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GENETIC STUDIES OF HALF SIB FAMILIES IN RANDOM MATING POPULATION OF SUNFLOWER (*Helianthus annus* L.)

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ABSTRACT

The present study was undertaken to evaluate the response of recurrent selection for seed yield and its components from half-sib selection in a Sunflower, to assess the effect of selection on other quantitative traits and to select the half-sib families significantly superior over Cheru and A-28 (Standard checks) for further yield testing during *rabi* 2010-11. The expected genetic advance for seed yield plant^{-1} was 11.17 per cent over population mean and 5.82 per cent over check variety Cheru at 20 per cent selection intensity. The seed yield plant^{-1} was positively correlated with plant height, number of heads, number of seeds head^{-1} and 100 seed weight. The correlation between seed yield plant^{-1} with days to 50 % flowering and days to maturity was non significant, indicating breaking of linkages by recurrent selection method. This indicates that the half-sib recurrent selection is effective for increasing population mean and extraction of superior recombinant lines better than check varieties.

(Keywords: Sunflower, half sib-families, random mating population)

INTRODUCTION

Sunflower (*Helianthus annus* L.) is a member of the composite, family Asteraceae. There are twenty five species in this genus. Sunflower is cultivated mainly for its seeds, which yield edible oil traditionally. This crop was also grown for its flowers, used for colouring and flavoring foods and making dyes. The medicinal uses of flower in China have become known to the rest of the world in last few years rekindling the interest in this crop, because of its superior adoptability under drought conditions. Besides, it contains 30% oil in Indian varieties (Anonymous, 2007).

Earlier varieties of Sunflower have the genetic potential to give yield of 15-20 q ha^{-1} with oil content of about 30-40% under optimum condition. However, attempts to further improve the yield and oil content were not successful for the last three decades. Similarly there is no break through in the improvement of oil content in the last seven decades. This may be due to, use of pedigree selection technique in population derived from two line crosses and negative correlation between seed yield and oil content. The conventional breeding methods have been very useful only for recombining simple inherited characters. Therefore, these conventional breeding methods have not been very efficient for improving quantitatively inherited characters like seed yield and oil content. Moreover, regular methods of breeding have several limitations to use available genetic resource (Jensen, 1970). These limitations may be overcome by application of recurrent selection method. Therefore, present study was conducted to estimate the additive genetic variation, expected genetic gain and heritability in random mating population in Sunflower to identify the frequency of half sib families significantly superior over check varieties.

MATERIALS AND METHODS

The experimental material consisted of random mating population developed by using HUS-305 MS-2, genetic male sterile line with 12 parental lines viz., Cheru, A-28, KRAS-091, AKS-207, PRMSQ-091, Shraddha, Ravi, NI-577, JL-89, P-1-39, AKS-68 and IOR-576.

The population was grown for random-mating and development of half–sib families in *rabi* 2010. Approximately 300 half sib were developed in *rabi* 2010. Out of which 90 half sib families with sufficient seeds were selected and grown in *rabi* 2011 along with check varieties viz., Cheru and A-28 for evaluation in randomized complete block design with two replications as suggested by Panse and Sukhatme (1954). Each replication consisted of two blocks with 45 half sibs along with two check in each block. The plant to plant spacing were 30 cm and row to row spacing were 45cm. Two seeds hill^{-1} were initially sown in each dibble and latter thinning was practiced to retain only one plant hill^{-1}. Recommended package of practices were followed to raise the good crop. The data were recorded on five competitive fertile plants for characters like, days to 50% flowering, days to maturity, plant height (cm), number of heads plant^{-1},

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number of seeds head^{-1}, 100 seed weight and seed yield plant^{-1}. Statistical analysis was calculated for heritability, additive genetic variance and genetic advance. The estimation of half sib family components of variances were worked out from the family mean squares as suggested by Hallauer and Miranda (1889). Heritability in narrow sense was estimated as the ratio of additive variance to the phenotypic variance suggested by Hallauer and Miranda (1989). The expected genetic advance cycle^{-1} was estimated assuming that five and ten per cent of a large number of families were selected under Hallauer and Miranda (1989).

RESULTS AND DISCUSSION

The analysis of variance for the half-sib families are presented in table 1. The mean square due to half-sib families were significant for all the characters indicating substantial genetic variability existed among half-sib families after one cycle of recurrent selection. Naole (2004) also reported significant variance of half-sib families in Safflower. The basic objective of all recurrent selection method is to increase the frequency of favorable genes in a population so that the opportunities to extract superior genotypes are enhanced.

The data regarding maximum, minimum, range and mean values of agronomic characters measured on selected 80 half-sib families are presented in table 2. The maximum range was recorded by number of heads plant^{-1} (24.8) and seed yield plant^{-1} (24.07g) indicating considerable amount of genetic variance in random mating population which facilitate selection of superior families. For recurrent selection programme, significant and large genetic variation among half-sib families is prerequisite. The genetic variance among half- sib families ($^{2}_{H.S}$) and additive variance ($^{2}_{A}$) was highest for plant height (13.66 and 54.64) followed by number of heads plant^{-1} (13.24 and 52.96) and seed yield plant^{-1} (9.27 and 37.06 g). Kripalani (2003) also reported very high and significant genetic variation and family component variance in some Sunflower population segregating for genetic male sterility.

Estimates of heritability in Sunflower populations segregating for genetic male sterility are useful in determining the best method of selection to improve the population for specific traits. The most important function of heritability in determining the best method of selection to improve population for specific traits and the genetic study of quantitative traits in its predictive role, expressing the reliability of the phenotypic value as a guide to the breeding value. In the present study, the narrow sense heritability estimates on family means basis (Table 3) were highest for days to 50% flowering (0.59) followed by plant height (0.47) and 100 seed weight (0.29). High estimates of heritability have been reported in random mating population of Safflower for several agronomic traits by Naole (2004) and Goyal (2006). Similarly high estimates of heritability were also reported in sorghum for several agronomic and quality traits by Eckebil *et al*. (1977) and Ross *et.al*. (1981).

The data regarding expected genetic advance cycle^{-1} from single trait selection and expected genetic advance expressed as per cent population mean are presented in table 4. The expected genetic advance from single trait selection at 5,10 and 20 per cent of half-sib families was highest for plant height (5.24, 4.48 and 3.56) respectively, followed by days to 50% flowering (4.59, 3.92 and 3.12), number of heads plant^{-1} (3.68, 3.14 and 2.50) and seed yield plant^{-1} (2.80, 2.39 and 1.90). The expected genetic advance expressed as per cent of population mean at 5, 10 and 20 per cent was highest for seed yield plant^{-1} (16.44, 14.04 and 11.17), followed by number of heads plant^{-1} (11.89, 10.16 and 8.08), and 100 seed weight (9.26, 7.92 and 6.30). The expected genetic advance per cent over check variety Cheru at 5, 10 and 20 per cent selection intensity was highest for number of capitula plant^{-1} (8.93, 7.63 and 6.07), followed by seed yield plant^{-1} (8.57, 7.32, and 5.82) and 100 seed weight (7.80, 6.67 and 5.30). In Sunflower, Kileour (2002) reported 11.51, 9.48 and 7.82 per cent genetic advance in seed yield plant^{-1} from 5, 10 and 20 per cent selection intensity in random mating population of Sunflower after one cycle of recurrent selection. The expected genetic advance obtained from second cycle of recurrent selection was 28.8, 23.99 and 19.08 per cent at 5, 10 and 20 per cent selection intensity (Naole, 2004). In third cycle Goyal (2006) reported 49.49, 42.29 and 33.64 per cent genetic advance from 5, 10 and 20 per cent selection intensity. This clearly indicates the accumulation of favorable genes for yield. Genetic advance is a measure of expected progress under selection and it depends on the

Table 1. Analysis of variance of half sib families

Source of Variation	d.f.	Mean squares						
		Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of heads plant^{-1}	No. of seeds head^{-1}	100 seed weight (g)	Seed yield plant^{-1} (g)
Replication	1	6.64	7.47	320.04	73.91	7.83	0.96	7.18
Half - sib families	81	22.36**	18.30**	42.46**	68.16*	30.34*	0.36**	55.78*
Error	81	5.59	10.54	15.14	41.68	20.62	0.20	37.25

*** - Significant at 5%, ** - Significant at 1%**

Table 2. Mean value of agronomic characters measured on randomly chosen half-sib families

Statistic	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of heads plant^{-1}	No. of seeds capitulum^{-1}	100 seed weight (g)	Seed yield plant^{-1} (g)
Maximum	100.5	135	106.5	15.5	30.52	4.23	32.48
Mimimum	78	124	84.9	8.9	14.0	2.68	8.41
Range	22.5	11.0	21.6	6.6	16.52	1.55	24.07
Mean (H.S.)*	84.46	129.88	95.27	12.36	22.11	3.36	17.02
A-28**	85	134	97.25	10.3	25.01	4.22	20.0
Cheru**	91.5	142.5	97.95	13.1	28.55	3.99	32.65

***- Mean performance of 80 half- sib families ** - Mean performance of check varieties**

Table 3. Estimates of half-sib family components of variance and heritability for different agronomic traits

Half sib family components	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of heads plant^{-1}	No. of seeds head^{-1}	100 seed weight (g)	Seed yield plant^{-1} (g)
$^2_{H.S}$		3.88	13.66	13.24	4.86	0.08	9.27 8.34
$^2_A = 4 \ ^2_{H.S.}$		15.52	54.64	52.96	19.44	0.32	37.06 33.34
$^2_P = ¼ \ ^2_A + \ ^2_e$		14.42	28.8	54.92	25.48	0.28	46.52 14.03
H^2 (n.s.) $= \frac{¼ \ ^2_A}{¼ \ ^2_A + \ ^2_e}$		0.27	0.47	0.24	0.19	0.29	0.20 0.59

Table 4. Expected genetic advance per cycle from single trait selection using half- sib family selection system

Unit of evaluation and selection	Generation/ Cycle	Selection intensity #	Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of heads plant^{-1}	No. of seeds head^{-1}	100 seed weight (g)	Seed yield plant^{-1} (g)
Half-sib	2	5	4.59	2.10	5.24	3.68	1.98	0.31	2.80
		10	3.92	1.80	4.48	3.14	1.69	0.27	2.39
		20	3.12	1.43	3.56	2.50	1.35	0.21	1.90
			Expected genetic advance percent Mean of population						
Half-sib	2	5	5.43	1.62	5.50	11.89	8.97	9.26	16.44
		10	4.64	1.38	4.70	10.16	7.66	7.92	14.04
		20	3.69	1.10	3.74	8.08	6.10	6.30	11.17
			Expected genetic advance percent over Cheru						
Half-sib	2	5	5.01	1.48	5.62	8.93	6.95	7.80	8.57
		10	4.28	1.26	4.57	7.63	5.94	6.67	7.32
		20	3.41	1.00	3.64	6.07	4.72	5.30	5.82

Response to recurrent selection of top 5 % (2.06%), 10 % (k=1.76) and 20% (1.40) of large number of families where 'k' is standardized selection differential

Table 5. Genetic correlation among eight quantitative characters for half- sib family selection

Characters	Days to maturity	Plant height (cm)	No. of heads plant^{-1}	No. of seeds head^{-1}	100 seed weight (g)	Seed yield plant^{-1} (g)
Days to 50 % flowering	0.355**	0.249*	0.072	0.053	-0.093	0.207
Days to maturity		0.149	0.040	0.133	-0.205	0.201
Plant height (cm)			0.643**	0.393**	0.375**	0.631**
No of primary branches plant^{-1}			0.909**	0.553**	0.326**	0.866**
No of Capitula plant^{-1}				0.841**	0.496**	0.973**
No. of seeds capitulum^{-1}					0.681**	0.989**
100 Seed weight						0.803**

*** - Significance level at 5 % (0.217) **- Significance level at 1 % (0.283)**

magnitude of genetic variance, heritability and selection intensity. The information about magnitude of genetic variance and heritability can be used in ascertaining the possibility of extracting superior progenies for use in the development of superior Sunflower varieties.

In the present study random mating population in Sunflower segregating for genetic male sterility, Seed yield plant^{-1} has positive and significant correlation with plant height (0.631**), number of heads plant^{-1} (0.866**) and number of capitula plant^{-1} (0.973**) as reported in Table 5. This result of estimates are in agreement with those reported in Sunflower true breeding lines (Pure lines) by various workers (Argikar *et al*., 1957; Trechan *et al.* ,1977). The association between seed yield plant^{-1} to days to 50 % flowering and days to maturity were non significant indicating breaking of linkages. Naole (2004) reported negative and significant correlation between seed yield plant^{-1} and days to maturity (-0.377**) which shows that unfavorable gene combination can be broken by recurrent selection. This will facilitate selection of recombinant lines with high yield and earliness. The recurrent selection experiments are mainly designed and conducted for improving seed yield plant^{-1}. However, this does not mean that other traits are unimportant.

It is concluded from this study that half-sib recurrent selection is effective for increasing population mean and extraction of superior recombinant lines better than check varieties.

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD, NUTRIENT UPTAKE AND SOIL CHARACTERISTICS OF SUGARCANE

T .Usha Rani [1], K. Prasada Rao [2] and P. Shakespear [3]

ABSTRACT

A four year field experiment was conducted at sugarcane research station, Vuyyuru, Krishna district to assess the use of organic materials and inorganic fertilizers on plant and subsequent ratoon crops (2004-2007). The tested variety was 99 V 30. The organic materials include press mud, farmyard manure (FYM), vermicompost and green manure (GM) of sunhemp (*Crotalaria juncea*), the oil cakes (neem cake and castor cake). The fertilizers were urea, single super phosphate (SSP) and muriate of potash (MOP). Neem cake was applied @ 1t ha^{-1} accompanied with a chemical fertilizers (168 kg N, 75 kg P_2O_5, 100 kg K_2O ha^{-1} for plant crop and 280 kg N, 100 kg P_2O_5, 168 kg K_2O ha^{-1} for ratoon crop) which produced mean cane yield of 102.2 t ha^{-1} and 122.8 t ha^{-1}, 91.8 t ha^{-1}, 90.65 t ha^{-1} in plant crop (1^{st},2^{nd}) and first , second ratoon crops respectively. The quality parameters i.e juice sucrose, % CCS and sugar yield did not show any significant effect on application of 50% N through inorganics and 50% N through organics.

The organic carbon, available N,P,K contents of soil increased due to the application of 50% N through urea along with neem cake and castor cake. The uptake of NPK and the fertilizer use efficiency were maximum with the application of 50% N through urea along with neem cake followed by castor cake in both plant and ratoon crops.The results of the study revealed that 50% reduction of inorganic fertilizer with oil cakes or organic materials in plant cane and addition of 50% more N with same amount of fertilizer suggested for ratoon crop showed better yield, nutrient uptake and improved juice quality and soil characteristics in first and second ratoon crops of sugarcane.

(Key words : Sugarcane, INM, yield, nutrient uptake, soil characteristics)

INTRODUCTION

Sugarcane is an exhaustive crop and depletes soil nutrient heavily. A sugarcane crop giving cane yield of 100 t ha^{-1} may remove about 130 kg N, 22 kg P, 146 kg K, and 30 kg S ha^{-1} from soil besides other micronutrients (Sammuel, 1965). Application of fertilizers along with organic manures is one of the ways to minimize the yield gap of plant and successive ratoon crops. There is a great need for nutrient replenishment through addition of organic material along with inorganic fertilizer for achieving higher yield in plant and subsequent ratoon crops without deterioration of soil health. The quantities of fertilizer for plant and ratoon crops varied in different regions depending upon the soil type, organic matter, and nutrient content of the soil. One of the major causes for cane yield decline in successive ratoons is the decline in soil nutrient status (Plucknett *et al*., 1970). Most of the soils are low in organic matter generally containing less than 1.5% while 2.5 to 3.0% organic matter are necessary for sustainable crop production (Bhander *et al.,* 1998).

Crops generally require adequate quantities of major nutrients especially nitrogen during most of the crop growth period. The availability of nitrogen in soils is the key factor to determine the growth and yield of the crop. The mineralisable N in the soil play a dominant role in the nutrition of crops. Incorporation of organic materials with fertilizer N is known to stimulate the mineralisable fractions. Exclusive use of chemical fertilizers under continuous cropping of sugarcane leads to depletion of physical, chemical and biological fertility of the soil. During the last two decades the production cost of sugarcane increased with increase in cost of chemical fertilizers. The use of organic manures has been reported to improve physico-chemical and biological properties of soil (Shinde and Subbaiah, 1969).

The soils under intensive sugarcane cultivation were subjected to decline in soil fertility due to the inadequate supply of organic manures and over dependence on chemical fertilizers. As per the findings of Shah and Anwar(2003) the imbalance in the use of organic manures and fertilizer nutrients, lead to deleterious effect on soil productivity, yield and quality of sugarcane. Organic wastes are considered as a rich source of macro and micronutrients. The integrated use of organic and inorganic plant nutrient sources not only recycles organic waste but also conserves rich pool of nutrients resources, which can reduce the sole dependence on

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chemical fertilizers. The integrated use of organic nutrient sources with inorganic fertilizer was shown to increase the potential of organic fertilizer (Heluf, 2002) and to improve the efficiency of inorganic fertilizer. So their use could be reduced upto certain levels with addition of organic materials. Incorporation of chemical fertilizers in composted materials improves its efficiency and reduces losses .

N losses due to leaching, denitrification or volatilization might have reduced due to blending of N fertilizer with compost resulting in improved N use efficiency and long term release of nutrients from compost (Rizwan Ahmad *et al*., 2006).Keeping these facts in view, study was conducted to ascertain the effect of INM treatments on yield and other factors related to sugarcane crop and soil.

MATERIALS AND METHODS

The field experiment was conducted on clay loam soils for four years i.e. two years in plant crop and two years in ratoon crop at Sugarcane research station, Vuyyuru, Krishna Distt. with a variety 99V 30 during 2004-05, 2005-06 (1st plant, 1st ratoon) and 2005-06 ,2006-07 (2nd plant, 2nd ratoon). Each plant crop was ratooned during January month. After harvest of the mature crop by cutting at ground level, buds on the left-over underground portion of the stem germinate again and give rise to another crop, which is usually referred as "ratoon crop." Ratoons are cheaper to grow by around 25–30% (Sundara, 1998) since no cost is involved on fresh seed material and land preparation, besides saving in irrigation and crop maintenance.

The experimental soils were clayey in texture, well drained, very deep, non calcareous almost neutral in reaction (7.4), normal in conductivity (0.18 ds m^{-1}), low in available nitrogen, (240 kg ha^{-1}) medium in available phosphorus (40.5 kg ha^{-1}) and high in available potassium (397 kg ha^{-1}). **The treatments were** T_1= 50% N through Urea + 50% N through pressmud cake @ 12 t ha^{-1}, T_2= 50 % N through Urea + 50 % N through Vermicompost @ 2 t ha^{-1}, T_3= 50 % N through Urea + 50 % N through castor cake @ 2t ha^{-1}, T_4 =50 % N through Urea + 50 % N through greenmanure @ 25 kg ha^{-1}, T_5 = 50 % N through Urea + 50 % N through Neem cake @ 1t ha^{-1}, T_6 = 50 % N through Urea + 50 % N through FYM @ 25 t ha^{-1} and T_7=Recommended dose of NPK.

The treatments were tested in randomized block design with four replications. Irrigations were given as and when required and all the recommended agronomical practices were followed. The recommended dose of fertilizers were 168 kg N+ 75 kg P_2O_5+ 100 kg K_2O ha^{-1} for plant crop and 280 kg N+ 100 kg P_2O_5 + 168 kg K_2O ha^{-1} for ratoon crop. Uniform dose of phosphorus, potash and organic nitrogen were applied as per treatments as basal dose. In case of inorganic form of nitrogen urea was applied to plant crop in two splits at 30 and 60 days after planting to plant crop and to ratoon crop at stubble shaving and 45 days after ratooning. The whole plant samples were collected by taking ten canes from each treatment. The entire canes were chopped with knife and from these whole plant samples, a representative sample weighing about 200 g was taken, dried in the oven and then powdered. The sheath and leaf samples were collected from the index leaf i.e. 3rd leaf from the top of the plant and the leaf and sheath samples were dried, powdered and the analysis was done as per the procedures mentioned in the table.

