides, oxyflorfen(M_1) was applied as preplant, three days before transplanting and the others (M_2 to M_4) were given as post emergence spray at 15 DAT. The effect of management practices on weed seed dynamics was studied by analyzing the weed seed bank in the soil before and after each crop season using the seedling emergence method [6]. Prior to the experiment, observations were made from composite soil samples collected from the field while soil samples from individual treatment plots were used after the field experiment. Soil samples were collected from a depth of 0-15 cm. One kg soil was weighed out, transferred and evenly spread in plastic trays kept under direct sunlight to simulate actual field conditions and the soil was maintained at adequate moisture level. The emerging weed seedlings were counted at fortnightly intervals up to 70 days and classified into blood grass and associated weeds.

Results and Discussion

Species Composition of the Soil Seed bank : The data on the species composition of the soil seed bank in the selected wetland field prior to the revealed that there were 13 weed species which belonged to 12 genera and 10 families (Table 1). Of these two were grasses, three sedges and eight broad leaved weeds. The total seed bank density was worked out as 672 m^{-2} out of which 84 per cent were blood grass seedlings. During the first crop season the seed bank weed spectrum included 16 species. The predominance of blood grass in the soil seed bank continued during the first crop also and the Relative density (Rd) value recorded was 87 per cent which was even higher than that observed prior to the experiment which indicated that the seed reserve was not depleted during the crop season. During the second season also there were 16 weed species present in the soil bank and blood grass dominance continued with a slightly lower Rd value(82 per cent). The results were indicative of the very rich soil seed bank of blood grass in the selected experiment site. The dominance of blood grass in the locality is in line with the reports [1]. The species dominance in weed seed bank in rice fields might be related not only to cultural practices and crop history but also to the reproductive capacity of the weed species. In the present study the soil seed bank was naturally enriched by the continued presence of blood grass which was found capable of producing 614 seeds plant^{-1} in addition to the rooted stem bits. It was also clear that in spite of the predominance of blood grass there was considerable species diversity in the soil seed bank which would probably take over if blood grass seeds were alone depleted through effective management practices.

Effect of Tillage (P), Water Regimes (W) and Weed Management (M) on dynamics of soil seed bank of Blood grass : Initially the total density of blood grass recorded from the soil seed bank was 672 m^{-2}.After the first and second crop seasons, the density was found to be considerably less than that of the initial status. It was also observed that the density declined steadily from the first crop to the second crop under all treatments including the weedy check (Table-2 and 3).

The soil seed bank was found significantly influenced by the tillage intensity, higher water regimes and weed management treatments. The effect of weed

Table-1 : Botanical composition and relative density of the soil weed seed bank.

Sl. No.	Scientific name	Common name	Family	Prior to experiment		After the first crop		After second crop	
				Present /absent	Relative Density	Present /absent	Relative Density	Present /absent	Relative Density
	Grasses								
1.	*Dactylocteniumaegyptium* (l.) Willd. Ex Asch &Schweinf	Crow foot grass	Poaceae	X		X		✓	1.20
2.	*IsachaemumrugosumSalisb.*	Wrinkle grass	Poaceae	x		X		✓	0.80
3.	*Isachnemiliacea* Roth ex Roem et Schult.	Blood grass	Poaceae	✓	84.00	✓	87.00	✓	82.00
4.	*Panicumrepens* L.	Ginger grass	Poaceae	✓	2.00	✓	0.50	✓	0.80
	Total grass sp.			2		2		4	
	Sedges								
1.	*Cyperusdifformis* L.	Umbrella sedge	Cyperaceae	✓	1.00	✓	1.00	✓	1.70
2.	*Cyperusiria* L.	Rice flat sedge	Cyperaceae	✓	1.00	✓	1.30	✓	1.40
3.	*Fimbristylismiliacea* (L.) Vahl.	Globe finger rush	Cyperaceae	✓	3.00	✓	1.40	✓	2.30
	Total sedges sp.			3		3		3	
	Broad leaved weeds/Ferns								
1.	*Bergiacarpensis* L.	Bergia	Elatinaceae	✓	0.25	✓	0.10	✓	1.40
2.	*Charagymnoptiys* Braun	Stonewort	Characeae	X		✓	1.40	x	
3.	*Cryptocorynespiralis*	Spiral water trumpet	Araceae	✓	1.00	✓	1.00	x	
4.	*Cyanotisaxillaris* (L.) D. Don	Spreading day flower	Commelinaceae	x	0.25	✓	0.40	✓	0.60
5.	Eclipta alba	False daisy	Asteraceae	✓	0.25	✓	0.10	✓	2.40
6.	*Hygrophilaauriculata* (Schum.) Heine	Vayalchulli	Acanthaceae	X		X			1.80
7.	*Ipomoea aquatica* Forsk.	Water spinach	Convolulaceae	x		✓	0.80	✓	0.60
8.	*Linderniacrustacea* F. Muell.	Malasian false pimpernel	Linderniaceae	✓	0.25	✓	0.20	✓	0.30
9.	*Ludwigiaperennis* L.	Water prime rose	Onagraceae	✓	2.00	✓	1.50	✓	1.60
10.	Marsileaquadrifolia *L.*	Water clover	Marsileaceae	✓	2.00	✓	0.40	x	
11.	*Monochoriavaginalis* (Burm, f.) C. Presl ex Kunth	Pickerel weed	Pontederiaceae	✓	3.00	✓	1.10	✓	0.80
12.	*Nymphaeanouchali* Burm. f	Yellow water lilly	Nymphaeaceae	x		✓	1.80	✓	0.30
	Total Broad leaved weed sp.			8		11		9	
	Total number of species			13		16		16	

Present : v Absent : x

management practices on soil seed bank was also significant and after both seasons azimsulfuron treated plots recorded significantly lower density than all other treatments. When compared to the weedy check the soil seed bank was much lower in all the treated plots. However the results showed that the interaction effect of tillage (P) x water regime (W) x weed management (M) on the soil seed bank of blood grass was statistically non significant after both seasons.

When compared to the farmers' practice of tillage, the blood grass seedlings that emerged out from the soil samples were significantly lower under intensive tillage, after both crop seasons. The intensive tillage operations brought out the weed seeds from sub-surface to favorable moist upper soil layer for good germination which in turn was helpful in depleting the soil seed bank reserve. In the present trial also, it is likely that the weed seeds which were brought to surface layers during the initial ploughings must have been destroyed during the third round of ploughing given under the modified cultural practice (P_1), thus depleting the seed bank that existed in the soil prior to the experiment. The role of intensive tillage operations for reducing the weed population which brought out the weed seeds from sub-surface to favorable moist upper soil layer for good germination [7].

Just as in the case of above ground weed population, the soil seed bank density was also greatly influenced by the differences in water regime treatments. After both cropping seasons, the seed density under maintenance of the higher water regime upto crop maturity, was significantly lower than that under the other two water regimes. Flooding conditions reduced the number of viable seeds in the soils especially grasses and sedges and suppressed germination of certain weed species in the seed bank [8].

A critical analysis of the effect of the weed management practices on the blood grass soil seed bank

Table-2: Effect of tillage (P), water regimes (W) and weed management (M) on density of blood grass in the soil seed bank, no. kg^{-1}.

Treatments	Blood grass		Associated weeds flora	
	After the first crop#	After the second crop#	After the first crop#	After the second crop#
Tillage (P)				
Intensive tillage (P_1)	17.95 (326.50)	13.49 (189.19)	4.86 (24.07)	5.12 (26.78)
Farmers practice (P_2)	18.97 (363.54)	14.17 (207.35)	5.22 (27.67)	5.50 (30.65)
SEm(+/-)	0.06	0.05	0.02	0.03
CD (0.05)	0.17	0.16	0.07	0.11
Water regimes (W)				
>7.5 cm till grain filling stage (W_1)	17.71 (317.00)	13.15 (180.19)	4.69 (22.50)	4.97 (25.19)
>7.5 cm till PI stage (W_2)	18.36 (339.89)	13.49 (188.56)	4.90 (24.47)	5.17 (27.14)
POP recommendation (W_3)	19.32 (378.17)	14.85 (226.06)	5.52 (30.64)	5.79 (33.81)
SEm(+/-)	0.07	0.06	0.03	0.04
CD (0.05)	0.21	0.20	0.09	0.14
Weed management (M)				
Oxyflourfen @ 0.15 kg ha^{-1} fbHW (M_1)	17.16 (294.06)	12.08 (146.22)	4.23 (17.17)	4.46 (19.06)
Azimsulfuron @ 35 g ha^{-1} (M_2)	16.85 (283.72)	11.69 (137.11)	4.02 (15.44)	4.29 (17.61)
Bispyribac Na + metamifop@ 70 g ha^{-1} (M_3)	17.41 (303.00)	12.47 (155.78)	4.38 (18.44)	4.63 (20.61)
Fenoxaprop-p-ethyl @60 g ha^{-1} (M_4)	17.61 (309.83)	1273 (162.44)	4.58 (20.28)	488 (23.06)
HW at 20 and 40 DAT (M_5)	18.89 (356.39)	14.74 (216.56)	5.82 (33.00)	6.11 (36.50)
Unweeded control (M_6)	22.86 (523.11)	19.29 (371.50)	7.20 (50.89)	7.50 (55.44)
SEm(+/-)	0.08	0.08	0.03	0.04
CD (0.05)	0.23	0.24	0.08	0.10

\# Figures in original scale are given in parenthesis.Data subjected to $\sqrt{x \quad 1}$ transformation.
Total density of blood grass and associated weeds flora in the soil seed bank prior to the experiment is 672 and 46 respectively.

revealed that under application of azimsulfuron @ 35 g ha^{-1} the weed seed density was significantly lower than that under all the other treatments. Another important observation was that between hand weeded *vs*herbicide treated plots, the weed seed density values were generally much lower in the later. Such reduction in seed bank density was as expected since the herbicides destroyed the weed plants in the early crop season before they get a chance to flower and set seeds which prevented soil seed bank enrichment while under hand weeding it was likely that those weed plants which escaped as well as the fragmented stem bits matured and set seeds, adding to the seed density. It was also observed that the seed density was very high under the untreated weedy check, which was possible since the uninterrupted blood grass plants were able to have continuous seed rain throughout the year thus enriching the seed bank.

Between seasons, the weed seed bank was found to have declined from first crop to second crop in all the treatments. This can be attributed to the effects of the management practices followed during the first crop season as well as the possible seasonal effect. However the interaction effect of tillage-water regime-weed management practices on the seed bank density was statistically non significant after both crop seasons.

Effect of Tillage (P), Water Regimes (W) and Weed Management (M) on dynamics of soil seed bank of Associated weed flora : The results showed that the total density of the associated weeds in the soil seed bank after both first and second crop seasons was considerably less than that of the initial status under all the treated plots while under the weedy check it was more than the initial. It was also observed that the seed bank density after the second crop in general was more than that of the first crop under all treatments including the weedy check. The soil seed bank of the associated weeds was found significantly influenced by the tillage intensity. When compared to the farmers' practice of tillage (P_2), the density was significantly lower under intensive tillage (P_1) after both seasons.The water regimes also recorded significant influence on the soil seed bank. After both seasons the total number of seedlings emerged under W_1 was significantly lower than that under the other two water regimes. Between W_2 and W_3, the seed bank density was higher under W_3. The effect of the weed management practices on density of the soil seed bank of associated weeds was also significant and after both seasons azimsulfuron treated plots recorded significantly lower density than that under all the other treatments. When compared to the weedy check the soil seed bank was much lower in the treated plots.In general, the effect of the

Table-3 : Interaction effect of tillage, water regimes and weed management (P x W x M) on density of blood grass and associated weeds flora in the soil seed bank, no. kg^{-1}.

Treatment	Blood grass				Associated weeds flora			
	After the first crop#		After the second crop#		After the first crop#		After the second crop#	
	p_1	p_2	p_1	p_2	p_1	p_2	p_1	p_2
w_1m_1	15.81 (249.00)	17.18 (294.33)	10.87 (117.67)	11.72 (136.67)	3.65 (12.33)	4.03 (15.33)	3.95 (14.67)	4.24 (17.00)
w_1m_2	15.35 (234.67)	16.88 (284.00)	10.31 (106.00)	11.33 (127.67)	3.41 (10.67)	3.87 (14.00)	3.70 (12.67)	4.16 (16.33)
w_1m_3	15.95 (253.67)	17.47 (304.33)	11.15 (123.67)	12.10 (145.67)	3.78 (13.33)	4.19 (16.67)	4.12 (16.00)	4.43 (18.67)
w_1m_4	16.13 (259.33)	17.61 (309.00)	11.40 (129.33)	12.36 (152.00)	3.99 (15.000	4.35 (18.00)	4.31 (17.67)	4.69 (21.00)
w_1m_5	17.90 (319.67)	18.60 (345.000	14.40 (206.67)	14.66 (214.33)	5.45 (28.67)	5.74 (32.00)	5.68 (31.33)	594 (34.33)
w_1m_6	21.34 (454.33)	22.31 (496.67)	18.53 (342.33)	19.01 (360.33)	6.71 (44.000	7.14 (50.000	7.07 (49.00)	7.39 (53.67)
w_2m_1	16.63 (275.67)	17.79 (315.67)	11.21 (125.33)	12.16 (147.00)	3.87 (14.00)	4.27 (17.33)	4.16 (16.33)	4.43 (18.67)
w_2m_2	16.49 (271.33)	17.37 (300.67)	10.77 (115.67)	11.76 (137.67)	3.65 (12.33)	4.07 (15.67)	3.87 (14.00)	4.39 (18.33)
w_2m_3	16.92 (285.67)	17.97 (322.00)	11.58 (133.67)	12.59 (157.67)	4.04 (15.33)	4.43 (18.67)	4.28 (17.33)	4.65 (20.67)
w_2m_4	17.03 (289.33)	18.20 (330.33)	11.81 (139.00)	12.80 (163.00)	4.20 (16.67)	4.61 (20.33)	4.51 (19.33)	4.90 (23.00)
w_2m_5	18.24 (331.67)	18.88 (355.33)	14.47 (208.67)	14.72 (216.00)	5.56 (30.00)	5.86 (33.33)	5.91 (34.00)	6.13 (36.67)
w_2m_6	2191 (479.00)	22.87 (522.00)	18.77 (351.33)	19.20 (367.67)	6.97 (47.67)	7.30 (52.33)	7.26 (51.67)	7.53 (55.67)
w_3m_1	17.38 (301.67)	18.14 (328.00)	13.06 (170.00)	13.46 (180.67)	4.61 (20033)	4.96 (23.67)	4.73 (21.33)	5.22 (26.33)
w_3m_2	17.17 (294.00)	17.85 (317.67)	12.79 (163.00)	13.16 (172.67)	4.39 (18.33)	4.76 (21.67)	4.54 (19.67)	5.06 (24.67)
w_3m_3	17.65 (311.00)	18.50 (341.33)	13.48 (181.33)	13.90 (192.67)	4.72 (21.33)	5.13 (25.33)	4.87 (22.67)	5.41 (28.33)
w_3m_4	17.86 (318.33)	18.80 (352.67)	13.70 (187.33)	14.29 (204.00)	4.96 (23.67)	5.38 (28.00)	5.16 (25.67)	5.70 (31.67)
w_3m_5	19.24 (369.33)	20.45 (417.33)	14.90 (221.33)	15.27 (232.33)	6.02 (35.33)	6.29 (38.67)	6.35 (39.33)	6.66 (43.33)
w_3m_6	24.09 (579.33)	24.66 (607.33)	19.60 (383.00)	20.62 (424.33)	7.44 (54.33)	7.62 (57.00)	7.77 (59.33)	8.02 (63.33)
SEm (+/-)	0.20		0.20		0.07		0.09	
CD (0.05)	NS		NS		NS		NS	

#Figures in original scale are given in parenthesis.Data subjected to $\sqrt{x \quad 1}$ transformation.

management practices on the density of the soil seed bank of the associated weeds was found similar to that on blood grass. However, in this case, seed density in the weedy check showed an increase over the initial status as well as from the first crop season to second crop season which was contradictory to the effect on blood grass. Under the uninterrupted conditions in the unweeded plots, the associated weeds which were mostly sedges and broad leaved weeds had the opportunity to flourish and were able to mature and set seeds, towards the later crop growth stages thus enriching the soil seed bank from season to season. The ability to produce a very high number of seeds is one of the main features developed by weeds that occur in rice fields to escape the stress imposed by the control methods and ensure the species survival [3]. The significance of the results of the presentstudy is that such information can help the farmers to predict future weed infestation in the field and plan for weed management.

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Bioefficacy of Some Insecticides against Cotton Aphid, Aphis Gossypii Glover

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Abstract

Bioefficacy of Imidacloprid 17.8 SL ((0.007%), Dimethoate 30 EC (0.06%), Emamectin Benzoate 5 SG (0.02%), Chloropyriphos 16 + Alpha-cypermethrin 1 EC (0.02%) & Fipronil 4 + Acetamiprid 4 SC (0.02%) was tested against cotton aphids by leaf dip bioassay method. Rearing of aphids was done according to IRAC method number 09. Fipronil + Acetamiprid was the most toxic insecticide with lowest LC_{50} values 0.001%, 0.0005% and 0.0001% at 12, 24 and 48 hours after exposure (HAE) respectively followed by Imidacloprid with LC50 values being 0.001%, 0.0006% and 0.0003% at 12, 24 and 48 HAE respectively. Fipronil 4 + Acetamiprid 4SC was found to be 12.34, 12.39 & 43.5 times more toxic as compared to emamectin benzoate at 12, 24 and 48 hours after exposure. The relative toxicity of tested insecticides were in the order as Fipronil 4 + Acetamiprid 4 SC> imidacloprid 17.8 SL> Dimethoate 30 EC> Chlorpyriphos 16 + alpha cypermethrin 1 EC and taking emamectin benzoate 5 SG as one at 12, 24 and 48 hour after exposure.All the insecticides were effective in controlling the pest. Combination insecticide Fipronil+ acetamiprid and imidacloprid were most promising insecticides by leaf dip bioassay technique showing systemic action. Emamectin benzoate was the least toxic insecticide and is considered as a safe insecticide. These insecticides are well utilized in pest control programmes.

Key words : *Insecticides, LC_{50}, mortality, leaf dip bioassay, relative toxicity.*

Introduction

The aphid, *Aphis gossypii* Glover is one of the most widespread species of aphids and displays a large range of host-plants covering different families. It is extremely polyphagous infesting over 900 plant species in the world (Blackman and Eastop, 2000., Fuchsberg *et al*., 2007). The aphid has become a serious pest of field and glasshouse crops especially cotton, okra, gourd, melon, chilli, brinjal and several ornamental plants such as chrysanthemums, roses, etc. Many pest management programs are utilized for the control of this notorious insect. Neonicotinoids being systemic in nature, possess lower mammalian toxicity, less resurgence problems, environmental protection, pest management selectivity and less toxicity to natural enemies(Kunkel *et al*., 1999) and give effective control of this pest (Sympathy & Rai, 2006).Keeping this view, a study was conducted to test the bioefficacy of various insecticides against cotton aphid, *A. gossypii.*

Materials and Methods

All the experiments were conducted in Plant Protection Laboratory, Department of Entomology at VCSGUUHF. The experiments were carried out in two phases, preliminary screening (Imidacloprid 17.8 SL @ 0.007%, Dimethoate 30 EC @ 0.06%, Emamectin benzoate 5 SG @ 0.02%, Chloropyriphos 16 + Alpha-cypermethrin 1 EC @ 0.02%) & Fipronil 4 + Acetamiprid 4 SC @ 0.02% and final testing (Imidacloprid 17.8SL @ 0.001, 0.002, 0.004, 0.005, 0.007%, Dimethoate 30EC@ 0.02, 0.03, 0.05, 0.06, 0.07%, Emamectin Benzoate 5 SG @ 0.008, 0.01, 0.02, 0.03, 0.04%, Chloropyriphos 16 + Alpha-cypermethrin 1 EC @ 0.005, 0.01, 0.015, 0.02, 0.025% and Fipronil 4 + Acetamiprid 4 SC@ 0.001, 0.005, 0.01, 0.015, 0.02% alternatively, to study the lethal concentration of insecticides**.** Rearing of aphid was done according to IRAC method number 09. Leaf dip method was followed according to Kodandaram and Dhingra (2007). The full grown matured host plant leaves i.e. Hibiscus were plucked from surrounding area of college campus and brought to the laboratory. After proper washing, they were dipped in the required concentration of different insecticides for one minute. Excess liquid was shaken from the foliage. This was then allowed to dry at room temperature. Treated leaf was then transferred to clean petridish of diameter 9 cm. Later 10 apterous neonate aphids of same size were carefully released on the treated leaf by using a soft camel hair brush of zero size. Each treatment including control was replicated thrice. For control, the hibiscus leaves were dipped in water, dried and used. The petridishes were kept in incubator at 20±5°C. The data on mortality was recorded after 12, 24 and 48 hour after exposure (HAE). Moribund aphids were counted as dead. Mortality data was corrected using Abbott's formula (Abbott, 1925).The data so obtained was subjected to probit analysis (Finney (1971) using OPSTAT. Relative toxicity (RT)

Table-1 : Dosage-mortality response of selected insecticides against *Aphis gossypii* by Leaf Dip Bioassay at 12 hours after exposure.

Insecticides	LC50 in ppm (%)	*RT at LC50	Chi-square	Regression equation	Fiducial limit at LC50	
					Lower	Upper
Imidacloprid 17.8 SL	12.268 (0.00122)	11.70	0.620	0.312x + 4.6	6.602 (0.00066)	22.796 (0.00227)
Dimethoate 30 EC	41.207 (0.00412)	3.50	0.987	0.109x + 5.401	13.248 (0.00132)	128.168 (0.01281)
Emamectin benzoate 5 SG	144.34 (0.01443)	1.00	0.985	0.167x + 4.581	61.141 (0.00611)	340.754 (0.03407)
Chlorpyriphos 16 + Alpha cypermethrin 1 EC	65.255 (0.00652)	2.21	0.867	0.255x + 4.643	36.875 (0.00368)	115.476 (0.01154)
Fipronil 4 + Acetamiprid 4 SC	11.676 (0.00116)	12.34	0.316	0.35x + 4.67	4.613 (0.00046)	29.550 (0.00295)

* RT = Relative toxicity = LC values of the least toxic insecticide/ LC value of the candidate insecticide.

Table-2 : Dosage-mortality response of selected insecticides against *Aphis gossypii* by Leaf Dip Bioassay at 24 hours after exposure.

Insecticides	LC50 values in ppm (%)	*RT at LC50	Chi-square	Regression equation	Fiducial limit at LC50	
					Lower	Upper
Imidacloprid 17.8 SL	6.412 (0.00064)	11.30	0.70	0.28x + 4.962	3.077 (0.00030)	13.358 (0.00133)
Dimethoate 30 EC	35.655 (0.00356)	2.04	0.98	0.121x + 5.481	12.140 (0.00121)	104.718 (0.01047)
Emamectin benzoate 5 SG	72.780 (0.00727)	1.00	0.99	0.158x + 4.85	29.017 (0.00290)	182.548 (0.01825)
Chlorpyriphos 16 + Alpha cypermethrin 1 EC	48.707 (0.00487)	1.49	0.92	0.255x + 4.827	27.124 (0.00271)	87.464 (0.00874)
Fipronil 4 + Acetamiprid 4 SC	5.874 (0.00058)	12.39	0.35	0.372x + 4.862	2.11 (0.00021)	16.347 (0.00163)

* RT = Relative toxicity = LC values of the least toxic insecticide/ LC value of the candidate insecticide.

Table-3 : Dosage-mortality response of selected insecticides against *Aphis gossypii* by Leaf Dip Bioassay at 48 hours after exposure.

Insecticides	LC50 values in ppm (%)	*RT at LC50	Chi-square	Regression equation	Fiducial limit at LC50	
					Lower	Upper
Imidacloprid 17.8 SL	3.626 (0.00036)	13.86	0.520	0.56x + 4.714	1.648 (0.00016)	7.978 (0.00079)
Dimethoate 30 EC	33.223 (0.00332)	1.50	0.959	0.161x + 5.647	13.170 (0.00131)	83.810 (0.00838)
Emamectin benzoate 5 SG	49.921 (0.00499)	1.00	0.957	0.156x + 4.984	19.238 (0.00192)	129.541 (0.01295)
Chlorpyriphos 16 + Alpha cypermethrin 1 EC	43.302 (0.00433)	1.15	0.888	0.277x + 4.875	24.565 (0.00245)	76.330 (0.00763)
Fipronil 4 + Acetamiprid 4 SC	1.147 (0.00011)	43.5	0.620	0.527x + 4.887	0.268 (0.00002)	4.912 (0.00049)

*Relative toxicity = LC values of the least toxic insecticide/ LC value of the candidate insecticide.

of insecticide was calculated based on LC_{50} (Ramangouda and Srivastava, 2009).

$$RT = \frac{\text{LC value of least toxic insecticide}}{\text{LC value of candidate insecticide}}$$

Results and Discussion

The results of the study showed that Fipronil 4+ Acetamiprid 4 SC was the most toxic insecticide. The combination insecticide showed lowest LC_{50} values of 0.0011% at 12HAE,

Table-4 : LC_{50} value of selected insecticides against *Aphis gossypii* at different hours after exposure (HAE).

Insecticides	LC_{50} at different HAE* ppm (%)		
	12	24	48
Imidacloprid 17.8 SL	12.268 (0.00122)	6.412 (0.00064)	3.626 (0.00036)
Dimethoate 30 EC	41.207 (0.00412)	35.655 (0.00356)	33.223 (0.00332)
Emamectin benzoate 5 SG	144.340 (0.01443)	72.78 (0.00727)	49.921 (0.00499)
Chlorpyriphos 16 + Alpha cypermethrin 1 EC	65.255 (0.00652)	48.707 (0.00487)	43.302 (0.00433)
Fipronil 4 + Acetamiprid 4 SC	11.676 (0.00116)	5.874 (0.00058)	1.147 (0.00011)

*HAE= Hours After Exposure.

Table-5 : Duration-mortality response of selected insecticides against cotton aphid, *Aphis gossypii* by Leaf Dip Bioassay.

Insecticides	Concentrations ppm (%)	LT_{50} value in hours	Chi-square	Regression equation	Fiducial limit	
					Lower	Upper
Imidacloprid 17.8 SL	10 (0.001)	12.509	0.839	0.135x + 4.676	0.265	589.710
Dimethoate 30 EC	20 (0.002)	1.287	0.843	0.16x + 5.336	0.000	4041.756
Emamectin benzoate 5 SG	80 (0.008)	30.270	0.763	0.16x + 4.626	0.029	31379.500
	100 (0.01)	15.112	0.889	0.215x + 4.700	0.060	3797.470
Chlorpyriphos 16 + Alpha cypermethrin 1 EC	50 (0.005)	17.629	0.882	0.13x + 4.786	0.002	187056.442
Fipronil 4 + Acetamiprid 4 SC	10 (0.001)	10.463	0.882	0.32x + 4.736	0.240	457.078

0.0005%at 24HAE and 0.0001% at 48 HAE followed by Imidacloprid 17.8SL with LC50 values of 0.0012%, 0.0006% and 0.0003% at 12, 24 and 48 HAE respectively as indicated in Table no. 1, 2 & 3.Acetamiprid has been reported as most toxic insecticide against grubs of *Cheilomenes sexmaculata* by Pandi *et al.* (2013) and based on LC_{50} values, the descending order of toxicity of different insecticides was acetamiprid (50 ppm) > thiamethoxam (60 ppm) > imidacloprid (170 ppm). The LC_{50} values of Dimethoate 30 EC were as follows 0.0041%, 0.0035% and 0.0033% at 12, 24 and 48HAE respectively. Chlorpyriphos 16EC+Alpha cypermethrin 1EC showed LC50 values of 0.0065% at 12HAE, 0.0048% at 24 HAE and 0.00433% at 48HAE. Emamectin benzoate 5 SG was found to be least toxic insecticide with LC_{50} values 0.0144%, 0.0072% and 0.0049% at 12, 24, and 48 HAE respectively. Various researchers have reported the toxicities of acetamiprid as 63.23ppm followed by imidacloprid 133.87ppm, dimethoate 334.84ppm and methyl demeton 348.45ppm. (Powar *et al.,* 2015; Levchenko *et al.,* 2018).Acetamiprid was the effective insecticide followed by imidacloprid, profenophos, and trizophos with LC_{50} values of 12857, 3214, 35295 and 2133 ppm, respectively in a study conducted by Khan *et al.* (2012).The variation in the LC_{50} values of their study is due to methodology adopted, equipments used and test insects susceptibility.Acetamiprid is a promising insecticide against sucking insects (Iwasa *et al*., 2010; Carvalho *et al*., 2010). Neonicotinoids such as acetamiprid and imidacloprid showed excellent systemic properties, therefore these were very effective in leaf dip bioassay studies. Emamectin benzoate 5SG proved to be the least effective insecticide in our studies. It is widely used against lepidopteran pests and is a stomach poisonwith contact activity(Jansson and Dybas, 1998., Kumar and Devappa 2006., Shekeben *et al*., 2010). In the present study, Emamectin benzoate 5 SG showed higher LC_{50} values compared to all other insecticides, hence it can be considered as safe insecticide.With respect to RT values at LC_{50} Fipronil 4 + Acetamiprid 4 SC was found to be 12.34, 12.39 & 43.5 times more toxic as compared to Emamectin benzoate at 12, 24 and 48 hours after exposure. The relative toxicity of these insecticides were in the order as Fipronil 4 + Acetamiprid 4 SC> imidacloprid 17.8 SL> Dimethoate 30 EC> Chlorpyriphos 16 + alpha cypermethrin 1 EC. With respect to the LT50 values it was observed that at 0.001% concentration Fipronil 4 + Acetamiprid 4 SC was quicker in action causing 50% mortality within 10.46 hours while Imidacloprid 17.8 SL took 12.51 hours at same concentration. At 0.002% concentration the LT_{50} value of Dimethoate 30 EC was 1.287 hours. LT_{50} value of Emamectin benzoate 30 EC was 30.27 and 15.11 h at concentration 0.008 and 0.01%, respectively. Chlorpyriphos 16 EC + Alpha cypermethrin 1 EC took 17.629 hours to kill 50% population of *A. gossypii* at 0.005% concentration (Table 5).

The experiment results clearly confirm the effectiveness of neonicotinoids alone and in combination with other insecticides against sucking insect pests and due to their low mammalian toxicity they are widely utilized in pest management programmes.

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Assessment of Water Footprint of the Urban Households

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Abstract

The paper scrutinizes the water footprint of households on the basis of their water consumption pattern. Water footprint is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of a country. A sample of 120 households was selected from four areas of Bikaner city of Rajasthan. Average annual water footprint of homemakers's household was found 3639.67 kL per year (Sd= 1582.31). Majority of the homemakers (81.67 per cent) were average water consumer followed by low (14.16 per cent) and high (4.17 per cent). Average per capita water footprint was 778.23 kL per year (Sd = 506.54). Half of the households had high per capita water footprint. Rest of the households was in average (42.5 per cent) and low (7.5 per cent) category of per capita water footprint.

Key words : *Water footprint, consumption pattern.*

Introduction

The water footprint concept has become a popular tool to estimate water usage arising directly and indirectly from the activities of individuals and households. It has been introduced to create a consumption©\based indicator of water use (Hoekstra and Chapagain, 2007). This is important because households are ultimately the main consumers of water, food and other goods and services that increase consumption. The choices individuals make in their households-indoor and outdoor, travel, the food they eat, buy and throw away all influence household water footprint, which help to ensure a stable climate for future generations.

The concept of the water footprint is in contrast to the traditional production-sector-based indicators of water use, that are useful in water management but do not indicate the water that is actually needed by the inhabitants of a country in relation to their consumption pattern. The water footprint is defined as the volume of water needed for the production of the goods and services consumed by the inhabitants of a country. The water footprint can be divided into an internal and an external water footprint. The internal component covers the use of domestic water resources and the external component covers the use of water resources elsewhere (Kampman, 2007). Water footprint can be divided into blue, green and gray water footprint. The blue component covers the use of groundwater and surface water during the production of a commodity, the green component covers the use of rain water for crop growth (Falkenmark and Rockström, 1993), and the gray component covers the water required to dilute the water that is polluted during the production of the commodity (Chapagain *et al*., 2006).

Another water scarcity reducing strategy can be quantitatively described with the concept of virtual water. This concept defines the virtual water content of a commodity as the volume of water that is actually used to produce the commodity, measured at the place where the commodity is actually produced (Allan, 1994).

Direct and Indirect Water Footprint : The direct water footprint of consumers within the nation refers to consumption and pollution of water related to domestic water supply. The indirect water footprint of consumers refers to the water used to produce the food, products, energy consumed by the consumers and even the water saved when recycles. The indirect water footprint of a consumer is generally much larger than the direct one (Hoekstra and Mekonnen, 2011).

India's water footprint is below average at 980 cubic meters per capita, the massive population makes the country's overall footprint 12 per cent of the world's total. India has faced dire water shortages, but on the bright side the country has adopted more rainwater harvesting than in other regions. India's higher incidence of vegetarianism (approximately 30 per cent of the population) does play a role in keeping individual footprints lower - the water contained in our diets varies with a vegetarian diet using 2.60 cubic meters of water each day, while a U.S. style meat based diet uses over 5 cubic meter (Streeter, 2009).

Necessity to Reduce Water Footprint : Fresh water is getting increasingly scarce in the world. Earlier, the common perception was that water was an infinite resource. That time, there were only half the current number of people on the planet. Even people were not as wealthy as today, used to consume only fewer calories and ate less meat, so less water was needed for the production of their food. They required one third of the water people presently take from rivers or underground. Today, the consumption of water resources is much more intense. This is because there are nearly seven billion people on the planet; their consumption of eatables like meat and vegetables is rising. Further, there is huge competition for water consumption from industrial sector, urbanization and agricultural crops. In future, even more water will be needed to produce food because the Earth's population is forecast to be rise to 9 billion by the end of year 2050 (Environmental Essay, 2012). At present, the most pressing problem before humanity is not the fear of outbreak of war, epidemic or the collapse of civil administration but the daunting problem of short supply of drinking water. The slowly decreasing water will hit us hard, for we are used to the "unlimited water supply" But the bullet of catastrophe can be postponed or maybe even dodged for a while if we use the water saving alternatives in households. Thus, it can be said "it's the little things that matter". Over the next two decades our population is set to increase by 40 per cent. We use 70 per cent of our water for agriculture, and studies by the world water council have shown that we will need 17 per cent more water for agriculture by 2020 in order to feed the growing world. So if nothing is done to postpone this catastrophe for another time when an ideal alternative is developed, millions more will go to bed hungry and thirsty (Environmental Essay, 2012).

Calculating household water footprint will show exactly how choices in homes and purchases, have impact on world freshwater resources. The present empirical research is an Endeavour to assess the urban households' water footprint which gave a rough estimate of how much water it takes to keep their daily lives afloat. By changing individual's habits (behaviour) and by efficient utilization of water households can live sustainably by conserving water without compromising with comfort and quality of life.

Research Methodology

In order to fulfillment of the objective of the study, a household survey was conducted in four areas of different directions of Bikaner city. A sample of 30 households was selected from each area which comprise to 120 homemakers. The unit of inquiry was urban households and homemakers between the age group of 25-40 years were the key informers. A semi structured interview schedule was used to gather relevant information regarding water consumption pattern and water footprint of homemakers' household. All the information was further used to calculate water footprint and then gathered data were tabulated and analyzed by using frequency, percentage, mean, standard deviation, analysis of variance and student't'-test.

Results and Discussion

Water Footprint of Homemakers' Households : It is comprised of households' water footprint of home and yard, diet, energy and transportation, stuffs and services etc.

Water Footprint of Home and Yard : Table-1 data portray water directly used in different indoor and outdoor household activities. Average annual water footprint of households' home and yard was 1010.03 kL/ year (Sd= 766.94). Majority of households' (86.67 per cent) water footprint of home and yard lies between 200.001 to 1,800 kL per year. Surprisingly, none of the households' water footprint lies below 200 kL per year. the amount of water used in one toilet flush can satisfy the drinking requirements of an adult (1L/ day) for about three weeks; the water used for one load in a cloth washer can be enough for almost 6 months; water used in industry to refine a tone of petroleum would be enough to do about 200 loads in a cloth washer. When crops are irrigated, it takes much more water to grow a tone of grain than it does to manufacture a tone of most industrial materials (e.g., metals or plastics, etc.). (Purohit *et al.,* 2007).