At harvest cane juices were analysed for per cent juice sucrose and the data on leaf and sheath NPK, whole plant uptake of nutrients were recorded. Soil samples were collected initially and harvest of each crop and analysed for different chemical properties using standard procedures. Leaf, whole plant samples were collected at grand growth phase to study the nutrient uptake studies. Chemical analysis of soil and plant samples was done as per the procedure described by Tandon (1973). In order to compare the effect of various treatments on fertility status and nutrient uptake, Analysis of Variance (ANOVA) was performed using standard procedures for Randomized Block Design.

Parameters Soil analysis	Method of analysis
pH	1:2 soil water suspension by using combined glass electrode pH meter
EC	1:2 soil water extract by using digisun D1-901 EC meter
Organic carbon	Wet digestion method by Walklay and Black, 1935
Available N	Alkaline permanganate method by Subbaiah and Asija, 1956
Available P	Olsens method by Watanabe and Olsen, 1965
Available K	Neutral normal Ammonium acetate by using flame photometer method (Schollenberger and Simon, 1945)
Plant Analysis	
Total N	Micro- kjeldhal method by AOAC 1956
Total P	Vanadomolybdo method in diacid extract by Piper 1966
Total K	Flame photometer in diacid extract by Jackson,1958

The nutrient content of organic manures

Sr.No.	Manure	Nutrient content (%)		
		Nitrogen	**Phosphorus**	**Potassium**
1.	Castor cake	3.5-4.0	1.5-2.0	1.0-1.5
2.	Neem cake	5.0-5.5	0.8-1.0	1.0-1.5
3.	Vermicompost	1.5-2.0	1.1-2.2	1.1-1.8
4.	Pressmudcake	1.0-1.5	4.0-4.5	2.0-3.0
5.	Sunhemp	2.0-3.1	1.0-2.0	2.5-3.0

RESULTS AND DISCUSSION

Cane yield :

The results on the effect of different organic source of nitrogen along with inorganic source of nitrogen on the productivity of sugarcane clearly revealed that highest cane yield (122.8 t ha^{-1}) was obtained with the application of 50 % of nitrogen through urea along with 50% of nitrogen through neem cake as shown in table 5. The second plant crop also showed the same trend. Similarly, application of 50% nitrogen through urea and 50 % nitrogen through castor cake was also recorded higher cane yield but was on par with the application of vermicompost. Integrated use of chemical fertilizers and organic manures resulted in markedly higher productivity besides bringing out a general improvement in soil fertility status than that of chemical fertilizers alone (Singh *et al*.,1995). Jadhav *et al.* (2000) reported that application of 100% NPK along with compost @ 10 t ha^{-1} recorded significantly higher cane yield over 100% NPK. The higher yield may be attributed to release of plant nutrients and also due to the higher nutrient contents in oil cakes that might have facilitated better crop growth. Increased availability of nutrients accompanied with favourable soil environment might be the reason for higher yields. The enhanced yield might be due to the increment in growth parameters like number of millable canes caused due to enhanced nutrient availability and improvement in soil physical properties and increased nutrient use efficiency in the presence of organics. Significant variation in cane and sugar yields were recorded among manure sources and chemical fertilizers alone (Paul and Mannan, 2007). The increase in yield of sugarcane could be attributed to the balanced fertilization of sugarcane with fertilizers, nutrients and organic manures besides the use of urea. Mani *et al.* (2008) reported that continuous application of farmyard manure (FYM) along with NPK fertilizer improved physico-chemical properties of soil, cane yield and juice quality. Bokhtiar *et al.* (2002) reported that addition of organic manure/ green manure with chemical fertilizers produced higher cane yield as compared with treatments where only chemical fertilizers were used. It is expected that use of organic manures in the soil had a positive effect on cane yield and soil properties as well. The favourable soil conditions under treatments receiving organic manures might have helped in the mineralization of soil N leading to build up of available N content. Kale (1981) reported that the delay in the availability of nutrients in pressmud cake treated plots could be due to the wax content of 8-15% in press mud cake. Babu (2009) reported that 125% N as castor cake,100% P and 100% K by integrated use of castor cake and inorganic fertilizer recorded highest cane yield.

Ramesh *et al*. (2004) reported that integration of biofertilizers, crop residues management, organic manures with mineral fertilizers have shown potential for 20-50% economy in fertilizer nutrients to sugarcane besides soil sustainability. A judicious combination of inorganic, organic and biofertilizers is a potential tool for sustaining the cane productivity.

Ratoon crop :

The mean highest cane yield (91.80 t ha^{-1}) and sugar yields (10.84 t ha^{-1}) were recorded with the application of 50 % application of nitrogen through urea and 50% application through neem cake while the lowest cane yield (70.12 t ha^{-1}) and sugar yield (9.23 t ha^{-1}) were recorded with the application of recommended dose of fertilizer where no organic manures were applied as shown in table 6. The reduction in millable stalk population in ratoon crop when compared to plant crop might be due to higher requirement of nitrogen fertilizers in ratoon crop (280 kg N ha^{-1}) when compared to plant crop (168 kg N ha^{-1}) and also due to differences in physical condition of soil as well as nutrient use efficiency between plant crop and ratoon crop. The major causes for cane yield decline in successive ratoons is the decline in soil nutrient status (Plucknett *et al.,* 1970).

Uptake of nutrients :

Plant crop :

Maximum mean uptake of NPK was recorded with the application of nitrogen through urea and neem cake (257 kg ha^{-1} , 49.20 kg ha^{-1}, 276 kg ha^{-1}) followed by castor cake (251kg ha^{-1}, 48.30 kg ha^{-1}, 273.90 kg ha^{-1}) and then by vermicompost (247 kg ha^{-1}, 43.3 kg ha^{-1}, 268.10 kg ha^{-1}) which was significantly superior over control. While the lowest uptake values (166 kg ha^{-1}, 32.79 kg ha^{-1}, 217 kg ha^{-1}) were recorded with the application of recommended dose of fertilisers (Table 1).

These results are in agreement with the findings of Bokhtiar and Sakurai (2007) who reported that the phosphorus, potassium, calcium, magnesium, copper, iron, zinc and manganese contents in leaves were higher in organic manured plots over chemical fertilizer.

Ratoon crop :

The mean uptake of NPK were observed maximum with the application of 50% N through neem cake (348.3, 54.15, 305.46 kg ha^{-1}) while the recommended dose of fertilizers recorded the lowest uptake of NPK (206, 48, 216.8 kg ha^{-1}) (Table 2).

Physical and chemical properties of soils after harvest of the crop :

pH and E.C. (Plant and ratoon crop)

Application of 50% nitrogen through oil cakes decreased the soil pH, electrical conductivity of 0-15 cm layer as compared to recommended dose of fertilizers but the significant difference was not observed among the treatments. The available nutrients i.e. NPK were in increasing trend after the harvest of sugarcane crop due to application of 50% nitrogen through organics and 50% nitrogen through inorganics and thereby maintain the soil health. Though the pH and EC tended to decrease in manured plot from initial value, the decrease was non significant. Decrease in pH in manured plots was attributed to increase in partial pressure of CO_2 and organic acids due to organic matter decomposition. Slight increase in pH and EC in RDF alone plots over initial value might be due to some salt accumulation in chemical fertilizers alone plots (Table 3 and 4**).**

Available Nutrients : (Plant and ratoon crops)

Organic carbon :

The mean organic carbon content in plant crop ranges from 0.79 to 0.87 %. The application of 50% N through urea along with neem cake recorded the highest mean organic carbon (0.87%) followed by the application of castor cake (0.85%) along with urea in plant crop and the ratoon crop also followed the same trend (0.89% and 0.88%) but the significant difference was not observed among the treatments while the lowest values were recorded with the application of recommended dose of fertilizers 0.81% in plant crop and 0.82% in ratoon crop. The results revealed that the addition of different organic manures in addition to recommended dose of fertilizers resulted in the higher organic carbon content and available nutrient status of the soil compared to chemical fertilizers alone. The organic carbon content of surface soil increased significantly with the application of organic nitrogen like Neem cake, castor cake, pressmud, vermicompost, FYM and green manure in combination with urea and this may be attributed to direct incorporation of organic

matter in the soil leads to better root growth and more plant residues addition on realizing higher cane yields in these treatments The subsequent decomposition of these material might have resulted in the enhanced organic carbon content of the soil. They stated that addition of organic material facilitates better root growth.The organic carbon, total N, and available P, K and S contents of soils increased slightly due to incorporation of organic materials (Bokhtiar and Sakurai, 2007). The increase in organic carbon content without decline in yield on combined use of organic and inorganic N indicates sustainability of the system. These findings were in accordance with Kumarjit Singh *et al*., (2005). Slight increase in soil organic carbon content and available nutrient status was observed in ratoon crop than plant crop might be due to residual and cumulative effects of added organic manures in succeeding ratoon crop, though a ratoon crop will exhibit more nutrient uptake (Vliet *et al.,*2000 and Singh and Singh 2002).

Nitrogen and phosphorus : **(Plant crop and ratoon crop)**

Available nitrogen and phosphorus content of surface soil showed significant difference among the treatments. The highest soil available nitrogen was recorded with the application of urea along with neem cake (254.5 kg ha^{-1} in plant crop and 249 kg ha^{-1} in ratoon crop) followed by castor cake (251.4 kg ha^{-1} in plant crop and 248 kg ha^{-1} in ratoon crop) compared to other treatments due to highest initial content of nutrients in these materials while the lowest available nitrogen was recorded with the application of recommended dose of fertilizers (239 kg ha^{-1}). Highest available P content could be attributed to the organic manure mediated complexation of cations like Ca, Mg and Al responsible for fixation of P in soil. However, maximum available P_2O_5 (65.56 kg ha^{-1}) was observed in plots which received press mud cake @ 12 t ha^{-1}might be due to press mud cake is a rich source of phosphorus while the lowest phosphorus content was recorded with the addition of recommended dose of fertilizers (59.24 kg ha^{-1}). As per the results of Sharma *et al*.(2006) the increase in soil available phosphorus leads to increasing yields of sugarcane to pressmud application boosts the sugarcane yields and the main effect was that it is a soil ameliorant, in addition to this it is a rich source of nutrients. The continuous addition of organic manures along with chemical fertilizers may stimulate mineralization and immobilization of plant nutrients there by affecting their amounts in different organic and inorganic forms in soil (Sihag *et al.*,2005). They also reported that highest P content was noticed in pressmud treated plots when compared to other organic manured plots. The highest N content may be due to the favorable soil conditions under treatments receiving organic manures (oil cakes) might have helped in the mineralization of soil N leading to build up of available N content. Use of organic materials in combination with inorganic fertilizer and incorporation of green manure crops increased soil N, concentrated P, maintained and renewed organic matter and improved physico-chemical properties of soil, cane yield and juice quality as reported by several workers (Jiao, 1983; Alam *et al*.,1997). The results in the present study revealed that organic carbon, available NPK and S were built up in treatments where press mud or FYM organic manure were incorporated with inorganic fertilizers over control. Soil organic matter and NPK status was influenced by integrated use of green manure, crop residues, cane trash and urea in sugarcane-based crop sequences. (Vineela *et al*.,2008) (Table 3 and 4).

Potassium : (Plant and ratoon crops)

The available potassium content of surface soil differed significantly due to various sources of organics in combination with inorganics and recorded significantly higher amount of available potassium than control. The highest amount of available potassium (415.33 kg ha^{-1} in plant crop and 380 kg ha^{-1} in ratoon crop) was recorded with the application of 50% nitrogen through urea and 50% nitrogen through neem cake followed by the application of urea along with castor cake (410.6 kg ha^{-1} in plant crop and 377 kg ha^{-1} in ratoon crop) while the lowest available potassium was recorded with the application of recommended dose of fertilizers (359.34 kg ha^{-1} in plant crop and 350 kg ha^{-1} in ratoon crop). Decomposition of products of organics contain various organic acids, these might have aided in release of non exchangeable potassium to the water soluble forms Chithra ,1999).

In general application of 50% nitrogen through urea and 50% nitrogen through castor cake followed by neem cake results in increasing yield, nutrient uptake, juice quality parameters and nutrient

Table 1. Effect of integrated nitrogen management on nutrient uptake of sugarcane (Plant crop)

Treatment details	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	1stplant	2ndplant	Mean	1stplant	2ndplant	Mean	1st plant	2ndplant	Mean
T_1:50% N by urea + 50% N pressmudcake 12 t ha^{-1}	237	239	238.0	44.90	47.60	45.25	258.6	263.4	261.00
T_2:50% Nby urea + 50% N VC @2.5 t ha^{-1}	246	248	247.0	43.10	43.50	43.30	264.9	271.2	268.10
T_3:50% N by urea + 50% N Castor cake @ 2 t ha^{-1}	251	250	250.5	47.70	48.90	48.30	271.9	275.8	273.90
T_4:50% N by urea + 50% N GM @25 kg ha^{-1}	230	232	231.0	42.80	43.90	43.35	259.9	267.6	263.80
T_5 :50% N by urea + 50% N Neem cake 1 t ha^{-1}	258	256	257.0	49.60	49.80	49.20	273.6	278.5	276.10
T_6:50% N Urea + 50% N FYM 25 t ha^{-1}	242	240	241.0	42.20	43.23	42.72	254.6	261.3	257.95
T_7:Recommended dose of NPK	167	165	166.0	31.90	33.67	32.79	214.0	220.0	217.00
Mean	**233**	**233**	**232.9**	**43.17**	**44.37**	**43.55**	**256.8**	**262.5**	**259.68**
S Em	7.6	7.6	7.5	6.9	7.1	6.8	8.2	8.3	8.2
CD at 0.05	16.2	16.2	16.0	14.2	14.9	14.2	18.4	19.3	18.5
CV									

Table 2. Effect of integrated nitrogen management on nutrient uptake of sugarcane (Plant crop)

Treatment details	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	1st ratoon	2nd ratoon	Mean	1st ratoon	2nd ratoon	Mean	1st ratoon	2nd ratoon	Mean
T_1: 50% N by urea + 50% N by pressmudcake 12 t ha^{-1}	304.00	330.5	317.55	45.70	46.40	46.05	292.94	291.80	292.37
T_2: 50% Nby urea + 50% N by vermicompost 2.5t ha^{-1}	320.00	345.9	332.95	47.60	47.80	47.70	296.40	295.90	296.15
T_3: 50% N by urea + 50% N by castor cake @ 2 t ha^{-1}	331.40	357.9	344.65	50.50	54.60	54.05	305.84	302.98	304.41
T_4:50% N by urea +50% N by green manure@25kg	305.91	334.7	320.31	48.80	50.90	50.35	297.68	293.90	295.79
T_5: 50% N by urea + 50% N by neem cake@ 1t ha^{-1}	335.92	360.7	348.31	52.60	53.70	54.15	307.46	303.45	305.46
T_6: 50% N by urea + 50% N by FYM 25 t ha^{-1}	309.89	334.8	322.35	48.00	50.80	51.65	289.85	294.89	292.37
T_7: Recommended dose of NPK	192.00	220.0	206.00	32.67	33.40	48.05	217.70	215.90	216.80
Mean	**299.96**	**326.3**	**313.16**	**46.56**	**48.22**	**50.29**	**286.83**	**285.55**	**286.20**
S Em ±	8.1	9.8	8.7	7.2	7.9	8.3	8.9	8.2	8.9
CD	20.7	22.4	21.0	16.3	17.3	18.3	19.2	18.7	19.1
CV	10.2	10.7	10.3	10.7	10.9	11.1	11.2	11.3	11.1

Table 3. Effect of integrated nitrogen management on post harvest soil analysis of sugarcane (Plant crop)

Treatment details	pH	EC(dsm^{-1})	O.C %	N ------	P_2O_5 (kg ha^{-1})	K_2O ----------
INITIAL STATUS	7.89	0.27	0.79	234.8	59.41	356.23
T_1: 50% N through Urea + 50% N through PMC @12 t ha^{-1}	7.31	0.25	0.82	238.6	65.56	385.89
T_2: 50% N through Urea + 50% N through V.C @ 2.5 t ha^{-1}	7.28	0.24	0.84	249.6	60.23	375.57
T_3: 50% N through Urea + 50% N through Castor cake 2 t ha^{-1}	7.21	0.25	0.85	251.4	62.34	410.56
T_4:50%N throughUrea+50% N through Green manure 25 kg ha^{-1}	7.22	0.25	0.79	240.3	60.38	389.23
T_5 :50% N through Urea + 50% N through Neem cake @1 t ha^{-1}	7.20	0.27	0.87	254.5	64.89	415.33
T_6 :50% N through Urea + 50% N through FYM @ 25 t ha^{-1}	7.32	0.24	0.83	243.7	61.34	372.45
T_7: Recommended dose of NPK	7.50	0.26	0.81	239.3	59.24	359.34
Mean	**7.35**	**0.25**	**0.83**	**278.9**	**61.99**	**386.90**
S Em ±	0.07	0.008	0.09	5.15	4.04	8.90
CD	---	---	---	10.30	8.08	17.80
CV	11.50	12.00	9.60	10.50	10.67	11.60

Table 4. Effect of integrated nitrogen management on post harvest soil analysis of sugarcane (ratoon crop)

Treatment details	pH	EC(dsm^{-1})	O.C %	N ------	P_2O_5 (kg ha^{-1})	K_2O ----------
INITIAL STATUS	7.53	0.25	0.84	250	60.54	380
T_1 :50% N Urea + 50% N through PMC @12 t ha^{-1}	7.45	0.23	0.87	244	58.76	362
T_2:50% N through Urea + 50% N through V.C @2.5 t ha^{-1}	7.41	0.21	0.85	246	55.89	375
T_3:50% N through Urea + 50% N through Castor cake @ 2 t ha^{-1}	7.39	0.22	0.88	248	59.62	377
T_4 :50% N through Urea + 50% N through Green manure @25 kg ha^{-1}	7.34	0.21	0.86	243	57.34	363
T_5 :50% N through Urea + 50% N through Neem cake @1 t ha^{-1}	7.32	0.20	0.89	249	58.98	380
T_6 :50% N through Urea + 50% N through FYM @ 25 t ha^{-1}	7.28	0.22	0.84	240	53.67	370
T_7: Recommended dose of NPK	7.47	0.23	0.82	235	52.35	350
Mean	**7.38**	**0.22**	**0.86**	**244**	**56.66**	**367**
S Em ±	0.09	0.006	0.12	2.82	3.89	7.80
CD	---	---	----	5.98	7.78	14.90
CV	11.50	11.70	10.40	9.67	10.23	11.23

Table 5. Effect of Integrated nitrogen management on yield parameters of sugarcane (Plant crop)

Treatments	NMC. No ha^{-1}			Cane Yield t ha^{-1}			Sugar yield t ha^{-1}		
	1st plant	2nd plant	Mean	1st plant	2nd plant	Mean	1st plant	2nd plant	Mean
T_1 50% N by urea + 50% N byPMC @12 t ha^{-1}	79,973	81,237	80605.0	93.90	109.26	101.58	10.76	10.75	10.76
T_2 50% N by urea + 50% N by V.C @2.5 t ha^{-1}	82,235	83,002	82618.5	94.70	101.60	98.15	11.09	11.09	11.09
T_3 50% N by urea + 50% N by castor cake @ 2 t ha^{-1}	89,435	91,465	90450.0	96.10	112.80	104.45	11.20	11.20	11.20
T_4 50% N by urea + 50% N by green manure	81,863	83,435	82,649.0	88.30	92.90	90.60	10.76	10.87	10.82
T_5 50% N by urea + 50% N by neem cake @ 1t ha^{-1}	92,345	95,423	93,884.0	102.20	122.40	112.30	11.89	11.98	11.94
T_6 50% N by Urea + 50% N by FYM @ 25 t ha^{-1}	82,345	83,010	82,667.5	94.90	102.40	98.65	10.87	10.89	10.88
T_7 Recommended dose of NPK	78,567	79,478	79023.0	84.60	85.04	81.53	10.47	10.67	10.57
Mean	**83,823**	**85,293**	**84557.5**	**93.53**	**103.77**	**98.18**	**12.84**	**12.90**	**12.87**
S Em +	795	808	800.0	2.21	2.63	2.35	0.37	0.38	0.36
CD	1904	2008	1960	5.20	5.60	5.90	0.83	0.85	0.84
CV	12.40	12.80	12.60	11.60	11.70	11.50	11.00	11.00	11.00