Table-1 : Distribution of Homemakers according to their Water Footprint of Home and Yard. n=120

S. No.	Water Consumption in Home and Yard (annual basis in kL)	f	%
1.	Low (up to 200 kL)	-	-
2.	Medium (200.001 to 1800 kL)	104	86.67
3.	High (above 1800.001 kL)	16	13.33
	Total	120	100
	Mean	1010.03	
	S.D.	766.94	

Water Footprint of Diet : The tabulated data in table-2 included the water used in production of food products which was consumed by the homemakers' household. The data reveals that average quantity of water used in households' diet was 2410.36 kL per year (Sd= 1331.27). Near about two third of hohouseholds (67.50 per cent) were under the average category followed by low (20 per cent) and high (12.50 per cent).

Table-2 : Distribution of Homemakers according to their Water Footprint of Diet.

S. No.	Water Used in Diet (annual basis in kL)	f	%
1.	Low (up to 200 kL)	24	20
2.	Average (1200.001 to 3800 kL)	81	67.50
3.	High (above 3800.001 kL)	15	12.50
	Total	120	100
	Mean	2410.36	
	S.D.	1331.27	

Water Footprint of Energy and Transportation : This aspect covers indirect water footprint of the homemakers' household. It involves the water emerged in their transportation and consumed energy. The data in table-3 reveals that average water used in energy and transportation was 40.13 kL per year (Sd= 10.15). Sixty percent of the homemakers' household belongs to average category followed by high (35.83 per cent). The meagre percentage of homemakers (4.17 per cent) were in low category. According to National Geographic (2013) water is used to produce the fuels that keep us moving and our planet humming. A gallon of gasoline, for example, requires nearly 49 liters of H_2O to produce. The average American relies on nearly 2536 liters of water a day just for electricity production. A cross-country roundtrip (about 3,000 miles each way) could be worth more than 1,125 flushes of an efficient toilet.

Table-3 : Distribution of Homemakers according to their Water Footprint of Energy and Transportation. n=120

S. No.	Water Used in Transportation and Energy (annual basis in kL)	f	%
1.	Low (up to 25 kL)	5	4.17
2.	Average (25.001 to 57 kL)	72	60
3.	High (above 57.001 kL)	43	35.83
	Total	120	100
	Mean	40.13	
	S.D.	10.15	

Water Footprint of Stuffs and Services : Table-4 shows indirect water footprint of the homemakers households, which includes water used in production of stuff and services used by homemakers and family members. Average amount of water used by homemakers' households' stuff and services was 177.93 kL per year (Sd=113.26). Slightly less than half of the homemakers' (59.16 per cent) water footprint was average followed by low (31.67 per cent) and high (9.17 per cent). It takes around 2650 gallons of water to make a cotton shirt, and 9842 gallons to make a pair of jeans most of them to grow the cotton. On an average, every single paisa individual spent on clothes and shoes costs about 1.75 liters of water (National Geographic, 2013).

Table-4 : Distribution of Homemakers according to their Water Footprint of Stuff and Services. n=120

S. No.	Water Used in Stuffs and Services (annual basis in kL)	f	%
1.	Low (up to 100 kL)	38	31.67
2.	Average (100.001 to 300 kL)	71	59.16
3.	High (above 300.001 kL)	11	9.17
	Total	120	100
	Mean	177.93	
	S.D.	11326	

Water Footprint of Household : The data in table-5 revealed that the average annual water footprint of homemakers's household was 3639.67 kL per year (Sd= 1582.31). Majority of the homemakers (81.67 per cent) were average water consumer followed by low (14.16 per cent) and high (4.17 per cent).

Per Capital Water Footprint : The average per capita water footprint was 778.23 kL per year (Sd= 506.54). Half of the households had high per capita water footprint followed by less than half (42.5 per cent) in average and low (7.5 per cent) per capita water footprint.

Table-5 : Distribution of Homemakers according to their Overall Annual and Per Capita Water Footprint n=120

S. No.	Level of Water Footprint of Household (annual basis in kL)	f	%
1.	Low (up to 2000 kL)	17	14.16
2.	Average (2000.001 to 5200 kL)	98	81.67
3.	High (above 5200.001 kL)	5	4.17
	Total	120	100
	Mean	3639.67	
	S.D.	1582.31	
	Per Capita Water Footprint of Household (annual basis in kL)		
1.	Low (up to 300 kL)	9	7.5
2.	Average (300.001 to 1300 kL)	51	42.5
3.	High (above 1300.001 kL)	60	50
	Total	120	100
	Mean	778.23	
	S.D.	506.54	

Relationship between water footprint of the homemakers with household, personal and situational variables of the homemakers : The results indicated significant difference between the water footprint of the homemakers related to household variables i. e. per capita income (F=4.115, sig. level=0.05) and personal variables i.e. homemakers' age (F=4.555, sig. level=0.01) and education (F=1.979, sig. level=0.05). Significant difference was also found between situational variable i.e. type of house (F= 6.532, sig. Level= 0.01) and water footprint.

As the household per capita income increases individuals start spending more on extravagance resulting in increased water footprint. Moreover, young and educated homemakers have greater knowledge of the world around. They are more aware of the latest products and try to experiment with them leading to increased water footprint. Large houses with or without garden increases homemakers' water footprint.

Computed test results highlighted significant difference between the homemakers' employment status water footprint (t=2.479, sig. level=0.01). This may be attributed to homemakers employment outside the four

Table-6 : Analysis of Variance Showing Relationship between Household, Personal and Situational Variables with Homemakers' Household Water Footprint. n=120

S. No.	Particulars	Sum of Square	Degree of Freedom	Mean of Square	F-Ratio	Level of Significance
	Household Variables					
1.	**Family size**					
	Between Groups	363.87	107	3.401	0.675 NS	0.858
1.	Within Groups	60.50	12	5.042		
2.	**Household income**					
1.	Between Groups	15374113908000.00	107	143683307551.40	0.882 NS	0.659
1.	Within Groups	1955664000000.00	12	162972000000.00		
3.	**Per capita income**					
1.	Between Groups	1114091696322.99	107	10412071928.25	4.115**	0.005
1.	Within Groups	30362892449.00	12	2530241037.42		
	Personal Variables					
4.	**Age of homemakers**					
1.	Between Groups	4041.300	107	37.769	4.555**	0.003
2.	Within Groups	99.500	12	8.292		
5.	**Education**					
1.	Between Groups	171.200	107	1.600	1.979*	0.021
1.	Within Groups	10.500	12	1.594		
6.	**Homemakers annual income**					
	Between Groups	565581888000.00	107	5285812037.38	0.776 NS	0.765
	Within Groups	81792000000.00	12	6816000000.00		
	Situational Variables					
7.	**House ownership**					
	Between Groups	14.667	107	0.137	0.822 NS	0.718
	Within Group	2.000	12	0.167		
8.	**Housing type**					
	Between Groups	262.09	107	2.449	6.532**	0.000
	Within Group	4.500	12	0.375		

Table-7 : Students't' Test Showing Relationship between Household, Personal and Situational Variables with Homemakers' Household Water Footprint n=120

S. No.	Variables	Mean Difference	t-value	df	Level of Significance
1.	**Household Variables**				
	Family type	109121.3354	0.379 NS	118	0.706
2.	**Personal Variables**				
	Employment status	748863.16	2.479**	118	0.015
3.	**Situational Variables**				
	House ownership	199219.09	0.516 NS	118	0.607

NS-Non Significant, **Significant at 0.01 level of probability.

walls increased their horizon of world around leading to higher expenditure on consumer goods and durables thus increasing their water footprint.

Conclusions

The study provides a baseline regarding water footprint of homemakers'. Our study will be helpful to understand water consumption pattern and how to decrease the level of consumption. Households' annual water footprint was average because of the water availability in Bikaner city. The indirect water footprint of households' was higher then their direct water footprint it must be due to their choices of food, stuffs, energy, transportation and services. Awareness regarding how to reduce water footprint is essential in order to conserve water resource and to live sustainably without compromising with comfort and quality of life. Behavioral change lies at the heart of most individual actions on reducing our individual water footprint by being sensible about household water use, contribution to the environment by making household energy efficient. The study guides to invest in more sensible technologies that help us in our day to day lives. It shows that there is a need to buy water efficient appliances which lower water consumption.

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A study on Socio-Economic and Socio-Psychological Characteristics of the Kisan Credit Card Beneficiary Farmers in Gariaband District of Chhattisgarh

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Abstract

The study was conducted in Gariaband district of Chattissgarh state during 2016-17 Descriptive research design was followed for the conduct of the study. The total sample for the present study was 120. The study was conducted with the objectives of to identity the socio-economic and socio-psychological characteristics of selected Kisan Credit Card holder farmers. It is indicate that out of total respondents, majority of the respondents had small size of land holding, involved in agriculture + service occupation, along-with more than one occupation and had annual income between Rs. 25000 to 50000. They acquired credit both sources for short term period, which fulfilled their demand for agricultural purposes up to 60.00 per cent. Remaining credit requirement of the respondents were fulfilled through KCC. They regularly repaid their loan by kind and cash mode, on yearly basis. Majority of the respondents were having medium level of economic motivation (49.17%) and low level of risk orientation (55.00%). they were 62.50 percent of the KCC holders belonged to category of partially satisfied, and followed by 21.67 percent of the KCC holder respondents belonged to category of fully satisfied, and 15.83 percent KCC holder respondents belonged to category of least satisfied.

Key words : *socio-economic, socio-psychological, Kisan Credit Card.*

Introduction

The Kisan Credit Card (KCC) scheme is a credit introduced in August 1998 by Indian banks. This model scheme was prepared by the National Bank for Agriculture and Rural Development (NABARD) on the recommendations of R.V. Gupta to provide short term loans and agricultural needs.

Due to lack of awareness among farmers and unnecessary delays, cumbersome procedure and improper practices adopted by institutional lending agencies; a large number of formers heavily depend on non-institutional sources of credit for their frequent needs to purchase farm inputs such as seeds, fertilizers, pesticides etc. The non-institutional credit is not only expensive but also counter-productive. The Kisan Credit Card scheme was launched to provide adequate, timely and cost effective institutional credit from the banking system to the farmers for their cultivation needs. Farmers can not only purchase inputs but also can withdraw cash from this credit card their inputs needs.

There has been a steady increase in the flow of institutional credit to agriculture over the years. The agency-wise share of credit flow to agriculture shows that the commercial banks accounted for major share followed by co-operatives banks. However, there is a declining trend in the share of co-operatives banks in the flow of institutional credit in 2005-06 over 2004-05, which is indicative of the need for restructuring and reforming these banks. Aggregate credit flows, both short-term and long-term are estimated to reach Rs.1, 17,899 crore in 2005-06 from a level of Rs.1, 25,309 crore in the previous year (Anonymous, 2005- 06).

Research Methodology

Gariaband district have 5 blocks, out of which one block i.e. Gariaband was selected purposively for this study, because maximum number of Kisan Credit Cards have been issued in these blocks. Therefore, the operational area of Gariaband district Cooperative Bank was purposively considered for the study, Villages were selected purposively on the basis of maximum availability of KCC holders in the Villages. In this way a total of 6 Villages were selected for this study. Out of total Kisan Credit Card holders of the Village, 20 KCC holders were selected randomly from each selected Villages. In this way a total of 120 KCC holders were considered as respondents for collection of data in this study.

Results and Discussion

Socio-economic characteristics of the respondents : The distribution of the respondents according to their land holdings is presented (Table-1) which indicated that about 40.00 per cent of the selected KCC holders were small farmers, followed by 30.00 per cent of the respondents had less than 1.00 ha. of land holdings (marginal farmers), 21.67 per cent of the respondents had 2.01 to 3 ha. of land holdings (medium farmers) , and 8.33 per cent of the respondents had >3 ha. of land holdings (large formers). It could be calculated that maximum number of respondents belonged to small farmer’s category.

Table-1 : Distribution of the respondents according to socio-economic characteristics.

(Respondent =120)

S. No.	Category	Frequency	Percentage
Size of land holding			
1.	Marginal farmers (less than 1.00 ha)	36	30.00
2.	Small farmers (1.01 to 2.00 ha)	48	40.00
3.	Medium farmers (2.01 to 3ha)	26	21.67
4.	Large farmers (>3 ha)	10	8.33
Occupation			
1.	Agriculture	45	37.50
2.	Agriculture + Service	50	41.67
3.	Agriculture + Business	25	20.83
Annual income			
1.	Rs. 2,500	30	25.00
2.	Rs.25001-50000	58	48.33
3.	Rs.50001-75000	24	20.00
4.	Above Rs. 75000	8	6.67
Credit acquisition			
1.	Acquired through KCC only	43	35.83
2.	Acquired from other source	5	4.17
3.	Acquired from both sources	72	60.00
Extent of demand and availability of credit			
1.	Credit available >75% of the demand	22	18.33
2.	Credit not available from 50% to 75% of the demand	35	29.17
3.	Credit not available <50% of the demand	63	52.50
Repayment of loan			
1.	Defaulters	20	16.67
2.	Cash	75	62.50
3.	Kind	11	9.16
4.	Both	14	11.67

The occupation is contributing factor for the annual family income of the farmers. With this assumption, it was though appropriate to study the occupation of the KCC holders. The KCC holders were classified in to three categories according to their occupation as shown in the Table-1. The results leads to conclude that majority of the KCC holders disclose that 41.67 per cent of the respondents were engaged in agriculture + Service, followed by 37.50 per cent of the respondents were agriculture and, 20.83 per cent of the respondents were engaged in agriculture + business.

The distribution of the respondents according to their annual income data presented in Table-1 shows that (48.33%) of the KCC holder respondents belonged to category of Rs.25001-50000 (annual income group) and followed by 25.00 percent of the KCC holder respondents belonged to category of Rs.2500 (annual income group), 20.00 per cent KCC holder respondents belonged to category oh Rs.50001-75000 (annual income group) and 6.67 per cent belonged to category of above Rs. 75000 (annual income group). Thus, it can be concluded that most of the respondents were in the category of Rs.25001-50000, followed by low income category, Rs.2500 category, Rs.50001-75000 and above Rs. 75000 category.

The Credit acquisition data in Table-1 shows that most of the respondents (60.00%) were found to acquired from both sources, followed by 35.83 per cent were found to acquired through KCC only, and 4.17 per cent respondents were found to acquired from other source.

The Extent of demand and availability of credit data presented in Table-1 shows that (52.50%) of the KCC holder respondents belonged to category of credit not available <50% of the demand, and followed by, 29.17 percent of the KCC holder respondents belonged to category of credit not available from 50% to 75% of the demand, and 18.33 per cent KCC holder respondents belonged to category of credit available >75% of the demand. Thus, it can be concluded that most of the respondents were in the category of credit not available <50% of the demand, followed by, category of credit not available from 50% to 75% of the demand and category of credit available >75% of the demand.

The data of Repayment of loan presented in Table-1 shows that (62.50%) of the KCC holder respondents belonged to category of cash, for mode of repayment of credit, and followed by, 16.67 percent of the KCC holder respondents belonged to category of defaulters and 11.67 per cent KCC holder respondents belonged to category of both and 9.16 per cent of KCC holders for mode of repayment of credit.

Table-2 : Distribution of the respondents according to socio-psychological characteristics.

(Respondent =120)

S. No.	Category	Frequency	Percentage
	Economic motivation		
1.	Low level (<18 score)	37	30.83
2.	Medium level Medium level (18 to 21 score)	59	49.17
3.	High level (>21 score)	24	20.00
	Risk orientation		
1.	Low level (<16 score)	66	55.00
2.	Medium level (16 to 20 score)	39	32.50
3.	High level (>20 score)	15	12.50
	Level of satisfaction		
1.	Least satisfied	19	15.83
2.	Partially satisfied	75	62.50
3.	Fully satisfied	26	21.67

Socio-psychological characteristics of the respondents : The data of Economic motivation in Table-2 shows that most of the respondents (49.17%) were found to medium economic motivation category followed by 30.83 per cent low category and 20.00 per cent found to high economic motivation category. Thus, it can be concluded that most of the respondents were in the medium economic motivation category followed by low and high economic motivation category.

The data of Risk orientation presented in Table-2 shows that (55.00%) of the KCC holder respondents belonged to category of low level (<16 score) and followed by 32.50 percent of the KCC holder respondents belonged to category of medium level (16 to 20) and 12.50 per cent KCC holder respondents belonged to category of high level of (>20 score).

The Level of satisfaction data presented in Table 2 shows that (62.50%) of the KCC holder respondents belonged to category of partially satisfied and followed by 21.67 percent of the KCC holder respondents belonged to category of fully satisfied and 15.83 percent KCC holder respondents belonged to category of least satisfied.

Conclusions

Regarding size of land holding, maximum number of the respondents (40.00%) belonged to category of small farmer's, followed by 30.00 per cent having s belonged to category of marginal farmers. In case of occupation, all the respondents were involved in farming occupation. Majority of respondents (41.67%) were involved in agriculture + services, and about (37.50%) were involved in agriculture, and only (20.83%) were involved in agriculture + business. However, majority of the respondents (48.33%) reported the annual income between (Rs.25001 to 50000) followed by (25.00%) reported up to Rs. 25000.

With regards to credit acquisition was concerned (60.00%) respondents acquired credit from both sources for the short term period, followed by (35.83%) respondents acquired through KCC only, and (4.17%) respondents credit acquired from other sources like friends, moneylenders, etc.

Majority of respondents (62.50%) of the KCC holder respondents belonged to category of cash, for mode of repayment of credit, and followed by, 16.67 percent of the KCC holder respondents belonged to category of defaulters, and 11.67 per cent KCC holder respondents belonged to category of both, and 9.16 per cent of KCC holders for mode of repayment of credit.

Majority of the respondents were having medium level of economic motivation (49.17%) and risk orientation (55.00%).

Majority of the respondents were (62.50%) of the KCC holders belonged to category of partially satisfied, and followed by, 21.67 percent of the KCC holder respondents belonged to category of fully satisfied, and 15.83 per cent KCC holder respondents belonged to category of least satisfied.

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Population Dynamics of Major Sucking Pests Infesting Soybean (*Glycine max*) in Relation to Weather Parameters at Sagar District of Madhya Pradesh

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Abstract

Field experiments were carried out at JNKVV–Dryland Horticulture Research & Training Centre, Garhakota during Kharif 2017 on soybean variety JS 9305. During the course of study at various growth stages four sucking pests namely, whitefly (*Bemisia tabaci* Gennadius), jassid (*Empoasca kerri* Pruthi), aphids (*Aphis craccivora* Koch) and thrips (*Thrips tabaci* Lindeman) and one natural enemy, namely, lady bird beetle (*Coccinella septempunctata)* were observed to prey on these sucking pests. The peak activity of sucking pests that is, *B. tabaci* (6.50 whiteflies / 3 leaves) was noticed during Second week of September and *E. kerri* (2.55 jassids /3 leaves) during Fourth week of August to First week of September. Thrips (2.80 thrips / 3 leaves) during Fourth week of August. Aphids (4.25 aphids/3 leaves) during Third week of August. The biocontrol agent *i.e.* lady bird beetle, (*Coccinella septempunctata)* was found predating mainly upon whiteflies and jassids. The lady bird population recorded on the crop ranged from 0.10 to 0.85/mrl during *Kharif,* 2017.

Key words : *Soybean, sucking insect pests, population dynamics, weather parameters, correlation.*

Introduction

Soybean [*Glycine max* (L.) Merrill] is an important oil seed crop belonging to family Fabaceae. Soybean is one of the most important crops of the world largely grown in United States of America, Brazil, Argentina, China, and India and plays crucial role in international trade (Baig *et al*. 2017). Soybean occupies 42% of India's total oilseeds and 25% of edible oil production in India. Soybean is mainly grown in the states of Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Telangana as a rainfed crop during *kharif* season. It is a unique crop with high nutritive value, providing 40 per cent protein and 20 per cent edible oil besides minerals and vitamins (Sasvihalli *et al*. 2017).It supports many industries; in manufacturing antibiotics, paints, varnishes, adhesives and lubricants and also used as protein supplement in human diet, cattle and poultry feed (Alexander, 1974).The luxuriant crop growth, soft and succulent foliage attracts many insects and provides unlimited source of food, space and shelter. About 380 species of insects have been reported on soybean crop from many parts of the world. About 65 insect species have been reported to attack soybean from cotyledon stage to harvesting stage (Rai *et al*. 1973; Adimani, 1976; Thippaiah, 1997). Major insect pest in soybean of national importance are stem fly (*Melanagromyza sojae* Zehntner), tobacco caterpillar (*Spodoptera litura* Fabricius), green semiloopers (*Chrysodeixis acuta* Walker, *Gesonia gemma* and *Diachrysia orichalcea* Fabriciussensu Hübner), girdle beetle (*Obereopsis brevis* Gahan), pod borer (*Helicoverpa armigera* Hubner), white fly (*Bemisia tabaci* Gennadius), leafhopper (*Empoasca kerri* Pruthi), Thrips (*Thrips tabaci* Lindeman), aphids (*Aphis craccivora* Koch) and pod bug (*Riptortus pedestris* Fabricius)

Materials and Methods

Field experiment was carried out at JNKVV–Dryland Horticulture Research and Training Centre, Garhakota during Kharif 2017. Soybean cultivar, JS 9305 were sown on 05th July, 2017 for the study and raised by recommended agronomical practices.. The crop was raised in six plots with 4 × 4 m^2 size of each plot. Experimental area was kept free from insecticidal spray throughout the crop season. The data related to weather parameter viz., temperature, rainfall, relative humidity and daily sunshine hours throughout the period of investigation was collected from Regional Agricultural Research Station, Sagar. Observation on the number of sucking pests infesting the soybean crop *viz.,* whiteflies, aphids and leafhoppers was recorded on three compound leaves (upper, middle and lower) per plant from five randomly selected plants from each plot. Populations of tobacco caterpillar were counted per meter row length (mrl) at 5 randomly selected places in the experimental plot. The data was recorded early in the morning at weekly intervals from 1 week after germination. The data on bio control agents (lady bird beetle was recorded from ten plants from randomly selected three places of one meter row length from field. Later mean number of bio-control agents per plant was calculated. Correlation of pest and

Table-1 : Seasonal incidence of sucking insect pests and their natural enemies on soybean during kharif, 2017.

Duration	No. of sucking pests / 3leaves				Natural enemies (mrl)	Temperature (°C)		Morning Relative humidity (%)	Evening Relative humidity (%)	Wind velocity (kmph)	Rainfall (mm)	Sunshine (hrs)
	White-flies	Thrips	Aphids	Leafhoppers	Coccinellid beetle	Maximum	Minimum					
25 – 31 July	0	0	0	0	0					7.9		
1 – 7 Aug.	1.25	0.65	0	0	0	29.7	24.0	89.00	64.17	6.8	28.4	4.47
8 – 14 Aug	2.35	1.95	0.65	1.25	0.25	24.4	24.1	90.17	59.88	7.2	53.5	5.23
15 – 21 Aug	2.75	2.25	4.25	1.55	0.35	26.5	22.8	90.35	66.32	7.6	25.4	1.95
22 – 28 Aug	3.95	2.80	2.55	2.10	0.55	31.1	23.4	89.95	60.25	6.4	60.23	5.02
29 Aug– 4 Sep	4.25	2.05	2.05	2.55	0.60	31.5	24.1	88.76	53.21	5.2	46.23	6.20
5 – 11 Sep.	6.50	1.75	1.40	1.95	0.50	31.4	24.1	88.32	59.65	4.7	12.42	6.55
12 – 18 Sep.	5.10	1.55	0.95	1.55	0.85	34.3	28.8	87.96	54.20	3.2	5.20	7.89
19 – 25 Sep	4.35	1.25	0.35	1.20	0.45	33.7	28.6	89.05	52.32	3.6	0	6.87
26 Sep – 02 Oct	2.50	0.85	0.25	0.75	0.20	33.0	28.4	93.25	54.25	3.4	14.55	7.55
3 – 9 Oct	2.65	0.65	0.15	0.60	0.10	33.8	28.7	91.25	58.63	2.1	18.20	7.95
10 – 16 Oct	2.70	0.60	0.25	0.45	0	34.0	25.7	92.20	51.10	1.3	0	8.57
17 – 23 Oct	2.15	0.50	0	0.85	0	34.3	24.2	89.55	53.87	0.7	0	8.63
24 – 30 Oct	1.20	0.25	0	0.35	0	33.4	23.7	90.35	55.24	0.8	0	8.21

Table-2 : Correlation coefficient of sucking insect pests and their natural enemies with weather parameters.

Abiotic factor	Leafhoppers	Whiteflies	Thrips	Aphids	Coccinellid beetle
Maximum Temperature (°C)	0.423	0.137	0.075	0.425	0.407
Minimum Temperature (°C)	0.617*	0.662**	0.583*	0.056	0.485
Morning Relative humidity (RH-I (%)	0.384	0.314	0.516	0.013	0.259
Evening Relative humidity (RH-II (%)	0.784**	0.520	0.687**	0.189	0.679**
Wind velocity (Km/hr)	0.569*	0.483	0.334	0.472	0.462
Bright sunshine hours	0.521	0.414	0.514	0.165	0.343
Rainfall (mm)	0.692**	0.325	0.572*	0.307	0.673*

*=Significant at 5% level, **=Significant at 1% level

natural enemy populations with weather factors were computed.

Results and Discussion

Whitefly, *Bemisia tabaci* Genn. : The occurrence of whitefly population during *Kharif*, 2017 season commenced from first week of August and continued to infest the soybean crop throughout the crop growth period and the number of whiteflies recorded on 3 leaves /plant ranged from 1.20 to 6.50. The initial infestation started with a whitefly population of 1.25/3 leaves during 1st week and it reached to peak population of 6.50/3 leaves on 2nd week of September. At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity, bright sunshine hours were 12.42 mm, 31.40°C, 24.10°C, 88.32%, 59.65%, 4.70 km/hr, and 6.55 hrs/day respectively and there after the population declined and reached to a lowest population of 1.20 whiteflies/3leaves on last week of October. The whitefly population during *kharif*, 2017 was highly influenced by the minimum temperature (0.662**). Ahirwar *et al.*, (2015) reported similar findings where the peak activity of sucking pests with *B.tabaci* (3.2 white flies per plant) and *E. kerri* (3.4 jassids per plant) was recorded during the last week of August and second week of August, respectively. Chaudhary *et al.*, (2018) also reported similar findings relating to the activity of white flies and jassids. Netam *et al.*, (2013) reported the peak density of sucking pests on soybean was observed in the third week of September with 4.4 sucking pests /plant and a seasonal mean of 3.62 white flies and jassids per plant. Bhavasar and Kumar, (2019) also reported that the highest population of whiteflies 12.0 whiteflies/3 leaves was recorded during 44th standard week. Chaudhari *et al.,* (2020) reported similar findings where the peak incidence of white flies was recorded during the fourth week of August (2.20/3 leaves). Bhavasar and Kumar (2019) reported that the population of whitefly showed non-significant negative correlation with minimum temperature and maximum relative humidity, significant negative correlation with minimum relative humidity and rainfall. On the other hand, it showed non-significant positive correlation with maximum temperature and significant positive correlation with sunshine.

Thrips , *Thrips tabaci* Lindeman : The thrips population recorded more or less similar trend as observed for leafhoppers and the population remained in low numbers and it ranged from 0.25 to 2.80 / 3 leaves during *Kharif*, 2017 by recording maximum number during 4th week of August with 2.80 / 3 leaves .At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity and bright sunshine hours were 60.23 mm, 31.10 °C, 23.40 °C, 89.95%, 60.25 %, 6.40 km/hr, 5.02 hr/day respectively and thereafter the population decreased to lowest number of 0.25/leaves on last week of October. The thrips population was mainly influenced by minimum temperature (0.583*) and evening relative humidity (0.687**) showed significant positive relationship with the above weather parameters.

Aphids, *Aphis craccivora* Koch : The aphid infestation started on the crop with an initial population of 0.65 / 3 leaves on second week of August and reached to peak population of 4.25 aphids/3 leaves on third week of August. At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity and bright sunshine hours were 25.4 mm, 26.50 °C, 22.80 °C, 90.35 %, 66.32 %, 7.6 km/hr and 1.95 hr/day respectively. The aphid population disappeared from the crop from 3rd week of October. The correlation studies carried out between aphids and weather parameters revealed that there was no significant influence of weather parameters on aphid population. Chaudhari *et al.,* (2020) reported that the peak incidence of aphids was recorded during the fourth week of August (18.40/ 5cm twig). The present results corroborates with the findings of Gaur *et al.,* (2015) who recorded positive correlation of aphids with morning and evening RH. In the present studies, maximum temperature, rainfall, rainy days, sunshine hours and wind speed recorded negative correlation which is in line with the earlier works of Gaur *et al.,* (2015) who recorded negative correlation with maximum temperature, rainfall and wind speed.

Leafhoppers, *Empoasca kerri* Pruthi : The observations recorded on seasonal incidence of leafhoppers revealed that leafhoppers have been presented in table-1. The data revealed that leafhoppers infestation (1.25 /3 leaves) was initiated in the second week of August during the year 2017. The population increased gradually and reached its peak population of 2.55/3 leaves was observed during 4th week of August to 1st week of September. At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity and bright sunshine hours were 46.23 mm, 31.50°C, 24.10°C, 88.76% ,53.21% , 5.2 km/hr and 6.2 hr/day ,respectively and then reached to lowest population (0.35/3 leaves) during last week of October. The weather parameters during *kharif* 2017 showed highly significant positive correlation with evening relative humidity (0.784**) rainfall (0.692**), while it was significant and positive with wind velocity (0.569*) and minimum temperature (0.617*) . Netam *et al.,* (2013) reported the peak density of sucking pests on soybean in the third week of September with 4.4 sucking pests/plant and a seasonal mean of 3.62 white flies and jassids per plant. Ahirwar *et al.,* (2015) reported similar findings where the peak activity of sucking pests, *B. tabaci* (3.2 whiteflies per plant) and *E. kerri* (3.4 leafhoppers per plant) was recorded during the last week of August and second week of August, respectively. Chaudhary *et al*., (2018) also reported similar findings relating to the activity of whiteflies and jassids. Bhavasar and Kumar, (2019) reported that the highest population of jassids with 3.8 jassids/3 leaves was recorded during last week of September . Chaudhari *et al.,*(2020) reported similar findings where the peak incidence of jassids was recorded during the second week of September (6.40/3 leaves). Earlier findings made by Vijay, (2013), Sutaria *et al.,* (2010); Yadav, (2013) corroborated with the present findings who showed that maximum temperature had negative correlation on leafhoppers. Yadav *et al*., (2015); Patidar, (2015) also recorded negative correlation between leaf hopper population and maximum temperature and rainfall. While, Sutaria *et al.,* (2010) recorded negative correlation of leaf hopper population with evaporation and wind speed. Chaudhary *et al*., (2018) observed that evening relative humidity showed significant positive correlation, whereas maximum temperature and sunshine hours showed non significant negative correlation with the jassid population. Pawar, (2012) observed morning and evening relative humidity, minimum temperature and rainfall had positive influence on jassid population. Bhavasar and Kumar (2019) reported that the population of leafhopper showed non-significant negative correlation with minimum relative humidity and rainfall, non-significant positive correlation with minimum temperature and sunshine while it showed significant negative correlation with maximum relative humidity and significant positive correlation with maximum temperature.

Predators : The soybean crop pests were mainly predated in the field by the lady bird beetle (*Coccinella septempunctata*) though the predator were found in low population. The lady bird beetle population was found mainly feeding on the sucking pests The lady bird population recorded on the crop ranged from 0.10 to 0.85/mrl during *Kharif,* 2017 .The peak activity of predatory fauna *i.e.* lady bird beetle was noticed in the second week to third week of September. Ahirwar *et al.,* (2015) reported similar findings where the lady bird beetle was found predating upon whiteflies and jassids, whereas lynx spider was noticed sucking the body sap of lepidopterous larvae in soybean ecosystem where the peak activity of lady bird beetle was reported in the second week of August and September with 0.4 grub and adult per plant whereas the peak activity of spiders were reported in the last week of August with 1.2 spiders per plant. Similar results were reported by Neetam *et al*. (2013) who reported the peak activity of lady bird beetle and spiders were in the third week of September with 0.2 to 0.9 (beetles/meter row) and (02 to 0.7 spiders /meter row) which were similar to present findings. Chaudhari *et al.,* (2020) reported similar findings where the peak incidence of coccinellid predator was recorded in the fourth week of August (3.33/plant).The results obtained from the correlation coefficient studies carried out between weather parameters and predators revealed that lady bird population was mainly influenced by evening relative humidity (0.679**) and rain fall (0.673**) which showed highly significant and positive correlation. Predators population of soybean pests were also significantly influenced by weather parameters and the coccinellid species population was highly influenced by minimum temperature, morning and evening relative humidity, wind velocity and sunshine hours.

Conclusion

During the course of study soybean crop was attacked at various growth stages by four sucking pests *viz.,*whitefly (*Bemisia tabaci* Gennadius), jassid (*Empoasca kerri P*ruthi), aphids (*Aphis craccivora* Koch) and thrips (*Thrips tabaci* Lindeman. The activity of whitefly and jassid was noticed right from germination whereas the activity of thrips and aphids were noticed during active vegetative and flowering stages. Among the predators, lady bird beetles, *Coccinella septempunctata*, was observed preying on whiteflies and jassids.

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Prototype Design and Development of Bluetooth Operatedtractor

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Abstract

The Experiment was designed to improve the efficiency of farming operations by using prototype of smart Autonomous tractor to do the farming works automatically. Today scarcity of man power became the main threat for agriculture sector. It reduces the dependency on man power by doing the works automatically and also enables the ladies and some disabled persons to do farming. Here GPS is used to locate the coordinates of farming field where the task has to be performed. By using this technology we can also communicate the other tractors also. Our tractor prototype has two PTO s, front and back through the PTOs we have to run the other implements by connecting the tractor. The design was developed to reduce the labor scarcity. The developed design consist of chassis, arduino, motor module, driver module, rare wheels, front wheels, Bluetooth module female and male jumped wires for connections, bread board sensors like GPS ,transmitter, receivers . This devices are used to design autonomous tractor and observe the performance of the tractor in both field and laboratory conditions.

Key words : *GPS, Sensors, Arduino UNO, Transceivers,*

Introduction

Tractor are self propelled attached with different types of tracks and pneumatic wheels to do different field operations, it also act as prime mover for stationary operations. Indian tractor industry has been in a positive growth trend during FY2016-2017. While increase in domestic volume by 18.2% between 2016-2017. A driverless tractor is a form of Autonomous technology. It is considered driverless because it operates without the presence of a human inside the tractor. Like other, they are programmed unmanned ground vehicles to independently observe their position, decide speed and avoid obstacles such as people, animals or objects in the field, while performing their task. The various driverless tractors are split into full autonomous technology and supervised autonomy. The idea of the driverless tractor appears as early as 1940, but has really come to fruition in the last few years. The tractors use GPS and other wireless technologies to farm land without the need of a driver. They operate simply with the aid of a supervisor monitoring the progress at a control station or with a manned tractor in lead. The interaction between machines and operators has hardly changed since that time. The human operator uses their intelligence to operate a mechanical tractor and implement. In agriculture, autonomous driving equipment would require technology where there is a slightly higher complexity, but not disproportionately higher. This auto drive technology is set to make farming more productive & profitable, reduce health hazard for farmers and change the future of food production. Researchers are now looking towards the realization of autonomous agricultural vehicles. The concept of fully autonomous agricultural vehicles is far from new; examples of early 'driverless tractor' prototypes using leader cable guidance systems date back to the 1950s and 1960s.

Based on the trends in regards to the advancement of technology, it would not be a surprise if the same technology alters its phase within the coming years. However, what may come as a surprise is the quiet revolution within the farming industry that is slowly changing the way farmers approach their concept of agriculture and farming, in general. Presently, farmers in advanced countries are giving a tactical approach to how they plant, harvest, as well as maintain their crops. A good example of such technology is the use of autonomous tractors in agriculture.

During these days, farmers used GPS technology as a guide to the tractors across the farmland. The aim of such sensors and electrical systems used, it approach the reduction of fuel consumption and enhancing the efficiency of the tractors and the farming activities. As such, these initial steps formed the basis for the development of autonomous tractors, following the introduction of technologies that improved communication over wireless devices. Autonomous tractors employ much the same approach as the driverless vehicles –uses advanced systems and sensors. The farmers can work their fields for long hours without exposing themselves to harsh weather or difficult operating conditions. They can also protect themselves from potential health hazards resulting from operations like insecticide spraying which now can be done without human intervention. It will also ensure better quality

Driverless tractors development is already advanced in the US, where John Deere, AGCO and others have working technology that can send tractors on pre-programmed routes. Mahindra & Mahindra (M&M) plans to introduce first driverless tractor in India in 2018. The tractor was developed at the automobile giant's research facility in Chennai.