Table 6. Effect of integrated nitrogen management on yield parameters of sugarcane (ratoon crop)

Treatments	NMC. No ha^{-1}			Cane Yield t ha^{-1}			Sugar yield t ha^{-1}		
	1st ratoon	2nd ratoon	Mean	1st ratoon	2nd ratoon	Mean	1st ratoon	2nd	Mean
T_1 50% N by urea + 50% N by PMC @12 t ha^{-1}	71,234	70,356	70,795	72.90	71.90	72.40	9.34	9.23	9.29
T_2 50% N by urea + 50% N by V.C. @ 2.5 t ha^{-1}	79,465	78,498	78,982	77.80	76.37	77.09	10.01	10.00	10.00
T_3 50% N by urea + 50% N by castor cake@ 2 t ha^{-1}	85,176	83,234	84,205	80.20	82.89	81.55	10.39	9.34	9.87
T_4 50% N by urea + 50% N by green manure 25 kg ha^{-1}	74,897	72,345	73,621	73.30	74.34	73.82	9.72	9.23	9.48
T_5 50% N by urea + 50% N by neem cake @1 t ha^{-1}	89,543	88,567	89,055	91.80	90.65	91.22	10.84	10.12	10.48
T_6 50% N by urea + 50% N by FYM @ 25 t ha^{-1}	78,934	77,890	78,412	77.25	78.90	78.08	9.78	9.12	9.45
T_7 Recommended dose of NPK	69,823	68,567	69,195	70.12	69.98	70.05	9.23	9.00	9.11
Mean	**68464**	**65938**	**77837**	**77.62**	**77.86**	**77.74**	**9.90**	**9.43**	**9.67**
S Em ±	687	658	723	1.23	1.32	1.29	0.30	0.28	0.28
CD	1456	1422	1523	2.89	2.93	2.90	3.23	3.12	3.10
CV	11.20	10.80	11.40	9.30	9.40	9.30	9.20	9.20	9.40

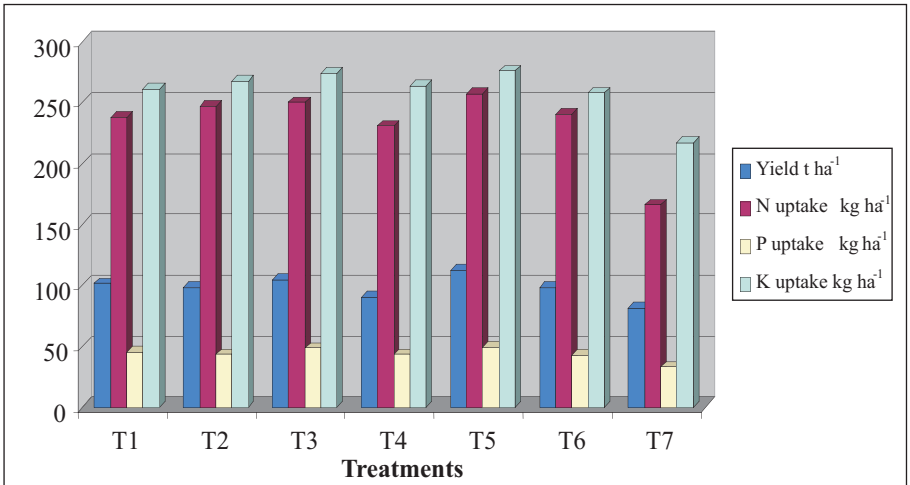

Fig.1. Effect of INM on mean yield and mean NPK uptake in sugarcane plant crop

use efficiency. Hence, application of oil cakes was beneficial to supplement nitrogen at a cost of 50% due to their high nutrient status. The integrated nutrient supply and management through judicious use of organic and chemical means will lead to sustainable and high crop production. There is an urgent need for adopting integrated nutrient supply system for promoting the efficient and balance use of macro and micronutrients for plants. While main emphasis has to be on increasing use of chemical fertilizer in the right and balanced amount, the role of the organic manure and recycled organic wastes has to be supplementary rather than substitutive. It is, therefore, possible to shift the plateau to a higher level with complementary use of organic with chemical fertilizer than chemical fertilizers alone. The complementary use of various sources of nutrients is helpful in improving fertilizer use efficiency, conserving nutrients, maintaining soil productivity and health and recycling nutrients from organic wastes. The recycling of organic wastes and its development into a value added product through blending/enriching with certain nutrients and plant growth regulators could not only help in achieving high productivity in agriculture but also in maintaining sustainable environment.

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RESPONSE OF RAYA (*Brassica juncea*) TO PHOSPHORUS AND SULPHUR IN INDO-GANGETIC ALLUVIAL SOILS OF NORTH-WESTERN INDIA

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ABSTRACT

Two field experiments were conducted during *rabi* season of 2002-03, 2003-04 and 2004-05 one at PAU Research farm and another at farmeer's field to study the effect of soil application of different levels of phosphorus (P) and sulphur (S) on seed yield, uptake and response of raya to P and S application. The seed yield of raya increased significantly by applying 33 kg P_2O_5 ha^{-1} and 15 kg S ha^{-1} from 12.8 to 16.2 q ha^{-1} at PAU farm and from 12.7 to 14.0 q ha^{-1} at farmers field and it was non-significant when $P_{60}S_{30}$ were applied at both the locations. As far as comparison of P and S diammonium phosphate and gypsum at PAU farm and farmers field respectively at both the levels of P and S application. Amongst the various treatments the oil yield increased significantly with the application of 15 kg S ha^{-1}. Phosphorus uptake increased significantly with the application of 33 kg P_2O_5 ha^{-1} and 66 kg P_2O_5 ha^{-1} at both sites, while Sulphur uptake increased significantly with the application of 15 kg S ha^{-1} at PAU research farm. Highest response to P and S were observed when P and S were added at their lower levels ($P_{33}S_{15}$). The apparent recoveries of S were higher as compared to P.

(Key words : Raya seed yield, P and S levels, Nutrient uptake, Nutrient response and revoveries)

INTRODUCTION

Due to dominance of rice-wheat cropping system in Punjab, the cultivation of oilseed crops like mustard have largely been relegated to relatively less productive coarse textured sandy soils which are prone to S deficiency. This crop may offer a good scope for diversification from the present rice-wheat cropping system (Khurana *et al*., 2003). The low yields of oilseed crops and poor quality of oils are due to various constraints including nutrient management. Besides nitrogen, phosphorus and sulphur also limit the productivity of mustard crop. Sulphur and phosphorus fertilization is of prime importance needed for normal growth and development of the plants due to its vital role in the chlorophyll synthesis and involvement in various physiological and metabolic processes of the plant (Brar *et al*., 2010). According to Aulakh (2003) all type of crops in India including cereals, pulses, oilseeds, forage crops and vegetables responded to sulphur applications with yield increase ranging from 14 to 74%. The response of mustard to P and S is determined by moisture availability, soil P and S status and yield level. Sulphur involved in oil synthesis and in many physiological functions like amiono acid synthesis in addition to productivity (Rana *et al*., 2005). Crops require sulphur in amounts similar to phosphorus to sustain growth, quality characteristics and yield. A favourable balance between phosphorus and sulphur fertilization should be maintained for optimum growth of plant. Both the nutrients interact each other differentially at their varying level of application (Maity and Giri, 2003). The sulphur requirement of rapeseed-mustard crops is nearly three times that of cereals (Aulakh *et al*., 1985). The information on S and P relationship in an important crop like raya is not adequate, especially in situations where both the interacting nutrients (P and S) are deficient in soil. Keeping the above facts in view the present investigation was carried out during 2002-03, 2003-04 and 2004-05 at PAU research farm and at farmers' field to study the effect of soil application of different levels of phosphorus and sulphur on their uptake, response and seed yield of ray.

MATERIALS AND METHODS

The present investigation was carried out during *rabi* season of 2002-03, 2003-04 and 2004-05 at Research Farm of Punjab Agricultural University, Ludhiana, Punjab (N 30^0 54' 326 latitude and 075^0 47' 147 E longitude, average altitude of 227 m above mean sea level) and at cultivators' field, village Kaulgarh, District Fatehgarh Sahib (300 36' 750 N latitude and 076^0 09' 386 E longitude average altitude of 251 m above mean sea level) on raya crop. The soil at PAU Research farm was classified as Samana coarse loamy, non- calcareous, Typic Ustochrepts.

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The soil samples were analyzed for available S (0.15% $CaCI_2$ extractable), pH, EC and organic carbon content by standard methods. The available P in the soils was determined by the method given by Olsen *et al*. (1954). The soil at PAU research farm was sandy loam, alkaline in pH (7.94), low in OC (0.11%), low in available P (11.4 kg ha^{-1}) and low in available S (18.5 kg ha^{-1}) and also the soil at farmers' field tested alkaline in pH (7.34), low in OC (0.25%), low in available P (11.2 kg ha^{-1}) and low in available S (15.0 kg ha^{-1}). The treatments were three levels of phosphorus 0,33 and 66 kg P_2O_5 ha^{-1} applied through Diammonium phosphate with three S levels 0,15 and 30 kg S ha^{-1} (1/2 applied through gypsum and 1/2 through elemental S) and two levels of P and S applied through Mosaic fertilizer (13:33:O:15::N: P_2O_5:$K2_O$:S) along with basal N application. Nitrogen was applied to all the plots at the rate of 100 kg N ha^{-1} through urea. The full doses of phosphorus and sulphur were drilled at the time of sowing and half of the N dose was applied during the last preparatory tillage before sowing and the second half dose of N was top dressed before first irrigation. The crops were grown till maturity by following the standard recommended crop production techniques and data of seed yields of raya crop were recorded. The seed and straw samples of raya crop were collected and analyzed for total S content by the turbidimetric method of Chesnin and Yien (1950), total P content in crop was also analysed by Vandao molybdophosphoric yellow colour method as outlined by Jackson (1987). Oil content in raya was determined by Nuclear Magnetic Resonance spectroscope (Newport analyzer model MK 111A) employing non destructive method of oil estimation (Alexander *et al*., 1967). Nutrient uptakes (P and S) were calculated by multiplying seed and straw yields of the crops with the respective nutrient concentrations. The frame work of Nova and Loomis (1981) was used to estimate P and S recovery efficiencies based on comparison of yield performances in the plots with and without applied P and S. The recovery efficiency for P and S was computed as follows.

$$\text{Recovery efficiency of P(\%)} = \frac{\text{P uptake with P applied - P uptake in control}}{\text{P applied}} \times 100$$

$$\text{Recovery efficiency of S (\%)} = \frac{\text{S uptake with S applied - S uptake in control}}{\text{S applied}} \times 100$$

RESULTS AND DISCUSSION

Seed yield :

Raya responded significantly to the application of phosphorus, at 33 kg P_2O_5 ha^{-1} both at PAU farm and at farmers' field (Table1). An application of 33 kg P_2O_5 ha^{-1} increased seed yield of raya from 12.8 to 16.2 q ha^{-1} at PAU farm and from 12.7 to 14.0 q ha^{-1} at farmers' field. By increasing the dose of P from 33 to 66 kg P_2O_5, improvement in seed yield of raya was observed, but increase was not significant. Mir *et al*. (2010) found that the optimum effect of the application of P on seed yield was presumably due to maximum pods $plant^{-1}$ and seed pod^{-1}, as these parameters are positively correlated with yield of the crop. At PAU farm significant increase in seed yield of raya was observed by applying 15 kg S ha^{-1} along with 33 kg P_2O_5 ha^{-1}. The positive response to S could be due to increased absorption of sulphur from the soil resulting in improvement in reproductive structure of sink strength thereby increasing production of assimilates to fill the seeds. Ravi *et al*. (2008) reported higher seed yield (1553 kg ha^{-1}) with the application of sulphur to the tune of 30 kg S ha^{-1} to Safflower crop. However, when doses of P and S were doubled, increase in seed yields was non-significant both at PAU farm and at farmers' field. An application of 33 kg P_2O_5 ha^{-1} and 15 kg S ha^{-1} through Mosaic sulphated phosphate and DAP + S produced 17.8 and 17.2 q ha-1 of raya at PAU farm. Similarly, raya yield of 15.1 and 14.8 q ha^{-1} were produced with the application of Mosaic sulphated phosphate and DAP + S at farmers' field respectively (Fig.1). The results clearly indicated that the application of both the sources on raya yield were at par. Therefore, Mosaic sulphated phosphate can be used as an alternate source of P and S to raya.

Phosphorus and sulphur uptake :

The uptake of P was significantly higher with the application of 33 kg P_2O_5 ha^{-1} both at PAU farm and farmer's field, it increased from 5.6 to 18.0 kg ha^{-1} at PAU farm and 13.4 to 15.2 kg ha^{-1} at farmers' field. When the dose of P was enhanced from 33 kg to 66 kg ha^{-1}, increase in P uptake further increased from 18.0 to 20.5 kg ha^{-1} and 15.2 to 18.1 kg ha^{-1} at PAU farm and at farmers' field respectively (Table 2). With the application of 15 kg S ha^{-1} along with 33 kg P_2O_5 ha^{-1} phosphorus, P uptake improved further significantly.

However, when 66 kg P ha^{-1} and 30 kg S ha^{-1} were applied in combination, P uptake was not significant both at PAU farm and at farmers' field. Maximum P uptake was noticed in plots, where mosaic sulphated phosphate fertilizer was applied as compared to DAP + gypsum ($P_{33}S_{15}$) both at PAU farm and farmers' field (Fig. 2). These results are in agreement with the results reported by Aulakh *et al*. (1985) that when S was applied along with P indicating a synergistic effect of S on P uptakes.

Sulphure uptake by raya increased significantly from 34.8 to 44.6 and 31.7 to 40.2 kg ha^{-1} with the application of 15 kg S ha^{-1} at PAU farm and at farmers' field respectively, S uptake further improved, when the level of S was enhanced from 15 to 30 kg S ha^{-1} along with P application the increase was not significant (table 3). The magnitude of S uptake is higher in plots receiving mosaic phosphte as compared to DAP + gypsum ($P_{33}S_{15}$) at both sites (Fig 3). On an average the highest S uptake was observed in plots where both P and S were added at their higher level ($P_{66}S_{30}$) both at PAU farm (53.9 kg ha^{-1}) and at farmers' field (46.9 kg ha^{-1}) and the lowest in control. These results are in conformity with the results obtained by Tandon and Messick (2002) who noticed the uptake of S and P to the tune of 45 and 25 kg ha^{-1} respectively.

Oil content :

The increase in oil content was non-significant in various treatments; however the oil yield increased significantly (Table 4). Oil yield increased significantly in plots where both P and S were applied in combination at their lower level. The oil yield was 6.39 q ha^{-1} in controls and it increased significantly to the tune of 7.57 q ha^{-1} in plots receiving 33 kg of P_3O_5 and 15 kg of S ha^{-1}. When the doses of P and S were enhanced the increase in oil yield was not significant. The oil yield was almost similar when both the sources of P and S i.e. DAP + Gypsum and mosaic phosphate were compared. The increase in oil yield was due to higher seed yield and oil content which ultimately increased the oil yield. In a sandy loam soil, Bharti and Prasad (2003) also found significant increase in oil yield of Indian mustard by applying 15 kg S ha^{-1}. According to Bharose *et al.* (2011) the oil content was maximum due to the higher concentration of phosphorus and sulphur, which increased the number of seeds and eventually the oil yield.

Response of raya to P and S and recovery efficiency :

As far as response of ray (kg seed kg^{-1} P) to P application was concerned, it was to the tune of 19.9 and 12.3 both at PAU farm and at farmers' field, with the application of S, it improved at PAU farm (24.5 kg seed kg^{-1}) but slightly declined at farmers' field (11.1 kg seed kg^{-1}). Response of ray to P application was the highest (27.5 and 15.7 kg seed kg^{-1} P) in plots where 33 kg P_3O_5 ha^{-1} and 15 kg S ha^{-1} were applied and lowest (13.2 and 5.0 kg seed kg^{-1} P) when the dose of P and S were increased (66 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1}) both at PAU farm and farmers' field respectively (Table 5). Higher response of raya (18.1 and 17.6 kg seed kg^{-1} S) to S application was observed in plots where mosaic phosphate was applied at its lower level ($P_{33}S_{15}$) both at PAU farm and at farmers' field, its values declined when the dose of P and S were enhanced to $P_{66}S_{30}$. Both P and S responded to raya at their lower level of application and magnitude of response to P and S was higher at Research farm and farmers' field with mosaic phosphate as compared to diammonium phosphate plus gypsum (Table 5). Khurana *et al.* (2003) reported that when S was applied at the rate of 20 kg S ha^{-1} the response of raya increased from 4.5 to 28.5 kg seed kg^{-1} S.

Apparent recoveries of P by raya were 20.4 and 12.6 per cent respectively with the application of 33 kg P_2O_5 ha^{-1}, and further declined when both P and S were applied at the rate of 33 kg P_2O_5 ha^{-1} and 15 kg S ha^{-1} (Table 6). Highest values of P apparent recoveries of 21.9% and 14.1% were observed both at PAU farm and at farmers' field when mosaic phosphate ($P_{66}S_{30}$) was applied. The values for apparent recoveries of S by raya were higher as compared to P but no systematic trends were observed in these values. In soybean-gobhi sarson cropping system, Manchanda and Bansal (2006) observed higher values of apparent S recovery with gypsum as compared to bentonite when 20 kg S ha^{-1} was applied. Similar were the observations of Jena *et al*. (2006) while evaluating the relative efficiency of gypsum and elemental S under groundnut-rice cropping system in an Inceptisol of Orissa.

Table 1. Seed yield of raya (q ha^{-1}) as affected by levels and sources of P and S fertilizers (pooled data of 3 years)

Treatments	S_0	S_{15}	S_{30}	Mean
P_0	11.5	13.1	13.7	12.8
P_{33}	14.4	17.2	17.1	16.2
P_{66}	15.6	17.1	17.8	16.8
Mean	13.8	15.8	16.2	
SE ±	1.22	1.36	1.21	
CD (p=0.05) P= 0.99, S =0.99, PXS = NS,				
		Farmers' field		
P_0	10.7	13.1	14.2	12.7
P_{33}	12.6	14.7	14.8	14.0
P_{66}	14.1	14.6	15.4	14.7
Mean	12.5	14.1	14.8	
SE ±	1.12	0.79	0.60	
CD (p=0.05) P= 0.75, S =0.75, PXS = NS, SE± 1.01				

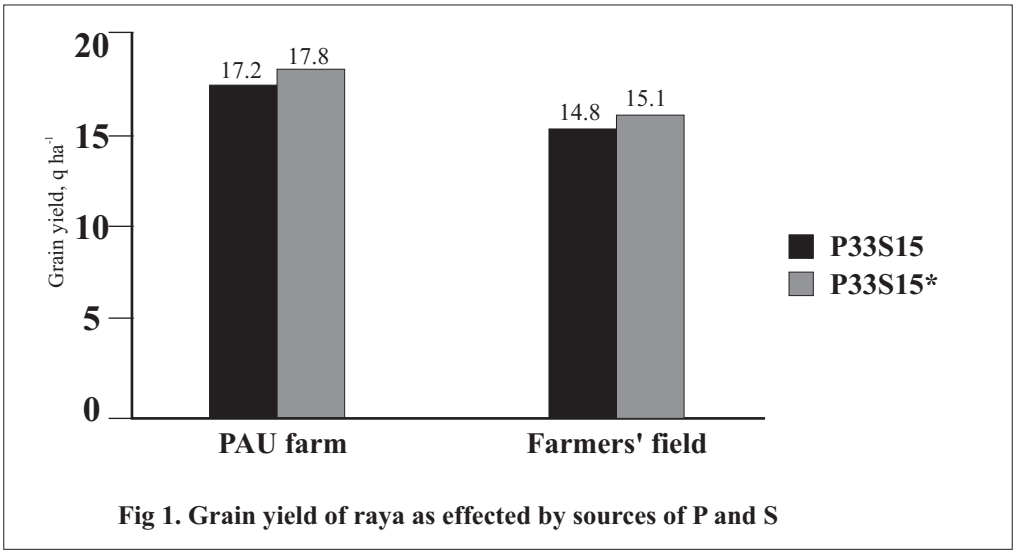

Fig 1. Grain yield of raya as effected by sources of P and S

***$P_{33}S_{15}$ is Mosaic Phosphate sulphate**

Table 2. Phosphorus uptake by raya (kg ha^{-1}) as affected by application of P and S fertilizer (pooled data of 3 years)

Treatments	S_0	S_{15}	S_{30}	Mean
		Ludhiana		
P_0	13.6	16.8	16.5	15.6
P_{33}	16.5	17.9	19.6	18.0
P_{66}	18.3	20.5	22.7	20.5
Mean	16.1	18.4	19.6	
SE ±	1.31	1.26	1.81	
CD (p=0.05) P= 1.4, S =1.4, PXS = NS,				
		Farmers' field		
P_0	12.9	13.5	13.8	13.4
P_{33}	14.1	15.2	16.2	15.2
P_{66}	15.8	18.8	19.6	18.1
Mean	14.3	15.8	16.5	
SE ±	1.40	1.23	1.41	
CD (p=0.05) P= 1.3, S =1.3, PXS = NS				

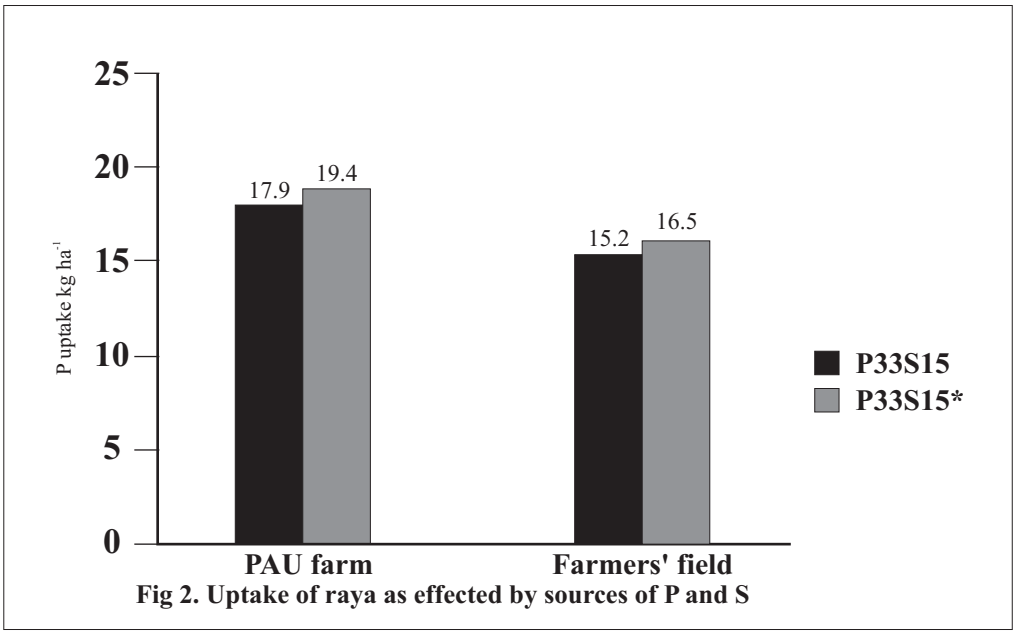

Fig 2. Uptake of raya as effected by sources of P and S

***$P_{33}S_{15}$ is Mosaic Phosphate sulphate**

Table 3. Sulphur uptake by raya (kg ha^{-1}) as affected by application of P and S fertilizer (pooled data of 3 years)

Treatments	S_0	S_{15}	S_{30}	Mean
		Ludhiana		
P_0	29.0	39.5	42.4	37.0
P_{33}	34.8	44.5	48.5	42.6
P_{66}	40.5	49.7	53.9	48.0
Mean	34.8	44.6	48.3	
SE ±	3.1	3.0	3.60	
CD (p=0.05) P= 3.4, S =3.4, PXS = NS,				
		Farmers' field		
P_0	27.1	39.7	43.6	36.8
P_{33}	30.7	38.3	41.9	37.0
P_{66}	37.4	42.7	46.9	42.3
Mean	31.7	40.2	44.2	
SE ±	4.8	3.0	1.8	
CD (p=0.05) P= 4.1, S =4.1, PXS = NS				

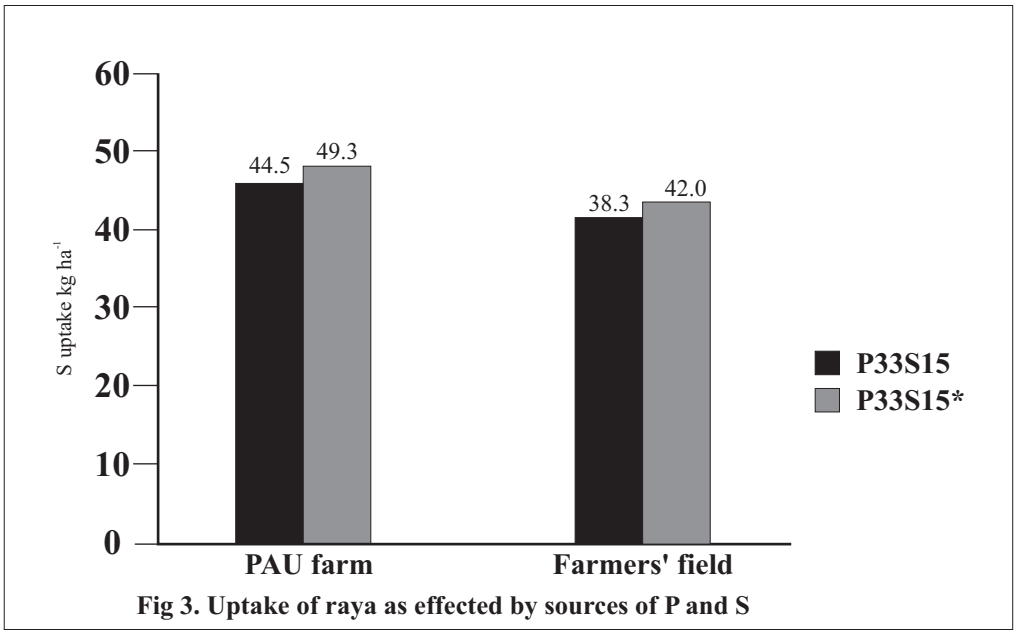

Fig 3. Uptake of raya as effected by sources of P and S

***$P_{33}S_{15}$ is Mosaic Phosphate sulphate**

Table 4. Oil content and oil yield of raya (average of 3 years) as effected by levels and sources of P and S at PAU, Research Farm

Treatments	Oil content (%)	Oil yield (q ha^{-1})
P_0S_0	38.2	6.39
$P_{33}S_0$	39.3	6.61
$P_{66}S_0$	39.6	7.05
$P_{33}S_{15}$	39.8	7.57
$P_{66}S_{30}$	39.4	7.48
$P_{33}S_{15}$*	40.0	7.56
$P_{66}S_{30}$*	40.2	7.61
SE ±	--	0.28
CD (5%)	NS	0.68

$P_{33}S_{15}$* & $P_{66}S_{30}$* is Mosaic Phosphate sulphate

Table 5. Raya response to P and S (kg seed/kg nutrient) at different sites

Treatments		PAU Farm				Farmers' field			
P	S	2002-03	2003-04	2004-05	Mean	2002-03	2003-04	2004-05	Mean
					Phosphorus				
33	0	17.4	22.2	20.1	19.9	13.2	10.4	13.4	12.3
66	0	15.6	16.0	14.2	15.3	14.6	6.6	11.8	11.0
33	15	22.2	16.7	28.5	24.5	13.9	8.3	11.1	11.1
33*	15*	26.4	23.6	32.4	27.5	15.3	17.4	14.3	15.7
66	30	13.5	12.1	14.0	13.2	7.3	3.5	4.2	5.0
66*	30*	16.7	13.5	17.5	15.9	8.7	7.6	5.3	7.2
					Sulphur				
33	15	9.3	12.0	18.7	13.3	14.0	12.0	13.8	13.3
33*	15*	13.3	18.7	22.4	18.1	15.3	20.7	16.9	17.6
66	30	2.0	6.7	7.1	5.3	2.0	9.7	4.6	5.4
66*	30*	5.0	8.0	10.4	7.8	3.3	13.7	5.7	7.6

$P_{33}S_{15}$* & $P_{66}S_{30}$* is Mosaic Phosphate sulphate

Table 6. Apparent recovery of P and S (%) in raya

Treatments		PAU Farm				Farmers' field			
P	S	2002-03	2003-04	2004-05	Mean	2002-03	2003-04	2004-05	Mean
					Phosphorus				
33	0	16.7	23.6	20.8	20.4	11.0	18.4	8.4	12.6
66	0	10.4	18.4	20.1	16.3	13.9	17.1	8.8	13.3
33	15	2.8	1.4	20.1	8.1	-	-	10.4	3.5
33*	15*	14.6	15.3	26.4	14.1	-	2.0	19.4	7.1
66	30	0.7	29.2	23.6	17.8	-	20.3	11.1	10.5
66*	30*	2.4	30.9	32.3	21.9	-	19.9	22.4	14.1
					Sulphur				
33	15	54.0	54.7	98.7	69.1	8.0	63.6	81.8	51.1
33*	15*	79.3	45.3	72.0	65.6	-	12.0	53.8	21.9
66	30	43.0	35.0	59.7	45.9	19.5	41.0	52.3	37.6
66*	30*	9.7	51.3	65.0	42.0	-	42.8	70.2	37.7

$P_{33}S_{15}$* & $P_{66}S_{30}$* is Mosaic Phosphate sulphate

From the present investigation, it can be concluded that seed yield, phosphorus and sulphur uptakes, oil yields and apparent recovery efficiencies of raya increased significantly with the application of 30 kg P_2O_5 ha^{-1} and 15 kg S ha^{-1} and mosaic sulphated phosphate, being a source of phosphorus and sulphur can be used as an alternate source of P and S, if other P and S supplying fertilizers are not available in the market.

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INFLUENCE OF WEATHER FACTORS ON LEAF BLIGHT OF TARO AGAINST DIFFERENT GENOTYPES

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ABSTRACT

The present investigations were carried out at the Main Experimental Station, Vegetable Science, NDUAT, Faizabad, Uttar Pradesh during *Kharif* 2006 and 2007 cropping season. Six taro genotypes were selected for studying leaf blight disease progress under field conditions. Disease showed a progressive increase and maximum terminal disease incidence in the 35th (03-09th September, 2006) standard meteorological week. The maximum disease incidence (100%) was recorded on the genotypes NDC-6 and NDC-50 while minimum on NDC-1 (42.50%) and PKS-1 (50.00%). The disease infection rate ('r') remained high at the initial stage but declined progressively due to adverse weather conditions and lack of availability of healthy tissues. All the genotypes showed more or less similar behavior in disease infection rate. The area under disease progress curve (AUDPC) pointed that disease pressure was more in year 2006 as compared to 2007. Multiple regression equation was drawn for the disease prediction based on data collected during the year 2006 and 2007 for all the six genotypes by taking the overall average of the disease incidence. In the year 2006, two weather parameters *i.e.* average relative humidity and cumulative rainfall explained maximum variability, whereas, in 2007, maximum temperature, average relative humidity and cumulative rainfall contributed in disease prediction with 100% precession. In all the genotypes, the predicted values lied in close proximity to the observed disease incidence.

(Key words: Taro, weather factors, area under disease progress curve, leaf blight, *Phytophthora colocasiae*, multiple regression)

INTRODUCTION

Taro (*Colocasia esculenta* var. antiquorum) is a tuber crop belonging to Araceae family. It is grown throughout India due to its wide adaptability, large scale acceptability and high return unit per area (Gurung, 2001). It is locally known as *Arvi* or *Ghuiya*. In India, it is grown in Andhra Pradesh, Bengal, Bihar, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra (Konkan region), Tamil Nadu, Uttar Pradesh and West Bengal. It grows well in lowland and upland areas. The cormel and leaves of taro are eaten as fried and cooked vegetable. Various delicious dishes are prepared by using different plant parts. Cormels are rich source of calcium, phosphorus, protein, starch and vitamin C (Fageria *et al.*, 2006). Besides, this crop also has great medicinal value and included in many Ayurvedic preparations. The juice from petioles or whole leaves is used for styptics, poultices and pulmonary congestion. It is also strongly recommended in prenatal diets as well as to nursing mothers. In addition to its nutritional and economic importance, taro also plays a significant role in cultural custom in different parts of India, and is also considered as an essential component of many traditional ceremonies (Chadha, 2003). The area and production of taro in the World was 1.49 million ha and 8.98 million tons during the year 2001 respectively, with a productivity 6.01 tons ha^{-1} (Anonymous, 2002). In India, area under taro is about 80,000 ha with a production is about 0.8 million tons (Swarup, 2006). Leaf blight of taro caused by soil borne fungus *Phytophthora colocasiae* (Raciborski, 1900) is the most vulnerable disease infecting all plant parts *viz.,* leaves, petioles, corms and cormels leading to heavy yield losses which may exceed upto the tune of 60% in severe cases (Maheshwari *et al*., 2007). The fungus is favoured by flooding conditions in field (Gadre and Joshi, 2003). The study of relationship between disease progressions with weather parameters is of paramount importance for effective disease management. Keeping in view the above facts, the present study was undertaken to determine the influence of weather factors on leaf blight against various taro genotypes in sub tropics of eastern Uttar Pradesh conditions.

MATERIALS AND METHODS

The present investigations were conducted at Main Experimental Station, Vegetable Science, NDUAT, Faizabad, Uttar Pradesh during *Kharif* 2006 and 2007 cropping season. The experimental site is

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situated at 26.47°N latitude, 82.12°E longitude and approximately 113 meters above mean sea level. Six taro genotypes *viz.,* NDC-1, PKS-1(moderately susceptible), NDC-4, NDC-16 (susceptible), NDC-6 and NDC-50 (highly susceptible) were selected for analysing the disease progress under field conditions. The selected taro genotypes were planted in 2m x 2m plots with three replications during 15th March in both the years, under randomized block design. The disease incidence was recorded at weekly intervals, from the appearance of first symptoms till the crop was harvested. Ten plants were randomly selected for recording the development of disease under natural epiphytotic conditions. Disease scoring was made on 0-5 rating scale 0= 0% healthy plant (HR),1= 0-1% not more than 1 spots leaf^{-1}, one to two spots plant^{-1} (R), 2= 2-5% one to two spots leaf^{-1}, two to five spots plant^{-1} (MR), 3= 6-25% two to three spots leaf^{-1}, five to ten spots plant^{-1} (MS), 4 = 26-50% three to five spot leaf^{-1}, ten to twenty spots plant^{-1}, spot tend to coalesce (S) and 5= 51-100% whole plant look blighted spots coalesce and leaves droop (HS) given by (Prasad, 1982) and per cent disease incidence (PDI) was calculated adopting following formula:

$$\text{Per cent disease intensity (PDI)} = \frac{\text{Sum of total numerical rating}}{\text{total numerical of leaves infected x Highest rating}} \times 100$$

The weather parameters *viz.,* minimum and maximum temperature (°C), average relative humidity (%), cumulative rainfall (mm) and sunshine (hour) were recorded from Meteorological observatory located at University Campus. The average of all the weather parameters during each standard meteorological week were considered while calculating their effect on disease incidence in terms of multiple regression analysis. In order to calculate the regression coefficient, minimum temperature, maximum temperature, average relative humidity, cumulative rainfall and sunshine were symbolized as X_1, X_2, X_3, X_4 and X_5 respectively.

RESULTS AND DISCUSSION

The results presented in table 1 and 2 indicated that among the six taro genotypes tested, leaf blight initiated during the 27th (9-15th July) and 29th (23-29th July) standard meteorological week (SMW) in 2006 and 2007 cropping season, respectively. Disease showed a progressive increase and higher terminal incidence in the 35th (3-9th September, 2006) and 36th (10-16th September, 2007) SMW. The maximum disease incidence was observed on genotypes NDC-6 and NDC-50 during both the years, whereas, minimum disease incidence was recorded on NDC-1 and PKS-1 during both the years, respectively. Disease infection rate ('r') in general remained high during the start of natural epiphytotic condition from 28th (16-22nd July, 2006) to 30th (30th July -5th August, 2006) SMW and later infection rate ('r') increased in NDC-6 and NDC-50 during 33rd (20-26th August, 2006) SMW. This could be attributed to weather factors *i.e.* maximum temperature (30.90°C), relative humidity (84.80%) and maximum rainfall (198.20mm), respectively. However, after 30th (July 30th – 5th August, 2006) SMW there was increase in maximum (34.00°C) and minimum (26.50°C) temperature. Simultaneously, there was decrease in relative humidity (<78.10%) and a dry spell of one week resulting in the decline of infection rate ('r'). However, with the weather conditions once again becoming congenial for the disease development, the infection rate ('r'=0.617) increased during 33rd (20-26th August, 2006) SMW in NDC-1 and NDC-50 and infection rate ('r'=0.601) in NDC-16, NDC-6 and NDC-50 during 31st (6-12th August, 2007) SMW. This could be directly correlated to rise in the average relative humidity due to cumulative rainfall and sunshine in 33rd (20-26th August, 2006) and 32nd (13-19th August) SMW, which restricted the minimum and maximum temperature (24.5 °C). The results are also supported by the earlier work of Suheri and Price (2000), Razdan *et al.* (2008) and Shakywar *et al*. (2012) who reported that maximum sporangia germination, zoospores formation and penetration of taro leaves by *Phytophthora colocasiae* was recorded at 21-26°C temperature, 90-100% maximum average relative humidity, sunshine hours 5-10 and frequent cumulative rainfall. They observed strong correlation between the total numbers of sporangia and zoospores at 20-25°C, and infection increased with the increasing duration of leaf wetness at all the temperatures tested with highest being at 20-29°C. Subsequently, the infection rate declined progressively due to adverse weather conditions and lack of tissues availability during course of

Table 1. Effect of meteorological factors on per cent disease incidence of taro genotypes during *Kharif* 2006

*SMW	Dates of SMW	Temperature °C		Average Relative humidity (%)	Cumulative rainfall (mm)	Sunshine (hours)	Genotypes/PDI						
		Min.	Max.				NDC-1	PKS-1	NDC-4	NDC-16	NDC-6	NDC-50	Infection rate unit^{-1}
27	9-15 July	27.10	34.40	68.10	6.20	4.60	0.00	0.00	0.00	0.00	5.72	6.24	0.000
28	16-22July	25.81	30.90	84.80	198.20	1.10	0.00	0.00	0.00	8.75	12.21	10.75	0.000
29	23-29July	26.50	33.20	73.20	129.50	7.20	8.25	6.13	9.25	17.81	28.1	25.12	0.519
30	30July-5Augt.	26.20	32.30	80.10	36.40	7.80	25.15	21.24	24.75	32.52	43.52	40.25	0.187
31	6-12 August	25.90	33.10	79.90	19.20	7.30	32.20	34.56	44.62	43.80	68.10	65.12	0.162
32	13-19August	26.00	32.40	77.80	6.20	7.50	39.12	38.52	53.75	62.72	89.00	85.00	0.376
33	20-26August	26.50	34.00	78.10	34.50	8.50	42.6	44.52	67.21	74.50	100.00	92.15	0.617
34	27Augt.- 2 Sept.	26.20	33.00	81.80	27.00	4.40	42.6	50.00	75.00	74.50	100.00	100.00	0.516
35	3-9 September	25.10	31.40	82.40	95.40	4.40	42.6	50.00	75.00	74.50	100.00	100.00	0.349
	Average	26.14	32.74	78.47	61.40	5.42	29.44	32.49	45.76	40.02	49.37	53.07	0.303

*SMW- Standard meteorological week

Table 2. Effect of meteorological factors on per cent disease incidence of taro genotypes during *Kharif* 2007