But our autonomous tractor is different from above innovational tractors.

Main reason for developing Auto-Drive technology for tractors, this technology is aimed at turning existing tractors into semi-autonomous machines. Falling costs for self-driving technology also will provide further catalysts for the shift. At the same time, the progress in self-driving technology for automobiles — including both object detection capabilities using multi camera systems, radar and lidar technology could help speed up and lower the cost of developing autonomous farm machinery.

In agriculture, autonomous driving equipment would require technology where there is a slightly higher complexity, but not disproportionately higher. The grower could remotely monitor and control the machine using a device such as a tablet or computer system.

Materials and Methods

This chapter deals with the materials various methods and design criteria adopted "Design of an Autonomous Tractor (proto-type) "It is also embedded with various views of designed materials which was further preceded for manufacturing and further development. The location of designing of tractor was selected in the work at Vikas college of Engineering and Technology, agriculture department in Nunna.

Design Arrangement of Autonomous Tractor (proto-type)

Design of Chassis : The Chassis frame is designed with the material ply wood. It is having high uniform strength , easy for cutting to make the shape of tractor chassis and cost also low compared to Iron .first we taken ply wood and it cutted in the shape of chassis .

Selection of Arduino : The Arduino is place on the chassis (frame) and in between the two rear wheels. The Arduino Uno is a microcontroller board based on the ATmega328, having the 14 input/output digital pins including ground (ground pin).It contains everything needed to support the microcontroller; It is connected to the computer with USB cable with a AC-to-DC adapter or battery to get started. The external power is supplied to the Arduino from the battery. The voltage range in between 7 to 12 volts. The Arduino Uno can be programmed with a Arduino software (Arduino programming language). Finally the Arduino is operated with the help of software downloaded. The Tractor is communicated with programming the arduino it communicate the other sensors.

Arduino programming

```
int motorLpin1=2;
int motorLpin2=3;
int motorRpin1=4;
int motorRpin2=5;
intmotorLpwm=10;
intmotorRpwm=11;
intmotorSpeed=125;
int turn=50;
void setup() {
Serial.begin(9600);
Serial.flush();
pinMode(motorLpin1,OUTPUT);
pinMode(motorLpin2,OUTPUT);
pinMode(motorRpin1,OUTPUT);
pinMode(motorRpin2,OUTPUT);
pinMode(motorLpwm,OUTPUT);
pinMode(motorRpwm,OUTPUT);
     }
 void loop() {
    String input="";
     while(Serial.available()){
        input+=(char)Serial.read();
         delay(5);
 }
    if(input=="n"){
stp();
        }
    else if(input=="F"){
fwd();
        }
    else if(input=="R"){
        rev();
        }
    else if(input.indexOf("TL")>-1){
lft();
}
    else if(input.indexOf("TR")>-1){
```

```
rght();
        }
    else if(input!=""){
motorSpeed=input.toInt();
        }
     }
 void fwd(){
analogWrite(motorLpwm,motorSpeed);
analogWrite(motorRpwm,motorSpeed);
digitalWrite(motorLpin1,0);
digitalWrite(motorLpin2,0);
digitalWrite(motorRpin1,1);
digitalWrite(motorRpin2,0);
}
void rev(){
analogWrite(motorLpwm,motorSpeed);
analogWrite(motorRpwm,motorSpeed);
digitalWrite(motorLpin1,0);
digitalWrite(motorLpin2,1);
digitalWrite(motorRpin1,0);
digitalWrite(motorRpin2,0);
    }
void lft(){
analogWrite(motorLpwm,motorSpeed-turn);
analogWrite(motorRpwm,motorSpeed+turn);
digitalWrite(motorLpin1,0);
digitalWrite(motorLpin2,1);
digitalWrite(motorRpin1,1);
digitalWrite(motorRpin2,0);
    }
void rght(){
analogWrite(motorLpwm,motorSpeed+turn);
analogWrite(motorRpwm,motorSpeed-turn);
digitalWrite(motorLpin1,1);
digitalWrite(motorLpin2,0);
digitalWrite(motorRpin1,0);
digitalWrite(motorRpin2,1);
     }
void stp(){
analogWrite(motorLpwm,0);
analogWrite(motorRpwm,0);
digitalWrite(motorLpin1,1);
digitalWrite(motorLpin2,1);
digitalWrite(motorRpin1,1);
digitalWrite(motorRpin2,1);
 }
```

Selection of Motor module : In motor module we have to connect the motors. The module is selected with suitable Speed of 1000 rpm (revolutions per minute).this speed is suitable to our proto type.

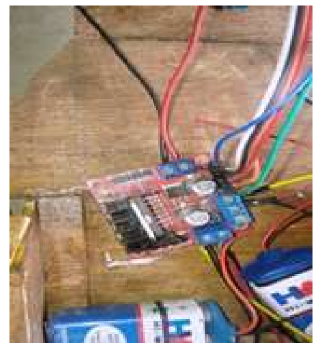

Fig.-1 : Motor module with battery connection.

Motor module Arrangement &Controlling : Motor module follows the programming (Arduino programming). The L298N H-bridge module can be used with motors that have a voltage of between 5 and 35V DC.

The Arduino and motor module is connected by pin system present in the Arduino and module through with the help of male and female jumped wires. Battery also connected to the motor module. This battery gives power to the two motors then the motors are worked. If we gives the power to the arduino with the help of motor module (If we didn't connect the Arduino the modules works independently).

Selection of Bluetooth module : Working of autonomous tractor by using arduino programming, before that we need the Bluetooth module. We selected the Bluetooth because the design is proto-type it is suitable for our tractor. It covers the signal strength up to 6 m wide.

Fig.-2 : Bluetooth Module.

Connection of Bluetooth module : In our design connect the Bluetooth module (HC-05) with arduino. Then to activate the mobile Bluetooth and arduino. When these three are activated then mobile shows the symbol likeHC-05 is connected. Then installed the controller app in our mobile that shows the three modes of operation. 3 modes are 1.test mode 2.contol mode 3.game mode. Our aim is to control the tractor while working in the field so chooses the control mode. It shows the commands like forward, backward, left, and right.

Controlling of mobile Bluetooth : Mobile Bluetooth is controlled by using commands present in the app. In this working we given the code of respective command, the arduino program code and this command code both are equal it moved the vehicle. It means to give the commands used in the program to given that command only given in mobile app. If you give incorrect commands in the mobile app the tractor not moved.

Bread board : A modern solder less breadboard socket consists of a perforated block of plastic with numerous tin plated phosphor bronze or nickel silver alloy spring clips under the perforations. The clips are often called tie points or contact points. The number of tie points is often given in the specification of the breadboard.

Interconnecting wires and the leads of discrete components (such as capacitors, resisters, and inductors) can be inserted into the remaining free holes to complete the circuit of the

It is a tool for holding the components of your circuit, and connecting them together, through holes. The holes on the breadboard are separated by 0.1-inch spaces. Using a breadboard, which is what, makes them very useful and convenient for building circuits. LED Lights also connected in this board. First we connect the two devices (arduino, motor module) in series by connecting the one end of one component to a row. It is having holes. All the holes in each of these lines are connected together with a strip of metal in the back. In the center are several short rows of holes separated by a central divider. All of the five holes in each row in the center are connected with a metal strip as well. Breadboards have evolved over time, with the term now being used for all kinds of prototype electronic devices.

GPS Module : The GPS is a space based navigation system that provides information on location anywhere on this earth. It makes use of 24 satellites that orbits the earth to get the location. The GPS receivers we use today are extremely accurate. It provides the exact location of the field where the task has to be performed.

By using GPS system the traveled history locations of our tractor is recorded in the GPS module. And when we enter the GPS code in the PC. It will show the path traveled by the tractor. This can prevent the tractor free from theft. The recorded data will also useful for the program RTH (return to home). When we give commands to tractor to travel from initial position to the farm area, after the completion of the work in the farm by using RTH program it will reverse the path which it had previously traveled and reach home without help of any commands. This RTH technology is mainly seen in drones now days. By using this GPS system, we can control multiple autonomous tractors by connecting them internally by GPS units and can control by a single person at a time. The other autonomous tractors will follow the main tractor for which the commands will be given by the farmer. A smart tablet will be provided with the tractor which has instructions itself to control the tractor. The Tab consists of the applications which will be useful to the following functions :

The controlling of the tractor by giving the commands.

The traveled path history of the tractor GPS.

The visibility of the tractor location with the detection of objects around it.

By using Panono camera we can see the tractor by virtual reality mode.

The autonomous tractor can also run with the help of voice commands. For this operation farmer need to register the voice first in the given tab.

Fig.-3 : GPS Connection.

Tractor : Farmers send command through smart phone using app Arduino to tractor using Bluetooth. Tractor has HC – 05 Bluetooth Module which receive the command and send it to Arduino UNO board for further processing. Arduino process the command and perform the operation accordingly.

Fig.-4 : Tractor Prototype.

Methods of operation of tractor : We followed the below methods for operation of our autonomous tractor. It is having four modes.

Mode-1 Tractor Controlling : In this mode farmer or operator can control the Navigation of Tractor. User can send left, right, forward, reverse, stop command tractor and can control its movement. It is a normal mode. So if users don't want any advance feature then he can simply control tractor.

Mode-2 finding of tractor location by GPS : In this Mode Farmer or operator can send command to arduino with the help of Bluetooth module to get the current GPS Location of tractor.

Mode-3 Controlling of Implement : In This Mode Farmer or operator can assign task to smart phone to the tractor with the help of Bluetooth module and will take help of implement to complete that task. We have implemented cutting task (on Tractor and implement both), completing task (Implement only), and Seeding task (Implement only). So farmer can select any task to perform. If cutting task is selected then tractor and implement work together or complete the task and if seeding or completing task is selected master will instruct slave to perform task. Between tractor and implement handshaking will happen i.e. Tractor will send any command and implement will send ACK for that command.

Mode-4 Tractor Cutting Task : In this Mode farmer will send cutting task to Tractor. Since tractor has cutting tools so it will perform cutting operation. In this mode Tractor will not ask any help of Implement. Tractor is controlled by following flow :

Tractor received the commands from farmer or operator through HC-05 Bluetooth module.

This received command send to Arduino –UNO for further processing.

If farmer or operator has selected mode 1 then based on command Arduino will send control signal to L298 motor driver unit to control tractor motor for tractor movement and directions.

If farmer has selected mode 2 then Arduino will start receiving GPS data and will extract latitude and longitude out of it to display current location of master vehicle and display it on tablet or computer.

If farmer or user has selected mode 4 then Arduino will send command to L298 motor driver unit to control operation of cutting tool attached Tractor vehicle. Simultaneously tractor will navigate to a predefined path (i.e. the movement for path navigation is predefined).

Tractor will continuously monitor for any ACK from slave (sent through cc2500) and any command from user (sent through Bluetooth).

Implement Equipment

Implement vehicle operate as per Tractor vehicle instruction.

When farmer operate tractor vehicle in swarm mode i.e. Mode 3 then tractor will send instruction to implement through radio receiver to execute particular task.

In cutting task master vehicle will perform cutting operation and slave vehicle will do picking operation. So master vehicle will cut the crops and slave vehicle will pick the crops.

In plugging and seeding task tractor vehicle will not perform any task it will only send instruction to implement vehicle to execute particular tasks.

Operations for Tractor & Implement operation : Implement vehicle will receive command from tractor vehicle through radio receiver.

All the received commands send to Arduino UNO for decision making and further processing.

Based on the task Arduino will instruct motor driver unit to operate.

For cutting task implement has gripper which work as a picking tool so when tractor will cut the crop implement will pick up it.

For cutting and seeding task tractor will send vehicle movement instruction also to implement so slave will navigation a predefined path decided by tractor.

For plugging task only plugging tool is operated no vehicle movement is involved.

Once slave will receive proper command from master will send ACK to master as a confirmation. Based on ACK from master will send next set of command to it.

Results and Discussion

This chapter contains the results and discussion of the research work conducted in order to full fill the objectives of study. The performance of the tractor was evaluated under laboratory and field conditions. The laboratory and field experiments were carried out to cheque the performance and working condition of a tractor (proto-type) and also how it cutted the weeds also observed. The laboratory and field experiments were conducted in the college laboratory and field in the college, Visas College of engineering and technology in department of Agricultural Engineering during the year 2017-18.

Development of Driverless Tractor : The drive less tractor is developed by assembling the electrical devices and parts viz, chassis frame, front wheels, rear wheels, arduino, motor module, Bluetooth module, bread board, driver module and attaching of an equipment or implement weeder. The details of the assembling procedure were explained in the chapter II.

Type of design : Laboratory &Field set –up(proto type)

Type of Implement : weeder. All type of implements also suitable

Table-1 : Specifications of Tractor.

S. No.	Name of device	Specifications	Material used
1.	Chassis frame	40 cm*15 cm	Ply wood
2.	Arduino	UNO	
3.	Motor module	L298 HV(DC)	
4.	Bluetooth module	HCO5	
5.	Bread board		
6.	Motors	1000 rpm	
7.	Shafts	5mm diameter, 15cm length.	Mild steel
8.	Batteries	HW(High –Watt)	
9.	Ultrasonic system		
10.	Rear wheels Front wheels	13-14 cm 5-6 cm	

Conclusions

The main aim of design set up to reduce the labor cost and modernize the autonomous tractor was developed at laboratory, Department of farm machinery and equipment, department of Agricultural engineering in Vikas college of engineering and technology, Nunna. The design was developed for calculating the working performance of autonomous tractor.

The various devices like chassis frame, Arduino, motor module, Bluetooth module, sensors, GPS, and drive motor were selected functionally and also withstand working performance. Tractor were tested on this design setup successfully in laboratory and field, Department of farm machinery and equipment, in Department of agricultural engineering in Vikas college of Engineering and technology, Nunna. The conclusion of related design under study is given below.

1. We have implemented a smart farming using autonomous tractor system. Our System successfully operates in four modes to perform various tasks; cutting, weeding.

2. Overall, the system performed quite well, navigating accurately up and down the rows, even in the presence of hazards such as irrigation ditches.

3. We are sure this is going to great help to our farmer because it is a affordable and low cost with user friendly to access also.

4. The main aim of this project is to reduce the labor cost and modernize the traditional agriculture with the help of available technology.

5. It can assure higher output and profitability.

Suggestion for future work

1. Based on the experience gained in this study, our suggestion is given for further modification in the design of autonomous tractor.

2. Instead of controlling tractor by using the smart phone, it's better to give it a program and try to run on its own as a robot for the better improvement of technology.

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Financial Support to Farmers for Sustainable Development of Agriculture in India : An Overview

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Abstract

In this paper we have study about government policy and financial supports to farmers through different scheme and project for sustainable development of agriculture in India. Govt of India has launch different scheme like PM KISAN scheme, which gives farmers direct cash benefit of Rs 6000 per farmer per year. The government has distributed around Rs 54,000 crore benefiting 87.1 million farmers. It will be great help to farmers support their living. As a farm of subsidy for the formers government has been given subsidy expenditure in 2017-18 about Rs. 3, 57,700 crores. By the government under the scheme of solar-powered pumps the farmers will have to spend only 10% of the total expenditure to acquire an install a solar pump remaining 90% of amount will be pay by central, state govt. and bank as an instalment. Apart from this assistance is provided under different schemes by the Government for promoting organic farming in the country for the sustainable development of agriculture.

Key words : *Agriculture, sustainable development and financial support.*

Introduction

India is an agricultural-based country, where 60% of its population is currently based on agriculture. Agriculture is the backbone of the Indian economy. The contribution of agriculture sector to India's GDP is about 15%. It has been said that India was a golden bird because of lot of natural resources in India. There is no shortage of natural resources but colonialism has caused great damage to the Indian agriculture-based economy, as a result, the Indian agricultural-based economy has faltered. But after independence the agro-based economy has gained momentum again and India has become 7th exporter across the world of agriculture produce.

Presently the Indian agriculture system is facing various challenges such as Week Finance Position of Farmer, Limited Report of Production, Climate Change and damage to the ecosystem. These are the biggest Challenge in Front of Indian Agriculture. To solve all the above challenges and sustainable development of agriculture, various schemes have been started by the Government of India through which financial assistance is being provided to the farmers directly and indirectly.

Objective : To study of financial support to farmers for sustainable development of agriculture in India

Materials and Methods

The study has been conducted mainly on the basis of secondary data and literature survey. Data have been found out from various journals, research papers, annual reports, Newspaper articles, Ministry of Agriculture & Farmers Welfare and R.B.I, NABARD annual report,

Results and Discussion

Result and discussion has classified in three part A, B, and C

A. Direct financial support to farmers

B. Financial support through loan wavier to farmers

C. Subsidy and other support for Agriculture Sector to sustainable development

A. Direct financial support to farmers

It is concluded in this study on the basis of secondary data PM Kisan Scheme was launched by the Government of India on December 2018 to make farmers financially strong and provide income support by way of a cash benefit to all landholding farmers (subject to certain exclusion criteria) to enable them to fulfil their agricultural requirements and support their families. Under this scheme, financial assistance of ₹ 6000 is being provided every year to the farmer brothers, ₹ 54000 has been distributed by the Government of India to the farmers till the year 2019. Govt have verifying them with states for linking it with their Aadhar number. In table number 5 it is found that the most beneficiary farmers are in Uttar Pradesh, whose percentage is 21.1 percentages the second place is from Maharashtra, which is about 8.4 percentages.

Table-1 : Income support to farmers under PM Kisan Scheme.

S. No.	State	Number of Beneficiary (million)	Percentage of total
1.	Uttar Pradesh	18.40	21.12
2.	Maharashtra	7.70	8.84
3.	Tamil Nadu	3.50	4.20
4.	Telangana	3.47	3.88
5.	Andhra Pradesh	5.01	5.74
6.	Bihar	5.34	6.13
7.	Rajasthan	5.09	5.84
8.	Madhya Pradesh	4.93	5.66
9.	Other State	33.66	38.64
	All India	87.10	100

Source : Lok Sabha question (PM Office)

B. Financial support through loan wavier to farmers

According to the information received from various sources of government, due to the adverse conditions of climate like drought, floods, a very bad effect was seen on the economic condition of the farmers, for which the government of different states announced loan waiver for the farmers. From 2014-2015 to 2019-2020, in this five years, only 10 states have gone in for such schemes. These are Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Maharashtra, Karnataka, Rajasthan, Uttar Pradesh and Punjab Telangana and Tamil Nadu. Since 2014-15, a total of Rs 2.31 lakh crore of loan waivers have been announced by all these states. In table no 5 data shows fiscal year 2017-18, Rs. 1.22 lakh crore was announced by the these states and in 2018-2019, Rs. 1.04 lakh caror loan waivers have been announced by all these states.

Table-2 : Financial support through loan wavier to farmers.

Year	Amount of Loan wavier (Rs. Lakh caror)	Source	Loan wavier 10 State
2017-2018	1.22	PRS Legislative Research	AP, Telangana, TN, Maharashtra, Karnataka, MP, Chhattisgarh, Rajasthan, UP and Punjab.
2018-2019	1.04	By Madan Sabnavis 2020	
Total	2.26		

C. Subsidy and other support for Agriculture Sector to sustainable development. It is also classified in four parts

1. Subsidy support for Agriculture Sector to sustainable development.

2. Financial support for sustainable agriculture development through National Adaptation Fund for Climate Change (NAFCC)

3. Financial support to Renewable Energy Revolutionizing Farmers Incomes and sustainable agriculture development

4. Financial support under different schemes by the Government for promoting organic farming

Subsidy support for Agriculture Sector to sustainable development : In the table number 6 have shown subsidy of different agriculture input. The maximum subsidiary have been given in power sector of Rs. 91000 crore followed why fertilizer Rs. 70000, price support Rs. 24000 credit rupees 20000 irrigations Rs. 17500 and crop insurance Rs 13000 respectively. The total subsidy has been given on agriculture input Rs. 2, 35,500. The govt. of India gives big relief to farmers as loan waivers of Rs. 1, 22,200 in the year of 2017-18. According to different sources in the table the grant total financial support to the farmers has been given Rs. 3,57,700.

Table-3 : Expenditure on major agricultural input subsidies and loan waivers (Rs. Crores).

S. No.	Subsidies Items	Year	Subsidies (Rs. Crores)	Source
1.	Crop Insurance	2018-19	13000	Union Budget
2.	Irrigation	2013-14	17500	Central Water Commission
3.	Credit	2017-18	20000	Union Budget
4.	Price Support	2015-16	24000	Author's estimate
5.	Fertilizer	2017-18	70000	Union Budget
6.	Puwer	2016-16	91000	Power Finance Corporation
	Total		235500	
7.	Loan waivers	2017-18	122200	PRS Legislative Research
	Grant Total		357700	

Source : Compiled from the sources mentioned in the Table. The price support subsidy is the author's computations.

Table-4 : Proportion of Subsidy expenditure on farm income per hectare.

S. No.	Subsidy Items (2014-15)	Source	Subsidy Amount in Rs. (2004-05)
1.	Price support subsidy per hectare	(Author's Estimate)	1050
2.	Input Subsidy per hectare	(Bathla et. al, 2017)	7750
	Total		8800
3.	Farm cultivator income per hectare	(Chand, 2017)	42,644
Subsidy income/Farm Income			21%

Financial support for sustainable agriculture development through National Adaptation Fund for Climate Change (NAFCC) : National Adaptation Fund for Climate Change (NAFCC) is a Central Sector Scheme which was set up in the year 2015-16 under this scheme government has allotted Rs.483.76 caror in last three year from 2015-16 to 2017-18 and sanction the amount of Rs. 236.32 crore. It revealed in the table maximum amount allotted and sanctioned in the year of 2015-16 of Rs 235.17 and fallowed Rs.113.93 in 2016-17,and Rs. 24.02 in 2017-18 respectively.

Table-5 : Financial support through national adaptation fund for climate change.

Year	Total cost of the project as per DPR (Rs. In Crore)	Amount Sanctions (Rs. In Corer)
2015-16	235.17	118.37
2016-17	200.55	93.93
2017-18	48.04	24.02
Total	483.76	236.32

Source : Ministry of Environment, Forest and Climate Change.

Financial support to Renewable Energy Revolutionizing Farmers Incomes and sustainable agriculture development : Pradhan Mantri Kusum Yojana has been started by the Government of India for the sustainable agriculture development and to increase the income of farmers. Under this scheme, a target has been set to install solar water pumps on the fields of 20 lakh farmers. The Govt. have been allotted Rs. 22000 crore under this scheme till 1st January 2020. The table no. has been shown under this scheme the farmers will have to pay only 10%, the rest of the 60 percentage payment for solar water pump will be given by the government in the form of subsidy remaining 30 percent will be taken cure by the bank as credit.

Table-6 : Subsidy support to farmer under PM Kusum Scheme.

S. No.	Particular	Subsidy Amount %	Remarks
1.	Central Government	60%	The total cost as Subsidy
2.	Banks	30%	The total cost as Loans to Farmers
3.	Farmers	10%	The Total Cost
	Total	100	

Financial support to other various schemes by the Government of India for promote organic farming : The Government of India is providing ? 50000 assistance per hectare for 3 years for Paramparagat Krishi Vikas Yojana, out of the above assistance amount, 62% i.e. ₹ 31000 is being provided as incentive for organic inputs. Mission Organic Value Chain Development for North Eastern Region farmers are given assistance of Rs 25000/ha/3 years and support for formation of FPOs, capacity building, post-harvest infrastructure up to Rs 2 corers are also provided in the scheme. National Mission on Oilseeds and Oil Palm financial assistance provide to bio-fertilizers, supply of Rhizobium culture/Phosphate Solubilising Bacteria (PSB)/Zinc Solubilising Bacteria (ZSB)/Azatobacter/Mycorrhiza and vermi compost. National Food Security Mission financial assistance is provided for promotion of Bio-Fertilizer. Capital investment Subsidy Scheme under Soil Health Management Scheme 100% assistance is provided to Government agencies for setting up of mechanized fruit/vegetable market waste/Agro waste compost production unit up to a maximum limit of Rs.190.00 Lakh. Similarly, for individuals/ private agencies assistance up 25% to 33% of cost limit to Rs 63 lakh/unit as capital investment is provided. Scheme detail is also given in table no seven.

Table-7 : Scheme for promoting organic farming in the country by government of India.

S. No.	Name of Scheme	Purpose	Amount Under Scheme
1.	Paramparagat Krishi Vikas Yojana (PKVY)	Promote organic farming.	Rs.50,000 per ha /3 years for organic inputs
2.	Mission Organic Value Chain Development for North Eastern Region (MOVCDNER)	Development of organic value chains	Rs 25000/ha/3 years for organic inputs
3.	National Food Security Mission (NFSM)	promotion of Bio-Fertilizer	@50% of the cost limited to Rs.300 per ha.
4.	National Mission on Oilseeds and Oil Palm (NMOOP)	promotion of Bio-Fertilizer	@ 50% subsidy to the tune of Rs. 300/-per ha
5.	Capital investment Subsidy Scheme (CISS)	capital investment to Promote Organic farming	25 to 33% subsidy of total project cost (190 Lakh limit of Project cost)

Source : Ministry of Agriculture & Farmers Welfare

India position in the world in organic farming : According to information received from various sources such as International Federation of Organic Agriculture Movements (IFOAM) and Research Institute of Organic Agriculture (FiBL) the Statistics 2020, India stands at 9th place in terms of certified agricultural land with 1.94 million ha (2018-19). Comparative Indian position in organic farming like China, Brazil and America is as follows :

Table-8 : India position in the world in organic farming

Sr. No.	State	Position	Area under organic Certification (in million ha.)
1	China	3rd	3.14
2	USA	7th	2.02
3	India	9th	1.94
4	Brazil	12th	1.18

Source : Press Information Bureau Government of India.

Conclusions

It is concluded in this study the various agricultural schemes have been started by the Government of India for the permanent solution of various problems of the agriculture sector for the sustainable development. The government of India gives big relief to farmers as loan waivers, providing subsidy on all inputs, providing financial assistance for organic farming and developing agriculture infrastructure. The main objective of all the above assistance is to strengthen the farmers and Indian agricultural economy on the basis of sustainable agriculture development.

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Effect of Integrated Pest Management Module for Management of Thrips in Onion (*Allium cepa* L.)

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Abstract

An experiment was conducted for two consecutive years during *rabi* season of 2019-20 and 2020-21 to assess the performance of IPM module against the onion thrips in comparison to the non-IPM module (farmers' practice) on ten farmers' field in adopted village of Krishi Vigyan Kendra, Khargone (M.P.). Treatments comprised IPM module T_1 (Blue sticky trap @ 50/ha at 10 DAP + Neem oil 3000 ppm @ 600 ml/ ha at 30 DAP and need based spray of Fipronil 5% SC @ 1 lit/ha) and non-IPM T_2 (Farmers' practice: spray of imidacloprid 17.8% SL @ 150 ml/ha at 15 days interval). It has been observed that minimum population of thrips was recorded in IPM fields and maximum population of the thrips was observed in non-IPM fields. Whereas, pooled bulb yield for IPM plots was 296.00 q/ha for both seasons, as against 252.15 q/ha in non-IPM fields. Hence, it is apparent that studied IPM module was able to increase the yield of onion with lower cost of production as against non-IPM.

Key words : *IPM module, onion, thrips, yield.*

Introduction

Onion (*Allium cepa* L.) is one of the essential commercial vegetable grown in India. It's far favoured via humans for its special flavour and is relished often as "green" for salad and Indian delicacies are incomplete without onion. There are several factors that lead to the low productivity of onion. Among these, one of the major constraints is insect pest. Among the insect pests, onion thrips, *Thrips tabaci* Lindeman has become a global pest of increasing concern in the past three decades (Diaz-Monatano *et al.,* 2011 and Gill *et al.,* 2015). Both nymphs and adults are the damaging stages which feed by rasping the leaves and other tissues of plants and suck the sap, as a result, it causes silver patches and streaks on leaves. Among the insect pests, onion thrips, *Thrips tabaci* is one of the major limiting factor in reducing the productivity and reported to cause significant economic losses up to 30-50 per cent (Nault and Shelton, 2012). Failure to control this pest by timely and effective means causes considerable damage and results in immense economic loss by remarkably reducing yield (Anonymous, 2000; Juan, 2002). To tackle this sucking pest menace, farmers are extensively using contact and synthetic insecticides and also synthetic pyrethroides. However, repeated application of same group of chemicals is not a desirable practice as this could lead to undesirable resistance problems. Thrips is susceptible to developing insecticide resistance and reduced effectiveness of conventional insecticides has been reported (Shelton *et al.*, 2006). To avoid further resistance in this pest, different IPM methods need to be evaluated. Integrated pest management strategies that boost onion plant health and tolerance to thrips, in addition to suppressing thrips densities, have to be developed for the most sustainable and economically viable thrips management tactics.

Materials and Methods

The experiment was conducted for two consecutive years during *rabi* season of 2019-20 and 2020-21 on ten farmers' field in adopted village of Krishi Vigyan Kendra, Khargone (M.P.). Onion cultivar Agrifound Light Red was used for the experiment. The crop was raised following recommended package of practices. Forty days old seedlings were transplanted in the main field at 15 cm × 10 cm spacing. There were two treatments comprised IPM module T_1 (Blue sticky trap @ 50/ha at 10 DAP + foliar spray of Neem oil 3000 ppm @ 600 ml/ ha at 30th day of after transplanting + need based spray of Fipronil 5% SC @ 1 lit/ha) and non-IPM T_2 (Farmers' practice: Spray of Imidacloprid 17.8% SL @ 150 ml/ha at 15 days intervals). All other agronomical practices were performed as per need uniformly in all the treatments. For thrips population, data were recorded at 45 and 60 days after transplanting (DAP) by counting the number of thrips (nymphs + adults) on 10 randomly selected plants in each plot. Yield data were recorded at harvest, cost of cultivation/ha, gross return/ha, net return/ha and BC ratio were worked out as per standard methods. Various parameters were compared as per paired "t" test of significance.

Results and Discussion

Effect of IPM module on population of thrips : The pooled data presented in table-1 revealed that significantly the thrips population at 45 DAP in IPM fields (Blue sticky trap @ 50/ha at 10 DAP + foliar spray of Neem

Table-1 : Effect of IPM module on population of thrips in onion crop.

Treatments	Thrips Population (No./plant) at 45 DAP			Thrips Population (No./plant) at 60 DAP		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
IPM	4.64	4.44	4.54	2.57	2.54	2.55
Non-IPM	7.39	7.24	7.32	4.66	4.51	4.58
t-value						

Table-2 : Effect of IPM module on yield of onion crop.

Treatments	2019-20		2020-21		Pooled Yield	
	Bulb Yield (q/ha)	Increase in Bulb yield (%) over Non IPM	Bulb Yield (q/ha)	Increase in Bulb yield (%) over Non IPM	Bulb Yield (q/ha)	Increase in Bulb yield (%) over Non IPM
IPM	297.70	18.08	294.30	16.69	296.00	17.30
Non-IPM	252.10	-	252.20	-	252.15	
t-value						

The result is significant at $p < 0.05$

Table-3 : Effect of IPM module on economics of onion crop.

Treatments	Cost of cultivation (Rs/ha)		Gross return (Rs/ha)		Net return (Rs/ha)		B:C ratio	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
IPM	96443	97534	297700	294300	201257	196766	3.09	3.02
Non-IPM	98900	100058	252100	252200	153200	152142	2.55	2.52

oil 3000 ppm @ 600 ml/ha at 30th day of after transplanting + need based spray of Fipronil 5% SC @ 1 lit/ha) were lower (4.54 thrips/plant) as compared to the Non-IPM fields (Farmers' practice: Spray of Imidacloprid 17.8% SL @ 150 ml/ha at 15 days intervals) (7.32 thrips/plant).

Further, data of thrips population were also observed at 60 DAP in onion. Pooled data recorded at 60 DAP reveal that the minimum 2.55 thrips/plant were observed with IPM module T_1 (Blue sticky trap @ 50/ha at 10 DAP + foliar spray of Neem oil 3000 ppm @ 600 ml/ ha at 30th day of after transplanting + need based spray of Fipronil 5% SC @ 1 lit/ha) as compared to the Non-IPM T_2 (Farmers' practice: Spray of Imidacloprid 17.8% SL @ 150 ml/ha at 15 days intervals) (7.32 thrips/plant). Pandey *et al.,* (2013) recorded that lowest thrips population by applying fipronil. The findings are also in conformity with the study conducted by Tripathy *et al.,* (2013) who reported that significant reduction of thrips population in IPM module over the untreated plot.

Effect of IPM Module on Yield and Economics : The results presented in Table-2 that the highest yield (297.70 q/ha) was recorded in IPM fields with 18.08% gain in 2019-20 and 294.30 q/ha with 16.69% gain in 2020-21 respectively over non-IPM fields. The lowest yield was recorded in non-IPM fields during 2019-20 and 2020-21. Similar observation was also reported in previous study where IPM module achieved more bulb production of onion over the farmers' practice (Tripathy *et al.,* 2013).

The cost of IPM was slightly lower (Rs 96443/ha & Rs 97534/ha) as against non-IPM (Rs 98900/ha & Rs 100058/ha) fields during 2019-20 and 2020-21, respectively which may be attributed to reduction in number of sprays of pesticides in IPM fields. The highest net return of Rs 201257/ha and BC ratio 3.09 were recorded in IPM fields. However, net return of Rs 153200/ha was recorded in non-IPM fields with B C ratio of 2.55 (2019-20). Similarly, the highest net return Rs 196766/ha with BC ratio 3.02 was recorded in IPM field and Rs 152142/ha with BC ratio 2.52 in non-IPM fields during 2020-21 (Table-3). These findings are in tune with the reports of Devi1 and Roy, 2018 who reported that incremental benefit cost ratio (IBCR) was found more in IPM module than the farmers' practice.

Conclusions

IPM module, a combination of organic and chemical insecticides outlined above, help reducing damage caused by thrips. It may be concluded that the IPM modules for management of thrips is more efficient and effective technology over non-IPM.

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Feeding Behaviour in Growing Deccani Sheep Fed with *Moringa* Leaf Meal-Based Diet

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Abstract

Present investigation has been carried out on Eighteen growing Deccani sheep of uniform body weight (14.22 kg) were reared in intensive farming at LFC, Rajendranagar Hyderabad to investigate the impact of feeding Moringa leaf meal on feeding behaviour and intake and digestibility in Deccani sheep. The animals were divided randomly into three groups (three males and females in each) taking into consideration the group averages of body weights in all 3 groups were as uniform as possible. Three experimental diets were prepared using 100 percent groundnut cake (T1), 75% groundnut cake+ 25% *Moringa oliefera* leaf meal (T2) and 50% groundnut cake+ 50 % *M. oliefera* leaf meal (T3) as protein source in the concentrate mixture and offered @ 1% of body weight along with *ad libitum* green fodder. Time spent and percentage of total time spent on eating and sleeping were significantly ($P<0.01$) higher in T2 (50.0 ±0.78 and 18.33±1.75) group lambs than T3 (47.91±1.69 and 22.5±0.68) and T1(46.25±0.78 and 26.26±0.48) group lambs and no significant difference was noticed between T1 and T3 group lambs. More time spent in eating in T2 group indicate that the Moringa based diet (25%) was relatively more palatable than the other two groups.

Key words : *Chemical composition, digestibility, feeding behavior, Moringa oleifera.*

Introduction

India is the largest producer of Moringa (Radovich et. al., 2011), with an annual production of 1.1 to 1.3 million tons of fruits pods and an average green leaf fodder yield up to 120 tons/ha/year (Sagbo *et. al.*, 2006). The advantage of using moringa as a protein source are numerous and include the fact that it is a perinial plant that can be harvested several times in one growing season and also has the potential to reduce feed cost of livestock ration. Due to its potential benefits it is popularly known as “Miracle Tree”.

Over the past decade a progressive decline in the global sheep population was observed, and in 2008 the universal flock size was estimated at 1000 million sheep. This decline could be ascribed to seasonal droughts, unpredictable weather patterns, diminishing land resources and an unstable economy with fluctuating meat prices. The global trend in animal production is a systematic transition from small-scale extensive production to large-scale intensive production systems (Venkatata Raju N *et al* 2015).