*SMW	Dates of SMW	Temperature °C		Average Relative humidity (%)	Cumulative rainfall (mm)	Sunshine (hours)	Genotypes/PDI						
		Min.	Max.				NDC-1	PKS-1	NDC-4	NDC-16	NDC-6	NDC-50	Infection rate unit^{-1}
29	23-29July	25.30	31.70	80.10	135.40	3.70	0.00	0.00	0.00	0.00	7.23	9.52	0.000
30	30July-5 Augt.	24.50	30.20	84.90	22.20	4.47	0.00	0.00	8.75	10.25	21.45	24.72	0.439
31	6-12 August	26.00	32.40	81.70	49.20	2.50	7.23	6.15	17.85	21.17	42.25	38.47	0.601
32	13-19August	27.80	34.30	77.10	2.20	6.80	9.12	11.21	21.62	28.65	54.72	50.25	0.133
33	20-26 August	25.90	30.90	82.70	54.70	0.08	22.45	25.15	33.43	37.12	65.75	70.10	0.221
34	27Augt.- 2 Sept.	26.40	31.90	79.90	15.60	3.80	31.00	38.70	48.52	52.70	82.13	79.25	0.150
35	3-9 Sept.	25.80	32.80	82.90	24.60	1.90	37.25	42.15	63.72	74.00	98.25	100.00	0.528
36	10-16 Sept.	25.30	32.10	85.50	20.80	3.80	42.50	48.00	73.75	74.00	98.25	100.00	0.423
Average		25.97	32.37	80.72	37.81	2.98	24.92	28.56	44.60	37.31	53.11	53.19	0.312

*SMW- Standard meteorological week

Table 3. Level of moderately susceptible (MS), susceptible (S) and highly susceptible (HS) in taro genotypes expressed as area under disease progress curve during *kharif* 2006 and 2007

	Area under disease progress curve	
Genotypes	**2006**	**2007**
NDC - 1	173.36	150.00
PKS - 1	198.30	171.92
NDC - 4	276.60	230.00
NDC - 16	236.00	218.04
NDC - 6	322.65	296.67
NDC - 50	327.00	320.31

Table 4. Regression of leaf blight infection rate ('r') and weather factors on taro genotypes during *kharif* 2006 and 2007

Genotypes	Regression equation 2006	R^2	Regression equation 2007	R^2
NDC-1	$Y = -27.25 + 1.27\ X_1 + (-0.38)\ X_2 + (0.079)\ X_3 + (-0.012)\ X_4 + 0.103 X_5$	0.646	$Y = 8.17 + (-0.148)\ X_1 + (0.143)\ X_2 + (-0.097)\ X_3 + (-0.065)\ X_4 + (-0.184) X_5$	0.676
PKS-1	$Y = 9.68 + (0.44)\ X_1 + (-0.17)\ X_2 + (-0.036)\ X_3 + (-0.016)\ X_4 + (-0.096) X_5$	0.720	$Y = 21.06 + (-0.038)\ X_1 + (0.075)\ X_2 + (-0.253)\ X_3 + (-0.080)\ X_4 + (-0.313) X_5$	0.728
NDC-4	$Y = 6.06 + (-0.31)\ X_1 + (0.12)\ X_2 + (-0.017)\ X_3 + (-0.015)\ X_4 + (0.057) X_5$	0.790	$Y = -2.54 + 0.07\ X_1 + (0.067)\ X_2 + (-0.135) X_3 + (-0.014)\ X_4 + (-0.090)\ X_5$	0.765
NDC-16	$Y = -1.68 + (-0.079)\ X_1 + (-0.43)\ X_2 + (0.096)\ X_3 + (-0.013)\ X_4 + (-0.010) X_5$	0.820	$Y = 5.852 + (-0.104)\ X_1 + 0.190\ X_2 + (-0.099)\ X_3 + (-0.046)\ X_4 + (-0.176) X_5$	0.881
NDC-6	$Y = -1.72 + (-0.082)\ X_1 + (0.51)\ X_2 + (0.097)\ X_3 + (-0.017)\ X_4 + (-0.013) X_5$	0.830	$Y = 8.47 + (-0.155)\ X_1 + 0.098\ X_2 + (-0.082)\ X_3 + (-0.067)\ X_4 + (-0.124) X_5$	0.849
NDC-50	$Y = 2.33 + (-0.48)\ X_1 + (0.34)\ X_2 + (0.097)\ X_3 + (-0.015)\ X_4 + (-0.085) X_5$	0.890	$Y = 6.97 + 0.018\ X_1 + (-0.049)\ X_2 + (-0.066)\ X_3 + (-0.016)\ X_4 + (-0.041) X_5$	0.913

Whereas, Y = Leaf blight intensity, a = Intercept, b = Slop, X_1 = Temperature Minimum (°C), X_2 = Temperature Maximum (°C), X_3 = Relative humidity (%), X_4 = Total Rainfall (mm), X_5 = Sunshine (hours), R^2 = Coefficient of multiple determination

investigation. All the genotypes showed more or less similar behavior in disease infection rate during both the years. The fact that increasing disease levels frequently occur late in the growing season is often attributed to increasing age of the susceptibility of plant tissues (Miller, 1983; Everts and Lacy, 1990 and Shukla Nandini, 2006). After calculating the area under disease progress curve (AUDPC) it was observed that the disease pressure was more in all the genotypes during 2006 as compared to 2007 (Table 3), which may be attributed to the fact that frequent cumulative rainfall, relative humidity and sunshine remained low during the year 2007. The present findings are also supported by earlier work done by Singh *et al.* (2004). Multiple regression equation drawn for the disease prediction on the basis of mean data collected for all the six taro genotypes by taking the overall average of the disease incidence during the year 2006 and 2007. It is indicated that in the year 2006, weather factors *viz.,* maximum temperature, relative humidity and continuous rainfall contributed in 100% disease precession in both the years. The regression equation values of a, b and coefficient of determination (R) are given in table 4. It is evident that the dependent variables (Y= Infection rate) can be predicted prior to the onset of infection on the basis of independent variable values (partial regression) obtained from equations. The highest value of coefficient of determination was recorded on highly susceptible genotype NDC-50 (89%) in the year 2006 and 91% in 2007. While, the lowest coefficient of determination was recorded on moderately susceptible genotypes NDC-1 (64%) in year 2006 and 67% in 2007. However, similar interactions with respect to few host-pathogen interactions have been reported by earlier workers (Mehrotra and Aggarwal, 2003).

For future line of work moderately susceptible genotypes NDC-1 and PKS-1 can be taken up for developing source of resistance against leaf blight of taro caused by soil borne fungus *Phytophthora colocasiae*. The farming community World over can take up commercial cultivation of taro using these genotypes for better yield purpose.

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GROWTH, SEED YIELD AND SEED QUALITY OF CHINESE CABBAGE (*Brassica napus* L.) AS AFFECTED BY DIFFERENT FERTILITY LEVELS AND ROW SPACINGS

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ABSTRACT

Investigations were made during 2008-09 to 2009-10 to study the growth, seed yield and seed quality of chinese cabbage as affected by different fertility levels (100 and 150% RDF) and row spacings (20, 30 and 40 cm) in clay soils at Research Farm, JNKVV, Jabalpur in factorial randomized block design with four replications. Plant height, leaf area index (LAI) and days to maturity increased significantly with higher fertility level i.e. 150% RDF (90:19.8:25 N:P:K kg ha^{-1}) but the plant stand was not affected by it. The number of siliquae plant^{-1}, weight of siliquae plant^{-1}, number of seeds siliqua^{-1} and test weight increased significantly with the increasing level of fertility upto 150% RDF. The seed and stalk yield (q ha^{-1}) significantly increased with the increase in the level of fertilizers upto 150% RDF. LAI and plant stand m^{-2} were the only growth parameters which significantly decreased with wider row spacing. Increment in row spacing significantly increased siliquae plant^{-1} and weight of silique plant^{-1} and seed yield (q ha^{-1}). Stalk yield decreased with the increasing row spacings. During both the years, the net monetary returns and B:C ratio increased with the increasing fertility levels upto 150% RDF and row spacing upto 40 cm. The oil yield (kg ha^{-1}) increased significantly with the increasing fertility levels and row spacing while oil content (%) had reverse trend for the same. Protein yield (kg ha^{-1}) and protein content (%) both increased with the increasing fertility levels and row spacings. Thus, it could be inferred that fertility level could be increased up to 150% RDF with row spacing of 40 cm.

(Key words: Chinese cabbage, seed yield, row spacing, fertility level, oil content, protein content)

INTRODUCTION

The Chinese cabbage i.e. *gobhi sarson* is a wonderful dual purpose crop i.e. oil and forage which could meet out the requirement of human and animals. This crop covers very less area under cultivation i.e. 809.4 thousand hectares with the production of 847.5 thousand tonnes in Madhya Pradesh (Anonymous, 2007). Chinese cabbage is a fast growing forage crop and has vigorous growth with good regeneration ability, if cut before flowering. It provides fodder from the first week of December to second week of March in areas where climate is cool and dry and farmers have assured irrigation facilities with them. It is responsive to fertilizer and irrigation. Considering the aforesaid qualities of chinese cabbage, it is possible to increase the yield and production of oilseeds in the country by it's inclusion in different cropping systems by generating improved production technology. Production of chinese cabbage is being taken in small pockets in Madhya Pradesh without adoption of suitable agronomical practices. Hence, keeping in view of above facts the present investigation was made to identify the suitable fertility level and row spacing for growth, yield attributes, seed yield and quality of seed of chinese cabbage.

MATERIALS AND METHODS

The field experiment was conducted during winter seasons of 2008-09 and 2009-10 on clay loam soils at Research Farm, JNKVV, Jabalpur. The soil of the experimental field was low in organic carbon (0.62%) and available nitrogen (236.8 kg ha^{-1}) but medium in available phosphorus (20.10 kg ha^{-1}) and moderate in potassium (272.3 kg ha^{-1}). The soil was neutral in reaction (7.3) with normal EC (0.32 dS m^{-1}). The field experiment was consisted of 6 treatments and was tested in a randomized block design following a factorial arrangement with four replications with plot size of 3.6 m x 3.6 m. The treatments comprised 2 fertility levels (100 and 150% of recommended dose of fertilizer i.e. 60:13.2:16.6 and 90:19.8:25 N:P:K kg ha^{-1}) and 3 row spacings, i.e. 20, 30 and 40 cm. The plant to plant spacing was kept 10 cm after thinning. To keep the crop free from weeds, 2 hand hoeings were given at 15 and 30 days after sowing. Leaf area index (LAI) was recorded at 60 DAS with the help of leaf area meter while number of plants m^{-2} was counted with the help of quardrat of 0.25 sq. m. at 90 DAS. Observations of plant height (cm), number of siliquae plant^{-1}, weight of siliquae plant^{-1} (g), number of seeds siliqua^{-1}, test weight and days to maturity were recorded on ten randomly

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selected plants in each plot at harvest time. Data on seed and stalk yield was also recorded plotwise at harvesting and converted to quintal ha^{-1}. The crop was harvested manually when majority of siliquae changed their colour from green to light yellow. Oil content (kg) was estimated by Soxhlet's extraction method (A.O.A.C., 1960) and oil yield was worked out by multiplying the oil content and yields. Estimation of nitrogen was done by colorimetric method using spectronic 20 after development of colour with Nessler's reageat. Nitrogen was calculated and protein content was calculated by multiplying per cent nitrogen content in gobhi sarson with the factor 6.25 (A.O.A.C.,1960). Economics of different treatments was worked out on the basis of input and output at the prevailing market rates.

RESULTS AND DISCUSSION

Growth parameters:

The growth parameters i.e. plant height and leaf area index increased significantly due to higher fertility level i.e. 150% RDF. Adequate quantity of nitrogen, phosphorus and potassium resulted in taller plants with more number of leaves which ultimately enhanced the LAI of the crops (Malvia *et al*., 1988). Fertility levels had no significant effect over plant stand m^{-2}(Table 1). The plants which received higher fertilizer, reached to maturity later as there was more food material assimilation in plants.

Row spacing had no significant effect over plant height. The leaf area index was significantly higher with 20 cm row spacing over 40 cm row spacing, due to more number of plants $unit^{-1}$ area. With the increase in row spacing, the plant stand decreased significantly. It was due to less number of rows under an unit area in case of wider spacing. The row spacing had non-significant effect over the maturity period of the plants.

Yield attributes and seed yield:

The number of siliquae $plant^{-1}$, weight of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$ and test weight increased significantly with increasing the level of fertility during both the years (Table 2). Because of vigorous vegetative growth and more available photosynthetic area there was more assimilation of food material which contributed towards superior yield attributes. Solanki *et al*. (1998) observed that increasing the N level upto 120 kg ha^{-1} increased the yield attributes significantly over lower N levels. These superior yield attributing characters ultimately helped to improve the yield (Table 3) with higher fertility levels. Thakur *et al*. (2005) also recorded significantly highest yield with 120 kg N ha^{-1}, being 34.1% higher than that obtained with the application of 60 kg N ha^{-1}. The positive significant correlation was found by Narits (2010) between seed yield and nitrogen application time (r=0.41), which indicated that increasing the N applications increased seed yield. Higher stalk yield was also obtained with higher fertility level due to more vegetative growth.

Number of siliquae $plant^{-1}$ and weight of siliquae $plant^{-1}$ were significantly higher at 40 cm row spacing as compared to 20 cm row spacing. Mausavi *et al.* (2011) observed that pod number $plant^{-1}$ tended to increase with increasing spacings from 30 cm to 50 cm. While in case of number of seeds $siliquae^{-1}$ and test weight there was no significant increase with increase in row spacing still there was numerical increase. Seed yield (kg ha^{-1}) increased significantly from 20 cm to 40 cm row spacing while stalk yield (kg ha^{-1}) significantly decreased from 20 cm to 40 cm spacing (Table 3). More number of siliquae $plant^{-1}$ and weight of siliquae $plant^{-1}$ under wider row spacing compensated the loss in yield due to less plant stand. The stalk yield was significantly more under narrow spacing due to more number of plants $unit^{-1}$ area.

The interaction effects between fertilizer doses and row spacings were not found significant.

Economics:

During both the years the net monetary returns and B:C ratio increased with increasing the fertility level and row spacing (Table 3). The treatment consisted of higher fertility level i.e. 150% RDF with widest row spacing (40 cm) led to record the highest net monetary return and B:C ratio which was Rs 33298/- $hectare^{-1}$ and 3.33 respectively.

Quality parameters:

The oil yield increased significantly with increasing the fertility levels and row spacing while oil content had reverse trend for the same (Table 4). The oil content decreased with the increasing fertility levels could be due to increasing availability of nitrogen which increased the proportion of proteinous substance in seed and hence, oil content was low (Yadav *et al*., 2010 and Tripathi *et al*., 2010).

Table 1. Influence of fertility levels and row spacings on growth of Chinese cabbage

Treatment	Final plant height (cm)			Leaf area index			Final plant stand m^{-2}			Days to maturity		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean
Recommended dose of fertilizer (%)												
100	110.08	114.95	112.52	6.15	9.12	7.64	33.30	32.43	32.87	122.00	122.92	122.46
150	115.21	119.06	117.14	6.61	10.67	8.64	30.51	31.13	30.82	128.50	128.08	128.29
SEm±	0.45	1.61	1.03	0.04	0.42	0.23	0.34	1.62	0.98	0.30	0.28	0.29
CD (P=0.05)	1.35	-	2.78	0.12	1.27	0.70	1.02	-	-	0.90	0.85	0.88
Row spacings (cm)												
20	111.59	115.55	113.57	6.17	10.78	8.48	38.55	43.75	41.15	125.62	126.50	126.06
30	113.01	116.80	114.91	6.42	10.10	8.26	30.52	32.91	31.72	125.25	125.25	125.25
40	113.14	118.66	115.9	6.24	8.80	7.52	20.65	20.67	20.66	124.87	124.75	124.81
SEm±	0.55	1.97	1.26	0.07	0.52	0.30	0.52	1.99	1.26	0.46	0.34	0.37
CD (P=0.05)	-	-	-	0.21	1.56	0.89	1.56	5.98	3.77	-	1.04	-

Table 2. Yield attributes of Chinese cabbage as affected by fertility levels and row spacings

Treatment	No. of siliquaeplant^{-1}			Weight of siliquae plant^{-1}(g)			No. of seeds siliqua^{-1}			Test weight (g)		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean
Recommended dose of fertilizer (%)												
100	161.70	166.05	163.9	17.14	17.74	17.44	21.36	21.07	21.22	4.61	4.74	4.68
150	173.20	168.92	171.1	19.72	19.58	19.55	22.00	22.07	22.04	4.63	4.86	4.75
SEm±	0.69	0.60	0.65	0.17	0.36	0.26	0.14	0.16	0.15	0.01	0.11	0.06
CD (P=0.05)	2.08	1.80	1.94	0.53	1.09	0.81	0.44	0.48	0.46	0.02	-	0.02
Row spacings (cm)												
20	164.85	160.50	162.7	17.57	16.07	16.82	21.47	21.51	21.49	4.61	4.70	4.66
30	167.43	168.05	167.7	18.52	19.87	19.19	21.77	21.57	21.67	4.62	4.77	4.70
40	170.07	173.91	172.0	19.02	20.04	19.53	21.81	21.63	21.72	4.63	4.92	4.78
SEm±	0.84	0.73	0.79	0.21	0.44	0.32	0.18	0.20	0.19	0.01	0.13	0.07
CD (P=0.05)	2.55	2.20	2.38	0.63	1.33	0.98	-	-	-	0.03	-	-

Table 3. Yields and economics of chinese cabbage as affected by fertility levels and row spacings

Treatments	Seed yield (q ha^{-1})			Stalk yield (q ha^{-1})			Net monetary returns (Rs ha^{-1})			B:C ratio		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean
Recommended dose of fertilizer (%)												
100	13.91	12.54	13.23	24.65	29.54	27.10	28740	22995	25868	3.20	2.57	2.89
150	15.39	13.59	14.49	28.14	30.31	29.23	32466	25300	28883	3.38	2.63	3.01
SEm±	0.27	0.25	0.26	0.07	0.25	0.16						
CD (P=0.05)	0.81	0.75	0.78	0.22	0.74	0.48						
Row spacings (cm)												
20	12.54	12.17	12.36	28.38	32.79	30.59	24288	21437	22863	2.81	2.42	2.62
30	14.78	13.13	13.96	26.23	32.18	29.21	31053	24347	27700	3.33	2.61	2.97
40	16.58	13.89	15.24	24.57	31.37	27.97	36468	26657	31563	3.74	2.77	3.26
SEm±	0.34	0.31	0.33	0.09	0.21	0.15						
CD (P=0.05)	1.02	0.92	0.97	0.27	0.67	0.47						
Recommended dose of fertilizer (%) x Row spacings (cm)												
100 x 20	12.00	11.92	11.96	22.66	30.83	26.75	22970	21115	22043	2.76	2.44	2.60
100 x 30	13.88	12.48	13.18	25.99	30.91	28.45	28640	22825	25733	3.20	2.56	2.88
100 x 40	15.86	13.21	14.54	25.31	31.67	28.49	34610	25045	29828	3.66	2.71	3.19
150x 20	13.08	12.42	12.75	26.48	30.66	28.57	25606	21760	23683	2.87	2.40	2.64
150 x 30	15.69	13.78	14.74	26.48	31.81	29.15	33466	25870	29668	3.46	2.67	3.07
150x 40	17.30	14.57	15.94	31.45	32.17	31.81	38326	28270	33298	3.82	2.83	3.33
SEm±	0.82	0.73	0.77	1.20	0.51	0.85						
CD (P=0.05)	-	-	-	-	-	-						

Table 4. Quality parameters of chinese cabbage as affected by fertility levels and row spacings

Treatments	Oil yield (kg ha^{-1})			Oil content (%)			Protein yield (kg ha^{-1})			Protein content (%)		
	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean	2008-09	2009-10	Mean
Recommended dose of fertilizer (%)												
100	363.6	343.0	353.3	35.5	36.2	35.85	235.9	174.5	205.2	16.8	16.7	16.75
150	443.8	417.9	430.9	32.5	33.2	32.9	292.7	216.3	254.5	18.9	18.9	18.90
SEm±	1.92	11.7	6.81	0.34	0.23	0.29	2.23	6.86	4.55	0.11	0.23	0.17
CD (P=0.05)	5.79	35.2	20.50	1.05	0.68	0.87	6.73	20.66	13.70	0.29	0.69	0.49
Row spacings (cm)												
20	308.0	300.2	304.0	36.0	36.1	36.1	208.6	151.4	180.0	16.6	16.8	16.7
30	428.7	399.5	414.1	33.9	34.8	34.4	265.2	202.3	233.8	17.8	17.5	17.7
40	474.3	441.5	457.9	32.1	33.2	32.7	319.1	232.5	275.8	19.2	19.1	19.2
SEm±	2.35	14.33	8.34	0.42	0.28	0.35	2.73	8.40	5.57	0.14	0.28	0.21
CD (P=0.05)	7.11	43.17	25.14	1.26	0.83	1.05	8.24	25.30	16.77	0.42	0.85	0.64

Ahmad *et al.* (2007) reported that increasing N levels had a depressing effect on the oil contents of canola. Higher oil contents were produced by the lower N rate of 40 kg ha^{-1} while lower oil contents were recorded by the highest dose of 80 kg N ha^{-1}. Protein yield and protein content (%) both increased with the increasing fertility levels and row spacings. Due to wider row spacing, plant could grow well and assimilate more proteinous substances.