Feeding behavioural studies are useful in the palatability and choice of feed for the sheep and the acceptability of feed is probably one of the prime parameters for ascertaining utility of the non-conventional feed resource.

Utilization of fodder trees and shrubs could be a potential strategy for increasing the quality and availability of feeds for resource-limited livestock farmers during the dry season. The trees provide a good and cheaper source of protein and micronutrients (Moyo *et al.,* 2012a). In recent years, there has been increased research on alternative protein sources from forage trees and shrubs that can be fed to sheep. In recent years, attention has been given to the use of moringa leaf meal (MLM) as a protein source and feed component in animal production especially in goats (Sarwatt *et al.,* 2002; Asaolu *et al.,* 2010). There are many advantages of using moringa foliage as protein source including the fact that it is a perennial plant that can be harvested several times in one growing season. The leaves can be fed fresh or dried with little effect on intake. Dried moringa leaf can be stored for longer periods

In India, there is scarce work on effect of feeding Moringa leves on feeding behavior and dry matter digestibility in sheep. Keeping in view of above points, the present investigation has been carried out to investigate the impact of feeding Moringa leaves on feeding behavior and dry matter digestibility.

Materials and Methods

Eighteen growing Deccani sheep of uniform body weight (14.22 kg) were reared in intensive farming at LFC,

Table-1 : Chemical Composition of feed ingredient and Moringa leaves (% DM Basis).

Constituent	De-oiled rice bran	Red gram chunni	Ground nut cake (De-oiled)	Cotton seed cake	Moringa Leaves	Para Grass
Dry matter	91.67	92.26	95.68	92.42	92.12	55.21
Crude Protein	13.54	13.87	34.03	24.45	24.39	6.48
Ether Extract	0.76	2.37	0.78	8.58	6.67	1.58
Crude Fiber	15.14	31.89	5.34	26.83	5.57	18.49
Total Ash	12.88	3.68	12.78	5.42	12.66	6.67
Acid Insoluble Ash	5.83	0.23	6.69	0.40	0.27	4.35
Total Phosphorus	1.92	0.72	0.75	0.98	0.65	0.10
Calcium	0.20	0.41	0.60	0.66	2.07	0.35
Neutral Detergent Fibre	24.10	18.60	26.28	34.60	38.84	68.70
Acid Detergent Fibre	11.50	15.17	22.3	20.20	12.94	42.3

Table-2 : Effect of feeding Moringa based diets on behavioural traits of Deccani lambs under Intensive farming system.

Behavioural Traits	Control T_1		T_2		T_3	
	Time Spent (Min)	% Total Time	Time Spent (Min)	% Total Time	Time Spent (Min)	% Total Time
Eating	114 ± 1.87	46.25 ± 0.78	120 ± 1.87	50 ± 0.78	115 ± 4.06	47.91 ± 1.69
Drinking Water	5 ± 0.37	2.8 ± 0.16	6 ± 0.37	2.5 ± 0.16	5 ± 0.45	2.8 ± 0.19
Ruminating	40 ± 4.47	16.16 ± 0.78	48 ± 1.87	20 ± 0.93	45 ± 2.24	18.75 ± 0.72
Standing	20 ± 2.00	8.33 ± 0.83	22 ± 1.87	9.16 ± 0.78	21 ± 2.45	8.75 ± 1.02
Sleeping	61 ± 2.92	26.26 ± 0.48	44 ± 1.16	18.33 ± 1.75	54 ± 4.2	22.5 ± 0.68
SEM	19.111	7.666	19.544	8.144	18.857	7.778
p-value	1.00	0.72	0.89	0.93	0.68	0.87

Rajendranagar Hyderabad and randomly allotted to three treatment groups with six lambs in each group (6 x 3) and reared in intensive farming.Three experimental diets were prepared using 100 percent groundnut cake (T1), 75% groundnut cake+ 25% *Moringa oliefera* leaf meal (T2) and 50% groundnut cake+ 50% *Moringa oliefera* leaf meal (T3) as protein source in the concentrate mixture and offered @ 1% of body weight along with *ad libitum* green fodder.

Behavioural recording was done by direct visual observation of lambs using a stopwatch for five days each for four hours from 8.00 AM-12.00 noon after refreshing of daily feed. The recorded activities were eating, ruminating, drinking, standing and sleeping as per the procedures of Fraser and Broom (1990).

Analytical Methods : The proximate analysis of feeds was performed as per the procedures described by AOAC (2005).

Statistical analyses : Statistical analysis of the data was carried out in accordance with Snedecor and Cochran (1994). Analysis of variance was used to test the significance of variance and the treatment means tested for significance by Duncans new multiple range F test (Duncan,1995).

Results and Discussion

Chemical composition of experimental diets : The chemical composition of the feed ingredients used in experiment i.e DORB, Red gram chunni, DGNC, CSC, dried leaves of Moringa, Para grass is presented in Table1. Proximate composition of feed ingredients and Moringa leaves used in the present study are shown in Table 1. The data indicated that the crude protein content of *Moringa oleifera* was 24.39%, this makes the Moringa leaves to be a good potential source of supplementary protein in animal diets. This level of crude protein content is of particular nutritional significance as it may meet animal's protein and energy requirements and boost the immune system against diseases. Moringa is reported to have high quality protein which is easily digested and that is influenced by the quality of its amino acids (Babeker and Bdalbagi, 2015). The acceptability of feed is probably one of the prime parameters for ascertaining utility of the non-conventional feed resource.

Feeding behaviour : Time spent and percentage of total time spent on eating and sleeping were significantly ($P<0.01$) higher in T2 group lambs than T3 and T1 group lambs and no significant difference was noticed between T1 and T3 group lambs. The percentage of time spent for ruminating was less than the time spent for eating in the present study. Time spent in eating and percentage of time spent in eating in T2 group indicates that the Moringa based diet (25%) was relatively more palatable. The literature on feeding behaviour with Moringa based diets are scanty in sheep. However, the present findings are disagreement with Abijoude et al. (2000) in sheep Nasrullah et al. (2013) in goats.

Conclusions

Moringa oliefera had a crude protein content of 24.39% on DB basis. Hence, it could be considered as an alternative proetein source for sheep feeding and dry matter intake was significantly higher in T2 group where as the sheep, more time spent in eating, ruminating, sleeping and dry matter intake, digestibility coefficients (%) suggests feeding of Moringa leaves 25% (T2) replacement in -intensive system of rearing and Moringa feeding can help small and medium scale farmers overcome shortages of good quality feeds and therefore sustain and improve their productivity. The result of the this study recorded that the supplementation of *Moringa oleifera* leaves 25%-in small ruminants shows boosting for all the parameter without any adverse effect and high protein content. However more research is needed to assure these finding.

There was no significant difference in feeding behaviour traits among lambs fed on different experimental diets in intensive farming system. More time spent in eating in T2 group indicate that the Moringa based diet (25%) was relatively more palatable than the other two groups.

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Population Dynamics of Aphid, *Lipaphis erisimi* (Kalt.) Infesting Mustard

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Abstract

Mustard is an important oilseed crop of family cruciferae grown in *Rabi* season. The seeds and oil of mustard have a peculiar pungency which makes it suitable for condiments and for the preparation of pickles, curries and vegetables. There are many insect-pests which are causing damage to the mustard crop. Among the different pests, a sucking insect, aphid (*Lipaphis erisimi* Kalt.) causes maximum damage to the mustard crop as both nymph and adults suck the cell sap from leaves, petioles, tender stem, inflorescence and pods and as a result plant becomes weak and stunted. Insects have capacity to change their behaviour and habitat with the changing of the environment and so, it is necessary to check the changing patterns of abiotic factors on infestation of mustard aphid. In mustard crop, the activity of aphid, *L. erisimi* was commenced from 1st week of December and remained upto 2nd week of March having first peak during during 3rd week of January (2.0 aphid index [A.I.] / plant). Thereafter, aphid population slightly declined *i.e.*, from 4th week of January to 2nd week of February. In 3rd week of February, aphid population was again increased and reached to its second peak during 5th week of February (4.20 aphid index/ plant) in mustard crop. In correlation data, there was positive significant impact on the incidence of aphid due to Maximum Temperature (MaxT) [0.536*] and BSS (Bright Sunshine Hours) [0.520*]. While, Minimum Temperature (MinT) [0.273], Morning Relative Humidity RH_1 [0.105] and Wind Speed [0.368] were positively correlated whereas, Evening Relative Humidity RH_2 [-0.301] was negatively correlated with the incidence of aphid population but the relationship was non-significant.

Introduction

Mustard (*Brassica juncea L.*) is an important oilseed crop of family cruciferae grown in *Rabi* season. Among the nine oilseed crops grown in the country, mustard assume significance in the national economy by occupying second position in area and production next to groundnut. In Gujarat, mustard is grown in an area of 2.21 lakh hectares with annual production of 3.99 lakh tonnes and productivity of about 1807.91 kg/ha (1). The green leaves and stems of mustard are good source of green vegetable and fodder. It is rich in oil content (40 %) which is used to extract edible oil. The seeds and oil of mustard have a peculiar pungency which makes it suitable for condiments and for the preparation of pickles, curries and vegetables. The oil is also used for soap making, softening of leather and lubrication purposes. After extraction of oil from seeds, the remnant (cake) is used as feed for mulching the cattle. The residual cake is valuable by product used as rich source of organic manure.

In mustard, various factors are responsible for reducing the crop yield, of which, insect pest are one of the important factors causes considerable yield losses in crop production. Among the different insect pests which are causing damage to mustard crop, aphid [*Lipaphis erysimi* (Kalt.); Family: Aphididae; Order: Hemiptera and Sub order: Homoptera] causes considerable economic losses in all the mustard growing regions of the country. The mustard aphid is a key pest feed on the stem, leaves, inflorescence and pods and often aerial parts of plant is covered over by a large number of aphids and also reported to infest roots of mustard plants (8). Both nymph and adult stages of this pest cause quantitative and qualitative losses in the mustard crop by sucking the cell sap from leaves, petioles, tender stems, inflorescence and pods. On the basis of economic importance, mustard aphid is considered as a key pest and can cause complete loss of the crop. Under different agro climatic condition, aphid causes 35.4 to 96 per cent yield loss, 30 per cent seed weight loss and 2.75 per cent oil loss (2) of the crop.

In the situation of global climate change and green house effects, living organism are changing their living habitat as well as approach which directly affect to their span of life. A dominant animal, insect, have capacity to change their behaviour and habitat with the changing of the environment and so, it is necessary to check the changing patterns of abiotic factors on mustard aphid so that a management programme might be formulated for this pest of mustard.

Materials and Methods

In order to determine the population dynamics of mustard aphids, the mustard crop was grown during second week of November, 2019 at the Instructional Farm, Department of Agronomy, College of Agriculture, JAU, Junagadh having plot area 20 square meter. Randomly, the experimental plot was divided into equal quadrates (1 x 1 square meters) and number of aphid (nymph and adult) was recorded from five randomly selected plants from each quadrate. The observation on population of aphids was recorded at weekly interval, starting from germination to the harvest of crop. The population of aphid were estimated by adopting zero to five index through the observation made on 10 cm terminal twigs. The mustard crop under experimentation was kept free from application of any insecticides. Generally, it was observed that mustard aphids sit in overlapping manner and hence, it was difficult to record aphids on numerical basis. Hence, aphid index is given for determining aphid population as described by (5).

Indices Description

0. Plant free from aphid infestation.

1. Only few aphids with very little injury.

2. Small colonies on few twigs, no curling or yellowing of leaves.

3. Aphid colonies on almost all the twigs, stunted growth, curling and yellowing of leaves.

4. Very heavy population of aphids on inflorescence, leaves, stem and siliqua (pod).

5. Complete drying of plants due to heavy infestation of aphids.

The average aphid index was worked out by using the following formula.

Average aphid index per plant

$$= \frac{0N+ 1N+ 2N+ 3N+ 4N+ 5N}{\text{Total number of plants observed}}$$

Where,

0, 1, 2, 3, 4 and 5 are aphid index.

N = Number of plants showing respective aphid index (5)

The observations on aphid index were recorded visually from five randomly selected plants from each plot. The weekly meteorological observations on maximum (MaxT) and minimum temperature (MinT), morning (RH_1) & evening relative humidity (RH_2), wind velocity (WV), bright sunshine hours (BSS) were obtained from the meteorological observatory of Instructional Farm, Department of Agronomy, College of Agriculture, JAU, Junagadh during the course of investigation. In order to study the influence of different meteorological parameters on pest incidence, simple correlation between periodical mean values of aphid with various abiotic parameters was calculated.

Results and Discussion

To know the effect of weather parameters on occurrence and abundance of aphid, *Lipaphis erisimi* (Kalt.) in mustard crop, a study was carried out during Rabi, 2020 at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh. The effect of various abiotic factors on the activity of aphid and its correlation coefficient were also worked out. The data on population of aphid presented in Table-1 indicated that the aphid population was commenced from 4th Week After Sowing (WAS) [1^{st} week of December i.e., 49^{th} Standard Meteorological Week- SMW)] and continued throughout the crop period which was ranged from 0.16 to 4.20 aphid index/plant. The infestation was gradually increased and reached to its first peak (2.0 aphid index/plant) in the 3rd week of January (3^{rd} SMW). Thereafter, aphid population slightly declined in the 4^{th} week of January (4^{th} SMW) to 2^{nd} week of February (6^{th} SMW) which was ranged from 1.80 to 1.20 aphid index/plant). Very next week, i.e., 3^{rd} week of February (7th SMW), population of aphid was again increased (2.0 aphid index/plant) and reached to its second peak during 5^{th} week of February (9^{th} SMW) (4.20 aphid index/plant). Thereafter, decreasing trend was observed up to 2^{nd} week of March (11^{th} SMW) as crop reached to its maturity. Relatively higher activity (1 - 4.20 aphid index/plant) was observed during 3^{rd} week of December to 5th week of February (51^{st} SMW - 9^{th} SMW) i.e., 6^{th} to 16^{th} WAS. Starting from the infestation to the harvest of the crop, pest showed continuous trend of increasing and after reaching its first peak, aphids were decreased and gained another peak. However, at the maturity of the crop, the negligible population with more number of winged aphids was observed on green stem of mustard.

Mustard aphid infestation was commenced in the 1st week of December with the population of 10.60 aphid /per plant. Thereafter, population increased gradually and gets its peak of 281.20 aphids/per plant during 2nd week of February (9). Lipaphis erisimi population was observed during 2^{nd} week of December to 1st week of March and the maximum (91.46 aphids/leaf) aphid population was observed in 2^{nd} week of February (6). Mustard aphid incidence started in 3^{rd} week of December in both years and attained first peak during the 3^{rd} week of February i.e., 4.92 aphid index. In case of second year, the population of aphid attained a first peak i.e., 4.26 aphid index during last week of February (4). The relatively higher (1 to 4.92 A.I. /plant) activity of aphid was observed during 2^{nd} week of January to 4^{th} week of February (3). Thus, the present findings are more or less in conformity with the earlier reports.

Table-1 : Population of aphid, *L. erysimi* infesting mustard.

Sr. No.	SMW	Month	Mean A.I. /plant
1	2	3	4
1	48	November	0.00
2	49	December	0.16
3	50		0.68
4	51		1.00
5	52		1.20
6	1	January	1.45
7	2		1.80
8	3		2.00
9	4		1.80
10	5	February	1.00
11	6		1.20
12	7		2.00
13	8		3.00
14	9		4.20
15	10	March	4.00
16	11		3.00

Note : SMW = Standard Meteorological Week; A.I. /plant means Aphid Index /plant.

The data on association between aphid infestation and weather factors presented in Table-2 indicted that there was significant positive relation with Maximum Temperature (MaxT) [0.536*] and Bright Sunshine Hours (BSS) [0.520*]. While, aphid population had positive correlation with Minimum Temperature (MinT) [0.273], Morning Relative Humidity (RH_1) [0.105] and Wind Speed [0.368] but the relationship was non-significant. However, Evening Relative Humidity (RH_2) [-0.301] were negatively correlated with the incidence of aphid population and the relationship was non-significant.

There was a positive correlation between aphid population and weather parameters *viz.*, bright sunshine hours (r = 0.101), maximum temperature (r = 0.128), morning relative humidity (r = 0.144) and wind speed (r = 0.169) (6). There was a significant negative correlation with evening relative humidity (r = -0.518*) and aphid population (4). There was a positive correlation of aphids with bright sunshine hours (r = 0.349), wind speed (r = 0.470) and maximum temperature (r = 0.405) while negative relationship with evening relative humidity (-0.334) (3). The aphid population had significant and positive correlation with wind velocity (r = 0.668*) and positive but non-significant correlation with minimum temperature (r = 0.230) (7).

Table-2 : Correlation of aphid, *L. erysimi* with biotic and abiotic factors in mustard.

Factors	Aphid
1	2
Bright Sunshine Hours, hrday-1 (BSS)	0.520*
Maximum Temperature, °C (MaxT)	0.536*
Minimum Temperature, °C (MinT)	0.273
Morning Relative Humidity, % (RH1)	0.105
Evening Relative Humidity, % (RH2)	-0.301
Wind Speed, kmhr-1 (WS)	0.368
Coccinelids	0.786**

Where, r = 0.497 at 5% level, r = 0.623 at 1% level
* Significant at 5% level, **Highly Significant at 1% level

Conclusions

In a nut shell, the incidence of aphid was commenced from 1st week of December i.e. 49th Standard Meteorological Week (SMW) and continued till 2nd week of March (11th SMW) which was ranged from 0.16 to 4.20 [aphid index (A.I.)/plant]. The infestation (0.16 A.I./plant) was started from 1st week of December (49th SMW) and showed first peak (2.0 A.I./plant) during 3rd week of January (3rd SMW). Thereafter, aphid population slightly declined in the 4th week of January (4th SMW) to 2nd week of February (6th SMW) which was ranged from 1.80 to 1.20 aphid index /plant). Very next week, *i.e.,* 3rd week of February (7th SMW), population of aphid was again increased (2.0 aphid index/plant) and reached to its second peak during 5th week of February (9th SMW) (4.20 aphid index/plant). In subsequent weeks, the incidence was decreased and reached to 3.00 A.I./plant during 2nd week of March (11th SMW). Starting from the infestation to the harvest of the crop, pest showed continuous trend of increasing and after reaching its first peak, aphids were decreased and gained another peak. However, at the maturity of the crop, the negligible population with more number of winged aphids was observed on green stem of mustard. In correlation data, aphid infestation and weather factors showed positive significant correlation with Maximum Temperature (MaxT) [0.536*] and Bright Sunshine Hours (BSS) [0.520*]. However, Minimum Temperature (MinT) [0.273], Morning Relative Humidity (RH_1) [0.105] and Wind Speed [0.368] were positively whereas Evening Relative Humidity (RH_2) [-0.301] was negatively correlated with the incidence of aphid population but the relationship was non-significant.

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Toxicity of Different Insecticides against Aphid, *Hyadaphis coriandri* Das and Coccinellid, *Menochilus sexmaculatus* (Fab.) in Fennel

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Abstract

Fennel, *Foeniculum vulgare* (Miller) is an important spices crop belongs to family umbelliferae. It is commonly known as '*Variali /Variari'* in Gujarati. The major constrains affecting yield of fennel are insect pests which causes injury to different growth stages of crop. Aphid (*Hyadaphis coriandri* Das) is to be considered as a key pest in all fennel growing regions. Therefore, it is necessary to find out the ecologically sound and environmentally safe methods for the control of this pest. Instead of widely used tool (chemical control) for the control of crop pests, biological control program may be proven to be better choice as many predacious coccinellid beetles have been successfully employed in this program against many injurious insects. In case of fennel crop, aphid population is naturally managed by coccinellids which plays a vital role in reducing the population of fennel aphid to a large extent. *Menochilus sexmaculatus* (Fab.), is one of the most common predatory coccinellids against aphids. Now days, indiscriminate uses of synthetic insecticides which cause resistance to this insect pest, destruction of beneficial organisms and environmental pollution. To find out the effect of different newer chemicals on aphid as well as predatory beetles *i.e.*, coccinellids, the toxicity of these insecticides was checked against aphids as well as predators. To test the toxicity, different nine insecticides were evaluated during *Rabi* 2019-20 and the results revealed that, after two sprays, aphid can be effectively managed by spray application of afidopyropen 5 DC, 0.007 % and cyantraniprole 10.26 OD, 0.014 % as they can restrict the aphid population below ETL *i.e.,* 1.00 AI. The date on toxicity of different insecticides against coccinellids revealed that, based on both the sprays, afidopyropen 5 DC, 0.007 %, cyantraniprole 10.26 OD, 0.014 %, spinetoram 11.7 SC, 0.011% and flonicamid 50 WG, 0.015% were found "safer" against coccinellid population.

Introduction

Fennel, *Foeniculum vulgare* (Miller) is an important spices crop belongs to family umbelliferae. It is commonly known as '*Variali/Variari'* in Gujarati. In Gujarat, the total area under fennel is 56,416 hectares with annual production of 1,17,340 million tonnes (MT) of seeds during 2018-19 (1). The major constrains affecting yield of fennel are insect pests which causes injury to different growth stages of crop. Aphid (*Hyadaphis coriandri* Das) is to be considered as a key pest in all fennel growing regions. The losses of fennel seeds due to injury by aphid up to 903 kg /ha, which means 50 per cent of the crop losses and considered as a major /key pest of fennel (11). Therefore, it is necessary to find out the ecologically sound and environmentally safe methods for the control of this pest. Instead of widely used tool (chemical control) for the control of crop pests, different IPM methods can be exploited to combat this obnoxious pest. The biological control program may be proven to be better choice as many predacious coccinellid beetles have been successfully employed in this program against many injurious insects. In case of fennel crop, aphid population is naturally managed by coccinellids which plays a vital role in reducing the population of fennel aphid to a large extent.

Menochilus sexmaculatus (Fab.), is one of the most common predatory coccinellids occupy all the habitats and niches of their preys and distributed worldwide (16). The adults of *M. sexmaculatus* are bright yellow in colour with black vertical zigzag lines on its elytra have gained much importance as biological control agents for aphids in India (3 & 13). Adults and larva of *M. sexmaculatus* (Coccinellidae: Coleoptera) are found predaceous on all stages of aphids (2) on different crops (4). In all, such an excellent predator *i.e.*, coccinellid have a great ability to combat aphids (*Hyadaphis coriandri* Das), a notorious pest infesting fennel.

Now days, indiscriminate uses of synthetic insecticides which cause resistance to this insect pest, destruction of beneficial organisms and environmental pollution. To find out the effect of different newer chemicals on aphid as well as predatory beetles *i.e.*, coccinellids, the toxicity of these insecticides was checked against aphids as well as predators. It is also indeed to check its benefit in form of safest chemicals against coccinellids. Looking of the importance of the fennel aphid and seriousness of this pest, it is necessary to have comprehensive detailed studies on relative toxicity of various insecticides against aphids and coccinellids.

Materials and Methods

In order to study the toxicity of different insecticides against coccinellids occurrence on fennel, the experiment was laid out in a Randomized Block Design with three replications having plot size of 3.75 x 3.00 m^2 during *Rabi* 2019-20 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. Fennel variety PF-35 was sown at a spacing of 75 x 30 cm in December, 2019. All agronomical practices were adopted as per the recommendation in vogue. Among the different coccinellids predating on aphids, *Menochilus sexmaculatus* (Fabricius) was found dominant and it was also confirmed by following conventional methods of identification. Details of insecticidal treatments are given in Table-1.

Application of insecticides : In fennel crop, first spray was carried out when the pest crossed its ETL (1.0 AI) and subsequent sprays were given after 15 days of first spray. The observations on aphid index from 10 cm terminal twigs from five randomly selected plant was recorded from the net plot prior to first spray and 3, 7, 10 and 14 day(s) after each spray. The data obtained were statistically analysed after following appropriate transformation. Numbers of larvae and adults of coccinellid beetles were also recorded from five randomly selected plants from the net plot before first spray and at 3, 7, 10 and 14 days after each spray. Fennel seed yield (Kg /ha) was recorded from the net plot area in each treatment. Further, the toxicity of different insecticidal treatments was adjudged based on pooled over period in the population of aphid and coccinellids.

Yield : With a view to ascertain the effect of different insecticides on aphid, *H. coriandri* in fennel, the seed yield was recorded separately from each plot. The yield was then converted on hectare basis.

Results and Discussion

Effect of different insecticides against aphid population after first spray : The incidence of aphid, *H. coriandri* was crossed it's ETL (i.e., 1.00 AI) after 13th week of sowing the fennel crop. The data of pooled over periods on mean aphid index after first application of insecticides presented in Table 2 revealed that all the treatments recorded significantly lower damage [0.83 to 1.74 A.I. /plant] than control [2.63 A.I. /plant]. Among the different insecticides, afidopyropen 5 DC @ 0.007% was found significantly superior [0.83 A.I. /plant] to the rest of the treatments and it was found at par with cyantraniprole 10.26 OD @ 0.014% [0.89]. The next best treatments were flonicamid 50 WG @ 0.015% [1.13], spinetoram 11.7 SC @ 0.011% [1.20], beta-cyfluthrin + imidacloprid 8.49 + 19.81 OD @ 0.011% [1.26], spirotetramate + imidacloprid 11.01 + 11.01 SC @ 0.022% [1.31] and sulfoxaflor 21.8 SC @ 0.0087% [1.44] as they were found mediocre in their effectiveness against *H. coriandri* and at par with each other. Dimethoate 30 EC @ 0.03% [1.67] and acetamiprid 20 SP @ 0.02% [1.74] was found least effective insecticides against *H. coriandri* and were found at par with each other. The performance of different insecticidal treatments was consistent over 3, 7, 10 and 14 days after spray as the interaction T x P non-significant. While, the performance was not consistent within the period because period showing significant impact.

Effect of different insecticides against aphid population after second spray : The subsequent spray *i.e.*, second spray was carried out after the 15 days of first spray as the pest population is very high at particular stage.

The data of pooled over periods on mean aphid index after second application of insecticides presented in Table-2 revealed that all the treatments recorded significantly lower damage [0.81 to 2.41 A.I. /plant] than control [3.35 A.I. /plant]. Out of nine different insecticides, afidopyropen 5 DC @ 0.007% was found significantly superior [0.81 A.I. /plant] to the rest of the treatments and it was found at par with cyantraniprole 10.26 OD @ 0.014% [0.89]. The next best treatment was flonicamid 50 WG @ 0.015% [1.32] which was at par with spinetoram 11.7 SC @ 0.011% [1.42] and beta-cyfluthrin + imidacloprid 8.49 + 19.81 OD @ 0.011% [1.55]. While, beta-cyfluthrin + imidacloprid 0.011% was found at par with spinetoram at one side while other side it was found at par with spirotetramate + imidacloprid 11.01 + 11.01 SC @ 0.022% [1.61]. Sulfoxaflor 21.8 SC @ 0.0087% [1.67] was found mediocre in their effectiveness and was at par with spirotetramate + imidacloprid 0.022%. While, dimethoate 30 EC @ 0.03% [2.29] and acetamiprid 20 SP @ 0.02% [2.41] were found to be least effective against *H. coriandri* and were at par with each other. The performance of different insecticidal treatments was consistent over 3, 7, 10 and 14 days after spray as the interaction T x P non-significant. While, the performance was not consistent within the period because period showing significant impact.

In nut-shell aphid, *H. coriandri* can be effectively managed by spray application of afidopyropen 5 DC, 0.007 % and cyantraniprole 10.26 OD, 0.014 % as they can restrict the aphid population below ETL i.e., 1.00 AI. Flonicamid, spinetoram, beta-cyfluthrin + imidacloprid, spirotetramate + imidacloprid and sulfoxaflor could manage the aphids but did not exhibit satisfactory protection and found mediocre in their effectiveness. Dimethoate and acetamiprid were found failed to provide satisfactory protection. Thus, the obtained results are

Table-1 : Details of insecticides used for their toxicity against coccinellid beetles.

Tr. No.	Technical name	Concentration (%)	Dose /10 l. water
1	2	3	4
T_1	Dimethoate 30 EC	0.03	10 ml
T_2	Acetamiprid 20 SP	0.02	10 gm
T_3	Flonicamid 50 WG	0.015	3 gm
T_4	Afidopyropen 5 DC	0.007	14 ml
T_5	Spinetoram 11.7 SC	0.011	10 ml
T_6	Cyantraniprole 10.26 OD	0.014	14 ml
T_7	Sulfoxaflor 21.8 EC	0.0087	4 ml
T_8	Beta cyfluthrin 8.49 + imidacloprid 19.81 OD	0.011	4 ml
T_9	Spirotetramat 11.01 + imidacloprid 11.01 SC	0.022	10 ml
T_{10}	Control (No Spray)	-	-

Table-2 : Toxicity of different insecticides against coccinellid beetles after first and second spray.

Treatments	Pooled over periods first spray)		Pooled over periods (second spray)	
	Aphid index /plant	No. of coccinellids /plant	Aphid index /plant	No. of coccinellids /plant
1	2	3	4	5
Dimethoate 30 EC, 0.03%	1.29 (1.67)	1.39 (1.93)	1.51 (2.29)	2.28 (5.20)
Acetamiprid 20 SP, 0.02%	1.32 (1.74)	1.43 (2.03)	1.55 (2.41)	2.30 (5.31)
Flonicamid 50 WG, 0.015%	1.06 (1.13)	1.99 (3.96)	1.15 (1.32)	3.06 (9.38)
Afidopyropen 5 DC, 0.007%	0.91 (0.83)	2.05 (4.18)	0.90 (0.81)	3.13 (9.78)
Spinetoram 11.7 SC, 0.011%	1.09 (1.20)	2.01 (4.05)	1.19 (1.42)	3.09 (9.57)
Cyantraniprole 10.26 OD, 0.014%	0.94 (0.89)	2.03 (4.11)	0.95 (0.89)	3.11 (9.66)
Sulfoxaflor 21.8 SC, 0.0087%	1.20 (1.44)	1.76 (3.11)	1.29 (1.67)	2.71 (7.34)
Beta-cyfluthrin + Imidacloprid 8.49+19.81 OD, 0.011%	1.12 (1.26)	1.47 (2.17)	1.24 (1.55)	2.32 (5.38)
Spirotetramate + Imidacloprid 11.01 + 11.01 SC, 0.022%	1.15 (1.31)	1.73 (2.98)	1.27 (1.61)	2.68 (7.20)
Control (No Spray)	1.62 (2.63)	2.32 (5.37)	1.83 (3.35)	3.51 (12.30)
ANOVA				
S. Em. ± Treatment (T)	0.03	0.04	0.03	0.06
Periods (P)	0.02	0.01	0.01	0.01
T x P	0.06	0.10	0.06	0.12
C.D. at 5% (T)	0.08	0.11	0.09	0.17
(P)	0.04	0.03	0.03	NS
T x P	NS	NS	NS	NS
C.V. %	8.39	7.37	8.48	7.29

Notes : 1. NS : Non-significant.
2. Figures in parentheses are retransformed values; those outside are square root transformed value.

compared with the results of different workers across the globe and found that afidopyropen insecticide have reduced the *Aphis glycines* populations followed by lambda-cyhalothrin, sulfoxaflor and flupyradifurone (9) while, cyantraniliprole 10% OD @ 60 g a.i./ha was found effective as it provided excellent protection against aphid infesting potato (10). Cyantraniliprole 10% OD @ 60 g a.i. /ha was found quite effective dosage for the management of aphids, *Lipaphis erysimi* and *Brevicoryne brassicae* (15). Flonicamid 0.015% was found effective in the control of fennel aphid and exhibited satisfactory protection with 70-90 per cent percent reduction over control (8).

In the present investigation, very few references were found against management of fennel aphid with insecticides and hence, the effective treatments of the present study were compared with the different aphid species attacking on different crops. More or less similar trend of insecticides and aphid population was observed but in majority case it was found in different crops and different aphid species. However, no information is available on rest of the insecticides evaluated in the present investigation and hence, results could not be compared with the work done in past.

Effect of different insecticides on coccinellids population after first spray : Different synthetic insecticides were also evaluated for their adverse effect on coccinellids and the pooled data on population of coccinellid beetles (Table-2) revealed that some of the

Table-3 : Effect of different treatments on fennel seed yield.

Sr. No.	Treatments	Seed yield (kg /ha)
1.	Dimethoate 30 EC	1463
2.	Acetamiprid 20 SP	1407
3.	Flonicamid 50 WG	1821
4.	Afidopyropen 5 DC	2204
5.	Spinetoram 11.7 SC	1802
6.	Cyantraniprole 10.26 OD	2191
7.	Sulfoxaflor 21.8 SC	1716
8.	Beta-cyfluthrin + Imidacloprid 8.49+19.81 OD	1772
9.	Spirotetramate + Imidacloprid 11.01 + 11.01 SC	1728
10.	Control (No Spray)	1321
	Mean	1743
	ANOVA	
	S. Em. ±	83.33
	C.D. @ 5%	247.59
	C.V. %	8.27

Notes-1 : Treatment mean are not significant at 5% level of significant within a column.

treatments are found less toxic as the coccinellids population was high in treated plots. All synthetic insecticides recorded significantly lower population of coccinellids (1.93 to 4.18 per plant) as compared to control (5.37). Out of nine insecticidal treatments, the plot treated with afidopyropen 5 DC, 0.007 % have recorded highest number of coccinellids (4.18 coccinellids /plant) and found least toxic insecticide. Somehow, afidopyropen 5 DC, 0.007 % was found at par with cyantraniprole 10.26 OD, 0.014 % (4.11), spinetoram 11.7 SC @ 0.011% (4.05) and flonicamid 50 WG @ 0.015% (3.96) and found less toxic to coccinellids. The next treatments i.e., sulfoxaflor 21.8 SC @ 0.0087% (3.11) and spirotetramate + imidacloprid 11.01 + 11.01 SC @ 0.022% (2.98) were found medium toxic to coccinellids and found at par with each other. The rest of the insecticides i.e., beta-cyfluthrin + imidacloprid 8.49 + 19.81 OD @ 0.011% (2.17), acetamiprid 20 SP @ 0.02% (2.03) and dimethoate 30 EC @ 0.03% (1.93) were found highly toxic in respect to the safeness towards the coccinellids. The performance of different insecticidal treatments was consistent over 3, 7, 10 and 14 days after spray as the interaction T x P non-significant. While, the performance was not consistent within the period because period showing significant impact.

Effect of different insecticides on coccinellids population after second spray : The data on population of coccinellids presented in Table 2 revealed that there was a significant difference among the treatments after second spray. All synthetic insecticides recorded significantly lower population of coccinellids (5.20 - 9.78 coccinellids per plant) as compared to control (12.30). More or less, the same result was obtained as of first spray. Afidopyropen 5 DC, 0.007 % was found the best treatment as highest number of coccinellids (9.78) was recorded in this treatment. Somehow, afidopyropen was found at par with cyantraniprole 10.26 OD, 0.014 % (9.66), spinetoram 11.7 SC @ 0.011% (9.57) and flonicamid 50 WG @ 0.015% (9.38) and found less toxic to coccinellids. The next treatments *i.e.*, sulfoxaflor 21.8 SC @ 0.0087% (7.34) and spirotetramate + imidacloprid 11.01 + 11.01 SC @ 0.022% (7.20) were found medium toxic to coccinellids and found at par with each other. While, the rest of the insecticides *i.e.,* beta-cyfluthrin + imidacloprid 8.49 + 19.81 OD @ 0.011% (5.38), acetamiprid 20 SP @ 0.02% (5.31) and dimethoate 30 EC @ 0.03% (5.20) were found highly toxic in respect to the safeness towards the coccinellids. The performance of different insecticidal treatments was consistent over 3, 7, 10 and 14 days after spray as the period (P) and its interaction (T x P) was non-significant.

In nut-shell, spray application of afidopyropen 5 DC, 0.007 %, cyantraniprole 10.26 OD, 0.014 %, spinetoram 11.7 SC @ 0.011% and flonicamid 50 WG @ 0.015% are found safer against coccinellids as very less mortality were found and the population were maintained throughout the crop period. It is also observed that after the application of these insecticides, coccinellids are behaving normal and continuing the predatory activity efficiently. The obtained results were compared with the results of different workers across the globe and found that afidopyropen was found not toxic to adult or third instar larvae of *Hippodamia convergens* (9). The higher population of natural enemies like coccinellids, green lacewings and spiders was observed in plots treated with cyantraniliprole 10 OD @ 45 g a.i./ha (12). Spinetoram 12% SC @ 300 and 375 g.a.i/ ha was found with a least adverse effect on natural enemies build up like coccinellids (5); Flonicamid allows for the possibility of longer-term lady beetle survivorship (14). There was negligible reduction on coccinellid population due to spinetoram 12 SC 36 g a.i./ha (17). Dinotefuran 0.01% was found the safer treatment against coccinellid predators as highest number of coccinellids (7.35) was recorded in this treatment while, dimethoate recorded more than 75 per cent reduction in coccinellids population over control and categorized as "harmful" (8).