Thus, it could be inferred that fertility level could be increased upto to 150% RDF with row spacing of 40 cm.

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EVALUATION OF SYSTEM OF RICE INTENSIFICATION (SRI) ON ALLUVIAL SOILS OF ANDHRA PRADESH

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ABSTRACT

Field experiments were conducted for two consecutive *rabi* seasons of 2009 and 2010 in seven randomly selected Farmers' fields covering both East and West Godavari Districts of Andhra Pradesh to compare the performance of System of Rice Intensification (SRI) over recommended practice and Farmers' practice of transplanted rice. The results revealed that SRI practice was proved to be a superior practice over the recommended practice as well as traditional Farmers' practice of transplanted rice. SRI matures early by 3-4 days with higher tiller to panicle conversion ratio (94.3%), higher spikelet fertility (83.2%) and panicle weight. Systems of rice intensification recorded 6.9 and 15.8% higher grain yield compared to recommended practice and Farmers' practice. SRI cultivation had taken 23.9 and16.2 % lesser water compared to Farmers' practice and recommended practices respectively. SRI resulted in higher root weight, root volume, NPK uptake and better grain quality with higher milling out turn compared to other methods. Energy use efficiency, fertilizer use efficiency and economic returns were also impressive in SRI. However, the net profit was not attractive in SRI due to higher cost of cultivation. However, this technology can be advocated safely where the water resources are limited requiring controlled water management.

(Key words: Rice, SRI, yield, returns , water saving)

INTRODUCTION

Area under rice is expected to be reduced to about 40 m. ha in the next 15-20 years and most of the reduction is attributed to water shortage and rapid urbanization (Kumar *et al.,* 2006). Water available for rice is getting scarce year after year due to increased competition from industrial and urban sectors, besides increased competition from commercial crops. Rice consumes 64% of the finite fresh water resources in Andhra Pradesh with very low water use efficiency of 2.45% during 2008-09.(Rao *et al.*,2011). The expenditure towards water alone accounts for 20-30% of the total variable cost of rice production (Kumar *et al.,* 2007). Decreased inflows in major delta systems of the state, particularly Krishna Godavari delta in the recent years is one of the major concern for the Farmers', researchers and policy makers. Predicted climate changes are likely to further accentuate the water crisis and warrants the need for exploring of water saving alternatives in rice cultivation. The conventional rice production system of transplanted rice by Farmers' not only leads to wastage of water but also causes environmental degradation and reduces fertilizer use efficiency (Singh and Chinnusamy, 2006). Systems of Rice Intensification (SRI), a new method of rice establishment practice has the potential to improve water efficiency and land productivity in irrigated rice (Kumar *et al.,* 2006). This study was therefore, programmed to evaluate the performance of SRI in Farmers' fields of Godavari delta of Andhra Pradesh.

MATERIALS AND METHODS

Field experiments were conducted for two consecutive *rabi* seasons of 2009 and 2010 in the Farmers' fields of Godavari delta, Andhra Pradesh to study the comparative performance of System of Rice Intensification (SRI) over recommended practice and Farmers' practice of transplanted rice. The experiment was conducted in seven randomly selected locations(Mandapeta, Ramachandrapuram, Padamatipalem, Kuppanapudi, Venkatramapuram, Akividu and Bhatlamaguturu) covering both East and West Godavari Districts of Andhra Pradesh .The soils were alluvial clay loam having pH 7.1-7.9, organic carbon 0.8 – 1.0%, available P_2O_5 35-41 kg ha^{-1} and K_2O 330-355 kg ha^{-1}. Test variety was Cottondora Sannalu (MTU 1010) of 120 days duration in all the locations .The trial consisted of three treatments viz., T1–Systems of rice intensification (SRI); T_2- Recommended practice and T_3- Farmers' Practice.

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SRI nursery was prepared with raised bed duly applying FYM as a fine layer on the bed. Pre-sprouted seeds were sown @ 5.0 kg ha^{-1}. Ten days old seedlings were transplanted at a spacing of 25 cm x 25 cm using single seedling $hill^{-1}$. Water management was done by maintaining saturation (no standing water except on the day of irrigation) upto PI stage and thin film of water (2 cm depth) thereafter. Weed control was done manually by using conoweeder for 4 times at 10 days interval starting from 10 DAT in both directions. Proper leveling was done before planting. Normal recommended practices were followed for conventional method by planting 24 to 26 days old seedlings at a spacing of 15 cm X 15 cm with 2-3 seedlings $hill^{-1}$. Weeds were controlled by one pre-emergence herbicide application followed by one hand weeding at 40 DAT. Water was maintained at a depth of 2 cm upto panicle initiation and 5 cm thereafter upto one week before harvest. The field was drained before application of fertilizers and one week before harvest. A uniform dose of FYM @ 5.0 t ha^{-1} and 180-90-90 kg ha^{-1} NPK were applied through Urea, SSP and MOP. Entire P and K and 1/3 N were applied as basal dose. Remaining N was applied in two splits at active tillering and panicle initiation stage for both SRI and recommended practice. Farmers' practice consisted of planting of 26-30 days old seedlings at random planting @ 40 hills m^{-2} using 4-5 seedlings $hill^{-1}$, maintaining 3-5 cm depth of water upto panicle initiation and 5-7 cm depth of water thereafter upto one week before harvest. Weeds were controlled by one pre-emergence herbicide application (Pretilachlore @ 0.75 kg a.i. ha^{-1}) followed by one hand weeding; Fertilizers were applied @ 200-90-100 kg of NPK $hectare^{-1}$. The experiments were provided uniform plant protection and cultural management practices throughout the period of crop growth.

Water was measured using Water meters and Parshall flume. Data on tillers m^{-2} were collected from ten randomly marked hills at active tillering stage. Root volume at flowering was calculated using water displacement method. Root biomass and weed biomass was estimated at flowering by collecting samples from 0.25 m^{-2} area in the net plot , samples were air-dried and then oven dried at 60°C upto attaining constant weight and expressed as g m^{-2}. The number of ear bearing tillers were counted from tagged plants, averaged to compute productive tillers $hill^{-1}$ and expressed as panicles m^{-2}, ten randomly selected panicles were counted, averaged and expressed as number of grains $panicle^{-1}$ and filled grains $panicle^{-1}$ at maturity stage. Dry matter production at harvest was recorded from ten randomly marked hills, samples were air-dried and then oven dried at 60°C to a constant weight and expressed as kg ha^{-1}. Thousand grains randomly drawn from the composite sample of grain yield of net plot in each treatment (dried to 14 per cent moisture content), were weighed and expressed in grams. Grain from the net plot was thoroughly sun dried to 14 per cent moisture content, weighed and expressed in kg ha^{-1}. Number of days taken for maturity was recorded and presented as days to maturity. The relationship of economic yield to the total biological yield was expressed as harvest index (HI).

Energy use efficiency was calculated by dividing energy input by energy output as per the procedure given by Panesar and Bhatnagar(1994). The quality parameters were assessed as per the procedure given by Ghosh (1971). A sample of five hundred grams of paddy was taken from each plot and milled with “Satake” grain testing husker and then polished to one minute. Ten randomly selected rice grains from each treatment were measured using dial micrometer, averaged and expressed in millimeters. L/B ratio was calculated by dividing length of the grain with breadth and expressed as L/B ratio. Nitrogen content of grain and straw was analysed separately using modified microkjeldahl method and crude protein was estimated by multiplying total N with factor 5.95; phosphorus content of grain and straw was estimated by calorimetric method using a Technicon autoanalyser and potassium content of grain and straw using flame photometry (Jackson, 1973). The nutrient contents of grain and straw were multiplied with respective dry weights of grain and straw, which were summed up to present nutrient uptake at harvest. Economic parameters like gross returns, net returns and rupee returned $rupee^{-1}$ invested were worked out treatment – wise taking prevailing market rates for different inputs and out puts. Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference ($p = 0.05$) by pooling two years data.

RESULTS AND DISCUSSION

Growth and yield attributes:

Two years pooled data showed that, significantly less number of tillers were recorded in SRI compared to both recommended practice and Farmers' practice (Table 1). Panicles m^{-2} were also significantly less in SRI compared recommended practice. However, the tiller to panicle conversion ratio was higher in SRI(94.3%),which was higher by 10.2 per cent over recommended practice and 17.1 per cent over Farmers' practice. Conspicuously higher number of total grains and filled grains $panicle^{-1}$ and test weight were recorded in SRI compared to Farmers' practice as well as recommended practice as spikelet fertility was higher in SRI (83.2%), which was higher by 6.3 and 4.1 % over Farmers' practice and recommended practice respectively. Higher tiller to panicle conversion ratio (93.1%) as well as higher spikelet fertility (84.5%) in SRI was also reported by Naidu (2009).The higher tiller to panicle conversion ratio as well as higher spikelet fertility in SRI might be due to favourable growth and better translocation of assimilates to the sink as it was revealed by sound filling of grains. Increased crop vigor, higher panicle size with more number of filled grains $panicle^{-1}$ in SRI was reported by Barla and Kumar (2011). Dry matter production at harvest was also significantly higher in SRI over both recommended and Farmers' practice of crop establishment.

Days to maturity and grain yield:

Systems of rice intensification had taken significantly less days to maturity i.e. four days earlier than Farmers' practice and three days earlier than recommended practice. Early recovery of crop at the time of transplanting in SRI compared to other practices might have reduced the crop duration in SRI. Systems of rice intensification recorded significantly higher grain yield compared to Farmers' practice and recommended practice (Table 1) which was 6.9 and 15.8% higher over recommended practice and Farmers' practice respectively. Though the recommended practice recorded significantly lower grain yield compared to SRI, but it was significantly superior over Farmers' practice. Large number of filled grains $panicle^{-1}$and higher test weight might be the reason behind the yield increase. These findings are in agreement with that of Murthy *et al.(*2006) who reported higher yields in SRI which were attributed to more number of filled grains and higher panicle weight . Sekhar *et al.,(*2009) also reported more number of filled spikelets $panicle^{-1}$ with higher test weight resulting in to higher grain yield than conventional transplanted rice .There was no marked difference in Harvest index with SRI compared to recommended practice.

Water use and fertilizer use efficiency:

As regards to water use, SRI cultivation had taken 23.9 and 16.2 % less water compared to Farmers' practice and recommended practices respectively. The water productivity of SRI was very impressive (6.59 kg ha^{-1} mm^{-1}) which was 51.5 and 27.0 % higher than Farmers' practice and recommended practices respectively. Maintenance of saturation upto PI stage and thin film of water thereafter, reduced the water requirement of SRI over other methods without any adverse effect on yield. Raju and Srinivas (2008) also reported the maximum water use efficiency of 8.19 kg mm ha^{-1} in SRI. Higher fertilizer use efficiency was also recorded with SRI compared to both Farmers' practice and recommended practice.

Economics and Energy parameters:

Economic appraisal of different crop establishment practices revealed that, the SRI practice resulted about Rs 5676 /- and 10074/- higher gross returns than recommended practice and Farmers' practice respectively .Higher grain yield of superior quality is the probable reason for higher gross returns. The net returns in SRI were also significantly superior , which were higher by Rs 7466/-and Rs 3776/-over Farmers' practice and recommended practice respectively. While Rupee retuned $rupee^{-1}$invested was at par with different cop establishment practices. Increased cost of cultivation of about Rs1900 to 2608/- in SRI over recommended and Farmers' practice reduced the net profits of this practice. Reddy *et al.(*2005) reported that SRI had no economic advantage over the conventional system of rice cultivation and that the prime gain from SRI was water saving rather than rice yield improvement. Energy output was significantly higher in SRI over both recommended practice and Farmers' practice (Table 2), whereas energy intake was also higher in SRI followed by Farmers' practice .The energy output input ratio of SRI was at par with recommended practice. However, it was significantly higher than Farmers' practice. Though the energy output was

Table 1. Effect of crop establishment practices on tillers, dry matter production at harvest, yield attributes, yield and water productivity of rice

(pooled data of two years)

Treatments	Tillers m^{-2}	Panicles m^{-2}	Total grins panicle^{-1}	Filled grains panicle^{-1}	Test Weight (g)	DMPH (kg ha^{-1})	Days to maturity	Grain yield (kg ha^{-1})	Harvest Index (%)	Water applied (mm)	Water productivity (kg $ha^{-1}mm^{-1}$)	FUE (kg kg^{-1})
SRI	436	363	155	129	21.12	15139	119	7149	0.47	1085	6.59	19.86
FP*	527	386	143	110	20.09	13423	123	6175	0.46	1425	4.35	15.83
RP*	493	415	139	110	20.73	14186	122	6687	0.47	1295	5.17	18.58
SE± d	16	11	5.1	4.5	0.46	423	1.3	186		41	-	-
CD (0.05)	35	25	10	9	0.99	918	3	404		88	-	-

FP- Farmers' Practice; RP- Recommended Practice; DMPH-dry matter production at harvest; FUE-Fertilizer use efficiency

Table 2. Economics ,energy use, weed dry wt and root parameters of rice as effected by crop establishment practices

(pooled data of two years)

Treatments	Gross returns (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net returns (Rs ha^{-1})	Rupee rupee^{-1} invested (Rs Rs^{-1})	Energy output (MJ)	Energy input (MJ)	Energy use efficiency (MJ MJ^{-1})	Weed dry weight (g m^{-2})	Root volume (ml cm^{-3})	Root dry weight (g m^{-2})
SRI	75827	33029	42798	1.34	204965	21514	9.53	30.94	25.35	4.18
FP*	65753	30421	35332	1.19	181373	20652	8.78	17.16	19.83	3.26
RP*	70151	31129	39022	1.30	193286	19856	9.73	21.44	21.07	3.51
SE± d	2132	323	1362	0.10	3571	493	0.31	0.96	0.53	0.17
CD (0.05)	4646	812	2966	--	7756	1071	0.67	2.09	1.15	0.37

Table 3. Effect of crop establishment practice on N P K uptake and quality parameters of

(pooled data of two years)

Treatment	N uptake at harvest (kg ha^{-1})	P uptake at harvest (kg ha^{-1})	K uptake at harvest (kg ha^{-1})	Crude protein content %	L:B ratio	Hulling %	Milling %	Per cent head rice recovery
SRI	140.0	28.36	159.7	8.36	3.31	78.30	74.80	65.1
FP*	129.8	23.17	130.3	8.28	3.20	73.70	68.60	58.90
RP*	132.4	25.62	139.1	8.19	3.47	75.40	70.30	59.70
SE± d	2.73	0.61	3.17	0.39	0.16	2.03	1.98	2.72
`CD (0.05)	5.93	1.33	6.9	--	--	4.36	4.25	5.84

significantly higher in SRI, the energy output input ratio was at par with recommended practice, because it requires conspicuously higher energy compared to recommended practice.

Weed dry weight, root parameters and NPK uptake:

SRI resulted markedly higher weed dry weight at flowering over famers' practice and recommended practice (Table2) while it was conspicuously lower in Farmers' practice. As cono weeding in SRI couldn't control the weeds nearer the plants effectively, it might have resulted in higher weed dry weight at flowering. Root volume as well as root dry weight at flowering was significantly higher in SRI over other two practices (Table 2). Providing sufficient aeration through cono-weeding might be the reason for better root growth in SRI compared to other two practices.SRI resulted in markedly higher NPK uptake at harvest over both recommended and Farmers' practice (Table 3). Higher root growth and rapid mineralization of N in was achieved in SRI, as a result of better aeration resulting in higher NPK uptake. A well developed and healthy root system in SRI plays an important role in uptake and translocation of nutrients from soil than conventional system (Uphoff ,2005).

Grain quality :

Among the quality parameters , there was no conspicuous difference in gain crude protein content as well as L:B ratio with different cop establishment practices (Table 3). Milling parameters like hulling per cent was conspicuously high in SRI than Farmers' practice only, while milling per cent and per cent head rice recovery were significantly high in SRI compared to both Farmers' as well as recommended practices. Whereas, there was no measurable difference in milling parameters between Farmers' practice and recommended practices.

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EFFECT OF FYM, BIOFERTILIZERS AND ZINC ON YIELD OF MAIZE AND THEIR RESIDUAL EFFECT ON WHEAT

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ABSTRACT

A field experiment was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur during two consecutive years of 2006-07 and 2007-08 to evaluate effect of FYM, biofertilizers and zinc on yield of maize (*Zea mays* L.) and their residual effect on wheat (*Triticum aestivum* L.) on Typic Haplustept . The results of the study showed that application of FYM @ 10 t ha^{-1} or application of 5.0 kg Zn ha^{-1} increased significantly the seed, stover and biological yield of maize as well as of succeeding wheat grown in sequence. Biofertilizers *viz*., *Azotobacter,* VAM and *Azotobacter* + VAM (dual inoculation) inoculation to maize significantly increased the grain, stover and biological yields of maize and yields of succeeding wheat. Application of FYM, biofertilizers and zinc significantly enhanced protein content in grain of maize. Combined use of FYM and biofertilizers significantly increased the grain, stover and biological yields of maize. Combined use of FYM and zinc significantly increased the grain, stover and biological yields of maize.

(Key words : Maize, wheat, farmyard manure, *Azotobacter*, VAM, yield, residual effect)

INTRODUCTION

Maize (*Zea mays* L.)- wheat (*Triticum aestivum* L.) is a common cropping sequence in large part of India, including Rajasthan. However, productivity of this sequence under rainfed condition is very low. A majority of farmers in Rajasthan do not apply zinc in this sequence, mainly beceause of their ignorance about its role as well as high cost. The cereal based cropping system and application of continuous profit motivated imbalanced nutrient application is the matter of great concern for sustainability. In spite of heavy inputs, the result in such system is the decline in crop yields, because of limition of one or more micronutrients. Use of chemical fetilizer or organic alone cannot achieve sustainable productivity. Hence, desired level of use of organic manure with chemical fertilizers is very essential as this will not only sustain higher levels of producitvity but also improve soil health and enhance the nutrient use efficiency. Keeping the above facts under consideration, an experiment was carried out to study the response of FYM, biofertilizers and zinc on crop yield of maize and wheat and nutrient status of soil.