In the present investigation, more or less same trend was also observed. However, no information is available on rest of the insecticides evaluated in the present investigation and hence, results could not be compared with the work done in past.

Yield : The data on seed yield harvested from the different treatments are summarized in Table 3 revealed that all insecticidal formulations recorded significantly higher seed yield than control. The highest (2204 kg /ha) seed yield was harvested in the plots treated with afidopyropen 5 DC, 0.007 % and it was at par with Cyantraniprole 10.26 OD, 0.014% (2191). The next best treatment were flonicamid 50 WG @ 0.015% (1821), spinetoram 11.7 SC @ 0.011% (1802), beta-cyfluthrin + imidacloprid 8.49 + 19.81 OD 0.011% (1772), spirotetramate + imidacloprid 11.01 + 11.01 SC @ 0.022% (1728) and sulfoxaflor 21.8 SC @ 0.0087% (1716) and found at par with each other. These treatments have recorded significant low yield than the afidopyropen 5 DC and cyantraniprole 10.26 OD. While, dimethoate 30 EC @ 0.03% (1463) and acetamiprid 20 SP @ 0.02% (1407) recorded lower seed yield and found at par with each other.

Flonicamid 0.015%, have recorded highest yield as well as the yield increase over control of fennel crop (7). 71.32 and 69.95 per cent yield increase over control in the treatments of dimethoate and imidacloprid on fennel crop (6). Except these two workers, no information is available on rest of insecticides under present investigation for their yield and per cent increase over control and hence, results could not be supported with work done in past.

Conclusions

To know the toxicity of different insecticides against coccinellids and management of aphids, two sprays were made during the experimentation. After the first spray, data on population of aphid infestation after pooled over periods revealed that afidopyropen 5 DC @ 0.007% was found significantly superior [0.83 A.I. /plant] to the rest of the treatments and it was found at par with cyantraniprole 10.26 OD @ 0.014% [0.89]. While, after the second spray, data revealed more or less same results as of first spray and found that afidopyropen 5 DC @ 0.007% was significantly superior [0.81 A.I. /plant] treatment followed by cyantraniprole 10.26 OD @ 0.014% [0.89]. In a nutshell, based on both the sprays, aphid, *H. coriandri* can be effectively managed by spray application of afidopyropen 5 DC, 0.007 % and cyantraniprole 10.26 OD @ 0.014% as they can restrict the aphid population below ETL i.e., 1.00 AI. Flonicamid, spinetoram, beta-cyfluthrin + imidacloprid, spirotetramate + imidacloprid and sulfoxaflor could manage the aphids but did not exhibit satisfactory protection and found mediocre in their effectiveness. While, dimethoate and acetamiprid were found failed to provide satisfactory protection.

As far as concerned with the data on population of coccinellids occurrence after pooled over periods after first spray revealed that afidopyropen 5 DC, 0.007 % have recorded highest number of coccinellids (4.18 coccinellids /plant) and found least toxic insecticide followed by cyantraniprole 10.26 OD @ 0.014% (4.11), spinetoram 11.7 SC @ 0.011% (4.05) and flonicamid 50 WG @ 0.015% (3.96) and categorised as less toxic to coccinellids. While after the second spray, the results are more or less same as per the results obtained in first spray and found that afidopyropen 5 DC, 0.007 %, (9.78 coccinellids /plant), cyantraniprole 10.26 OD @ 0.014% (9.66), spinetoram 11.7 SC @ 0.011% (9.57) and flonicamid 50 WG @ 0.015% (9.38) found less toxic in respect to the safeness towards the coccinellids. In a nutshell, based on both the sprays, coccinellids can be effectively managed by spray application of afidopyropen 5 DC, 0.007 %, cyantraniprole 10.26 OD, 0.014%, spinetoram 11.7 SC @ 0.011% and flonicamid 50 WG @ 0.015% are found safer against coccinellids as very less mortality were found and the population were maintained throughout the crop period. It is also observed that after the application of these insecticides, coccinellids are behaving normal and continuing the predatory activity efficiently.

All insecticidal formulations recorded significantly higher seed yield than control. The highest (2204 kg /ha) seed yield was harvested in the plots treated with afidopyropen 5 DC, 0.007 % and it was at par with cyantraniprole 10.26 OD, 0.014% (2191). The next best treatment were flonicamid 50 WG @ 0.015% (1821), spinetoram 11.7 SC @ 0.011% (1802), beta-cyfluthrin + imidacloprid 8.49 + 19.81 OD 0.011% (1772), spirotetramate + imidacloprid 11.01 + 11.01 SC @ 0.022% (1728) and sulfoxaflor 21.8 SC @ 0.0087% (1716). While, dimethoate 30 EC @ 0.03% (1463) and acetamiprid 20 SP @ 0.02% (1407) recorded lower seed yield and found at par with each other.

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Economics of Processing of Kesari Rawa in North Karnataka

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Abstract

Wheat belongs to family Poaceae or Gramineae. Being the second important cereal food, it is mostly eaten in the form of chapattis, used in manufacturing bread, flakes, cakes, biscuits *etc*. Wheat straw is good source of feed for cattle. Wheat serve as a good source of thiamine, riboflavin, niacin and vitamin B-6. It is an excellent source of iron, phosphorus, potassium, manganese and magnesium. Based on the highest production of wheat in the state, three districts namely Vijayapura, Belagavi and Dharwad districts were selected for the study. Proportionate sampling procedure was followed to select the processing units. Both primary and secondary data were collected from processing units. Analytical tools employed for the study were tabular analysis and rank based quotient. Around 19 persons were required to run the kesari rawa processing units with payment of salary and wages of 1,85,499 per month. Annual installed capacity in kesari rawa processing units was 96,000 quintals and total quantity processed per day was found to be 219 quintals. Kesari rawa processing unit had processed 65,833 quintals annually. Total capacity utilization was 68.58 per cent. The total cost of processing incurred to produce one quintal kesari rawa was 2,413 out of which the variable cost 2,381.24 (98.69%) followed by the total fixed cost with the share of 31 (1.30%) of the total processing cost. The main product obtained was 69.33 per cent and byproducts obtained were 30.67 per cent. The gross and net returns realized from processing of one quintal of wheat accounted for 2,767 and 162 per quintal. lack of availability of sufficient raw materials, High price of raw materials, improper quality of raw materials and high transportation cost were the severe problems faced by processors in production of kesari rawa.

Key words : *Kesari rawa, procurement, capacity utilization, cost of processing, returns and constraints*

Introduction

Wheat (*Triticum aestivum*) the most widely grown and commonly known as common wheat or bread wheat. The center of origin of wheat is South East Asia. Wheat belongs to family Poaceae or Gramineae. wheat is a grass widely cultivated for its seed, a cereal grain which is a worldwide staple food. The many species of wheat together make up the genus *Triticum* the most widely grown is common wheat (*T. aestivum*). The archaeological record suggests that wheat was first cultivated in the regions of the Fertile Crescent around 9600 BCE. Botanically, the wheat kernel is a type of fruit called a caryopsis. Wheat serve as a good source of thiamine, riboflavin, niacin and vitamin B-6. It is an excellent source of iron, phosphorus, potassium, manganese and magnesium. Being the second important cereal food, it is mostly eaten in the form of chapattis, used in manufacturing bread, flakes, cakes, biscuits *etc*. Wheat straw is good source of feed for cattle.

Wheat occupies the second position among all food grains production in the country accounting for 23.50 per cent of total food grains area and 36.32 per cent total food grain production. Wheat is grown on more land area than any other food crop (220.4 million hectares or 545 million acres, 2014). World trade in wheat is greater than for all other crops combined.

In 2020, world production of wheat was 761 million tonnes (1.7 trillion pounds), making it the second most-produced cereal after maize. Since 1960, world production of wheat and other grain crops has tripled and is expected to grow further through the middle of the 21st century. Global demand for wheat is increasing due to the unique viscoleastic and adhesive properties of gluten proteins, which facilitate the production of processed foods, whose consumption is increasing as a result of the worldwide industrialization process and the westernization of the diet.

Wheat is an important source of carbohydrates. Globally, it is the leading source of vegetable protein in human food, having a protein content of about 13%, which is relatively high compared to other major cereals but relatively low in protein quality for supplying essential amino acids. When eaten as the whole grain, wheat is a source of multiple nutrients and dietary fiber. In a small part of the general population, gluten – the major part of wheat protein – can trigger coeliac disease, noncoeliac gluten sensitivity, gluten ataxia and dermatitis hypertiformis.

Uttar Pradesh and Madhya Pradesh states stand first and second position respectively in India with respect to both in area and production of wheat. The total area and production of wheat in Uttar Pradesh state was 95.40 lakh hectares and 327.41 lakh tons respectively which accounted for nearly 32.54 and 31.60 per cent. Madhya Pradesh state the respective figures were 55.20 lakh hectares and 165.21 lakh tons which accounted for nearly 18.83 and 15.95 per cent of area and production of wheat in India respectively, during 2019-20. The area and production of wheat in Karnataka was 1.50 lakh hectares and 1.63 lakh tons respectively which accounted for nearly 0.51 per cent and 0.16 per cent to the total wheat area and production in India, in that order, during 2019-20.

Belagavi and Vijayapura are the leading disticts in North Karnataka with respect to both area and production of wheat. The total area of wheat in Belagavi and Vijayapura district was 38,759 hectares and 35,336 hectares respectively which accounted for nearly 24.68 and 22.50 per cent, respectively. The total production of wheat in Belagavi and Vijayapura district was 63,111 tons and 39,647 tons which accounted for nearly 38.79 and 24.37 per cent of wheat in North Karnataka respectively, during 2019-20.

Research Methodology

Based on the highest production of wheat in the state, three districts namely Vijayapura, Belagavi and Dharwad districts were selected. Based on the number of processing units involved in production of kesari rawa, proportionate sampling procedure was followed to select the production units in the study area. From three districts three processing units were selected for the study. For evaluating the objective of the study, the required data were collected through personal interview method using well-structured and pre-tested schedule. The secondary data relating to costs and returns involved in production of value added products were obtained from processing units. These data were collected from the respective processing units situated in the study area from the books of accounts of those processing units.

Analytical Techniques Employed

Tabular analysis : Tabular analysis was followed to analyze the capacity utilization, raw materials procurement management, inventory management, human resource management, processing management, storage costs, and economics of processing of kesari rawa in the study area. The data collected were presented in tabular form to facilitate easy comparisons with the help of averages and percentages.

Rank Based Quotient : RBQ technique was adopted for studying the severity of problems faced by the respondents in production of kesari rawa. The respondents were asked to give ranks for the problems, based on severity. The data thus collected were tabulated and statistically analysed to interpret the results. The processors were asked to list the constraints faced by them in production of kesari rawa. Later on respondents were asked to rank the constraints individually. These were compiled together and Rank Based Quotient (RBQ) technique was used to quantify the data collected by Preferential Ranking Technique. For calculating the Rank Based Quotient (RBQ), the following formula was used :

$$\text{RBE} = \frac{fi(n \quad 1 \quad i)}{N^* \, n}$$

Wherein, fi = number of processors and market intermediaries reporting a particular constraint under th rank

N = number of processors

n = number of constraints identified

Results and Discussion

It could be observed from the Table-1 that, the total quantity of raw materials procured by kesari rawa processing units was found to be around 65,833 quintals, with each time procurement of 2,124 quintals with the periodicity of 31 times per year. As, depicted in Table-2, the quantity of raw materials stored was around 10,000 quintals per year, a decision with regard to replenishment of raw materials, forecasting and planning decision was followed in purchase of raw materials and first come first serve inventory method was followed in kesari rawa processing units.

The results pertaining to the staffing pattern in the case of kesari rawa processing units is depicted in Table-3. It is evident from the table that every day 19 persons were required to run the kesari rawa processing units with payment of salary and wages of 1,85,499 per month. The labour requirement was directly proportional to the size of the unit. Similar pattern of labour usage was noticed in red gram processing units indicating higher employment generation in the study conducted by Avinash (2014) in red gram processing units in Gulbarga district of Karnataka, since it was handling larger quantity of raw material.

It can be observed from the Table 4 that, the installed capacity per hour in the case of kesari rawa processing units was 20 quintals, with the working of 300 days in a year. The average working hours per day was found to be 8 hours. Annual installed capacity in kesari rawa processing units was 96,000 quintals and total quantity processed per day was found to be 219 quintals. Kesari rawa processing unit had processed 65,833 quintals annually. Total capacity utilization was 68.58 per cent.

Table-1 : Pattern of procurement of raw materials in kesari rawa processing units.

Sl. No.	Particulars	Kesari rawa unit	
		Particulars	Rate of procurement (/q)
1.	Total quantity of raw materials procured in value addition and quantity procured per time (q)	Wheat (65,833) [2,123.7]	1,853
2.	Source of procurement	Traders	
3.	Periodicity of procurement (per year)	31 times	
4.	Lead time (days)	4	
5.	Period of maximum procurement	Mar – June	
6.	Method for procurement	Open market	
7.	Mode of transportation	Lorry	

Note : 1. Figures in '( )' indicate the total quantity procured in a year.
2. Figures in '[ ]' indicate the quantity procured per time.

Table-2 : Inventory management in kesari rawa processing units. (per year).

Sl. No.	Particulars	Kesari rawa processing units
		Wheat
1	Quantity of raw material stored (q)	10,000
2	Method of inventory management (%)	
	a. First come first serve	100
	b. First come last serve	-
	c. Demand based	-
3	Decision with regard to replenishment of raw material (%)	
	a. As and when exhausted	-
	b. Period Replenishment	-
	c. Forecasting and planning the purchases	100

Table-3 : Human resource management in kesari rawa processing units. (per month)

Sl. No.	Staff Particulars	Kesari rawa unit		
		No.	Salaries/ Wages per employee (₹)	Total
1.	Manager	02	6,500	13,000
2.	Technician	03	12,000	36,000
3.	Supervision	02	11,833	23,666
4.	Accountant	01	8,333	8,333
5.	Purchase	01	8,000	8,000
6.	Security guard	02	7,500	15,000
7.	Skilled labours (Men)	-	-	-
8.	Skilled labours (Women)	-	-	-
9.	Unskilled labours (Men)	05	11,400	57,000
10.	Unskilled labours (Women)	03	8,166	24,500
	Total	19		1,85,499

Table-4 : Capacity utilization in value addition process of kesari rawa processing units.

Sl. No.	Particulars	Kesari rawa unit
1.	Installed capacity per hour (q)	20
2.	Number of working days/annum	300
3.	Number of shifts/day	2
4.	Duration of each shift (hours)	8
5.	Annual installed capacity (q)	96,000
6.	Quantity processed/day (q)	219
7.	Annual quantity processed (q)	65,833
8.	Capacity utilization (%)	68.58

Table-5 : Cost of processing of wheat into kesari rawa.

Sl. No.	Particulars	Unit	Kesari rawa		
			Price (/unit)	Quantity	Total (₹)
A.	**VARIABLE COST**				
1.	Cost of raw material	quintal	1,853.80	100	1,853.80 (76.83)
2.	Cost of gunny bags	Rupees	8.29	2	16.58 (0.68)
3.	Electricity and water charges	Rupees	-	-	18.48 (0.76)
4.	Loading and unloading	Rupees	9.39	2	18.78 (0.77)
5.	Transportation charges	Rupees	105.5	2	211.01 (8.74)
6.	Wages for labours	Rupees	4.59	1	4.59 (0.19)
7.	Telephone charges	Rupees	-	-	0.18 (0.007)
8.	Market fee and commission	Rupees	-	-	27.81 (1.15)
9.	Repair and maintenance	Rupees	-	-	13.37 (0.55)
10.	Miscellaneous	Rupees	-	-	0.16 (0.006)
11.	Interest on working capital @10%		-	-	216.48 (8.97)
	TOTAL VARIABLE COST		-	-	2,381.24 (98.69)
B.	**FIXED COST**				
1.	Depreciation on building	Rupees	-	-	0.480 (0.01)
2.	Depreciation on machinery	Rupees	-	-	11.248 (0.46)
3.	Insurance and license fee	Rupees	-	-	1.544 (0.06)
4.	Salary to permanent employees	Rupees	-	-	14.289 (0.59)
5.	Interest on fixed capital @14%	Rupees	-	-	3.858 (0.15)
	TOTAL FIXED COST		-	-	31.419 (1.30)
	Total processing cost (A+B)		-	-	2,412.7 (100.00)

Note : Figures in parentheses indicate percentage to total.

Table-6 : Returns from value addition process of kesari rawa processing units. (₹/q)

Sl. No.	Particulars	Kesari rawa		
1.	Total quantity of raw material processed (q/annum)		65,833.30	
2.	Total quantity of main product obtained (q/annum)		45,583.30	
	a. Kesari rawa		45,583.30	
3.	Total quantity of by product obtained (q/annum)		20,250.00	
	a. Cattle feed		15,150.00	
	b. Bran		5,100.00	
4.	Total value of main product (₹ lakh/annum)		1,488.45	
5.	Total value of by product (₹ lakh/annum)		271.31	
6.	Total returns (4+5)		1,760.00	
A.	Total Processing cost (/q)		2,605	
B.	Returns from main product			
	Particulars	Quantity (kgs)*	Price (₹/kg)	Value (₹)
	a. Kesari rawa	69.33	33.98	2,356
	Sub total	69.33		2,356
C.	Returns from by product			
	a. Cattle feed	23.00	12.70	292.10
	b. Bran	7.67	15.46	118.57
	Sub total	7.67		410.67
	Total (B + C)	100.00		2,767.00
D.	Gross returns (/q)		2,767.00	
E.	Net returns (/q)		162	

Note : *Quantity obtained by processing one quintal of wheat

Table-7 : Storage cost of value added product of kesari rawa.

Sl. No.	Particulars	Kesari rawa
1.	Quantity of value added product stored (q)	3,250
2.	Period of storage (days)	21
3.	Storage cost (Rent /q)	1.90
4.	Cost of stock maintenance (/q)	10
	Total storage cost (3+4)	13

Table-8 : Constraints faced by processors in production of kesari rawa.

Sl. No.	Constraints	Kesari rawa	
		RBQ score	Rank
1.	Lack of availability of sufficient raw material	96.30	I
2.	High price of raw material	92.59	II
3.	Improper quality of raw material	74.07	III
4.	High transportation cost	70.37	IV
5.	Difficulties in handling produce	51.85	V
6.	High market competition	44.44	VI
7.	Delay in payments	37.04	VII
8.	Scarcity of skilled labour	22.22	VIII
9.	Lack of availability of labour	11.11	IX

The details of cost of processing of wheat into kesari rawa are presented in the Table 5. The average total cost of processing was observed to be 2,413 per quintal. Out of which total variable cost (2,381.24/qtl) formed substantial component (98.69%) of the total processing cost. The total fixed cost being 31 per quintal, accounted for only 1.30 per cent of the total cost of processing.

Among the variable cost, the raw materials cost was accounted for highest share 1,854 (76.83 %) followed by interest on working capital (8.97%), transportation charges (8.74%). The remaining items altogether accounted for only 4.15 per cent. To get the good quality of kesari rawa the particular good quality of the raw materials is purchased from different parts of India, thus there will be increase in the transportation costs. These findings were in line with findings of Vijaylaxmi (2015) in her study on processing and marketing of maize products in Karnataka.

The researcher found that variable cost accounts more than 80.00 per cent in the cost of processing of maize products. In the total fixed cost 31.41 per quintal accounted for 1.30 per cent followed by salaries to permanent employees (0.59%), depreciation on machinery (0.46%), interest on fixed capital (0.15%), insurance and license fee (0.06%) and depreciation on building (0.01%) of the total processing cost.

The details of returns obtained from processing of wheat into kesari rawa are depicted in Table 6. The total quantity of main product obtained was found to be 45,583 quintals out of 65,833 quintals of total wheat processed. The total processing cost was observed to be 2,605 per quintal. The gross returns realized from processing of one quintal of wheat accounted for 2,767 per quintal i.e., 2,356 per quintal from main product (kesari rawa) indicating 69.33 per cent of recovery, 411 per quintal was from byproduct of wheat indicating 30.67 per cent of recovery and net returns were 162 per quintal. The recovery of main product should be increased by adopting new technologies and equipments. Procurement of good quality of raw materials also influences the recovery percentage of main product.

Annual quantity of kesari rawa stored was 3,250 quintals for period of 21 days with a storage cost of 13 per quintal (Table-7). The constraints faced by processor in production of kesari rawa are presented in Table-8. lack of availability of sufficient raw materials, High price of raw materials, improper quality of raw materials and high transportation cost were the severe problems faced by processors in production of kesari rawa. The availability of raw materials was less because the production of raw material in the study period was low. In order to earn more money by showing higher weight, the farmers did not maintain the required moisture content in the raw materials which they sold to the processors. To overcome this problem, the processors have to advice the farmers to maintain the minimum required moisture content and assure them that they would get better price. Improper quality of raw materials was because of adulteration in the raw material. The similar results were witnessed by Lal (2008), Naik (2009), Xess (2010), Amitkumar (2013) and Renuka (2019) in their respective study regarding the problems faced by processing units.

Conclusions

The kesari rawa processing industries are working with huge equipments and modern technologies. Human labour are required compulsorily to carry out different manual activities in the units and also the skilled employees are needed to manage the processing activities and supervise the working of labour. Lack of availability of sufficient raw materials, High price of raw materials, improper quality of raw materials and high transportation cost were the major problems faced by the processors in production of kesari rawa. To get the good quality of kesari rawa the particular good quality of the raw materials is purchased from different parts of India, thus there will be increase in the transportation costs. The availability of raw materials was less because the production of raw materials in the study area was low. In order to earn more money by showing higher weight the farmers did not maintain the required moisture content in the raw materials which they sold to the processors. To overcome this problem, the processors have to advice the farmers to maintain the minimum required moisture content and assure them that they would get better price.

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Status of Powdery Mildew Disease of Apple under Temperate Conditions of Kashmir

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Abstract

Survey of apple growing areas of three districts of Kashmir valley *viz.*, Srinagar, Ganderbal and Pulwama was carried out during the cropping season 2020 and 2021, in order to ascertain the status of powdery mildew disease. From each district, five locations and from each location three sites were randomly selected for recording observations on incidence and intensity of the disease. During the crop season 2020, the disease incidence ranged from 5.33 to 24.33 per cent in district Srinagar, 3.66 to 9.33 per cent in district Ganderbal and from 2.66 to 6.66 per cent in district Pulwama, whereas disease intensity ranged from 3.80 to 17.93, 1.71 to 2.56 and 1.59 to 2.35 in district Srinagar, Ganderbal and Pulwama, respectively. Similarly, during crop season 2021, the disease incidence ranged from 6.66 to 29.33 per cent, 5.33 to 9.00 per cent and 3.66 to 8.33 per cent and intensity from 2.35 to 4.61, 1.93 to 2.51 and 1.68 to 2.41 per cent in district Srinagar, Ganderbal and Pulwama, repectively. On an overall comparison amongst different locations surveyed, the highest disease incidence of 26.83 per cent was and intensity of 19.13 per cent were recorded from Theed location of district Srinagar and least disease incidence of 3.33 per cent and intensity of 2.13 per cent from Hardumir location of district Pulwama.

Key words : *Apple, Kashmir, powdery mildew, status.*

Introduction

Apple (*Malus × domestica*) is the third important fruit of the world in terms of production and consumption (Khajuria *et al.,* 2018). India stands fifth in world with a production of 1.900 million MT. In India, the most important apple growing states are Jammu and Kashir, Himachal Pradesh and hilly areas of Uttar Pradesh, Arunachal Pradesh, Manipur and Sikim (Negi *et al*., 1998). Owing to its favorable agro-ecological conditions the Jammu and Kashmir contributes almost 80 per cent of net produce (Anonymous, 2019). Comparing with international standards the productivity in Jammu and Kashmir is still low, attributable to numerous factors of which biotic stresses play principle role.. Of these biotic factors, fungal diseases have been reported to affect the crop under field and post harvest conditions which constitute a major constraint in realizing their true genetic potential. Among diseases, powdery mildew is of serious concern after scab and Alternaria leaf blotch. Powdery mildew is the major fungal diseases which affect approximately 10, 000 species of angiosperms worldwide, consisting of economically important crops including fruit crops (Amano, 1986; Braun and Cook, 2012; Marmolejo *et al*., 2018). The disease is easily recognizable by their conspicuous symptoms consisting of superficial white powdery patches of the anamorph, composed of mycelium, conidiophores and conidia, on leaves, stems and other plant organs. The disease causes considerable loss of productivity due to nutrient removal, reduced photosynthesis, increased respiration, transpiration and impaired growth. Powdery mildew caused by the fungus, *Podosphaera leucotricha* (Ellis. and Everh.) Salmon) is an important foliar disease of apple in Kashmir. The disease was first noted on apple seedlings in 1871 by Bessey in Lowa, United States. In 1900, the causal agent was renamed by Salmon from *Spharotheca leucotricha* to *Podospaera leucotricha* (Gupta and Sharma, 1988). The pathogen may cause death of vegetative shoots or flower buds, russetting of fruit (Jones and Aldwinckle 1990) and stunted terminal growth (Verma and Gupta, 1988). The disease is considered of less economic importance under Kashmir conditions, although under favourable weather conditions, severe damage to new terminal vegetative growth has been observed. To record the present status of apple powdery mildew disease in Kashmir, survey of different parts of valley was carried out during the cropping season of 2020 and 2021.

Materials and Methods

Survey of apple growing areas of three districts of Kashmir valley *viz.*, Srinagar, Pulwama and Ganderbal was carried out during the cropping season 2020 and 2021, in order to ascertain the status of powdery mildew disease. From each district, five locations and from each location three sites were randomly selected for recording observations on incidence and intensity of powdery mildew disease. In order to record the incidence and intensity of the disease, four scaffold branches from four sides of tree canopy of five trees were selected. Five terminals randomly selected from each marked branches were assessed. In all hundred terminals were selected from each site for recording per cent disease incidence and intensity. The per cent disease incidence was calculated by the formula :

Per cent disease incidence

$$= \frac{\text{No. of mildewed terminals}}{\text{Total number of terminals observed}} \quad 100$$

Per cent disease intensity was calculated by adopting the following 0-5 scale given by McKinney, 1923.

Grade	Mildewed araea (%)
0	Free from mildew (healthy)
1	Up to 25% of a.e.g. mildewed
2	26-50% of a.e.g. mildewed
3	51-75% of a.e.g. mildewed
4	Above 75% of a.e.g. mildewed
5	Complete leaf-fall plus bud necrosis

Where a.e.g. stands for annual extension growth.

The per cent mildewed annual extension growth was calculated by the following formula :

$$\text{Mildewed a.e.g \%} = \frac{\text{Mildewed length}}{\text{Total annual extension growth}} \quad 100$$

Total annual extension growth

Per cent disease intensity was calculated by using the following formula :

$$\text{Per cent Disease Intensity} = \frac{(n \quad v)}{N \quad G} \quad 100$$

Where,

= Summation

n = No. of diseased terminals

v = Numerical value of the category.

N = Total no. of terminals examined.

G = Highest grade value

Results and Discussion

The preliminary survey has revealed the occurrence of powdery mildew disease in all the surveyed locations in districts Srinagar, Ganderbal and Pulwama of the valley, though in varying proportions. In surveyed areas of the valley, the average disease incidence of 7.78 and 8.84 per cent and intensity of 5.08 and 5.59 per cent on leaves was recorded during the year 2020 and 2021, respectively. The higher level of disease was observed in 2021 as compared to 2020. The disease on leaves was prevalent during both the years. On an overall basis, the disease incidence was more (8.84%) in 2021 as compared to that of (7.78%) in 2020 (Table-1). The disease incidence over the years was highest in district Srinagar (12.51%) followed by Ganderbal (6.93%) and Pulwama (5.46%). During the crop season 2020, powdery mildew incidence ranged from 5.33 to 24.33 per cent in district Srinagar, 3.66 to 9.33 per cent in Ganderbal and 2.66 to 6.66 per cent in Pulwama. During crop season 2021, the disease incidence ranged from 6.66 to 29.33 per cent in district Srinagar, 5.33 to 9.00 per cent in district Ganderbal and 3.66 to 8.33 per cent in district Pulwama. On an overall comparison amongst different locations surveyed, the highest disease incidence of 26.83 per cent was recorded in Theed followed by Teilbal (13.83%) and Gutlibagh (9.00%) which was statistically at par with Gousu (8.16%). The least disease incidence of 3.33 per cent was recorded in Hardumir followed by Zahidabagh (4.66%) and Zazuna (4.66%) which was statistically at par with Midoora (5.16%).

Disease intensity also varied at all the surveyed locations during both the years. On an overall basis, the disease intensity was more (5.59) in 2021 compared to that of 2020 (5.08%) (Table-2). During the crop season 2020, powdery mildew intensity ranged from 3.80 to 17.93 per cent in district Srinagar, 2.20 to 5.73 in district Ganderbal and 1.73 to 4.13 per cent in district Pulwama, whereas, in 2021, the disease intensity ranged from 4.53 to 20.33 per cent in district Srinagar, 3.20 to 5.40 per cent in district Ganderbal and from 2.20 to 4.93 per cent in district Pulwama. On an overall comparison amongst different locations surveyed, the maximum disease intensity of 19.13 per cent was recorded from Theed followed by Teilbal (8.93%) and Gousu (5.63%) which was statistically at par with Gutlibagh (5.56%). The least disease intensity of 2.13 per cent was recorded from Hardumir which was statistically at par with Zazuna (2.76%) and Zahidbagh (2.86%). Powdery mildew is a common disease of apple and of worldwide occurrence (Biggs *et al*., 2009).The varied level of powdery mildew disease on apple at different surveyed locations has been also reported by Rachid and Alieu (2020). The varied level of disease incidence and intensity at different locations in the present study was attributed primarily to the number of fungicidal sprays that are being given to manage the major diseases of apple. Management of apple powdery mildew disease has been reported by various workers (Byarugaba *et al*., 2013; Rather *et al*., 2015).

Table-1 : Incidence of powdery mildew disease (*Podosphaera leucotricha*) of apple at various locations of Kashmir during 2020 and 2021.

Location	Disease Incidence (%)		
	2020	2021	Mean
District Srinagar			
Teilbal	13.66 (3.81)	15.00 (3.99)	14.33(3.91)
Batapora	5.33 (2.48)	8.00 (2.99)	6.66 (2.75)
Theed	24.33 (5.02)	29.33 (5.49)	26.83 (5.26)
Gousu	5.66 (2.38)	10.66 (3.40)	8.16 (3.02)
Gulabbagh	6.33 (2.70)	6.66 (2.76)	6.49 (2.73
Mean	11.10	13.93	12.51
District Ganderbal			
Batwina	9.33 (3.19)	6.33 (2.66)	7.83 (2.94)
Wusan	7.00 (2.58)	7.66 (2.67)	7.33 (2.63)
Zazuna	3.66 (2.03)	5.66 (2.52)	4.66 (2.29)
Khalmula	6.33 (2.49)	5.33 (2.33)	5.83 (2.41)
Gutlibagh	9.00 (3.09)	9.00 (3.15)	9.00 (3.13)
Mean	7.10	6.80	6.93
District Pulwama			
Zahidbagh	5.66 (2.57)	3.66 (2.00)	4.66 (2.34)
Renzipora	6.33 (2.66)	8.33 (3.02)	7.33 (2.85)
Midoora	4.33 (2.27)	6.00 (2.63)	5.16 (2.46)
Charibugh	6.66 (2.74)	7.00 (2.58)	6.83 (2.70)
Hardumir	2.66 (1.81)	4.00 (2.20)	3.33 (2.03)
Mean	5.13	5.80	5.46
Overall mean	7.78	8.84	8.30
CD (P=0.05)	1.31	1.30	1.16

Figures in parentheses are square root transformed values.

Table-2. Intensity of powdery mildew disease (*Podosphaera leucotricha*) of apple at various locations of Kashmir during 2020 and 2021.

Location	Disease Intensity (%)		
	2020	2021	Mean
District Srinagar			
Teilbal	8.33 (3.04)	9.53 (3.24)	8.93 (3.15)
Batapora	3.80 (2.16)	5.26 (2.50)	4.53 (2.34)
Theed	17.93 (4.34)	20.33 (4.61)	19.13 (4.48)
Gousu	4.20 (2.13)	7.06 (2.83)	5.63 (2.56)
Gulabbagh	4.33 (2.30)	4.53 (2.35)	4.43 (2.32)
Mean	7.72	9.34	8.53
District Ganderbal			
Batwina	5.66 (2.56)	3.66 (2.13)	4.66 (2.36)
Wusan	4.40 (2.16)	4.53 (2.17)	4.46 (2.17)
Zazuna	2.20 (1.71)	3.33 (2.04)	2.76 (1.89)
Khalmula	3.93 (2.08)	3.20 (1.93)	3.56 (2.01)
Gutlibagh	5.73 (2.54)	5.40 (2.51)	5.56 (2.54)
Mean	4.38	4.02	4.20
District Pulwama			
Zahidbagh	3.53 (2.35)	2.20 (1.68)	2.86 (2.07)
Renzipora	3.80 (2.15)	4.93 (2.41)	4.36 (2.29)
Midoora	2.46 (1.82)	3.53 (2.12)	2.99 (1.98)
Charibugh	4.13 (2.24)	3.93 (2.08)	4.03 (2.18)
Hardumir	1.73 (1.59)	2.53 (1.76)	2.13 (1.69)
Mean	3.13	3.42	3.27
Overall mean	5.08	5.59	5.33
CD (P=0.05)	0.98	0.93	0.85

Figures in parentheses are square root transformed values

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Nutritional Disorders of Fruit Crops : An Overview

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Abstract

Fruit crops is prone to different physiological disorders, which decrease its fresh market value and cause economic losses worldwide. In general, these disorders arise due to nonpathogenic factors such as adverse environment conditions, nutrient constraints, chemicals, and some genetic factors, which result in abnormal external or internal conditions and abnormal growth pattern of fruits. In this paper, special emphasis has been put on not only the causes of physiological disorders but also the management approaches to retain the high quality for higher market value by preventing these disorders.

Key words : *Crops, disorders, nonpathogenic, abnormal, internal, quality.*

Introduction

The productivity as well as the quality of fruit crops is affected to a greater extent due to the physiological and nutritional disorders. Disturbance in the plant metabolic activities resulting from an excess or deficit of environmental variables like temperature, light, aeration and nutritional imbalances result in crop disorders. In fruit crops, the deficiency of micronutrients causes many more disorders than that of macronutrients. Nutritional disorders have become widespread with diminishing use of organic manures, adoption of high density planting, use of root stocks for dwarfing, disease and salt tolerance, unbalanced NPK fertilizer application and extension of horticulture to marginal lands. To get high quality fruit and yields, micronutrient deficiencies have to be detected before visual symptoms are expressed. The deficiencies of Zn, Mn and B are common in sweet orange, acid lime, banana, guava and papaya in India. To correct both visual and hidden micronutrient deficiencies, appropriate foliar and soil applications are necessary. The description of physiological and nutritional disorders in crops include a number of technical terms and it is essential to understand the terms for better identification of symptoms. Some common terms are, bronzing (development of bronze or copper colour on the tissue), chlorosis (loss of chlorophyll resulting in loss of green colour leading to pale yellow tissues), decline (onset of general weakness as indicated by loss of vigour, poor growth and low productivity), die-back (collapse of the growing tip affecting the younger leaves), firing (burning of tissue accompanied with dark brown or reddish brown colour), lesion (a localised wound of the leaf/stem tissue accompanied with loss of normal colour), necrosis (death of tissue), scorching (burning of the tissue accompanied with light brown colour resulting from faulty spray, salt injury etc.)

Apple

Disorders

Bitter Pit : This is a physiological disorder, which reduces the fresh market quality of fruit. Young trees that are just coming into bearing are the most susceptible. Immature fruit are more susceptible to bitter pit than fruits harvested at the proper maturity stage. Small brown lesions of 2-10 mm in diameter (depending on the cultivar) develop in the flesh of the fruit. The tissue below the skin becomes dark and corky. At harvest or after a period in storage the skin develops depressed spots on the surface. These spots appear as water soaked spots on the skin near the calyx. The spots generally turn darker, become more sunken than the surrounding skin and get fully developed after one or two months in storage.