MATERIALS AND METHODS

A field study on typic haplustept during 2006-07 and 2007-08 at Maharana Pratap University of Agriculture and Technology, Udaipur was conducted. The soil of the experimental field was clay loam in texture, slightly alkaline in reaction (pH 8.4 and 8.3), medium in organic carbon (0.71 and 0.73 %), and medium in available nitrogen (233 and 235 kg ha^{-1}), low in available phosphorus (13.6 and 13.9 kg ha^{-1}) and high in potassium (336 and 340 kg ha^{-1}) in 2006 and 2007, respectively. The experiment consisted of thirty two treatment combinations of two levels of farmyard manure (0 and 10 tonnes ha^{-1}), four levels of biofertilizers [No innoculation, *Azotobacter*, Vesicular arbuscular mycorrhizae (VAM) inoculation and *Azotobacter* + VAM inoculation] and four levels of zinc (0, 2.5, 5 and 7.5 kg ha^{-1}). Treatments were applied only in maize crop and their residual effects were recorded in wheat crop. The field experiment was laid out in split plot design allocating farmyard manure and biofertilizers in main plots and zinc in subplots and replicated three times. *Azotobacter* and VAM were used as biofertilizers for maize for fixing atmospheric nitrogen and increasing phosphorus availability. Grain, stover/straw, biological yield and harvest index of maize and succeeding wheat estimated after harvesting of crops. The harvest index was worked out by the formula suggested by Donald and Hamblin (1976). The protein content in grain of maize was worked out by multiplying nitrogen content of grain with conversion factor 6.25 as per procedure described by Anonymous (1960). The nitrogen content in grain was estimated by colorimetric method (Lindner, 1944). The zinc content in plant was estimated by atomic absorption spectrophotometer method as suggested by Elwell and Gridley (1967). The concentration of zinc in soil (in DTPA extract) was determined by atomic absorption spectrophotometer method as given by Lindsay and Norvell (1978).

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RESULTS AND DISCUSSION

Effect of FYM :

An examination of data (Table 1) revealed that application of FYM at 10 t ha^{-1} resulted in significant increase in grain yield of maize (32.78 q ha^{-1}) which was 19.81 per cent higher over no FYM application on pooled basis (27.36 q ha^{-1}).

Data presented in table 1 revealed that the application of FYM at 10 t ha^{-1} resulted in significant increase in stover yield of maize over control during both the years of experimentation and on pooled basis. The corresponding increase in stover yield with application of FYM at 10 t ha^{-1} (59.71 q ha^{-1}) was 19.68 per cent higher than no FYM application (49.89 q ha^{-1}) on pooled basis.

Data presented in table 1 also revealed that application of FYM at 10 t ha^{-1} resulted in significant increase in biological yield of maize (92.49 q ha^{-1}) which was 19.73 per cent higher over no FYM application on pooled basis (77.25 q ha^{-1}). Addition of FYM is known to favorably improve soil physical and biological properties. FYM as a source of organic matter improves soil structure, reduces soil compaction, and increases water holding capacity (Biswas and Mukherjee, 1997). FYM also provides energy for N-fixation by free living heterotrophic microorganisms. The amount of N fixation by microorganisms is influenced by energy available in the form of organic residues. All these factors contributed to enhance crop yields. Results of present investigation also corroborate with the findings of Verma *et al.* (2006) who reported that highest maize grain and stover yield were obtained by applying 150% NPK, though the results were at par with those obtained with 100% NPK + FYM 10 tonnes ha^{-1}. Application of 100% NPK + FYM 10 tonnes ha^{-1} showed highest value of growth parameter and grain yield of wheat. Adeyemo and Agele (2010) also observed that application of manure significantly increased ($P < 0.05$) root dry weight, dry matter yield, 100 seed weight and grain yield of maize. The increases between unmanured and manured tilled plots 10 t ha^{-1} FYM was 13 per cent. Relative to unmanured plots (control), 10 t ha^{-1} FYM increased grain yields by 8.7 per cent. Arif *et al*. (2012) also observed that FYM significantly improved the grain yield of maize.

Effect of biofertilizers :

Data presented in table 1 showed that grain yield of maize increased significantly with inoculation by *Azotobacter*, VAM and *Azotobacter* + VAM over no inoculation, during both the years of experiment. On pooled basis dual inoculation of *Azotobacter* + VAM was found the best and resulted in 19.46 per cent (26.98 q ha^{-1}) higher grain yield over no inoculation.

A perusal of data presented in table 1 revealed that significant increase in stover yield was recorded with biofertilizer's inoculation during both the years of experiment. On pooled basis, inoculation of *Azotobacter*, VAM and *Azotobacter* + VAM resulted in 10.10, 12.51 and 18.79 per cent increase in stover yield over no inoculation (49.56 q ha^{-1}).

Data presented in table 1 also showed that biological yield of maize increased significantly with inoculation by *Azotobacter*, VAM and *Azotobacter* + VAM over no inoculation but the effect of *Azotobacter* remained at par with that of VAM, during both the years of experiment and pooled basis. Inoculation of *Azotobacter*, VAM and dual inoculation of *Azotobacter* + VAM increased 11.69, 12.80 and 19.02 per cent higher biological yield of maize over no inoculation, respectively, on pooled basis.Thus, combined application Azotobacter + VAM was more beneficial than their alone application in improving grain yield, stover yield and biological yield of maize. The observed additive influence of biofertilizers is attributable to mutually beneficial and synergistic role played by each group of biofertilizers used. Such mutually beneficial synergistic effect was also reported by Radwan (1998) in which they found that the combined treatment of VA - mycorrhiza + *Azotobacter* + 107.1 kg N ha^{-1} produced the highest growth, yield and yield component of maize. Faramarzi *et al.* (2012) also showed that application of *Azotobacter* increased plant height, grain yield, grain weight and biological yield.

Effect of zinc :

Data presented in table 1 further showed that application of zinc at increasing levels significantly improved the grain yield of maize upto 5.0 kg Zn ha^{-1}

during both the years and upto 7.5 kg Zn ha^{-1}on pooled basis. Further increase in level upto 7.5 kg Zn ha^{-1} though had positive influence but failed to bring about significant enhancement during both the years. On pooled basis, application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} resulted in 9.57, 15.86 and 17.22 per cent increase in the grain yield of maize over control, respectively.

Data presented in table 1 further showed that application of zinc at increasing levels significantly improved the stover yield of maize upto 5.0 kg Zn ha^{-1} during both the years and on pooled basis. Further increase in level upto 7.5 kg Zn ha^{-1} though had positive influence but failed to bring about significant enhancement during both the years. On pooled basis, application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} resulted in 8.30, 14.06 and 16.12 per cent increased the stover yield of maize over control, respectively.

Data presented in table 1 further showed that application of zinc at increasing levels significantly improved the biological yield of maize upto 5.0 kg Zn ha^{-1} during both the years and upto 7.5 kg Zn ha^{-1}on pooled basis. Further increase in level upto 7.5 kg Zn ha^{-1} though had positive influence but failed to bring about significant enhancement during both the years. On pooled basis, application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} resulted in 8.75, 14.70 and 16.51 per cent increased in the biological yield of maize over control, respectively. Such improvement in yield with increased zinc levels has also been observed by Dwivedi *et al*. (2002). They reported that the application of Zn up to 5 kg ha^{-1} increased the grain yield of maize by 19 per cent over control. The optimum dose of zinc was found to be 7.1 kg ha^{-1} giving maximum grain yield of 29.8 q ha^{-1}. Similar trend in yield response of stover was also recorded. Khan *et al.* (2007) also observed that tillage and Zn application methods had significant effects on maize grain yield.

Interaction effects :
FYM X Biofertilizers :

It is apparent from the data presented in table 2 that application of biofertilizers along with FYM significantly influenced grain yield of maize during both the years of experiment and on pooled basis. The yield obtained under the treatment involving dual inoculation of *Azotobacter* + VAM along with 10 t FYM ha^{-1} (35.41, 37.39 and 36.40 q ha^{-1} during 2006, 2007 and on pooled basis, respectively) recorded the maximum grain yield which was found significantly higher over rest of the treatments. The per cent increase with the application of *Azotobacter* + VAM dual inoculation along with 10 t FYM ha^{-1} over control was to the magnitude of 40.07, 44.87 and 42.47 during 2006, 2007 and on pooled basis, respectively.

The combined effect of FYM and biofertilizers on stover yield of maize (Table 3) revealed that *Azotobacter*, VAM and dual inoculation along with 10 t FYM ha^{-1} gave significantly higher stover yield of maize over control during both the years and on pooled basis. On pooled basis, the corresponding increase was 42.90 per cent in combination of FYM and biofetilizers.

It is apparent from the data presented in table 4 that application of biofertilizers along with FYM significantly affected biological yield of maize during both the years of experiment and on pooled basis. The yield obtained under the treatment involving dual inoculation of *Azotobacter* + VAM along with 10 t FYM ha^{-1} recorded the maximum biological yield (100.82, 105.01 and 102.92 q ha^{-1} during 2006, 2007 and on pooled basis, respectively) which was found significantly higher over rest of the treatments. The per cent increased with the application of *Azotobacter* + VAM dual inoculation along with 10 t FYM ha^{-1} over control to the magnitude of 41.98, 43.50 and 42.77 during 2006, 2007 and on pooled basis, respectively. Conjoint application of biofertilizers and FYM had been shown to improve crop yields (Hankare *et al.*, 2005). They revealed that application of N at 12 kg ha^{-1}, one quarter through organic manures and three quarters through urea + BNF (Biological nitrogen fixer; *Azotobacter*) recorded the highest leaf area, dry matter accumulation and grain and fodder yields of maize. Saini *et al.* (2005) also reported that the application of fertilizer nutrients along with FYM, use of nitrogen fixers, phosphate solubilizers and VAM increased grain ($r = 0.614$, $P < 0.05$) and stover yields ($r = 0.604$, $P < 0.05$) of maize and in general decreased C: N and C: P ration.

FYM X Zinc :

Data presented in table 5 revealed that there was significant interactive effect between FYM and zinc levels with respect to grain yield of maize during

both the years individually as well as on pooled basis. On pooled basis highest grain yield recorded with the application of FYM at 10 t ha^{-1} along with 7.5 kg Zn ha^{-1} (11.47 q ha^{-1}) was found at par with the application of 10 t FYM along with 5.0 kg Zn ha^{-1} and significantly superior to that recorded under all remaining treatments. Maximum and minimum grain yields (34.65 and 25.46, 36.35 and 26.32 and 35.50 and 25.89 q ha^{-1}, respectively during 2006, 2007 and on pooled basis) were obtained under the two treatment combination involving application of 7.5 kg Zn ha^{-1} + 10 t FYM ha^{-1} and control, respectively.

Data presented in table 6 revealed that application of zinc increased the stover yield of maize (46.43, 47.90 and 47.16 q ha^{-1} during 2006, 2007 and on pooled basis on no zinc application, respectively) to 50.96, 52.67 and 51.81 q ha^{-1} with the application of 7.5 kg zinc along with no FYM. Further, on pooled basis the addition of FYM at 10 t ha^{-1} recorded stover yield of 52.82, 58.88, 62.85 and 64.29 q ha^{-1} providing 12.00, 19.19, 22.78 and 24.09 per cent increase over no zinc and no FYM, 2.5 kg Zn ha^{-1} and no FYM, 5.0 kg Zn ha^{-1} and no FYM, and 7.5 kg Zn ha^{-1} and no FYM, respectively. Application of 7.5 kg Zn ha^{-1} along with 10 t FYM ha^{-1} gave the highest stover yield of maize during both the years. On pooled basis, the per cent increases with 7.5 kg Zn ha^{-1} along with 10 t FYM ha^{-1} by a margin of 36.23 over no FYM and no zinc which was at par with 5.0 kg Zn ha^{-1}+10 t FYM ha^{-1} but significantly increased over rest of zinc and FYM combinations.

Data presented in table 7 revealed that there was significant interactive effect between FYM and zinc levels with respect to biological yield of maize during both the years individually as well as on pooled basis. On pooled basis, the highest biological yield recorded with the application of FYM at 10 t ha^{-1} along with 7.5 kg Zn ha^{-1} (99.79 q ha^{-1}) and was found at par with the application of 10 t FYM along with 5.0 kg Zn ha^{-1} (97.75 q ha^{-1}) and significantly superior to that recorded under all remaining treatments. Maximum and minimum biological yields (97.81 and 71.89, 101.77 and 74.22 and 99.79 and 73.06 q ha^{-1}, respectively during 2006, 2007 and on pooled basis) were obtained under the treatments involving application of 7.5 kg Zn ha^{-1} + 10 t FYM ha^{-1} and control, respectively. The significant interactive effects as a consequence of FYM and zinc attributed to favourable nutritional status of soil resulting into increased biomass production of the crop. This may also be attributed to the zinc enriched organic manure beside being a source of micronutrients themselves, which improve their availability in soil by preventing their fixation and precipitation thereby enhancing the use efficiency of applied zinc sulphate thus saving the cost of fertilizer. Devarajan *et al*. (1987) observed that FYM at 15 t ha^{-1} + 12.5 kg $ZnSO_4$ ha^{-1} gave more grain yields of maize of 5.13 t ha^{-1}, compared with 3.61 t with NPK alone. Devarajan *et al*. (1988) also observed that the highest grain yields of maize of 3.30 t ha^{-1} were obtained with 25 t FYM + 25 kg zinc sulphate ha^{-1}, followed by 2.94-2.96 t ha^{-1} with 50 kg zinc sulphate or 12.5 t FYM + 12.8 kg zinc sulphate ha^{-1}. Yield with NPK alone was 2.31 t ha^{-1}.

Harvest index :

A perusal of data presented in table 1 revealed that application of FYM, biofertilizers and zinc levels to maize had no influence on harvest index of maize during both the years of experimentation and on pooled basis.

Protein content in grain of maize :

Data presented in table 8 revealed that application of FYM at 10 t ha^{-1} significantly enhanced protein content in grain of maize over no FYM application during both the years. On pooled basis, application of 10 t FYM ha^{-1} increased protein content in grain over no FYM (12.10 per cent protein content) by a margin of 10.33 per cent. Mohamed and EL-Aref (1999) reported that application of nitrogen fertilizer with farmyard manure produced highest grain and protein yields of maize.

A perusal of data presented in table 8 indicated that a significant increase in protein content of maize grain was recorded with biofertilizers inoculation during both the years of experimentation. On pooled basis inoculation of *Azotobacter*, VAM and *Azotobacter* + VAM resulted in 5.81, 3.35 and 7.03 per cent increase in protein content of maize grain over no inoculation (12.23 per cent protein content).

A perusal of data presented in table 8 also revealed that application of zinc significantly improved the protein content in grain of maize during both the years of investigation. On pooled basis,

application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} resulted in 3.37, 6.57 and 8.38 per cent increase in protein content in grain of maize, respectively over control (12.17 per cent protein content). Khattak *et al*. (2006) reported that zinc application increased the grain yield of maize. The economic dose appeared to be 5 kg Zn ha^{-1} or two times foliar spray with 0.5 per cent $ZnSO_4$ solution. Both the treatments increased yield from 3725 kg ha^{-1} (control) to 4825 kg ha^{-1} and 4182 kg ha^{-1}, showing 29 per cent and 12 per cent increase over the control, respectively. Results of seed analysis for protein and oil per cent showed that both the methods of zinc application enhanced its protein and oil content.

Yield of succeeding wheat :
Residual effect of FYM :

Data presented in table 9 showed that grain yield of succeeding wheat crop increased significantly with the application of FYM at 10 t ha^{-1} to maize as compared to no FYM application during both the years. On pooled basis, treatments receiving FYM and no FYM application resulted in 36.03 and 32.57 q ha^{-1} grain yield of wheat and it was found 10.62 per cent higher over control, respectively.

A perusal of data presented in table 9 indicates that straw yield of succeeding wheat increased significantly with the application of residual FYM at 10 t ha^{-1} to maize over no FYM application. Straw yield obtained with the residual effect of 10 t FYM ha^{-1} application was 51.83 q ha^{-1} and obtained with no FYM application was 46.33 q ha^{-1}. This resulted in 11.87 per cent increase in straw yield of wheat on pooled basis over control.

Data presented in table 9 showed that biological yield of succeeding wheat crop increased significantly with the application of FYM at 10 t ha^{-1} to maize as compared to no FYM application during both the years. On pooled basis, treatments receiving FYM and no FYM application resulted in 87.86 and 78.90 q ha^{-1} grain yield of wheat which was found 11.36 per cent higher over control, respectively. Vats *et al.* (2001) earlier reported that application of FYM to *kharif* crop gave significant residual effect on succeeding wheat grain yield.

Residual effect of biofertilizers :

A critical examination of data presented in table 9 also revealed that inoculation of maize with biofertilizers was found to increase significantly grain yield of succeeding wheat crop during both the years. Application of VAM and dual inoculation of *Azotobacter* + VAM to maize significantly increased yield of succeeding wheat during both the years. Inoculation of *Azotobacter* individually failed to show significant response on grain yield of succeeding wheat crop over control during both the years and on pooled basis. The yield obtained due to *Azotobacter,* VAM and *Azotobacter* + VAM was 33.53, 34.97 and 35.89 q ha^{-1}, respectively with increase to the magnitude of 2.16, 6.55 and 9.35 per cent, over no biofertilizers application, respectively on pooled basis.

Data presented in table 9 further revealed that inoculation of maize with biofertilizers was found to increase significantly straw yield of succeeding wheat crop during both the years. Application of VAM and dual inoculation of *Azotobacter* + VAM to maize significantly increased straw yield of succeeding wheat crop during both the years. Inoculation of *Azotobacter* individually failed to show significant response on straw yield of succeeding wheat over control during both the years and on pooled basis. The yield obtained due to *Azotobacter,* VAM and *Azotobacter* + VAM were 48.18, 49.95 and 51.15 q ha^{-1}, respectively with increase to the magnitude of 2.42, 6.19 and 8.74 per cent, over no biofertilizers application, respectively on pooled basis.

Data presented in table 9 also revealed that inoculation of maize with biofertilizers was found to increase significantly biological yield of succeeding wheat crop during both the years. Application of VAM and dual inoculation of *Azotobacter* + VAM to maize significantly increased biological yield of succeeding wheat crop during both the years. Inoculation of *Azotobacter* individually failed to show significant response on biological yield of succeeding wheat over control during both the years and on pooled basis. The biological yield obtained due to VAM and *Azotobacter* + VAM were 84.92 and 87.04 q ha^{-1}, respectively with increase to the magnitude of 6.34 and 8.99 per cent, over no biofertilizers application, respectively on pooled basis. Similar findings had earlier been reported by Tomar *et al.* (2003) who reported that residual effects

of inoculation with *Rhizobium*, VAM and PSB individually or in combination and phosphorus applied to black gram were significant on succeeding wheat crop.

Residual effect of zinc :

A perusal of data presented in table 9 revealed that application of 2.5 kg Zn ha^{-1} to maize did not show significant residual effect on grain yield of succeeding wheat over control but application of 5.0 kg Zn ha^{-1} and 7.5 kg Zn ha^{-1} significantly increased the grain yield of succeeding wheat crop over control during both the years of experimentation and on pooled basis. However, there was no significant difference between treatments receiving 5.0 kg Zn ha^{-1} and 7.5 kg Zn ha^{-1} during both the years and on pooled basis. This highest grain yield of wheat (35.28 q ha^{-1}) was recorded under the treatment receiving 7.5 kg Zn ha^{-1} and the lowest (33.04 q ha^{-1}) was recorded under treatment receiving no zinc application. The per cent increase of grain yield of wheat was 3.06, 5.45 and 6.78 with the application of residual zinc at 2.5, 5.0 and 7.5 kg Zn ha^{-1}, respectively on pooled basis.

A close examination of data presented in table 9 revealed that application of 2.5 kg Zn ha^{-1} to maize did not show significant residual effect on straw yield of succeeding wheat crop over control but application of 5.0 kg Zn ha^{-1} and 7.5 kg Zn ha^{-1} significantly increased the straw yield of succeeding wheat crop over control during both the years of experimentation and on pooled basis. However, there was no significant difference between treatments 5.0 kg Zn ha^{-1} and 7.5 kg Zn ha^{-1} during both the years and on pooled basis. On pooled basis, maximum straw yield (50.41 q ha^{-1}) was obtained under the treatment receiving 7.5 kg Zn ha^{-1} and minimum (47.34 q ha^{-1}) under no Zn application. Residual application of 2.5, 5.0 and 7.5 kg Zn ha^{-1} recorded significantly higher straw yield of succeeding wheat and representing 3.02, 5.18 and 6.49 per cent, respectively on pooled basis.