Control : Calcium sprays prior to harvest and calcium dips before storage control the incidence of bitter pit. The plants should be sprayed 45 days prior to harvest followed by a repeat spray after 15 days. The post-harvest dip for 1-2 minutes should be given before storage.

Brown Heart : This physiological disorder is associated with large and overmature fruits. It can also occur when the CO concentration in storage increases above 1%. The symptoms appear as brown 2 discoloration in the flesh, usually originating in or near the core. Brown areas have well defined margins and may include dry cavities developed due to desiccation. Symptoms range from a small spot of brown flesh to entire browning of flesh with a margin of healthy white flesh remaining just below the skin. Symptoms develop early in storage and may increase in severity with extended storage time.

Control : Harvesting of overmature fruits should be avoided. In case of storage in controlled atmosphere (CA) the fruits should be harvested at optimum maturity The CO concentrations in CA 2 should be below 1% to reduce the development of brown heart incidence.

Cork Spot : The initial symptoms of this physiological disorder appear as small blushed area on the skin of the fruit above the affected brown spot The affected tissue is usually much harder than the healthy tissue. Boron and calcium deficiencies are occasionally found responsible for development of cork spot.

Control : Proper nutrient management especially boron and calcium helps in preventing this disorder.

Scald : This physiological disorder is a serious concern for apple growers. Susceptibility to this storage disorder varies with the variety of apple, environment and cultural practices. Incidence and severity of scald is favoured by hot, dry weather before harvest, immature fruit at harvest, high nitrogen and low calcium concentrations in the fruit. Inadequate ventilation in storage rooms or in packaging boxes also promotes this disorder. Irregular brown patches of dead skin develop within 3 to 7 days due to warming of the fruit after removal from the cold storage. The warm temperatures do not cause the scald but allow symptoms to develop from previous injury, which occurred during cold storage. Symptoms may be visible in cold storage when injury is severe.

Control : Harvesting at proper maturity and ventilation in cold storage help to reduce the scald incidence. The most common method used to control scald is application of an antioxidant immediately after harvest. Diphenylamine (DPA) is commonly used. Ethoxyquin is also effective for some varieties, but can cause damage to other apple varieties. Antioxidants should be applied within one week of harvest for maximum control.

Water Core : This physiological disorder is promoted by high leaf to fruit ratio, high levels of nitrogen and boron in the fruits, low levels of fruit calcium, excessive thinning, and exposure of fruits to high temperatures. Large size fruits are mostly susceptible to this type of disorder. Disorder at pre-harvest stage results in the development of water soaked regions in the flesh. These regions are hard, glassy in appearance and only visible externally when infection is very severe. Severely affected fruits may smell and have a fermented taste. Water soaked areas are found near the core or on the entire apple. If symptoms are mild to moderate, they may disappear completely in storage.

Control : The most effective way to reduce the incidence is to avoid delayed harvests. As fruits approach maturity stage, samples of fruit should be examined for water core development. Fruit should be harvested before water core develops extensively. Fruits lots with moderate to severe water core symptoms should not be placed in controlled atmosphere (CA) storage but should be marketed quickly.

Sun Burn : This physiological disorder occurs due to intense heat of the sun. Fruit on the southwest side of the tree are generally affected. Water stress can also increase the incidence of sunburn. Initial symptoms are white, tan or yellow patches on the fruits exposed to the sun. With severe skin damage, injured areas of the fruit can turn dark brown before harvest. These areas may become spongy and sunken. Fruit exposed to the sun after harvest can develop severe sunburn.

Control : The best method of control is to avoid sudden exposure of fruit to intense heat and solar radiation. Proper tree training and pruning are critical. Summer pruning must be carefully done to avoid excessive sunburn. Pruned orchards should be regularly irrigated to reduce heat stress. Careful sorting to remove affected fruit upon packing is the only solution once the injury has occurred.

Russeting : Russeting of apples in a humid environment is a major concern of the fruit growers. Russeting occurs shortly after petal fall. The apple cultivars, which have thin cuticle, are more susceptible to russeting. It is commonly noticed on exposed fruits than on fruits remaining in shade. Frost during the blossom or at the early fruit formation stage may also cause russeting. Russeting leads to rupture of the fruit skin and development of cracks.

Control : Selection of less susceptible clones and adequate irrigation, manuring and effective pest management can reduce russeting.

Fruit Drop : Most of the commercial varieties of apple exhibit 3 cycles of fruit drop viz., early drop, June drop and pre-harvest drop. The early drop is considered natural and is due to lack of pollination and fruit competition. Moisture stress and environmental conditions cause the June drop. These two drops neither cause substantial economical losses nor are controlled effectively by artificial means. The preharvest drop causes serious economic loss as the full grown marketable fruits abscise before the harvest due to the reduction in the levels of auxins.

Control : The pre-harvest drop can be controlled by application with NAA (15 ppm) sprayed 20 days before the expected fruit drop or 20-25 days before the harvest.

Mango

Black tip : Coal fumes of brick kilns containing sulphur dioxide, ethylene and carbon monoxide are observed to be responsible for black tip. The damage has been noticed in the mango orchards located up to 200metres of distance from brick kiln. It is characterised by depressed spots of yellowing tissues at the distal end of the fruit, which gradually increase in size, become brown and finally black. The necrotic area is always restricted to the tip of the fruit. The growth of the fruit is almost at stand still and the fruit becomes soft after premature ripening. Such fruits never reach full maturity and drop earlier. The preventive measure is to have orchards 1.5km to the east and west and 0.75km to the north and south away from the kilns. Spraying of 2% sodium carbonate or 0.6% borax is recommended as control measure.

Spongy tissue in fruit : A non edible sour patch developed in the mesocarp of mango fruit is broadly termed spongy tissue. The malady has been reported only in Alphonso. The peculiarity of this malady is that external symptoms of the fruit affected by spongy tissue are not apparent at the time of picking or at the ripe stage. These can be detected only on cutting the ripe fruit. This malady renders the fruit unfit for human consumption. It is a physiological disorder in which fruit pulp remains unripe because of unhydrolyzed starch due to physiological and biochemical disturbances caused by heat in mature fruit at pre-and post-harvest stages. Single and double preharvest dip of fruits in calcium solution significantly increased the calcium content in the ripe fruits, whereas there was no significant increase in calcium content by post harvest Ca dip treatment. The pre harvest dip significantly reduced the occurrence of spongy tissue in the ripe 'Alphonso' fruits. The use of wind-breaks for protecting the orchard from warm air during May, and use of proper precautions at post-harvest stage checks the disorder.

Malformation : Among all the known diseases and insect pests of mango, malformation is undoubtedly the most serious. Depending on the plant part affected, two categories of the malformation, vegetative and floral, have been recognized. In vegetative malformation, the vegetative buds in the leaf axils or at the apical meristem of the younger plants, on activation, develop abnormally as compact rosette-like shootlets, bearing tiny leaf rudiments. Many such shoots may arise to form a bunch, hence it is also sometimes known as bunchy top. The problem is not serious in the grown-up trees. The affected new shoots on the old trees, however, become thick, stunted, and develop a whorl of small leaves. Floral malformation, in contrast, is very virulent and can cause the loss of the entire crop. It affects the fruit production directly by converting the panicle to a barren one. Floral malformation exhibits all sorts of symptoms, but any deviation of a part of the panicle, or all the parts of a panicle, from the normal to abnormal should be considered as a symptom of this malady. In severe form, the affected panicle, appears like a compact mass, being more green and sturdy. It bends down due to its own weight. It is found that the application of 200ppm NAA during the first week of October as spray resulted in considerable reduction of floral malformation. Early deblossoming, combined with NAA spray during October, may reduce the extent of malformation considerably.

Fruit drop : In mango, there is a heavy drop of hermaphrodite flowers and young fruits amounting to 99% or more. In general, in mango 0.1% or less hermaphrodite flowers develop fruits to maturity. The maximum drop of fruits in 'Langra' and 'Dashehari' takes place in the first three weeks of April and differs significantly from the drops in the following weeks. Fruit drop is to some extent associated with the variety, as the variety 'Langra' is more prone to fruit drop than 'Dashehari'. Deficient nutrition of many developing embryos may be the most important internal factor leading to post-fertilization drop in mango. This results due to competition among overcrowded fruitlets on panicle. Degeneration of the embryo in the initial stages of its development may yet be another cause of drop. This occurs invariably, if the flowers are self-pollinated. 2,4-D produced better results at concentrations below 20ppm, because at higher concentrations fruit and seed development is retarded. Single spray of NAA or 2,4-D each at 20ppm or Alar 100 ppm at pea stage of fruit gives promising results.

Zinc deficiency : The major nutritional disorder in mango is little leaf caused by the deficiency of zinc. This leads to stunted growth of roots, shoots and leaves. The lamina of leaves turn pale yellow while midrib remain green. Leaves become very small, little with interveinal chlorosis. Yellowing, necrotic patches develop on old leaves with drying of leaves. Subsequently necrotic patches turn grey and cover the entire surface.Two sprays of 1-2% Zinc sulphate, one at the time of flowering and the other at one month after the first spray correct the disorder.

Grapes

Flower-bud, flower and berry-drop : This problem has been reported from the states of Punjab, Haryana and Rajasthan in North India. The malady has been investigated and the association of a number of factors such as, improper nitrogen application, improper fertilization, ambient temperature, heavy crop load, uneven ripening and endogenous auxin deficiency at a particular stage of berry development are reported to cause the malady. To control bud, flower and berry drop, the following measures are suggested; making 0.5 cm wide girdle from the trunk about 10 days before full bloom which results in better berry set; judicious application of fertilizers under a given set of conditions, particularly N fertilizers, for 'even' ripening; 500 ppm ethrel at veraison stage should be applied; dipping of bunches in NAA

100ppm 10 days before ripening reduces berry drop, heavy irrigation at bloom should be avoided.

Blossom-end rot : A black sunken spot develops at the blossom-end of the berry which later on spreads with water-soaked region around it. Defective calcium nutrition and assimilation appear to be the cause for it. Spray of 1.0 per cent calcium nitrate may correct it.

Boron deficiency : The presence of small sized fruits and large sized fruits in the same bunch is known as hen and chicken disorder. The fruits are sour in taste. The symptoms include death of growing tips, leaf fall and brittleness of young shoots. The leaves may be deformed with interveinal chlorosis spreading from margins to inwards and this is particularly evident after the fruiting. Spraying of 0.2% boric acid a week before bloom and another at full bloom control the disorder effectively.

Iron deficiency : The leaves turn yellow (chlorosis) during iron deficiency and the entire shoot become yellow to yellowish green under extreme conditions. Iron deficiency may occur due to the presence of excess calcium in the soil (lime induced chlorosis). The corrective measure is two sprays of 0.2% ferrous sulphate, one before bloom and the second after fruitset.

Pomegranate

Fruit cracking : Fruit cracking is a serious problem of pomegranate. The malady is thought to be due to boron deficiency in young fruits while in developed fruits it may be caused due to variations in soil moisture content and atmospheric humidity. At the time of fruit ripening, if the soils become too dry and then irrigated heavily or there is some rains, cracking may occur. Some cultivars, like Guleshan, Khog, Kazaki are reported to be resistant to fruit cracking. Regular irrigation to maintain soil moisture at desired level, spraying of calcium compounds or GA3 at 120 ppm on young fruits are reported to minimize the fruit cracking.

Papaya

Boron deficiency : Boron deficiency is one of the serious disorders limiting yield in papaya. It results in malformed fruits. Spraying of boric acid 0.1% at 3 months interval from sixth month after planting onwards correct the deficiency.

Guava

Die-back : The disease infects young as well as the old bearing trees. Some trees are more prone to attack. The typical symptoms include withering of lowermost branch of the tree from top downwards. The growing tip turns dark brown and necrotic areas extend backwards. A typical lesion develops at the junction of the diseased and healthy areas which advances down the healthy areas. The infected branches defoliate giving them a barren appearance. Application of 1.8 kg lime or gypsum reduce the mortality of trees by maintaining soil pH.

Bronzing : Bronzing in guava is a complex nutritional disorder. When fruiting starts in a soil marginal in P and K, the nutrients are mobilised from older leaves to the fruits, causing bronze coloured leaves which results in reduced photosynthate transfer to the roots and reduced uptake. In mild symptoms, mixture of 20 kg of FYM, 1 kg of SSP, 0.5kg MOP and 100g $ZnSO_4$ /tree should be applied in soil. In severe cases, the dose may be doubled except FYM and foliar spraying of DAP 0.3% and SOP 0.5% is to be given 45 days after the emergence of leaves.

Boron deficiency : The disorder is identified with appearance of red spots on the newly emerged leaves. Leaves become dry and brittle. Spraying of 0.3% boric acid 10-15 days before flowering correct the deficiency. In general, foliar application of 0.5 per cent zinc sulphate and 0.4 per cent boric acid 10 to 14 days before flowering effectively eliminate the zinc and boron deficiencies.

Citrus

Fruit drop : The most pronounced stages of fruit drop are, (i) immediately after fruitset at marble stage which lasts for a month after full bloom, referred as post-set drop, (ii) the second wave of intense fruit drop occurs at the onset of hot summer weather during May-June, known as June drop, and (iii) preharvest drop or premature drop occurring during ripening period, which lasts from August to December-January. Higher summer temperature, excess or deficiency of soil moisture, lack of nutrients like zinc, phosphorus and potash and attack of fungal diseases like anthracnose, styler-end rot and stem-end rot are some of the primary factors responsible for fruit drop. Application of 2,4-D 10ppm combined with aureofungin 20ppm in the first week of September provides excellent check against physiological and pathological pre-harvest fruit drop in citrus.

Granulation : Granulation is a serious problem of citrus, especially under North Indian conditions. This abnormality is initiated at the stem end of the fruit which gradually extends towards the stylar end. The affected juice sacs become hard and dry, fruits become grey in colour, enlarged in size, have flat and insipid taste and assume a granular texture. Granulated fruits contain less extractable juice as most of it turns into gelatinous mass. This results in more quantity of rag and thus low pulp/rag ratio. The terms granulation, crystallization and dry end are used to describe this trouble. It is much more prevalent in larger sized fruits than in small fruit, in young than in old trees and in humid than in dry areas. Several factors like luxuriant growth, rootstock and the variety, frequent irrigation, mineral constituents in plant tissue, time of harvest, exposure to sunlight, etc., are found to be associated with this malady. Singh and Singh (1980) reported that in the areas with high incidence of granulation, the plant tissues contain high Ca and Mn, and low P and B. The incidence is relatively high in the fruits of younger plants as compared to those in older plants. The vigorous rootstocks like rough lemon increase the incidence of granulation as compared to less vigorous rootstocks. Late maturity and persistent cold weather throughout the period of maturity have been found to increase the incidence of granulation. The incidence of granulation could be reduced to 50 per cent by applying two to three sprays of NAA (300 ppm) in the months of August, September and October. Spraying of GA 15 ppm followed by NAA 300 ppm in October and November also reduce granulation.

Boron deficiency : The deficiency causes yellowish translucent spots accompanied by leaf distortion or deformation. Mature and old leaves may show corky veins. They may be somewhat twisted or totted. Immature fruits become hard and somewhat misshaped. To control various leaf deficiencies, a combined spray of different microelements at a concentration of 25-50 ppm depending on the intensity of deficiency is generally applied. It is very likely that some of the components of such a spray would be a waste, if the trees are really not deficient in those elements. Copper and zinc are antagonistic when sprayed together. It is also observed that combined spray may cause tip burning of leaves in the absence of continuous stirring of spray fluid. It is, therefore, best to spray different micronutrients which are deficient individually rather than in combination based on leaf analysis.

Banana

Choke throat : It is due to low temperature affecting active growth of the plant. Leaves become yellow and in severe cases, the tissue gets killed. In case of normally flowering plants, the stalk carrying bunches elongates freely so that the entire inflorescence comes out of the pseudostem and hangs down. Bunch development is normal, but when the time of flowering synchronizes with low temperature, the bunch is unable to emerge from the pseudostem properly. The distal part of the inflorescence comes out and the basal part gets stuck up at the throat. Hence, it is called Choke throat. Maturity of the bunch is delayed by taking 5-6 months instead of 3.5-4 months for harvest. Provision of shelter belts using Casuarina or Eucalyptus to prevent the effect of cold wind blowing into the orchard and planting low temperature tolerant varieties like Kullan check the disorder.

Chilling injury : Chilling occurs when pre-harvest or post-harvest temperatures fall below 14°C for various time periods. The peel of banana become dark and the fruit exhibit uneven ripening. Ripening fingers show dull yellow to smoky yellow colour and watery dark patches are observed on the skin. Brittleness of the fruit and fungal invasion is also observed. The vascular bundles of the sub epidermal layer show brown streaks. The discoloration is ascribed to the enzymatic oxidation of dihyroxy phenylalanine.

Kottaivazhai : It is a serious malady in Poovan variety of banana, reducing the production by 10-25%. The symptoms are distinctly conical and illfilled fruits with a prominent central core having many underdeveloped seedy structures making the fruit inedible. The pseudostem exhibits streaks, striations and blotches on the surface. Bunches are held at an angle above the horizontal position. Pollen grains are infertile, shriveled, shrunken and broken while the pericarp is smaller and the locular cavity is bigger than normal. The absence or the occurrence of auxin, gibberellins and cell dividing factors at sub epidermal levels affect the development of parthenocarpic fruits. Application of 2,4- D 25ppm and GA 100ppm after the opening of last hand favours development of parthenocarpic fruit.

Potassium deficiency

Chlorosis : The most characteristic of the K deficiency symptoms is the yellowing of older leaf tips followed by inward leaf curling and death.

Stunted growth : Usually, a K deficient banana plant will grow slowly and have a sturdy appearance due to the shortening of internodes.

Bunch deformation : The banana bunches in K deficient plants are short, slim and deformed as a consequence of poor fruit filling caused by reduced photosynthesis and sugar transportation.

Cherry

Physiological Disorders : Pitting and bruising are common problems caused by harvest injury as well as rough postharvest handling (Facteau and Rowe, 1979; Thompson et al., 1997). Fruit pitting is a manifestation of subsurface damage that develops into sunken areas near the fruit surface. Bruising can occur from excess compression, drops or large impacts during harvest, transport or packing. Visual symptoms of pits and bruises often do not appear until well after the fruit has been packed, resulting in visible damage appearing in wholesale or retail markets. Sweet cherries are also prone to shrivel and water loss due to the lack of a well developed cuticle. Water loss can be minimized by prompt cooling and storage in a high RH environment. Stem browning is another potential physiological disorder. Stem browning can be minimized by proper temperature and RH management, however, packing procedures that scrape or injure stems create wounds that will brown. In addition to proper temperature management, use of chlorine dioxide in hydrocooler water can reduce development of stem browning (Roberts, 1989).

Apricots

Physiological Disorders : Apricots (Prunus armenia) suffer from a number of cold storage disorders of the flesh, similarly to peaches, nectarines, and plums. Gel breakdown, which detracts from storage quality of apricots, can develop in the orchard, but is aggravated by cold storage (Ginsburg and Combrink, 1972). It begins at the pit and spreads toward the skin (Ryall and Pentzer, 1982). Gel breakdown differs from other IB symptoms as described by Dodd (1984) in that the mesocarp initially does not discolor, but takes the form of a translucent, gelatinous mass. Another type of IB is called internal browning since the flesh is discolored. Even in advanced stages of IB, apricots may have a normal external appearance (Harvey et al., 1972). The more advanced the stage of fruit maturity at harvest the greater the incidence of gel breakdown after storage (Ginsburg and Combrink, 1972; Taylor and De Kock, 1991). The incidence of these disorders can vary from year to year in the same orchard due to unknown orchard and=or climactic factors. For example from two cultivars of apricots from South Africa, 'Peeka' and 'Royal' had 0.8% and 0.2% gel breakdown in one season, and 1.3% and 45% in the next season (Taylor and De Kock, 1991).

Nectarine and Peach

Physiological Disorders : For both nectarines and peaches (Prunus persica), O_2 levels between 1 and 2 kPa have been related to delayed ripening and CO_2 levels between 3 and 5 kPa induced a limited reduction in CI and fruit softening. An oxygen level below 1 kPa may induce failure to ripen, skin browning, and off flavors while carbon dioxide higher than 10 kPa has been associated with flesh browning and 'off-flavor' (Kader, 1992). Thus, specific evaluation per cultivar should be carried out to conclude if any potential CA benefit can be used commercially.

Plums

Physiological Disorders : Recently the global production and consumption of plums (*Prunus salicina* Lindell) and prunes (*Prunus domestica* L.) have increased sharply and the need for longer storage periods is also increasing. Maintaining quality for a period of 5 weeks or even longer is needed for orderly overseas marketing. Incorporation of new cultivars has extended the harvest season from late spring through the summer months. Plums are climacteric fruits and undergo rapid deterioration after ripening, including softening, dehydration, and decay. Commercial storage conditions (08C–58C and 80%–95% relative humidity) may delay the softening process, but may also lead to the development of storage disorders. Storage disorder symptoms include flesh browning, gel breakdown, mealiness, flesh translucency, red pigment accumulation (bleeding), overripening, and loss of flavor (Dodd, 1984; Taylor et al., 1995; Taylor, 1996; Crisosto et al., 1999).

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Role of Agro-Advisory Services on Risk Management in Agriculture

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Abstract

In the resent year, anomalous weather and climate change have drastically impact on agricultural and allied sectors and with greater risk.1t also impact the quality, of absolute production levels, of major mitigation crops. Agro- Advisory Services (AAS) deliberated to the farmers on every day, daily weather data and weather forecasting are given to the adverse effects through various channels. Agro advisory bulletin (bi-weekly) is prepared and sent to all government bodies, NGO's, Kisan helpline, ETV, All India radio etc. through E-mail and is uploaded on the website working on office day and time. The increasing weather risks affect the livelihoods of farming community and GDP growth of the country. Under these threating and alarming threat condition, it is becoming increasingly important for farmers to proactively and allied sector manage the weather and climate risks to agriculture for sustainable livelihood.

***Key words :** AAS-Agro advisory services, climate change, livelihood, weather forecast.*

Introduction

India has an agriculture-based economy. the SW monsoon season is the main rainfall season for the almost all the stage. The success and failure of crops in the large parts of the country depend on the monsoon rain. We have generally numerous and diverse sources of weather and climate-related risks in farming; limited water resources, drought, land degradation, desertification, hail, flooding, early frosts and many more. Efficient mechanism of weather and climate information and advisory services can ensure the appropriate decision-

making of farmers and sustainable management of agricultural risks. Such services can help to evolve sustainable and economically so and agricultural systems, improve production and quality, reduce losses and risks, saving in production costs, increase efficiency in water management and enhanced, labor and energy, conserve natural resources, and minimization of pollution by agricultural chemicals or other agents that contribute to the deterioration of the environment. Thus, the importance of the Agromet Advisory Services have now been emerged as an important tool for risk mitigation and sustainable production.

These Services obviously meet the real-time needs of farmers and contribute to climate change weather-based crop/livestock management strategies and operations dedicated to enhancing crop productivity.

India is a vast country and, it is very tedious to maintain a network of manual meteorological observatories. To fulfill the present and future needs, India Meteorological Department (IMD) has established a network of manual observatories, automatic weather stations, automatic rain gauges, ground based radar network. The Agro-Advisory Service (AAS) rendered by IMD, Ministry of Earth Sciences (MoES) is a efficient mechanism to use so relevant meteorological judicious information that farmer make the most efficient use of natural resources, with the aim of improving agricultural production; both in quantity and quality. Advisory services delivered to the farmers on every day, daily weather data and weather forecasting disseminated through the newspapers like; Dainik Bhaskar, Dainik Jagran, Star Samachar, Jan Sandesh, Patrika, Nav Swadesh, Nav Bharat, etc. on phone call for the general public in surrounding area. Agro advisory bulletin/Weather forecast (Twice in a week- Tuesday and Friday) is also prepared and sent to NGO's, FPOs, ATMA, ETV, the office of District agricultural and horticulture officers, all local newspapers published in the district, All India radio, through E-mail. It is also sent to the KMA as well as www.imdagrimet.gov.in. (IMD, Pune).

Agromet Advisory Bulletins : The Agromet Advisory Bulletins are issued at district and block level by District Agro Met Unit (DAMU) and embrace location and crop specific advisories including field crops, horticultural crops, and livestock. The State Level bulletin is jointly prepared by State Meteorological Centre of IMD and

MCs is a composite of district bulletins helping to identify the concerned districts of the state as well as plan to supply appropriate farm inputs such as seeds, irrigation water, fertilizer, pesticides etc. Irrigation Department, Seed Corporation, Transport, and other organizations which provide inputs in agriculture. National Agromet

Advisory Bulletins are prepared by National Agromet Advisory Service Centre, Division of Agriculture Meteorology, IMD, Pune, using inputs from various states. This bulletin are very useful to identify stress on various crops for different regions of the country and suitably incorporate advisories.

The bulletins are also used by a large number of other agencies including seed, fertilizer and pesticide industries. At present bulletins are being issued twice in a week i.e. Tuesday and Friday. Agromet advisories help to enhance profits by consistently delivering actionable weather information, analysis and decision support for farming situations such as; to manage pests through the forecast of relative humidity, temperature and wind; manage irrigation through rainfall & temperature forecasts; protect the crop from thermal stress through forecasting of extreme temperature etc. A typical Agromet Advisory Bulletin enables farmers to reap benefits of benevolent weather and minimize or mitigate the impacts of adverse weather are :

District specific weather forecast, in quantitative terms, for next 5 days for weather parameters like; rainfall, cloud, maximum and minimum temperature, wind speed/direction and relative humidity, including forewarning of hazardous weather events (cyclone, hailstorm, heat/cold waves, drought and flood etc.) likely to cause stress on standing crop and suggestions to protect the crop from them.

Weather forecast based information on soil moisture status and guidance for application of irrigation, fertilizer and herbicides etc.

Advisories on sowing/planting dates and suitability of intercultural operations covering the entire crop spectrum from pre-sowing to post harvest to guide farmer in their day-to-day cultural operations.

Weather forecast based forewarning system for major pests and diseases of major crops and advises on plant protection measures.

Reducing contribution of the agricultural production system to global warming and environmental degradation through judicious management of land, water and farm inputs, agro-chemicals and fertilizers.

Advisory for livestock on health, shelter, and nutrition.

The support on above is rendered through preparing district specific agro-meteorological advisory bulletins which are tailored to meet the farmers' need and are made relevant to his decision making processes. The suggested advisories generally alter actions in a way that improves outcomes as it contains advice on farm management actions aiming to take advantage of good weather and mitigate the stress on crop/livestock. The bulletins are encoded in a format and language which is easy to understand by the farmer. The agrometeorologists first interpret the immediate past weather and the forecast for the next 5 days and translate it into layman's terms so that the farmers can understand it. They use state-of-art technology such as crop weather models, climatic risk management tools etc. for framing the advisory bulletins. Also, the interaction between the DAMUs and farmers to identify the weather sensitive decisions is promoted under the service through a participatory approach. This step fosters a relationship between the IMD, DAMUs, farmers and other stakeholders so that they can identify or diagnose the gaps in weather information and services available from the IMD.

Weather forecast and agromet information : Quantitative district level weather forecast up to 5 days is issued from first June 2008. The product comprises of quantitative forecasts for weather parameters viz. rainfall, maximum and minimum temperatures, wind speed and direction, relative humidity and cloudiness. In addition, the weekly cumulative rainfall forecast is also provided. The products were disseminated to Regional Meteorological Centers and Meteorological Centers of IMD located across the country. These products after value addition using the synoptic interpretation of model output are communicated to DAMUs co-located with SAUs, institutes of ICAR etc. for preparation of district level agro-met advisories bulletin twice a week i.e. Tuesday and Friday. IMD mandate to issue weather forecast for different time scale in advance, it provides an opportunity to efficiently minimize the loss from adverse weather and took the benefit from benevolent weather.

Short range weather forecast : Short range forecast of up to 3 days resolution and now-casting of 3 hours to 6 hours resolution having significance in efficient utilization of agricultural inputs. A network of Doppler Weather Radar (DWR) of IMD efficiently monitors the track of tropical cyclone, cloud movements, rainfall occurrence etc. informs very well in advance and mitigate the risk in agriculture quickly.

Medium range weather forecast : Medium range forecast having a temporal resolution of 3-10 days, this forecast is considered to be most important for in-situ agricultural practices. IMD issues Medium Range Weather Forecast (MRWF) quantitatively for seven weather parameters viz. rainfall, maximum temperature, minimum temperature, wind speed, wind direction, relative humidity, and cloudiness. In addition, the weekly cumulative rainfall forecast is also provided. The accuracy of the forecast is near around 70%. The model has been very successfully capturing the weather related to synoptic system leading to large scale rainfall and such forecast are very important for agricultural operationssuch as irrigation, ploughing, fertilizer application, and chemical spray etc. District-specific medium-term forecast information and advisory services help to maximize output and prevent crop damage or loss. It also helps farm communities anticipate and plan for irrigation scheduling, pesticide applications, disease, and pest outbreaks and manymoreweatherrelatedagriculture-specific operational practices. Such operations include cultivar selection, their dates of sowing/planting, important dates of intercultural operations, dates of harvesting and also performing post-harvest operations.

Extended range forecast : Long breaks in critical growth periods of agriculturally important crops lead to substantially reduced yield. Thus, the forecast of this active/break cycle of monsoon, commonly known as the Extended Range Forecasts (ERF) is very useful. The forecasts of precipitation on this intermediate time scale are crucial for the optimization of planting and harvesting. Therefore, is of great importance for agricultural planning (sowing, harvesting etc.) and yield forecasting, which can enable tactical adjustments to the strategic decisions that are made based on the longer- lead seasonal forecasts, and also will help in timely review of the ongoing monsoon conditions for providing outlooks to farming communities.

IMD has been issuing experimental ERF since 2009 using available products from statistical as well as an MME technique based on outputs available from dynamical models from various centers in India and abroad. The MME forecast is being prepared once in a week with the validity for subsequent four weeks. However, model runs are made for 45 days every week. The latest generation coupled models are found to be very useful in providing skillful guidance on extended range forecast in agriculture. The performance of extended range forecasts for the SW monsoon seasons clearly captured the delay/early onset of monsoon over Kerala, active / break spells of monsoon and also the withdrawal of monsoon in the real-time in providing guidance for various applications. On the experimental basis, the MME forecast on meteorological subdivision level up to two weeks are also being used in providing the agromet advisory for the farming community. During the other season, the MME based ERF also provides encouraging results in case of NE monsoon rainfall over the southern peninsula and tropical cyclogenesis over the north Indian Ocean during the post-monsoon season from October to December (OND). In addition, the MME based technique ERF forecast also provides useful guidance pertaining to rainfall associated with Western Disturbances (WD) over northwest India during winter. The ERF for minimum and maximum temperatures during winter and summer seasons are also found to be very useful for mitigating risk[4].

Long range forecast : Long-range forecast (LRF) / Seasonal forecast, based on statistical methods LRF has been issued for the SW monsoon rainfall over India for many years in two stages. Rainfall- induced stress associated with the amount and date of occurrence viz. early, the mid and late deficit in rainfall is predicted by long range forecast. Long range forecast provides lead time for strategic planning in agriculture.

Gramin krishi mausam sewa : India Meteorological Department (IMD) is rendering district level weather based agromet advisory service named as "Gramin Krishi Mausam Sewa" since 2008 in the country to cope up with weather and climatic risks and uncertainties. GKMS is multi-disciplinary and multi-institutional project. It involves all State Agricultural Universities (SAUs), Indian Council for Agriculture Research (ICAR), Krishi Vigyan Kendra (KVKs) Department of Agriculture & Cooperation and Farmers' Welfare, State Department of Agriculture, NGOs, Media Agencies etc. Under GKMS scheme weather- based crop and locale-specific agro-advisories for rural districts are prepared and disseminated to farmers deploying various modes of information dissemination e.g. radio, television, print media, internet, Kisan Call Centers and mobile phones. Presently 1.14 crore farmers in the country receive abridged advisories through short message service (SMS) and Integrated Voice Response System (IVRS) on their mobile phone[7].

The services at its current spatial resolution made significant contribution to reduce risk and improve agricultural productivity farm income, despite local climate variations. It also focuses on environment-friendly integrated solutions that are within the farmers' capabilities. It was observed that there has been a substantial increase in productivity for cereals, oilseeds, and vegetable. A comprehensive study on impact assessment and economic benefits of this service carried out in the year 2010 by the National Council of Applied Economic Research (NCAER) report that the contribution to GDP has estimated Rs. 50,000 crores. Weather forecast and warnings have helped to enhance the livelihood security for farmers and rural community in the project region. Further to improve the relevance of this service at block level with high resolution weather forecast will be utilized to develop the services. As a part of GKMS, it is proposed to establish 660 District Agromet Units (DAMUs) at KVKs at each district will be included in a phased manner. Efforts are being made to atomize the process of farm advisory preparation and dissemination through Kisan portal. Service delivery at block and village level will be established using all the dissemination channels including DD Kisan, Kisan portal.

Weather risk management tools : The emerging weather and climate risk clearly offer new risk management tools and opportunities for agriculture. Identifying the location wise risk to weather, the time period during which risk is prevalent and further quantifying and designing a weather risk management strategy based on an index is more relevant to neutralize the risk in agriculture. Under the GKMS scheme, more focus has been started to be given to using the crop simulation model to decide crop management strategies, for the given weather condition. This will help the farmers and planners in tactical and strategical decisions regarding irrigation scheduling and efficient water management in both irrigated and rainfed agriculture system. For particular districts based on realized forecast for strategic/tactical decision support system were generated in few states; the outcomes of risk management options are useful for taking decisions well in advance for crop as well as for other input management and farm activities during different stages of the crop growing season.

Conclusions

In the present scenario of climate change and uncertainty weather condition. Sustainable and adverse farmers need both weather and climate adversely services for crop production. Agromet Advisory services are the of appropriate and efficient mechanism based technical associated with requirement the agriculture locally-appropriate climate and weather information play a making crucial role on risk management in agriculture. At the district level, AAS is underway to extend up to sub-district/block level with dissemination up to village level to

Fulfil the end user's requirements in the irrigated and rainfed systems pertaining to agricultural and allied sectors. Establishment of 660 DAMUs in each district of India at KVK is under which includes 130 existing AMFUs at agricultural university level till 2019 for the weather forecast. Presently these are 200 DAMU running in 200 districts for increasing Agro advisory services proposed plan of IMD and ICAR. Agro advisory services under DAMU has proven to worth in dissemination the weather based technical information to the farming community in desired manner.

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Variability and Inter-Relationships of Quantitative Traits in Sewan Grass (*Lasiurus sindicus* Henr.) Accessions

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Abstract

The present investigation was carried out to estimate variability in green fodder yield and related traits in sewan grass accessions. Data were recorded for eleven agro-morphological characters during *kharif*-2017 at Agricultural Research Station, Bikaner. Biometrical approaches such as genetic variation and character association were studied for 30 sewan grass accessions based on dry matter yield per plant. Coefficient of variation was high for number of tillers per plant (74.93) followed by dry matter yield per plant (28.84), plant height (27.07) leaf stem ratio (18.86) and green fodder yield per plant (18.62). It indicated that relative magnitude of the phenotypic variances among the accessions for above traits is very important prerequisite for making simultaneous selection. Trait plant height (-1.06) showed a left skewed distribution that indicates the presence of non-additive gene action environmental influence. Considering kurtosis, all the traits except days to complete seed maturity and spike length showed mesokurtic distribution. The result from character association indicated that dry matter yield per plant showed positive and significant correlation with green fodder yield per plant (0.634), number of tillers per plant (0.489) and leaf width (0.453) showing possibility of simultaneous improvement of these characters along with dry matter yield per plant.

Key words : *Sewan grass, phenotypic variation, character association, accessions.*

Introduction

Dichanthium-*Cenchrus*-*Lasiurus* type grasslands are associated with sub-tropical arid and semi-arid regions comprising the northern portion of Gujarat, the whole of Rajasthan, excluding the Aravalli ranges in the South, western Uttar Pradesh, Punjab, Haryana and Delhi State with a coverage of more than 436,000 km^2 between 23¢X and 32¢XN and 68¢X and 80¢XE.The dominant perennial grass is the indigenous sewan grass popularly known as the “king of desert grasses”. The only known species is sewan grass (*Lasiurus sindicus*) belongs to family *Poaceae* is native to dry areas of North Africa, Sudanese and Sahelian regions, East Africa, and Asia. Sewan grass is a diploid species with somatic chromosome number (2n) = 20 however in wild species chromosome number and ploidy level can vary. Sewan grass is a perennial grass that can live up to 20 years. Propagation is done by sowing or root slips. It grows best on alluvial soils or light brown sandy soils with a pH of 8.5. This grazing pasture is of utmost importance in areas where annual rainfall is below 250 mm. The crude protein in the sewan herbage is high (8.14 per cent) in the early vegetative stage of growth. A 30-day cutting interval at a height of 15 cm gives the best dry matter yields. Sewan grass yields 2.7 to 10.5 tonnes fresh forage/ha/year and up to 3.4 tonnes DM/ha in well-established swards. Species like sewan grass are very important in arid environments because they provide forage, which maintains both wild mammals and livestock, and soil cover. Sewan grass can be used to stabilize desert sandy dunes and hummocks (Ecocrop, 2010; FAO, 2010). In deteriorated rangelands of Saudi Arabia, sewan grass helps to control the low value invasive species *Rhazya stricta* by smothering its seedlings. It is a useful tool to improve rangeland management (Assaeed and Al-Doss*,* 2001). In India, sewan grass covers 0.1million hectares of area (Bhagmal, *et al.,* 2011). The variability in plant population is the first requirement for improvement in any crop. The amount of variability in the accessions of any crops sets the limits of progress that can be achieved through selection. Inter-relationship measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield.

Therefore, present investigation was conducted to determine the variation and inter-relationship in 30 accessions of sewan grass based on mean values of dry matter yield per plant.

Materials and Methods

All the germplasm accessions are established in germplasm block of AICRP on Forage Crops and Utilization, Agricultural Research Station, SKRAU, Bikaner. Each accession was established in unreplicated design with length spaced at 1m between rows and 1m between plants. The observations were recorded for eleven characters namely days to 50% flowering (DF), days to complete seed maturity (DM), plant height (PH), numbers of tillers per plant (NOT), leaf length (LL), leaf width (LW), spike length (SL), green fodder yield per plant

Table-1 : Mean performance and variability parameters in eleven agro-morphological traits in sewan grass accessions.

Accessions no.	DF	DM	PH	NOT	LL	LW	SL	GFY	DMY	DM%	LSR
RLSB 1-22	38	69	80.2	40	33.36	0.50	7.82	0.900	0.357	39.66	1.30
RLSB 1-25	38	71	70.1	52	14.18	0.40	7.82	0.662	0.295	44.61	1.28
RLSB 1-31	38	71	89.1	75	24.60	0.40	7.58	0.902	0.361	40.02	0.94
RLSB 1-39	41	71	83.4	6	20.92	0.46	7.20	0.720	0.281	39.04	0.97
RLSB 1-50	36	73	87.3	17	35.30	0.44	7.84	0.726	0.295	40.59	0.88
RLSB 1-9	42	71	84.3	20	38.32	0.60	7.18	1.015	0.347	34.21	1.04
RLSB 2-11	41	73	80.2	64	41.16	0.74	10.12	0.857	0.363	42.32	0.99
RLSB 2-23	43	73	75.4	6	28.52	0.58	6.32	0.626	0.326	52.15	0.87
RLSB 2-34	37	72	93.4	32	27.64	0.40	8.14	0.873	0.372	42.58	1.09
RLSB 2-7	43	68	61.1	10	12.52	0.52	7.20	0.862	0.334	38.77	1.20
RLSB 3-28	38	70	97.4	65	26.90	0.56	8.08	0.924	0.376	40.74	0.78
RLSB 3-39	48	75	56.3	12	28.10	0.30	7.30	0.670	0.282	42.06	0.86
RLSB 3-8	42	70	77.2	12	20.00	0.44	7.32	0.725	0.282	38.90	1.25
RLSB 5-3	37	70	52.1	4	15.22	0.52	7.42	0.803	0.318	39.56	0.77
RLSB 6-10	41	72	86.3	11	32.00	0.42	9.42	0.481	0.295	61.33	0.90
RLSB 6-18	38	69	99.7	29	26.12	0.68	7.42	0.840	0.365	43.46	0.86
RLSB 7-19	37	73	91.3	50	26.56	0.66	8.22	0.780	0.331	42.38	0.95
RLSB 7-2	42	69	74.2	32	17.88	0.52	7.90	0.800	0.375	46.83	0.89
RLSB 8-20	39	70	83.3	12	24.96	0.50	10.06	1.060	0.354	33.42	0.70
RLSB 8-36	48	86	65.2	38	24.34	0.42	8.22	0.667	0.287	43.02	1.04
RLSB 8-44	48	67	65.2	3	21.94	0.40	7.86	0.803	0.318	39.56	0.77
RLSB 9-18	48	80	39.3	38	24.58	0.42	8.18	0.500	0.308	61.60	0.87
RLSB 9-29	38	70	107.4	31	22.18	0.42	7.32	0.687	0.279	40.58	1.20
RLSB 10-10	44	75	94.9	22	24.56	0.60	8.94	0.723	0.299	41.34	0.90
RLSB 10-11	43	74	93.2	10	20.98	0.52	9.38	0.781	0.304	38.89	0.83
RLSB 10-12	37	68	14.9	58	24.34	0.44	8.24	0.667	0.327	49.02	0.87
RLSB 10-31	45	70	60.6	3	17.34	0.30	7.56	0.587	0.280	47.65	1.35
RLSB 10-38	36	69	70.2	19	15.16	0.36	7.84	0.706	0.304	43.12	0.76
RLSB 11-17	34	72	39.3	38	17.32	0.34	7.54	0.521	0.342	65.64	0.97
RLSB 11-28	42	74	75.2	15	20.04	0.62	9.82	0.689	0.309	44.87	0.87
Mean	40.73	71.83	74.92	27.47	24.23	0.48	8.04	0.75	0.32	43.93	0.97
Standard Deviation	3.96	3.76	20.28	20.58	6.99	0.11	0.92	0.14	0.03	7.50	0.18
Standard error	0.71	0.68	3.64	3.69	1.26	0.02	0.17	0.03	0.01	1.35	0.03
CV (%)	9.72	5.23	27.07	74.93	28.84	22.79	11.44	18.62	9.31	17.07	18.65
Skewness	0.50	2.17	-1.06	0.75	0.56	0.47	0.93	0.09	0.26	1.64	0.81
Skewness shape	Symmetric	Asymmetric	Asymmetric	Symmetric	Symmetric	Symmetric	Asymmetric	Symmetric	Symmetric	Asymmetric	Symmetric
Kurtosis	-0.61	6.48	1.42	-0.42	0.17	-0.27	0.46	-0.06	-1.31	2.58	-0.29
Tail shape	Meso	Lepto	Meso	Meso	Meso	Meso	Meso	Meso	Meso	Lepto	Meso

DF days to 50 % flowering, DM days to complete seed maturity, PH plant height, NOT number of tillers per plant, LL leaf length, LW leaf width, SL seed length, GFY green fodder yield per plant, DMY dry matter yield per plant, DM% dry matter percentage, LSR leaf stem ratio.

(GFY), leaf: stem ratio (LSR), dry matter percentage (DM%) and dry matter yield per plant (DMY). For the traits leaf length, leaf width and spike length five observations were recorded on each plant and averaged to obtain mean. However, sewan grass is a perennial nature so that observations were recorded on first cut from June 1, 2017 to September 10, 2017. Biometrical methods such as variability parameters (Burton 1952), correlation (Johnson *et al.,* 1955) were statistically analysed for thirty sewan accessions.

Results and Discussion

Variability parameters : Range for green fodder yield per plant and dry matter yield per plant was (0.481-1.06 kg) and (0.279-0.379 kg), respectively. Sewan accession RLSB 8-20 (1.06 kg) recorded high *per se* performance for green fodder yield per plant followed by RLSB 1-9 (1.02 kg), RLSB 3-28 (0.924 kg), RLSB 1-31 (0.902 kg) and RLSB 1-22 (0.900 kg) (Table 1). The increased green fodder yield per plant in accession RLSB 8-20 was due to

Table-2 : Correlation coefficient among yield and related traits in sewan grass accessions.

Traits	DCM	PH	NOT	LL	LW	SL	GFY	DMY	DM (%)	LSR
DF	0.471**	-0.167	-0.362*	0.012	-0.100	0.027	-0.210	-0.373*	0.009	0.013
DCM	1	-0.072	0.093	0.189	-0.025	0.210	-0.362*	-0.318	0.247	-0.061
PH		1	0.008	0.315	0.398*	0.139	0.434*	0.150	-0.464**	0.051
NOT			1	0.245	0.174	0.147	0.160	0.489**	0.099	0.079
LL				1	0.386*	0.234	0.256	0.278	-0.082	-0.090
LW					1	0.311	0.443*	0.453*	-0.270	-0.206
SL						1	0.107	0.116	-0.005	-0.303
GFY							1	0.634**	-0.802**	-0.104
DMY								1	-0.085	-0.207
DM (%)									1	-0.046

DF days to 50 % flowering, DM days to complete seed maturity, PH plant height, NOT number of tillers per plant, LL leaf length, LW leaf width, SL seed length, GFY green fodder yield per plant, DMY dry matter yield per plant, DM% dry matter percentage, LSR leaf stem ratio.

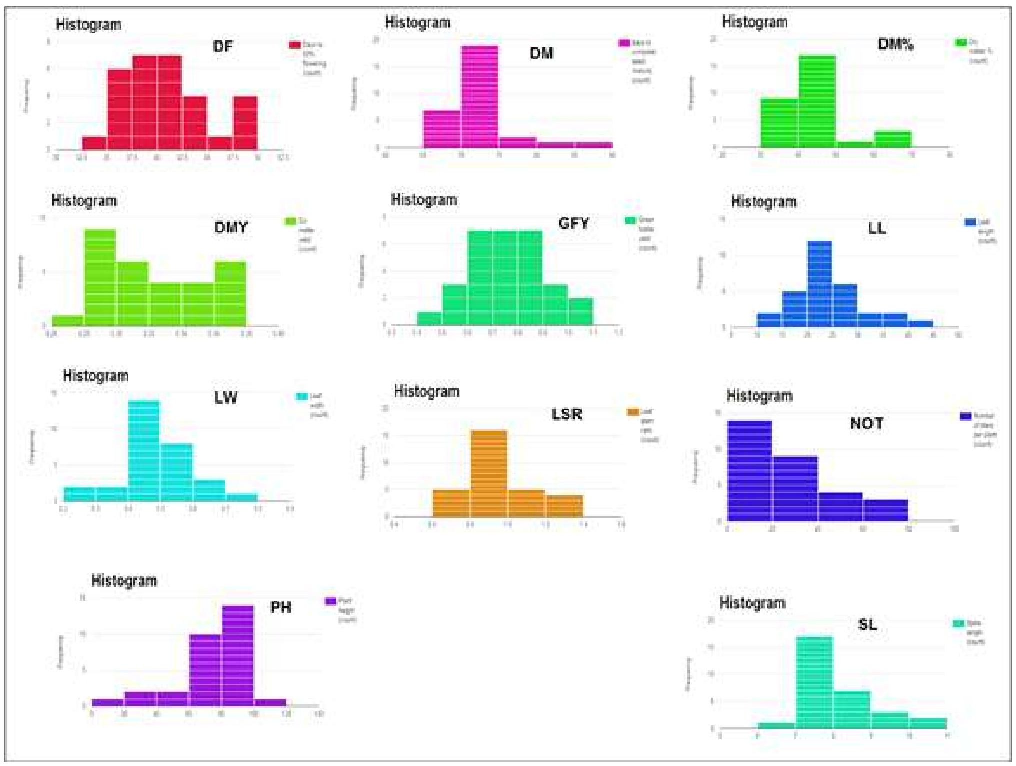

Fig.-1 : Frequency distribution for eleven agro-morphological traits in sewan grass accessions.
DF days to 50 % flowering, DM days to complete seed maturity, PH plant height, NOT number of tillers per plant, LL leaf length, LW leaf width, SL seed length, GFY green fodder yield per plant, DMY dry matter yield per plant, DM% dry matter percentage, LSR leaf stem ratio.

higher mean values of spike length. Similar observations were taken by Shekhawat *et al.* (2003) in this grass for some characters. In present investigation, wide ranges of differences for coefficient of variation were observed which varied from 5.23 for days to complete seed maturity to 74.93 for number of tillers per plant. Such result was also reported by Yadav (1974) in the pasture grass, *Pennisetum pedicellatum*. In present investigation, all the traits showed continuous variation, among them most of the traits showed asymmetrical normal distribution except two traits plant height and leaf length as evidenced from the skewness (indicates the sign of asymmetry and deviation from normality) and kurtosis (indicates the peakness or flatness of normal distribution curve) parameters. In this study, all the traits except plant height exhibited a right tailed distribution (Figure 1). The skewed distribution of this trait could be attributed to the presence of non-additive gene action and environmental influence. Considering kurtosis, all the traits except days to complete seed maturity and spike length showed a leptokurtic distribution. The traits with leptokurtic are known to be governed by less number of genes.

Inter-relationship with dry matter and green forage yields : Dry matter yield per plant had significant and positive correlation with green fodder yield (0.634), number of tillers per plant (0.489) and leaf width (0.453). Similar results were reported by Yadav and Krishna (1986) in sewan grass, Rajora (1998) in buffel grass, Thakral and Jatasra (1994) in *Cenchrus setigerus*, Patel *et al*. (2007) in anjan grass (*Cenchrus ciliaris*) and Gore *et al.* (2016) in marvel grass. Dry matter yield per plant had significant and negative correlation with days to 50 % flowering (-0.373) and dry matter percentage (-0.802). Similar result was reported by Yadav *et al*. (1974) in *Cenchrus ciliaris*. Days to 50% flowering (0.471) had significant and positive inter-relationship with days to complete seed maturity. This result was in accordance with Kumari *et al.* (2013) in pearl millet.

Conclusions

High to moderate coefficient of variation was reported in sewan accessions could be due to genotypic variation and environmental variables. Since data were recorded on single plant basis and unreplicated design therefore, in total variation genotypic and error variations could not be estimated independently. However, this study will give the general idea of variation found in cross pollinated sewan grass accessions collected from different part of state Rajasthan. as per third degree of statistical approaches such as kurtosis and skewness represented the symmetrical distribution among studied traits and also found gene action as plant height showed non additive gene action. In forage grasses and crops economic traits are complex and polygenic such as green fodder yield and dry matter yield and inter-relationship with component traits give the basic idea of selectable associate traits directly and indirectly influencing the economic traits values. In present study, for dry matter yield and green fodder yield, plant height, spike length, number of tillers and leaf width showed positive correlation. Therefore, these traits could be utilized for simultaneously selection to improve fodder values in sewan grass.

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Seasonal Incidence of Major Insect Pest of Button Mushroom in Relation to Weather Factors under the Conditions of Sub Tropics of Jammu

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Abstract

Mushroom flies are the most serious insect pest affecting the cultivation of button mushroom (*Agaricus bisporus* Lange) and among them sciarid fly, phorid fly and beetles are the most common. This study was set out to determine the occurrence of mushroom flies at mushroom farming areas in Jammu region. The occurrence of mushroom flies were highest in January as temperature increases thus causing huge losses in mushroom productivity. Adult flies invade mushroom farms and ovipositor in freshly spawned compost. The activity of mushroom flies were recorded at spawn run stage, pin head stage and sporophore stage. The incidence of pest complex was observed up to the spawn run stage. Later on, the population disappeared, except for the beetle that is noticed even at the sporophore maturation stage. The button mushroom was abundantly infested by major insect pests, which were phorid fly and sciarid fly during both years. Infestation by phorid fly initiated in November and that of sciarid fly initiated in the month of 2nd week of November. The major insect pests reached their peak mean populations during November to January. The mean atmospheric temperature had a significant positive correlation (r = 0.37 and 0.25) with phorids and sciarid flies, respectively. Whereas, relative humidity had a significant negative correlation with phorid flies (r = -0.53) and sciarid flies (r = -0.36) during both cropping seasons.

Key words : *Agaricus bisporus, seasonal incidence, insect pests, correlation*

Introduction

In India, in spite of varied agro-climate conditions and huge agri and industrial wastes available, the growth of mushroom industry in our country is slow as compared to other mushroom growing nations. Among the several factors, occurrence of various insect pest and disease significantly affect the production and also the interest of growers in the enterprise future, it is because of large number of small and satellite growers who cultivate mushroom either on long method unpasteurized compost or on pasteurized compost under natural climatic conditions. In these farms hygienic and sanitary measures are rarely followed. As a result, a large number of insect pests like phorids, sciarids, springtails and mites gain easy access to the cropping area. These pests take heavy toll of crop every year. The larvae of mushroom flies feed on mycelium enter into the young primordial and tunnel the well-developed mushroom. Mushrooms are recognized as alternative source of good quality protein and are capable of producing the highest quantity of protein per unit area from the Agro wastes. Mushroom can sustain the suffering from malnutrition to some extent because they produce large quantity in a short time and provide more protein per unit area than other crops. However, it is infested by many insect-pests such as phorid flies, scairid flies, springtails and mites. Of these scairid fly, *Bradysia tritici* (Coquillet) and phorid fly, *Megaselia sandhui* (Disney) are the serious pests of white button mushroom, *Agaricus bisporus* all over India. Sciarids, cecids and phorids were found to cause 17-26, 26-33 and 46% loss in yield, respectively by Agarawal and Topwal 2018. Occurrences of sciarid and phorid flies vary with the prevailing temperatures under seasonal conditions. The mushroom flies also spread mites and other pathogens on the mushroom beds by carrying them on their bodies. The sciarids contaminate the compost by their fecal matter which results in making the compost soggy and unsuitable for spawn run. The various insect pests which affect cultivated mushrooms, larvae of the phorid fly, *Megaselia sandhuii* Disney, the sciarid fly, *Bradysia tritici* (Coq) and the cecid fly have been recorded on mushrooms in Punjab and Chandigarh.

Materials and Methods

Monitoring of adult dipteral stages : Survey was conducted at different mushroom farms of three districts *viz.,* Jammu, Samba and Udhampur of Jammu division. Monitoring was done during the cropping period (November-March) for identification of different insect pests associated with button mushroom (*Agaricus bisporus*) during 2019-20 and 2020-21.Three double sided sticky yellow plates (20 × 14 cm) were used to trap the adults in each farm where one of the plate was placed near the front door, the second one, in the middle of the farm and the third one, in the back area, near the ventilation window. Each farm covers approximately 300 m^3area. In order to monitor the patterns of both diptera species in detail, the sticky plates were put in position two

Table-1: Insect-pest incidence in button mushroom farms.

Insects	2019-20		2020-21		Overall mean	
	No. of farms with insect occurrence	Incidence (%)	No. of farms with insect occurrence	Incidence (%)	No. of farms with insect occurrence	Incidence (%)
Jammu						
Sciarid fly	7	11.86	6	10.16	6.50	11.01
Phorid fly	9	15.25	12	20.33	10.50	17.79
Beetle	5	8.47	3	5.04	4.00	6.77
Samba						
Sciarid fly	11	18.33	8	13.33	9.5	15.83
Phorid fly	19	31.66	21	35.00	29.5	49.16
Beetle	2	3.33	4	6.66	3.00	5.00
Udhampur						
Sciarid fly	2	5.26	9	23.68	5.5	14.47
Phorid fly	5	13.15	2	5.20	3.5	9.21
Beetle	1	2.63	3	7.89	2.0	5.26

Table-2 : Succession of insect life stages during cultivation of button mushroom in Jammu division.

Date of observations	Crop stage	Sciarid fly (No.)			Phorid fly (No.)		
		Maggot	Pupa	Adult	Maggot	Pupa	Adult
4th November	Spawn run	03.30	01.95	16.25	06.50	04.50	17.60
11th November	Spawn run	06.75	10.75	20.26	07.00	07.50	16.70
18th November	Spawn run	13.55	13.25	14.75	14.30	09.10	14.30
25th November	Casing	00.00	00.00	22.80	00.00	12.00	12.20
1st December	Casing	01.60	00.50	27.40	07.70	03.70	09.80
7th December	Casing	06.45	01.80	23.00	10.40	03.20	08.80
14th December	Pinhead	00.00	0.00	21.40	00.00	00.00	07.70
21st December	Pinhead	00.00	0.00	15.10	00.00	00.00	08.10
28th December	Sporophore	03.75	0.00	11.65	08.60	00.00	07.50
4th January	Pinhead	00.00	0.00	10.25	00.00	00.00	06.60
11th January	Sporophore	02.85	0.00	09.60	05.10	00.00	05.20
18th January	Pinhead	00.00	0.00	07.60	00.00	00.00	04.90
25th January	Sporophore	02.10	0.00	05.50	00.00	00.00	03.50

Table-3 : Insect pest incidence during cultivation of button mushroom.

Insect pest	Life stage of insect	Crop stage	No. of insect bag-1 (Range)	Period of activity	Crop stage of maximum insect population
Sciarid fly	Maggot	Spawn run to sporophore maturation	1.60-13.55	1 week of 4 November to 25 January	Spawn run
	Pupa	Spawn run	0.5-13.25	1 week of 4 November to 25 November	Spawn run
	Adult	Spawn run to sporophore maturation	5.5 – 27.40	1 week of 4 November to 25 January	Pinhead to mature sporophore
Phorids fly	Maggot	Spawn run to sporophore maturation	5.1 – 14.3	1 week of 4 November to 25 January	Spawn run to casing
	Pupa	Spawn run	3.2 – 12.0	1 week of 4 November to 25 November	Spawn run
	Adult	Spawn run to sporophore maturation	3.5 – 17.6	1 week of 4 November to 25 January	Spawn

days before starting the crop cycle and remained until the end of the cycle. The plates were frequently renewed. Trapped diptera were then identified and counted.

Monitoring of immature dipteral stages : Immature diptera stages were studied in the growing substrates of button mushroom. First, six samples of compost and two samples of the casing layer were taken before they were applied. Later, during the crop cycle, three samples of both substrates were collected at the end of the incubation period, during the induction period and at the end of the first, third and fifth flushes. From each sample, a

Table-4 : Correlation between population of mushroom files and abiotic factors of the cropping room.

Date of observation	Crop stage	Sciarid maggot population	Phorid maggot population	Temperature (°C)	Humidity (%)
4th November	Spawn run	03.30	06.50	21.35	74.00
11th November	Spawn run	06.75	07.00	20.05	73.00
18th November	Spawn run	13.55	14.30	21.60	74.50
25th November	Casing	00.00	00.00	22.55	76.00
1st December	Casing	01.60	07.70	16.75	80.00
7th December	Casing	06.45	10.40	15.95	82.00
14th December	Pinhead	00.00	00.00	17.90	79.60
21st December	Pinhead	00.00	00.00	18.80	80.50
28th December	Sporophore	03.75	08.60	16.25	79.00
4th January	Pinhead	00.00	00.00	14.50	81.85
11th January	Sporophore	02.85	05.10	18.70	81.15
18th January	Pinhead	00.00	00.00	16.40	78.05
25th January	Sporophore	02.10	00.00	17.50	80.40

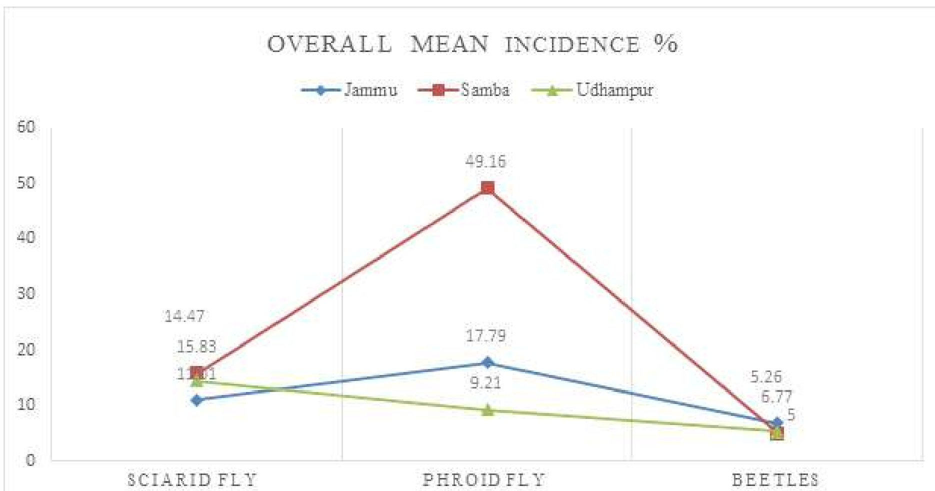

Fig.-1 : Insect-pest incidence in different mushroom farms.

subsample of 50 g was extracted using the method described by Fordyce and Cantelo (1981) and examined for immature diptera stages. The numbers were then counted directly.

Collection of coleopteran insects : The beetles and their grubs were collected from individual sporocarp and the mean number of beetles/grubs per sporocarp was calculated, while beetles were collected from 250 cc casing soil and the infested fruiting bodies of *Agaricus bisporus*. The collected fauna were preserved separately in 70 per cent ethyl alcohol for identification. Identification was done with the help of taxonomic keys and was confirmed from insect taxonomists.

Statistical study : A spatial distribution of diptera in mushroom farms was calculated by trapping adults with sticky plates. The data concerning the trapped adults for all the growing cycle periods were subjected to logarithmic transformation [log (x +1)] and linear regression. An analysis of variance of the slopes was performed.

Results and Discussion

Incidence of major insect pests on button mushroom : Survey of 59 mushroom farms of various blocks of Jammu district revealed the incidence of sciarid fly, phorid fly and beetle insects in button mushroom crop. It was observed that 6.77 per cent of farms were infested with beetles while maximum (17.79%) farms were infested with phorids flies. However, 11.01 per cent farms showed infestation of sciarid flies.

In Samba district, 60 mushroom farms were surveyed, which were distributed across five blocks and the results presented in Table-1 revealed that the mean number of farms showing infestation of various insects varied between 5.0 to 49.16 per cent. The incidence of phorids fly was recorded to be highest in 49.16 per cent of farms while beetle was lowest with infestation in 5.00 per cent farms. However, 15.83 per cent farms showed infestation of sciarid flies. Survey of 38 mushroom farms of the district Udhampur revealed mean incidence of sciarid fly, phorid fly and beetle to vary between 5.26 to 14.47 per cent of surveyed farms. Incidence of sciarid fly was observed in maximum (14.47%) farms whereas beetle infestation was in minimum 5.26 per cent of farms. However, 9.21 per cent farms showed infestation of phorids fly. Similar observations have been reported by Navarro *et al.* (2000) who surveyed 24 mushroom growing farms in Spain for 18 months and reported that the population of phorid was higher than sciarid and the highest population was recorded in spring although phorid population increased in autumn. In a two-year survey study carried out in the Antalya-Korkuteli district, three sciarid species, namely, *Lycoriella auripila* (Winnertz), *L. ingénue* (Dufour), which was the first record for the Turkish fauna, and *L. solani* (Winnertz), were detected in mushroom growing cellars in the district. Of the three sciarid species determined in the surveys, *Lycoriella solani* was the most common species, accountingfor up to 61% and 65% of the total population of mushroom sciarid flies in 2002 and 2003, respectively (Erler and Vurus 2004). During another surveyon mushroom flies, *L. solani* was determined to be the most common species in the mushroom growing cellars in Izmir province (Western Part of Turkey) (Civelek and Onder 1997).

Succession of major insect pests on button mushroom : The infestation of the sciarid flies *viz.,* maggots, pupa and adults began with the spawn run i.e., from the first week of November (Table 2). The population of the maggots was highest (13.55) near to the stage of completion of spawn run and lowest near to fruit maturity, whereas pupa were also highest (13.25) near to completion of spawn run and no pupa was observed after the application of casing layer. However, the adults were recorded to be maximum in casing (27.00) whereas minimum sciarid population (5.5) was observed at fruit formation stage. In case of phorids, again the infestation of the mushroom bags was observed for its maggots, pupa and adult flies. During the spawn run from first week to third week of Nov the number of maggots bag^{-1} were 6.5, 7.0 and 14.3 respectively. During this period, the number of pupae was observed to be 4.5, 7.5 and 9.1 bag^{-1}, whereas, the adults was 17.6, 16.7 and 14.3 bag^{-1}respectively. After spawn run (4th week of November) no maggots were recorded until casing was done, however, 12.0 pupae and 12.2 adults bag^{-1} were observed in the 4th week of November. The maggots reappeared in the first and second week of December (7.7 and 10.4 bag^{-1}). The no. of pupae was 3.7 and 3.2 bag^{-1}(1st& 2nd week of December), whereas, there were 9.8 and 8.8 adults bag^{-1}. Similar to sciarids, the phorid maggots and pupae disappeared during pinhead stages (second week of December) and appeared along the sporophores. The infestation of adults remained throughout the cropping season, i.e., 7.7, 8.1 and 7.5 adults bag^{-1} for 3rd to 5th week of December, whereas, 6.6, 5.2, 4.9 and 3.5 adults bag^{-1} were observed for the 1st to 4th week of January respectively. Similar observations have been reported by Erler and Polat (2008). The sciarid species prefer cool temperatures and are most active when outdoor temperatures are between 10 and 24^{0}C, the threat of infestation is greatest from March to May and September through late November. This threat was reported to be diminished during the hottest part of the summer, especially under dry conditions. Sciarid fly (*Bradysia tritici)* is one of the most destructive pests of button mushroom (*Agaricus bisporus*) and causes huge yield losses by tunneling in its sporophores. Sciarid fly has been found infesting the mushroom upto 32.7 per cent in Punjab (Sandhu and Brar, 1980) and 75 per cent in Pakistan (Khan *et al*., 2002).

Insect pest incidence in relation to crop growth stages of button mushroom : The result presented summarizes the insect pest incidence in relation to crop growth stage, period of activity and crop stages of maximum insect population. An insight into the Table 3 reveals that although maggots of sciarid were present throughout the crop growth stages but were found maximum during the spawn run stage (1.66-13.55 bag^{-1}). Similarly, pupa were also found highest during spawn run (0.5-13.25 bag^{-1}). Although adults were present in all the stages of crop growth but were found maximum in casing to sporophore formation (5.5-27.40 adults bag^{-1}).Similarly, in case of phorids, maggots of phorids were present throughout the crop growth stages but were maximum during the spawn run to casing stage (5.10-14.30 bag^{-1}). Also, pupa were found highest during spawn run (3.20-12.00 bag^{-1}) while adults were present in all the stages of crop growth but were maximum in spawn run stage (3.5-17.6 adults bag^{-1}).

Correlation between populations of mushroom files

Effect of temperature : The effect of the temperature on the maggots were recorded and analyzed for November to January. The average temperature of the cropping room ranged between 14.5 to 22.5 ^{0}C. For both the scarid and phorid flies, temperature had positive but non- significant correlation. The average relative humidity over the two years for the months November to January ranged between 73 to 82 per cent (Table 4). Unlike temperature, relative humidity showed a negatively non- significant correlation with the population of the scarids and phorid flies. The multiple correlation coefficients between the insect infestation and mean temperature and relative humidity were non-significant while coefficient of determination (R_2) was 0.53 and 0.36 for scarids and phorid flies respectively.

Conclusions

Survey of different mushroom farms revealed the presence of sciarids fly, phorids fly and beetles in the mushroom farms.From the observation on mushroom flies activity, itwas found that dipteran flies were major insect pests which severely infestthe mushroom crop. The spawn running crop growth period are most susceptible and provided congenial microenvironment. The pest activity associated and influenced more by growth stages of the mushroom crop than the prevailing abiotic conditions.

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Growth Performance, Carbon Sequestration and Economics of Gambhar (*Gmelina arborea*) Based Agrisilvicultural System in Coastal Ecosystem

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Abstract

The experiment was carried out in a Randomized Block Design with 7 treatments and 3 replications, i.e *Gmelina arborea* + Arhar, *Gmelina arborea* + Cowpea-Toria, *Gmelina arborea* + Green gram-Toria system, four sole cropping system i.e Arhar, Cowpea-Toria and Green gram- Toria and sole *Gmelina arborea* system to assess the growth performance, carbon sequestration and economics of Gambhar (*Gmelina arborea*) based agrisilvicultural system in Coastal ecosystem. Among agrisilvicultural systems *Gmelina arborea* attained maximum growth in association with Green gram-Toria *i.e* tree height (4.52 m), D.B.H (7.7 cm) and crown spread (3.74 m) after 48 months of planting. The highest total biomass of 18,525 kg ha^{-1} was obtained in *Gmelina arborea* + Green gram-Toria system in which incremental biomass of the tree was 4631 kg ha^{-1}yr^{-1}, crop biomass of Greengram-Toria was 4451 kg ha^{-1}yr^{-1}. The maximum carbon sequestration (5132 kg ha^{-1}) was observed in *Gmelina arborea* + Green gram-Toria. Among agrisilvicultural systems yield of Cowpea green pod was 3724 kg ha^{-1} and yield of Toria seed was 541 kg ha^{-1} was obtained in *Gmelina arborea* + Cowpea-Toria system. The highest net return and BC ratio (Rs 96,559 ha^{-1}, 2.75) was recorded with *Gmelina arborea* + Cowpea-Toria system. In this agrisilvicultural system highest Arhar equivalent yield (1269 kg ha^{-1}) and rain water productivity (3.17 kg ha mm^{-1}) was recorded in *Gmelina arborea* + Cowpea-Toria system.

Key words *: Biomass, Carbon Sequestration, Rain water productivity, B:C ratio, Gmelina arborea*

Introduction

The need for more efficient and sustainable land use is becoming more urgent as the world's population grows. As a new land use system, agroforestry can be part of the solution to solving environmental, economic and social issues. In the recent past, the choice of agroforestry as a land-use system has demonstrated an increasing trend. Complex and diverse systems of agroforestry systems have become a research interest globally, raising fundamental questions such as carbon sequestration and nutrient cycling (Swamy *et al*. 2005). Diverse environmental as well as socio economic benefits can be derived from the biomass that comes from farms, forestry, timber and Short Rotation Forestry (SRF) for energy purposes. The production of biomass for energy entails, reducing carbon discharges and enhanced forest utilities, such as the protection of hydro-ecological and biodiversity activities. *Gmelina arborea* , belongs to Lamiaceae family & being an indigenous fast growing species identified as white teak / Gambhar, used as multipurpose tree. In addition, the species has a high ability to sequester carbon. Intercrops viz. arhar, cowpea, green gram, toria can be grows successfully in the allies. . Tree-based land use programs have made a vital impact in improving production, sequestering carbon and providing an alternate source of revenue. It is regarded as the most complex and appropriate mechanism that expands the profitability and increases productivity for greater socio-economic, ecological and environmental benefits (Verma *et al*. 2017). The limited information is available in the interaction of tree crops and carbon sequestration capacity of agrisilvicultural systems. Therefore, an experiment was conducted to study the growth performance, carbon sequestration and economics of Gambhar (*Gmelina arborea)* based agrisilvicultural system in Coastal ecosystem

Materials and Methods

The present investigation was carried out in the Agroforestry Research Station, OUAT, Ghatikia, Bhubaneswar from June 2019 to July 2020. The experiment station lies in the sub-tropical climate. It is about 66 km from the Bay of Bengal in the East. It has a warm and humid climate characterized by a cool winter and a hot humid summer. The station's annual daily rainfall is 1493.7 mm, with 113 rainy days a year mainly obtained from the south-western monsoon. The experimental field is fairly levelled and well drained. The texture of the soil is sandy loam. Oxides of iron and aluminum are richly found but poor in soluble salts and di-basic cations. Soil samples were collected prior to the experiment from a depth of 0-15 cm following proper procedure of soil sampling. The plantation of *Gmelina arborea* based agroforestry system was continued from June 2016. The experiment was performed in a Randomized Block Design (RBD) with three replications. The experiment consisted of seven treatments out of which three were agrisilvicultural systems, three open control tree crop sequences and one sole silvi plantation. Agroforestry systems were comprised of on silvi tree species i.e. *Gmelina arborea* with three field crop sequences i.e. arhar, cowpea-Toria and green gram-Toria, these crop sequences without tree and one sole *Gmelina arborea.* The experiment plot of size 24m x 7.5m for different treatments as per the layout plan. In each plot clods were broken for leveling and proper weeding was done before sowing/planting. The intercrops viz. arhar, green gram and cowpea are grown in kharif season and Toria in rabi season as per recommended package of practices. Height of *Gmelina arborea* measured vertically from ground level to the leading shoot with Hypsometer. Crown spread was measured along the widest diameter in east-west direction as well as North-South direction with the help of a measuring tape.

$$\text{Crown spread} = \frac{\text{E} - \text{W crown spread} + \text{N} - \text{S Crown spread}}{2}$$

Diameter at breast height (DBH) over bark of trees was measured at a height of 1.37 m at 42 and 48 months after planting with the help of tree caliper in two directions (major axis and minor axis) and the average was computed and expressed in centimeter (cm).

$$\text{DBH} = \text{d1+d2/2}$$

Where d1 = Diameter of major axis

d2 = Diameter of minor axis

The biomass of standing tree was calculated by applying following formula :

Biomass of tree (above ground)

$= 0.1245 \times (\text{DBH})^{(2.4163)}$ (Hung *et al.* 2012)

Biomass of tree (below ground) is a factor of 0.26 of the above ground biomass (Cairns *et al.* 1997).

In the measurement of plant biomass, one ton of net sequestered or mitigated carbon dioxide is equal to one carbon credit (IPCC, 2007). The carbon credits are then measured in terms of Rs ha^{-1} yr^{-1} on the basis of the amount of carbon dioxide removed from the atmosphere and locked in the form of biomass. One tonne of biomass-fixed carbon dioxide is equivalent to one carbon credit and the value of one carbon credit is US$30.

Soil samples were taken from the 0-15 cm depth of each plot before planting and at the end of the season for physico-chemical examination viz Available Nitrogen, Available Phosphorous, Available Potassium, Organic carbon and pH.

The yield attributing characters of the intercrops like plant height, number of branches, number of pods per plant, number of seeds per pod and yields of crops recorded with time intervals from each plot and the total yield was calculated at the end of each season and converted to yield per hectare.

Arhar equivalent yield was calculated to compare the yield of other crops within the system and it was calculated by dividing gross return from the system with arhar market price.

$$\text{Arhar Equivalent Yield (q/ha)} = \frac{\text{Gross return (Rs / ha)}}{\text{Price of Arhar (Rs)}}$$

Rain water productivity was calculated by dividing the yield of crops with the total rainfall during the crop growth period.

$$\text{Rainwater Productivity} = \frac{\text{Yield of crop}}{\text{Total rainfall in crop growth period}}$$

In order to compare the profitability of various treatments, a comprehensive economic analysis was carried out. The cost of the output of the various agricultural systems was estimated and translated to the value per hectare, then the return of each procedure was determined and the net return (Rs/ha) was determined by subtracting the cost of cultivation from the gross return received. The Benefit:Cost ratio was determined by dividing the gross return by the cost of cultivation and provided in order to measure the profitability of the various treatments.

Statistical research was carried out to assess the importance of the means of therapy and to draw a rational inference. Data from multiple treatments was subjected to statistical analysis by following the required “Analysis of Variance” procedure. (Gomez and Gomez, 1984).

Growth of timber trees under agroforestry system : At 48 months after planting the highest tree height of 4.52 m of *Gmelina arborea* was recorded in *Gmelina arborea* + Green gram-Toria followed by *Gmelina arborea* + Cowpea-Toria (3.66 m) and lowest tree height of 3.17 m was recorded with *Gmelina arborea* + Arhar system. Average height of 3.54m was obtained by trees of sole *Gmelina arborea* system.

The highest DBH of 7.7 cm after 48 months was found in *Gmelina arborea* + Green gram-Toria followed by *Gmelina arborea* + Cowpea-Toria (6.71 cm). The DBH of *Gmelina arborea* (5.8 cm) found to be lowest in *Gmelina arborea* + Cowpea system. The DBH growth trend was similar to tree height in all systems. *Gmelina arborea*

Table-1 : Growth performance of trees under agroforestry system.

Treatments	Plant height (in m)	DBH (in cm)	Crown spread (in m)
	48 MAP	48 MAP	48 MAP
T1-*G. arborea* + Arhar	4.6	5.8	2.26
T2-*G. arborea* + Cowpea-Toria	5.4	6.71	2.9
T3-*G. arborea* + Green gram-Toria	6.1	7.7	3.58
T4-Sole *G. arborea*	5.2	6.11	2.81
CD 5%	0.719	0.532	0.24

Table-2 : Biomass Production of Agrisilvicultural system.

Treatments	Tree Biomass (48 MAP)	Crop Biomass (Kg ha^{-1})	Total Biomass (Kg ha^{-1})	Incremental Biomass (Kg ha^{-1} yr^{-1})	Carbon sequestration (Kg ha^{-1})
T1-*G. arborea* + Arhar	7313	2783	10,096	2524	2960
T2-*G. arborea* + Cowpea-Toria	10401	3688	14,089	3522	3967
T3-*G. arborea* + Green gram-Toria	14504	4021	18,525	4631	5132
T4-Sole *G. arborea*	8294	0	8294	2073	1338
T5-Sole Arhar	-	3243	3243	3243	1622
T6-Sole Cowpea-Toria	-	4131	4131	4131	2066
T7-Sole Green gram-Toria	-	4451	4451	4451	2226
CD 5%	891	107	242	184	141

Table-3 : Crop yield, equivalent yield and rain water productivity of agrisilvicultural systems.

Treatments	Yield (Kg ha^{-1})			Arhar Equivalent yield (Kg ha^{-1})	Rain water productivity (Kg ha^{-1}/mm)
	Kharif	Rabi	Total		
T1-*G. arborea* + Arhar	745	-	745	745	0.67
T2-*G. arborea* + Cowpea-Toria	3724	541	4265	1269	3.17
T3-*G. arborea* + Green gram-Toria	689	223	912	806	1.14
T4-Sole G. arborea	-	-	-		-
T5-Sole Arhar	880	-	880	880	0.84
T6-Sole Cowpea-Toria	3838	635	4473	1356	3.41
T7-Sole Green gram-Toria	552	406	958	953	2.14

Table-4 : Economics of the agroforestry system.

Treatment	Gross Return (Rs ha^{-1})	Net Return (Rs ha^{-1})	B:C Ratio
T1-*G. arborea* + Arhar	95156	60156	2.71
T2-*G. arborea* + Cowpea-Toria	151559	96559	2.75
T3-*G. arborea* + Green gram-Toria	135156	80156	2.45
T4-Sole *G. arborea*	35864	25864	3.58
T5-Sole Arhar	74081	48581	2.96
T6-Sole Cowpea-Toria	113071	68071	2.51
T7-Sole Green gram-Toria	81415	36415	1.80

recorded significantly higher DBH with Green gram-Toria and Cowpea-Toria than other systems at all growth stages. Average DBH of 6.65 cm was obtained by trees of sole *Gmelina arborea* system.

In agrisilvicultural system crown spread of the tree varied from 2.63 to 3.74 m. The trend was similar to that of the other growth parameters like height and DBH. The maximum crown spread of 3.74 m was recorded with *Gmelina arborea* + Green gram-Toria followed by that of *Gmelina arborea* + Cowpea-Toria (3.07m). The minimum crown spread of 2.63 m was recorded with trees of *Gmelina arborea* + Arhar system. Average crown spread of 2.97 m was obtained by trees of sole *Gmelina arborea* system.

The higher growth rate was due to its more competitiveness, better nutrient cycling and moisture conservation due to leguminous crop like Green gram. Crops grown in the interspaces favorably influenced the growth of silvi components. Similar result was reported by Sharma *et al.* (2011).

Biomass production and Carbon sequestration under agroforestry system : The increment of biomass of tree species at 48 months was recorded in all agrisilvicultural systems. The highest biomass of 14,504 kg ha^{-1} was recorded with *Gmelina arborea* + Green gram-Toria system followed by *Gmelina arborea* + Cowpea-Toria system (10,401 kg ha^{-1}). The lowest biomass of 7313 kg ha^{-1} was found in sole *Gmelina arborea*.

The biomass of crop under different agrisilvicultural system was recorded in both kharif and rabi season. The highest crop biomass of 4451 kg ha^{-1} was recorded with sole Green gram-Toria system followed by sole Cowpea-Toria (4131 kg ha^{-1}) system. The highest total biomass of 18,525 Kg ha^{-1} in the agrisilvicultural system was recorded in *Gmelina arborea* + Green gram-Toria followed by *Gmelina arborea* + Cowpea-Toria (14,089 Kg ha^{-1}). The highest incremental biomass recorded with *Gmelina arborea* + Cowpea-Toria i.e. 4631 Kg $ha^{-1}yr^{-1}$ & lowest with sole *Gmelina arborea* (2073 Kg $ha^{-1}yr^{-1}$). Pacholi and Pandey (1998) revealed that the over the ground biomass and mean yearly biomass were influenced by the thickness of the estate.

The carbon sequestration of different agrisilvicultural systems was presented in Table 2. The highest carbon sequestration of 5132 kg ha^{-1} was recorded with *Gmelina arborea* + Green gram-Toria system followed by *Gmelina arborea* + Cowpea-Toria (3967 kg ha^{-1}). Swamy *et. al.* (2005) revealed that moderately more carbon put away in over the ground segments in estates contrasted with agrisilvicultural framework.

Yield and Economics of agroforestry system : During this investigation the performance in terms of yield of different intercrops grown in sequence during two seasons of the year was recorded and presented in table-3. It was observed from the table that there is a decline in crop yield under agroforestry systems compared to their respective sole crop yield during both seasons. The crop yield of agroforestry systems was highest under *Gmelina arborea* + Cowpea-Toria. However, the yield of *Gmelina arborea* + green gram-Toria system was more than sole green gram-Toria.

The highest total crop yield among the agrisilvicultural systems was observed in cowpea associated systems followed by green gram systems. The highest yield of arhar was obtained in sole arhar (880 Kg ha^{-1}) followed by *Gmelina arborea* + arhar system (745Kg ha^{-1}). The highest cowpea yield was obtained from sole cowpea-Toria (4473 Kg ha^{-1}) followed by *Gmelina arborea* + cowpea-Toria system (4265 Kg ha^{-1}). The highest green gram yield was recorded in *Gmelina arborea* + green gram-Toria system (958Kg ha^{-1}) followed by sole green gram-Toria (912Kg ha^{-1}). The highest yield of Toria (635 Kg ha^{-1}) was obtained from sole cowpea-Toria followed by sole green gram-Toria system (406 Kg ha^{-1}). There is a slight decrease in crop yield in agrisilvicultural system than open condition. Similar result was reported by (Mehta *et al.* 1996) found that the grain yield of gram, mustard and Indian bean crops is significantly higher in open fields than those grown in association with trees.

The highest arhar equivalent yield was recorded in sole cowpea-Toria (1356 Kg ha^{-1}) followed by *Gmelina arborea* + cowpea-Toria system (1269 Kg ha^{-1}). The lowest arhar equivalent yield was recorded in *Gmelina arborea* + arhar system (745 Kg ha^{-1}). The arhar equivalent yield of open condition was higher than agrisilvicultural systems.

The highest rain water productivity was recorded in sole Cowpea-Toria (3.41 kg ha^{-1} mm^{-1}) system subsequently *Gmelina arborea* + Cowpea-Toria (3.17 kg ha^{-1} mm^{-1}) and the lowest in *Gmelina arborea* + Arhar (0.67 kg ha^{-1} mm^{-1}) system. The rain water productivity of open condition was higher than agrisilvicultural system due to less competition for water and nutrient.

Under the agrisilvicultural system the highest gross return was obtained from *Gmelina arborea* + Cowpea-Toria (Rs 1,51,559 ha^{-1}) in comparison to the return from the open control of Cowpea-Toria of Rs 1,13,071 ha^{-1} and the lowest gross return was recorded in sole *Gmelina arborea* (Rs 35,864 ha^{-1}).

Similar results were obtained from the net return in Table-4. The net return of agrisilvicultural systems was more than open conditions. The maximum net return was obtained from *Gmelina arborea* + cowpea-Toria (Rs 96,559 ha^{-1}) while, the sole cropping has a net return of Rs 68,071 ha^{-1}. The net return was found to be lowest in sole *Gmelina arborea* (Rs 25,864 ha^{-1}). Kumar *et al*. (2012) discovered that the greatest net benefit was gotten in the vegetable-based model followed by blossom-based models.

The B:C ratio of respective agrisilvicultural system was found to be higher as compared to respective open systems (Table-4). In this agrisilvicultural systems, the value of B: C varied from 2.45 to 2.75. While in the open control cropping it varied from 1.80 to 3.58. In the sole *Gmelina arborea* system, the B: C ratio was found to be maximum (3.58) because of the low maintenance cost in *Gmelina arborea*. Under agrisilvicultural system, the B: C ratio was found to be highest in *Gmelina arborea* + Arhar (2.71) with respect to its open control condition (2.96). But B: C ratio was lowest in *Gmelina arborea* + Green gram-Toria system (2.45) compared to its open condition (1.80).

Conclusions

Gmelina arborea + Green gram-Toria was recorded the highest biomass of 18,525 kg ha^{-1} carbon sequestration of

5132 kg ha^{-1} . The highest net return of Rs 96,559 ha^{-1} and B:C ratio of 2.75 was obtained from *Gmelina arborea* + Cowpea-Toria among agrisilvicultural systems.

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Nutritional and Sensory Evaluation of Mango-Papaya-Ginger Based RTS Beverage

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Abstract

The present study was conducted with the objective to develop Mango(M)-Papaya(P)-Ginger(G) based Ready To Serve (RTS) beverage. The juice(J)/ pulp(P) of experimental fruits were blended in six different combinations. All the treatments were standardized as 10% blend juice,10°Brix and 0.3% acidity and stored at room temperature (28±4°C) for two months. Physico-chemical and organoleptic evaluations of all samples were conducted thirty days intervals. The score of overall acceptability, flavor and appearance was recorded highest in T_1followed by control (T_0) but in colour and texture highest value was recorded in T_0 followed by T_1. Storage period has negative effect on ascorbic acid content in beverages. At zero day maximum value of ascorbic acid content was observed in T_5 (5.7mg/100ml).Total soluble solids (TSS) content of beverages increased continuously with storage period for 10.1°Brix to 11.56°Brix and highest value recorded at sixty days in T_0(10.86°Brix)followed by T_1(10. 56°Brix). The acidity percentage also increased in the beverage with storage period, highest value was recorded in T_5(0.38%) at sixty days. Decreasing trend was recorded in pH value in all treatments with storage period. The pH range was recorded at initial to last observation for 4.06 to 3.16 in treatments, the highest value was recorded in T_0(3.6) and lowest in T_5(3.16).

Key words : *Ginger juice, mango pulp, papaya pulp, ready to serve.*

Introduction

India is the second-largest producer of fruits in the world as a golden revolution was came into existence in the 11th five year planting a new era was started in area production and productivity of fruits but as the production was increased wastage of fruits also increased due to improper post-harvest management. Although recently FAO (Food and Agriculture Organization) declared year 2021 as the international year of fruits & vegetables to reduce the loss and increases the awareness about the importance of fruits and vegetables.

Mango (*Mangifera indica*) is the most important fruit of India as well as the world which has unique popularity among all fruits, due to their peculiar taste, aroma and considerable amount of nutritional profile as carbohydrates, protein, fiber, vitamin-A, B1, C, and E (Labaka et al., 2021). It got the status of "King of Fruits" due to their prodigious characteristic it also has a great opportunity in the processing sector. In the recent year (2019-20) the production of mango was 20265000MT (PIB March, 2021) but about 12-15% of total production was a loss due to improper post harvest practices (Technical Bulletin: 41, IIHR, 2013).So through value addition, these losses can be reduced and preparing different types of nutrient rich-products can be helpful for the improvement of nutritional status of the human diet.

Papaya is the third important fruit after mango and banana that is distributed in the tropical and subtropical areas of countries. The current production status (2019-20) of papaya is 5780000MT (PIB, March, 2021) but faulty post harvest management and highly perishable nature about 7-8% of total production is wastage (Technical Bulletin:41,IIHR,2013).A study conducted by the association for social and economic transformation (2013) in six districts of U.P. concluded that about 11% of total papaya production in these districts was a loss due to lack of proper marketing and postharvest management which have a huge amount (61 Lac Rs). However, papaya is cheap fruit and easily available in all partsof the country so by value addition of fruits low price beverages can be developed as well as can reduce postharvest loss during peak period. Apart from this, it has sufficient amount nutritive value as carbohydrates, fibers, Vitamin-A, B2,C,Ca,Mg,and P(Ali et al., 2002) so can be helpful reduced various types of abnormality in the body as scurvy, night-blindness and improved mental and physical status of the body in Children's and adult.

Ginger (*Zingiber officinale*) is a herbaceous perennial aromatic plant which has been mostly used as a spice and as herbal medicine for ancient times. India is a larger producer of ginger in the world the current production status (2019-20) of ginger 1868000MT (PIB, March, 2021) which is approximately 30.2% of World production (AERC Report, 2020), but about 20% of total production is used in the processing sector. It is a rich source of various types of biochemical compounds such as phenolic compounds, polysaccharides, organic acids, fiber and lipids. These compounds have many health benefits like antioxidants, antimicrobial, anti-inflammatory, cardiovascular and respiratory and anti-cancer properties.

Material and Methods

Material collection and juice extraction : The mango, papaya and ginger were purchase by local market of Kanpur for the development of RTS. The collected freshly ripe mango and papaya fruits were washed thoroughly by tap water. The papaya fruits are peeled and cut by stainless knife seeds were removed manually. Mango fruits also peeled and removed seed by the help of peeler. Slices of papaya and mango are used to pulp extraction through the help of pulper, and then extracted pulp was filter through muslin cloth for separation of fiber particles to pulp. The filtered juice of mango and papaya are used to RTS (Sindhumathi et al.,2017); Kumar andManimegali, 2005), Rhizomes of ginger were peeled and washed through clean water and cut into small pieces by stainless knife, grind by the grinder and muslin cloth used to separation of juice and fibers, cleaned juice were used to RTS.

Standardization of blend juice and preparation of RTS beverage : The RTS prepared by using 10% blend juice (Mango-Papaya-Ginger) indifferent ratio T0 100% mango (Control), T1 90% 5% papaya 5% ginger T2 80% 10% papaya 10% ginger T3 70%, 15% papaya, 15% ginger T4 60% 20% papaya, 20% ginger T5 50% 25% papaya 25% ginger. The Total Soluble Solids(TSS) acidity present in different blend combinations were determined through hand refractrometer and titration method respectively and the remaining amount of sugar, citric acid, was calculated and maintained 10% TSS and 0.3% acidity in the final product, for increased the self life of the product used potessium metabisulphite as preservative @ 70 ppm. The prepared beverage was filled in a glass bottle (200ml) leaving 2cm headspace and stored at room temperature.

Physico-chemical analysis : The different samples of prepared RTS beverageswere analyzed in the analysis lab and bio-control lab(CSAU&T, Kanpur) by using different recommended standard methods.The TSS was determined by hand refractrometer, acidity through titration of the samples with the help of phenolphthalein indicator in N/10NaOH solution (Ranganna, 1986). Ascorbic acid value was determined by the 2, 6 dichlorophenol-indophenols (DCPIP) dye method (Ranganna, 1986), pH was estimated through a digital pH meter.The pH meter wasstandardized by using buffers of pH 7 and 4 prior to recordingpH of the samples. The estimation was conducted at 30 days interval up totwo months.

Organoleptic evaluation : The sensory evaluation was conducted using the Hedonic scale method consisting 25 semi-trained evaluators who have previous experience of sensory evaluation. The sensory evaluation of all samples was conducted at thirty days intervals up to sixty days.

Statistical analysis : The recorded data during studies of physico-chemicals and organoleptic parameters were analyzed using thetwofactorial Completely Randomized Design (CRD) by the help of OPSTAT software developed by CCSHAU, Hisar(Haryana).

Results and Discussion

Changes in organoleptic parameters during storage period

Appearance : The effect of different combination of fruits juice (Mango-Papaya-Ginger) on RTS hasa significant effect thus as the concentration of mango juice was decreased ranking value of appearance also noticed decreased. The highest value of appearance was observed in T_1 (7.3) followed by T_0 (7.2) and the lowest in T_5 (5.4). The storage period also has a significant effect on the appearance parameter; highest value was recorded of fresh beverages and as the time was spent value of appearance also decreased. The same result was recorded by Harshitha et al.,(2016) in mango RTS and squash.

Colour and Texture : The continuous gradual decreasing trend in colour was noticed in RTS with time, at the fresh stage highest value was recorded as the time has been passed the rank of colour also decline. Blending process of juice also has a significant effect on colour value the highest score of colure was noticed in T2 and lowest in T5. The same trend in colour parameter was observed by Harshitha et al.,(2016)in mango RTS and Kumar and Deen (2018) in squash and preservation of squash from wood apple.

In data, it is clearly displayed that as the papaya and ginger juice concentration increased the thickness of RTS was decreased resulting in textural value of beverage was noticed decreased in trend.

Taste and Flavour : The flavour of beverages masking with duration due to undesirable biochemical changes in which temperature plays an important role, the same

Ripe Mango	Ripe Papaya	Ginger
Selection	Selection	Selection
Washing	Washing	Washing
Peeling	Peeling	Peeling
Destining	Removing of seeds	Washing
Cutting in pieces	Cutting in pieces	Cutting in pieces
Pulping	Pulping	Juicing
Sieving	Sieving	Sieving

Blending of Juices in different combination
Mixing with syrups (Sugar-citric acid-water as per standard)
Heating up to 75-80°C for 25 minutesand cooling at 30°C
Add KMS (@70PPM)
Filling bottle and capping (maintain head space 2 cm)
Store at room temperature (28±4°C)

Flow chart of RTS beverage

situation was observed in taste parameter due to increased sureness in beverage and decreasing the status of flavor. The Combination of fruits juice also has a significant role in taste and flavour.

Overall acceptability : The overall acceptability of beverage was also affected by storage duration and different combinations, as the storage period increased the rank of overall acceptability decreased due to decreased all parameters of sensory evolution, the initial and final range of acceptability was observes7.94 to 5.92, the same trend was observed by Gautam et al., (2020) in persimmon RTS Kumar et al.,(2013) in mixed fruits beverage. The blending of fruits juice also affected acceptability the highest value was recorded in T_1 (7.37) and lowest in T_5 (6.16) showed the fig.-1.

Changes in physico-chemical parameters during storage period

Ph : The concentration of H^+ ion OH^-ion determined the pH value which affected the various physico-chemicals as well as microbial and sensory properties of the beverage. In result, it is clearly showed in table-2 as the storage period increased concentration of H^+ ion also increased resulted pH value decreased. After 60 days of storage lowest value of pH was recorded (3.07) as compared to initial stage (4.06). It occurred due to increased acid content by the various biochemical process resulting in

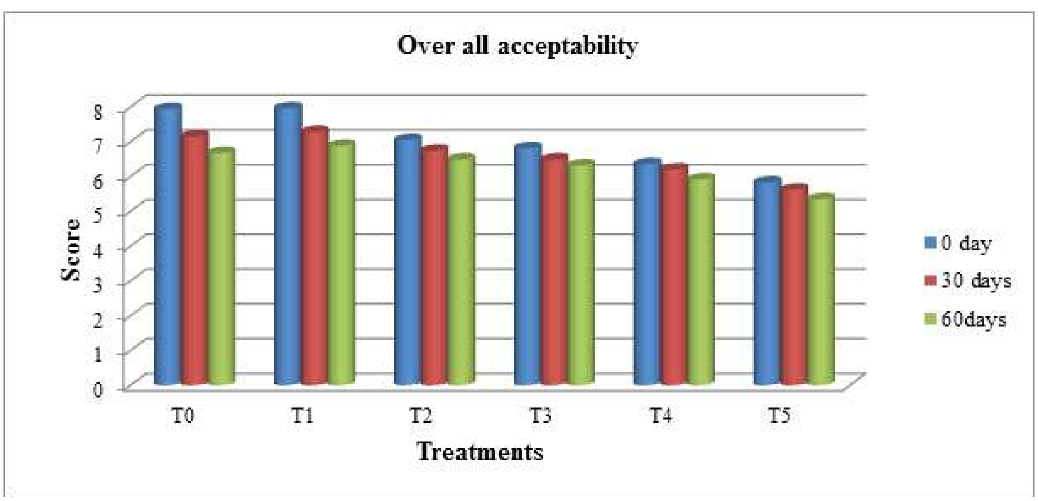

Fig.-1 : Over all acceptability.

Table-1 : Changes in sensory parameters during storage period.

Treatment	Parameters																			
	Colour				Texture				Flavour				Taste				Over all acceptability			
	0	30	60	M	0	30	60	M	0	30	60	M	0	30	60	M	0	30	60	M
T_0	8.32	7.44	7.32	7.69	7.16	7.32	6.48	7.19	8.08	7.16	6.88	7.37	7.64	6.80	6.00	6.81	7.94	7.15	6.68	7.26
T_1	7.88	7.44	7.28	7.53	7.68	7.24	6.40	7.11	8.24	7.24	6.88	7.45	8.00	7.32	6.88	7.40	7.96	7.28	6.88	7.31
T2	7.20	6.96	7.08	7.08	6.88	6.64	6.20	6.51	6.84	6.64	5.52	6.33	7.28	6.67	6.12	6.72	7.05	6.74	6.49	6.67
T_3	7.00	6.92	6.68	6.81	6.72	6.44	6.32	6.49	6.36	6.08	5.92	6.12	6.96	6.40	6.20	6.52	6.81	6.49	6.32	6.54
T_4	6.44	6.28	6.24	6.32	6.28	6.00	5.68	5.99	6.04	5.92	5.64	5.87	6.84	6.60	6..00	6.48	6.36	6.20	5.92	6.16
T_5	6.16	6.08	5.92	6.05	5.52	5.36	5.28	5.39	5.36	5.16	5.00	5.17	6.40	6.04	5.52	5.99	5.83	562	5.35	5.60
CD at 5%	T-0.32 S-0.12 TXS-NS				T-0.29 S-0.020 TXS-NS				T-0.30 S-0.21 TXS-NS				T-0.27 S-0.14 TXS-NS				T-0.11 S-0.08 TXS-NS			

M=Mean T=Treatment S=Storage

Table-2 : Changes in physico-chemical parameter.

Treatment	Parameters															
	pH				TSS				Acidity				Ascorbic acid			
	0	30	60	M	0	30	60	M	0	30	60	M	0	30	60	M
T_0	4.06	3.38	3.36	3.60	10.10	10.93	11.56	10.86	0.29	0.33	0.37	0.33	7.64	6.80	6.00	6.81
T_1	3.59	3.37	3.22	3.39	10.06	10.66	10.96	10.56	0.29	0.35	0.40	0.35	8.00	7.32	6.88	7.40
T_2	3.36	3.32	3.26	3.31	10.10	11.33	11.46	10.96	0.30	0.37	0.39	0.35	7.28	6.67	6.12	6.72
T_3	3.50	3.28	3.25	3.34	10.10	11.00	11.33	10.81	0.30	0.36	0.38	0.35	6.96	6.40	6.20	6.52
T_4	3.40	3.22	3.19	3.27	10.03	10.60	10.73	10.45	0.32	0.39	0.41	0.37	6.84	6.60	6.00	6.48
T_5	3.23	3.18	3.07	3.16	9.86	11.20	11.00	10.69	0.32	0.41	0.42	0.38	6.40	6.04	5.52	5.99
CD at 5%	T-0.16 S-0.075 TXS-0.18				T-0.16 S-0.11 TXS-0.27				T-0.016 S-0.011 TXS-NS				T-0.28 S-0.20 TXS-NS			

M=Mean T=Treatment S=Storage

increased free hydrogen ion concentrations in RTS which are responsible for decreased pH value. The effect of blending combination on different treatments was observed significant, and it was clearly showed as papaya and ginger juice concentration was increased pH value gradually decreased compared to control.

TSS (^{o}Brix) : In the data, it was clearly indicated that a significant difference was showed in TSS among control and othertreatments the highest value was recorded in T_2 (10.96^0 Brix) and lowest in T_4 (10.45 Brix). During storage TSS of all the treatments was increased, the result was confirmed by earlier workers Kumar and Deen(2017) in wood apple squash,Diveyasree *et al.*,(2018) in sweet orange based RTS and Kumar *et al.,*(2013) in Aloevera based RTS. At initial stage lowest TSS (9.86^0 Brix) was recorded but at sixty days highest value of TSS was observed (11.56^0 Brix)reason behind that may be degradation of complex carbohydrates in to simple carbohydrates. The effect of storage period and blending combination was found significant on TSS.

Acidity (%) : The acidity is the important constitute of RTS because it responsible for tartness in beverage which is an important factor of acceptability in beverage. In data, it is clearly mentioned that as the storage period is increased the percentage of acidity also increased, Panda *et al*,2019 also found same result in the jamun RTS, and similarly finding was observed by Meena *et al.,* (2017) in aonla based RTS and Sindhumathi & Premalatha, (2015) in Papaya-Pineapple RTS.The region behind this may be breakdown of complex carbohydrates into acid. The quantity of papaya and ginger juice affected the acidity percentage of RTS as the concentration of both juices increased significantly acidity level also increased, the highest acidity was recorded in T_5(0.38%) and lowest in T_0(0.33%).

Ascorbic acid (mg/100 ml) : Combination of juice significantly affected the quantity of ascorbic acid in data it is clearly showed as the concentration of papaya and ginger juice increased the value of ascorbic acid also increased hence the highest value of ascorbic acid was observed in T_5 and lowest in T_0 (control) demonstrate in the table no.2. The storage period also have a significant effect on ascorbic acid value, it has an inversely proportional relation with ascorbic acid. At initial stage average highest value of ascorbic acid was recorded (3.68ml/100gm) and at sixty days lowest value was recorded (3.28mg/100ml). The decreasing trend in ascorbic acid with storage period may be due to oxidation of vitamin-C in dihydroxy ascorbic acid by the trapped oxygen in the bottle and another factor may be effect of heating and exposure to light. The decreasing trend in ascorbic acid with storage period was reported by Balaji and Prasad, (2014) in Kinnow-Aonla blended RTS and Amravathi *et al.,* (2014).

Conclusions

The present study conducted with the objective to developed low cost, highly acceptable and nutritive RTS beverage by blending mango, papaya and ginger juice in different combination for the preparation of RTS beverage. The result was shown in above tables and it was concluded that sensory point of view T1 was found best among all the treatments and nutrition point of view T5that had high ascorbic acid among the all treatments. During the storage period the ascorbic acid loss was recorded 5-23% in among the treatments and beverage was consumable up to two month at room temperature without showing any symptoms of microbial spoilage.

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Quality Approaches of Phalsa (*Grewiaasiatica* L.) Fruit by the Study of Pruning Time and Pruning Numbers cv. Local

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Abstract

Phalsa (*Grewiaasiatica* L.) is one of the few fruit crops of semi-arid region, which can successfully be grown in hostile climatic condition of arid region with limited supplemental irrigation. Pruning is essential for fruit bearing. Plants pruned in different months in a year for two times stimulate quality. A field experiment carried out in the year 2019 and was laid out in Completely Randomized Design (Factorial) with 10treatmentcombinations with 4 replications. The treatment P_5N_1 (1st pruning in the month of December) was found significant with total sugar (5.96%) and juice (51.10%). While, P_1N_2 (2nd pruning in the month of January) found significant in total sugar (6.50%). Non-reducing sugar was recorded higher with both the pruning in a year with treatment P_2N_1 and P_2N_2, i.e. 2.17% and 2.68%, respectively. Likewise, for the juice (%), treatment P_2N_2 (2nd pruning in the month of February) was recorded higher i.e. 50.52%.

Key words : *Phalsa, pruning, pruning numbers, quality.*

Introduction

Phalsa (*Grewiaasiatica* L.) belongs to order malvales and family Tiliaceae which includes 18 genera and 350 species. The genera *Grewia* has about 140 species, out of which 40 species occur in India.

Phalsa is commercially propagated by seed. The fruits eaten fresh as dessert are made into syrup and extensively employed in the manufacture of soft drinks. (Singh and Singh, 2017)

Ripe fruits contain 50-60 per cent juice and 2.0-2.5 percent acid and good source of Vitamin A and C (Aykroyd, 1963) with following nutritive values: Energy, 90.5 Kcal; Protein, 1.58g; Fat, >0.1g; Crude fiber, 5.53g; Carbohydrates, 21.1g; Mineral content, 0.55g (parameters analyzed/100gm). (Rehman*et.al*, 2013)

The most important operation in the cultivation of phalsa is the pruning. Jadhav (1993) carried out the experiment of double cropping system in phalsa. They have tried winter as first off season crop and second regular crop in summer on the same bushes along with traditional single crop. He reported that by two times pruning i.e. August and January in a year resulted to increase in productivity also suggested that only winter season crop was not found economical, however, the total of double cropping system was found desirable.

On the basis of them research, two crops in year from one plant is possible and need to take research with different months combination for identify suitable period and time for double crops with their effect on quality of phalsa crops.

Pruning in better growth and development of phalsa bush resulting in better quality. Thus double pruning in a year may prove effective for increasing the size of fruit breadth and improved quality in phalsa.

Materials and Methods

The experiment was carried out on seven years old phalsa plants of variety 'Local' planted at Horticultural Research Farm, Anand Agricultural University, Anand. All the plants selected were uniform in growth and planted at the distance of 3×3 meters.The climate of Anand region is semi-arid and sub-tropical type. Winter is mild cool and dry, while summer is hot and dry.

The experiment was laid out in a Completely Randomized Design (Factorial) with 10 treatment combinations of two factor-1) Pruning time (Aug & Jan, Sept & Feb, Oct. & March, Nov. & April, Dec & May) 2) No. of pruning (N_1= 1st pruning in Aug, Sept, Oct, Nov, and Dec and N_2= 2nd pruning on the same plant in Jan, Feb, March, April, May after completion of 1st crop)

Pruning in January at 1m height with recommended dose of fertilizer in single split (RDF) as control treatment and pruning carried out at first week of particular month at 1m height from ground level.

Results and Discussion

The data presented in table-1 for pruning time and pruning numbers in a year with different quality parameters like total sugar (%), non-reducing sugar (%) and juice (%) affected by pruning time during 1st pruning, 2nd pruning

Table-1 : Interaction effect of pruning time with numbers of pruning in a year of quality parameters of phalsa berries.

Treatment	Total sugar (%)		Non-reducing sugar (%)		Juice (%)	
	N_1	N_2	N_1	N_2	N_1	N_2
P_1 (Aug & Jan)	4.40	6.50	2.14	2.38	44.58	50.21
P_2 (Sept & Feb)	4.52	6.49	2.17	2.68	44.04	50.52
P_3 (Oct & March)	4.02	5.30	1.30	1.41	44.12	47.23
P_4 (Nov & April)	5.43	5.20	1.77	1.89	37.45	47.78
P_5 (Dec & May)	5.96	5.09	2.04	2.01	51.10	45.09
S.Em+	0.14		0.18		0.86	
$Lsd_{0.05}$	0.40		0.53		2.45	
C.V.%	7.41		25.26		5.42	

analyse was found significant with the different pruning time.

Treatment P_1N_2 (2nd pruning in the month of January) was recorded higher total sugar i.e. 6.50% and it was at par with treatment P_2N_2 (2nd pruning in the month of February) i.e. 6.49%.While, treatment P_5N_1 (1st pruning in the month of December) recorded with higher total sugar i.e. 5.96%.Result indicate that fruit develop during early summer have higher total sugar and this finding is in agreement with the results of Ghosh *et.al* (2019) and Singh and Sharma (1961), they observed the higher sugar in moderate pruning during December and January.

Another quality parameter like non-reducing sugar, treatment P_2N_1 (1st pruning in the month of September) found significant with 2.17% non-reducing sugar and it was found at par with treatment P_1N_1 and P_5N_1, i.e. 2.14% and 2.04%, respectively. Similarly, for the same parameter, treatment P_2N_2 (2nd pruning in the month of February) found higher non-reducing sugar (%) i.e. 2.68% and it was at par with treatment P_1N_2. During the experiment it was observed that non-reducing (%) was higher in winter seasoni.e.September to February pruning as compare to summer season. This finding is in agreement with the results of Singh and Sharma (1961) in phalsa.

For the juice (%), treatment P_5N_1 (1st pruning in the month of December) was recorded higher i.e. 51.10%, while, with the 2nd pruning on the same plant during the month of February i.e. treatment P_2N_2, was found higher juice(%) i.e. 50.52% and it was found at par with treatment P_1N_2 (50.21%). It was observed that summer seasoni.e. December, January and February phalsa crop contain higher juice (%) as compare to winter seasoni.e. October and November crop and this might be due to requirement of the phalsa crop are fulfilled by atmosphere. This findings are accordance with those of Chundawat *et al.* (1976), Ghaffoor *et al.* (2001) and Meghwal (2006) in phalsa.

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