A perusal of data presented in table 9 revealed that application of 2.5 kg Zn ha^{-1} to maize did not show significant residual effect on biological yield of succeeding wheat crop over control but application of 5.0 kg Zn ha^{-1} and 7.5 kg Zn ha^{-1} significantly increased the grain yield of succeeding wheat over control during both the years of experimentation. However, there was no significant difference between treatments receiving 5.0 kg Zn ha^{-1} and 7.5 kg Zn ha^{-1} during both the years. On pooled basis, application of increasing levels of zinc up to 2.5 kg Zn ha^{-1} significantly increased the biological yield of wheat but further failed to bring about significant effect on increase in level of zinc. The highest biological yield of wheat (85.70 q ha^{-1}) was recorded under the treatment receiving 7.5 kg Zn ha^{-1} and the lowest (80.37 q ha^{-1}) was recorded under treatment receiving no zinc application on pooled basis. The per cent increase of biological yield of wheat were 3.06, 5.30 and 6.63 with the application of residual Zn at 2.5, 5.0 and 7.5 kg Zn ha^{-1}, respectively on pooled basis. Similarly Mawardi *et al.* (1975) also observed that residual effect of zinc increased plant dry matter of wheat. Interaction effect among residual FYM, zinc levels and biofertilizers was non-significant.

Harvest index:

A perusal of data presented in table 9 showed that application of FYM, biofertilizers and zinc levels to previous maize had no significant effect on harvest index of succeeding wheat during both the years of experimentation and on pooled basis.

Table 1. Effect of FYM, biofertilizers and zinc on grain, stover yield, biological yield (q ha^{-1}) and harvest index (%) of maize

Treatments	Grain yield			Stover yield			Biological yield			Harvest index		
	2006	2007	Pooled	2006	2007	Pooled	2006	2007	Pooled	2006	2007	Pooled
FYM (t ha^{-1})												
0	26.97	27.74	27.36	49.11	50.67	49.89	76.08	78.42	77.25	35.48	35.37	35.43
10	32.17	33.38	32.78	58.71	60.71	59.71	90.88	94.09	92.49	35.37	35.45	35.41
SEm ±	0.37	0.38	0.26	0.68	0.69	0.49	0.99	1.03	0.71	0.21	0.15	0.13
CD (P=0.05)	1.11	1.15	0.76	2.07	2.10	1.41	2.99	3.13	2.07	--	--	--
Biofertilizers												
No inoculation	26.55	27.42	26.98	48.65	50.46	49.56	75.21	77.88	76.54	35.30	35.20	35.25
Azotobacter	30.14	30.81	30.47	54.04	55.99	55.01	84.18	86.80	85.49	35.75	35.50	35.63
VAM	30.10	31.05	30.58	55.01	56.52	55.76	85.11	87.57	86.34	35.43	35.43	35.43
Azoto.+VAM	31.49	32.97	32.23	57.94	59.80	58.87	89.43	92.77	91.10	35.23	35.51	35.37
SEm ±	0.52	0.54	0.37	0.96	0.98	0.69	1.40	1.46	1.01	0.29	0.21	0.18
CD (P=0.05)	1.57	1.63	1.08	2.93	2.96	1.99	4.23	4.42	2.92	--	--	--
Zinc levels (kg ha^{-1})												
0	26.65	27.70	27.17	49.12	50.85	49.99	75.77	78.55	77.16	35.24	35.27	35.26
2.5	29.51	30.04	29.77	53.34	54.94	54.14	82.85	84.98	83.91	35.61	35.35	35.48
5.0	30.93	32.02	31.48	56.11	57.93	57.02	87.04	89.95	88.50	35.51	35.55	35.53
7.5	31.21	32.49	31.85	57.06	59.04	58.05	88.27	91.53	89.90	35.35	35.46	35.40
SEm ±	0.49	0.52	0.36	0.92	0.87	0.63	1.35	1.32	0.94	0.24	0.25	0.17
CD (P=0.05)	1.40	1.47	1.00	2.61	2.47	1.77	3.83	3.76	2.65	--	--	--

Table 2. Combined effect of FYM and biofertilizers on grain yield (q ha^{-1}) of maize

Treatments	Biofertilizers											
	2006				2007				Pooled			
	B_0	B_1	B_2	B_3	B_0	B_1	B_2	B_3	B_0	B_1	B_2	B_3
FYM (t ha^{-1})												
0	25.28	27.50	27.53	27.58	25.81	28.19	28.41	28.56	25.55	27.85	27.95	28.07
10	27.82	32.79	32.68	35.41	29.03	33.42	33.69	37.39	28.42	33.10	33.18	36.40
SEm±	0.73				0.76				0.53			
CD (P=0.05)	2.22				2.31				1.53			

Table 3. Combined effect of FYM and biofertilizers on stover yield (q ha^{-1}) of maize

Treatments	Biofertilizers											
	2006				2007				Pooled			
	B_0	B_1	B_2	B_3	B_0	B_1	B_2	B_3	B_0	B_1	B_2	B_3
FYM (t ha^{-1})												
0	45.73	50.03	50.21	50.47	47.37	51.63	51.73	51.98	46.55	50.83	50.97	51.22
10	51.58	58.05	59.80	65.41	53.56	60.35	61.31	67.63	52.57	59.20	60.55	66.52
SEm±	1.36				1.38				0.97			
CD (P=0.05)	4.14				4.19				2.81			

Table 4. Combined effect of FYM and biofertilizers on biological yield (q ha^{-1}) of maize

Treatments	Biofertilizers											
	2006				2007				Pooled			
	B_0	B_1	B_2	B_3	B_0	B_1	B_2	B_3	B_0	B_1	B_2	B_3
FYM (t ha^{-1})												
0	71.01	77.53	77.74	78.05	73.18	79.82	80.14	80.53	72.09	78.67	78.94	70.29
10	79.40	90.83	92.48	100.82	82.19	93.77	95.00	105.01	80.99	92.20	93.74	102.92
SEm±	1.97				2.06				1.43			
CD (P=0.05)	5.99				6.25				4.13			

Table 5. Combined effect of FYM and Zn grain yield (q ha^{-1}) of maize

Treatments	Zinc levels (kg ha^{-1})											
	2006				2007				Pooled			
	0	2.5	5	7.5	0	2.5	5	7.5	0	2.5	5	7.5
FYM (t ha^{-1})												
0	25.46	27.02	27.64	27.77	26.32	27.54	28.48	28.63	25.89	27.28	28.06	28.20
10	27.83	31.99	34.22	34.65	29.07	32.54	35.57	36.35	28.45	32.26	34.90	35.50
SEm±	0.70				0.73				0.50			
CD (P=0.05)	1.98				2.07				1.41			

Table 6. Combined effect of FYM and zinc on stover yield (q ha^{-1}) of maize

Treatments	Zinc levels (kg ha^{-1})											
	2006				2007				Pooled			
	0	2.5	5	7.5	0	2.5	5	7.5	0	2.5	5	7.5
FYM (t ha^{-1})												
0	46.43	48.78	50.27	50.96	47.90	50.03	52.11	52.67	47.16	49.40	51.19	51.81
10	51.82	57.91	61.94	63.17	53.81	59.85	63.76	65.42	52.82	58.88	62.85	64.29
SEm±	1.30				1.23				0.89			
CD (P=0.05)	3.69				3.49				2.51			

Table 7. Combined effect of FYM and zinc on biological (q ha^{-1}) yield of maize

Treatments	Zinc levels (kg ha^{-1})											
	2006				2007				Pooled			
	0	2.5	5	7.5	0	2.5	5	7.5	0	2.5	5	7.5
FYM (t ha^{-1})												
0	71.89	75.80	77.90	78.73	74.22	77.57	80.58	81.29	73.06	76.68	79.29	80.01
10	79.65	89.90	96.17	97.81	82.88	92.39	99.33	101.77	81.27	91.15	97.75	99.79
SEm±	1.90				1.87				1.33			
CD (P=0.05)	5.41				5.32				3.75			

Table 8. Effect of FYM, biofertilizers and zinc on protein content (%) in grain of maize

Treatments	Protein content (%)		
	2006	2007	Pooled
FYM (t ha^{-1})			
0	12.12	12.08	12.10
10	13.40	13.30	13.35
SEm ±	0.09	0.09	0.06
CD (P=0.05)	0.26	0.27	0.18
Biofertilizers			
No inoculation	12.27	12.19	12.23
Azotobacter	12.99	12.90	12.94
VAM	12.64	12.63	12.64
Azoto.+VAM	13.14	13.05	13.09
SEm ±	0.12	0.13	0.09
CD (P=0.05)	0.37	0.39	0.26
Zinc levels (kg ha^{-1})			
0	12.13	12.20	12.17
2.5	12.62	12.54	12.58
5.0	13.00	12.93	12.97
7.5	13.28	13.11	13.19
SEm ±	0.10	0.08	0.06
CD (P=0.05)	0.27	0.22	0.17

Table 9. Residual effect of FYM, biofertilizers and zinc on grain, straw yield, biological yield (q ha^{-1}) and harvest index (%) of wheat

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Biological yield (q ha^{-1})			Harvest index (q ha^{-1})		
	2006-07	2007-08	Pooled	2006-07	2007-08	Pooled	2006-07	2007-08	Pooled	2006-07	2007-08	Pooled
FYM (t ha^{-1})												
0	33.66	31.49	32.57	48.00	44.66	46.33	81.66	76.15	78.90	41.23	41.39	41.31
10	37.05	35.01	36.03	53.48	50.18	51.83	90.53	85.19	87.86	40.94	41.10	41.02
SEm ±	0.43	0.39	0.29	0.61	0.57	0.42	0.79	0.70	0.53	0.40	0.42	0.29
CD (P=0.05)	1.31	1.20	0.85	1.85	1.73	1.21	2.40	2.11	1.53	--	--	--
Biofertilizers												
No inoculation	33.80	31.83	32.82	48.75	45.34	47.04	82.54	77.18	79.86	41.03	41.25	41.14
Azotobacter	34.71	32.35	33.53	49.80	46.56	48.18	84.51	78.91	81.71	41.07	41.04	41.06
VAM	35.96	33.99	34.97	51.71	48.20	49.95	87.66	82.19	84.92	41.01	41.41	41.21
Azoto.+VAM	36.95	34.83	35.89	52.71	49.58	51.15	89.66	84.41	87.04	41.22	41.28	41.25
SEm ±	0.61	0.56	0.41	0.86	0.81	0.59	1.12	0.98	0.75	0.56	0.59	0.41
CD (P=0.05)	1.86	1.69	1.20	2.62	2.44	1.71	3.40	2.98	2.16	--	--	--
Zinc levels (kg ha^{-1})												
0	34.01	32.06	33.04	49.02	45.65	47.34	83.03	77.71	80.37	40.97	41.26	41.12
2.5	35.09	33.02	34.05	50.49	47.06	48.77	85.58	80.08	82.83	41.06	41.25	41.16
5.0	35.90	33.78	34.84	51.43	48.16	49.79	87.33	81.93	84.63	41.12	41.29	41.20
7.5	36.43	34.14	35.28	52.02	48.81	50.41	88.45	82.95	85.70	41.18	41.19	41.18
SEm ±	0.52	0.48	0.36	0.75	0.72	0.52	1.01	1.08	0.74	0.45	0.34	0.28
CD (P=0.05)	1.48	1.38	1.00	2.13	2.06	1.46	2.88	3.06	2.07	--	--	--

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INFLUENCE OF INTEGRATED NITROGEN MANAGEMENT ON NUTRIENT CONTENT AND UPTAKE OF GRAIN AMARANTH *(Amaranthus hypochondriacus* L.)

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ABSTRACT

A field trial was conducted during *rabi* season of 2004-05 and 2005-06 at Regional Research Station, S.D. Agricultural University, Sardarkrushinagar to study the "Integrated nitrogen management in grain amaranth (*Amaranthus hypochondriacus* L.)". The experiment comprised of ten nitrogen management treatments viz., N_1: Control, N_2: 100 per cent RDN (Urea), N_3: 75 per cent RDN (Urea), N_4: 50 per cent RDN (Urea), N_5: 50 % RDN from vermicompost + 50 % RDN from urea, N_6: 75 % RDN from vermicompost + 25 % RDN from urea, N_7: 37.5 % RDN from vermicompost + 37.5 % RDN from urea, N_8: 56.25 % RDN from vermicompost + 18.75 % RDN from urea, N_9: 25 % from RDN vermicompost + 25 % RDN from urea, N_{10}: 37.5 % RDN from vermicompost + 12.5 % RDN from urea and three bio-fertilizer treatments viz., B_1: No bio-fertilizer, B_2: *Azotobactor* and B_3: *Azospirillum* was laid out in FRBD with 3 replications. An application of fertilizer at 100 % RDN, recorded higher nitrogen content in grains (2.56 %) and straw (0.75 %) to the tune of 44.2 and 44.2 per cent higher over control in pooled results, respectively. Maximum nitrogen uptake was recorded under the treatment 50 % RDN from vermicompost + 50 % RDN from urea to the tune of 126.5 and 106.7 % over control in pooled basis by grains and straw, respectively. The maximum phosphorus content in grains was recorded in control (0.687 %) followed by 37.5 % RDN from vermicompost + 12.5% RDN from urea (0.678 %) and 25 % from RDN vermicompost + 25 % RDN from urea (0.673 %) on pooled basis. The magnitude of increase in phosphorus uptake under 50 % RDN from vermicompost + 50 % RDN from urea was to the tune of 49.7 per cent by grains and 67.3 per cent by straw over control in pooled data. The potassium content was higher under 100 % RDN over control in grains, whereas, in straw it was higher under control over 100 % RDN. The per cent increase in potassium uptake by grain under 50 % RDN from vermicompost + 50 % RDN from urea (7.50 kg ha^{-1}) was to the tune of 79.4 per cent over control (4.18 kg ha^{-1}) in pooled results. In case of straw, increase in potassium uptake under 50 % RDN from vermicompost + 50 % RDN from urea (67.37 kg ha^{-1}) was to the tune of 24.2 per cent over control (54.24 kg ha^{-1}) in pooled results. Bio-fertilizers influenced the nutrient content and uptake by grains and straw in pooled data, except potassium content and uptake in straw. The percentage increase in nutrient content and uptake was higher under *Azotobactor* followed by *Azospirillum* seeds inoculation. The nitrogen uptake by grains and straw was improved under treatment combination 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* to the tune of 181.9 and 187.5 per cent over control, followed by 100 per cent RDN (Urea) + *Azotobactor* in pooled results, respectively. Higher phosphorus uptake was recorded by grains under treatment combination of 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* to the tune of 87.4 per cent over control followed by 100 per cent RDN (Urea) + *Azotobactor* while, treatment combinations of 50 % RDN from vermicompost + 50 % RDN from urea + *Azospirillum*, 75 % RDN from vermicompost + 25 % RDN from urea + *Azotobactor*, 100 per cent RDN (Urea) +*Azospirillum* and 75 % RDN from vermicompost + 25 % RDN from urea + *Azospirillum* did not exert any effect in phosphorus uptake in pooled results. In case of straw, the highest phosphorus uptake was recorded with treatment combination of 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* followed by 100 per cent RDN (Urea) + *Azotobactor*, 100 per cent RDN (Urea) + *Azospirillum* and 50 % RDN from vermicompost + 50 % RDN from urea + *Azospirillum* on pooled basis. Potassium uptake was higher under 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* to the tune of 128.8 per cent over control followed by 100 per cent RDN (Urea) + *Azotobactor* by grains in pooled results.

(Key words: Grain amaranth, nutrient content, nutrient uptake, urea and vermicompost)

INTRODUCTION

Amaranth is a quick growing multipurpose crop suitable for poor soils of semi-arid and seasonal wet areas. Certain attributes, like higher productivity potential added with substantial quantities of minerals, carbohydrates, fats and proteins are comparable with any other important cereals. It is said to be highly nutritious with higher protein and lysine content than any other cereals (Joseph, 1979). It has higher crude protein (16.86 %), moisture (11.88 %), crude fat (4.30 %), crude fiber (2.90 %), ash (2.10 %), carbohydrates (63.13 %), calcium (169.63 mg 100 g^{-1}), iron (10.42 mg 100 g^{-1}), phosphorus (395.33 mg 100 g^{-1}) (Munjal *et al*., 1999). This is the only grain consumed by the people observing fast on Ekadasi & other festivals. Its leaves are used as leafy vegetable in its early stage. It also has medicinal value for the treatments of snakebite and kidney treatment. It is useful in the high quality, cosmetics, natural dyes, pharmaceuticals (laxatives) and squalene, (Anonymous, 1984). Being a profitable and potential crop, the area under this crop is increasing where irrigation facility is available. Increased usage of

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chemical fertilizers without adequate organic recycling has not only aggravated multi-nutrient deficiencies in soil-plant system, but also deteriorated soil health and created environmental pollution. According to Olaniyi *et al.* (2008) nitrogen is the most mobile and easily exhaustible nutrient in the soil and is subjected to substantial leaching and losses resulting in ground water nitrate pollution, if nitrogenous fertilizers are applied in excess. In addition to the environmental problem consequent upon excess application in most farming communities in many parts of the developing world, commercial fertilizers are often beyond the reach of poor resource farmers in terms of availability and affordability. Consequently, alternative soil fertility maintenance techniques need to be evolved in order to meet up with food need of the teeming populace. According Parmar and Patel (2009), the yield and yield attributes of grain amaranth were significantly increased due to INM over chemical fertilizer application. Hence, these studies were carried out to study the influence of Integrated N management and biofertilizers on nutrient content and uptake in grain amaranth.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of 2004-05 and 2005-06 at Regional Research Station, S.D. Agricultural University, Sardarkrushinagar (Gujarat) to study the "Integrated nitrogen management in grain amaranth (*Amaranthus hypochondriacus* L.)" on loamy sand soils. The soil was very low in organic carbon (0.12%) and available nitrogen (166.2 kg ha^{-1}) and medium in available phosphorus (31.33 kg ha^{-1}) and potash (233 kg ha^{-1}). The experiment comprised of ten nitrogen management treatments viz., N_1: Control, N_2: 100 per cent RDN (Urea), N_3: 75 per cent RDN (Urea), N_4: 50 per cent RDN (Urea), N_5: 50 % RDN from vermicompost + 50 % RDN from urea, N_6: 75 % RDN from vermicompost + 25 % RDN from urea, N_7: 37.5 % RDN from vermicompost + 37.5 % RDN from urea, N_8: 56.25 % RDN from vermicompost + 18.75 % RDN from urea, N_9: 25 % from RDN vermicompost + 25 % RDN from urea, N_{10}: 37.5 % RDN from vermicompost + 12.5 % RDN from urea and three bio-fertilizer treatments viz., B_1: No bio-fertilizer, B_2: *Azotobactor* and B_3: *Azospirillum* was laid out in FRBD with 3 replications. The crop var. GA-2 was sown in first fortnight of November and RDF was 60 kg N and 40 kg P_2O_5 ha^{-1}. Nitrogen was applied as per the treatment through urea and vermicompost, half quantity of nitrogen as basal application and remaining half at the time of second irrigation as per treatment. Required quantity of vermicompost for N was applied as basal before sowing as per treatment. For phosphorus application, phosphorus obtained from vermicompost was deducted from the total phosphorus required to the crop and remaining phosphorus from single super phosphate was applied as a basal dose in ploughed furrows before sowing. On the basis of nutrient content of vermicompost, the required quantity of vermicompost and SSP was applied to adjust the required dose of nitrogen and phosphorus as per the treatments (Table 1). For determination of nutrient content and uptake by plant, they were dried in an oven at 70°C for 48 hours. Dried samples were milled and ground for analysis. Total P was determined by the Vanadomolybdate method (Jackson, 1973), K by flame photometry (Jackson,1973) and total N was analyzed using micro-kjheldahl procedure and crude protein was evaluated by multiplying the total N by a factor of 6.25 (Anonymous, 1960).

RESULTS AND DISCUSSION

Effect of Nitrogen:

Nutrient content:

Nitrogen content in grains and straw (Table 2) was recorded higher under 50 % RDN from vermicompost + 50 % RDN from urea in pooled results. The treatments 100 per cent RDN (Urea) and 50 % RDN from vermicompost + 50 % RDN from urea were not distinguished for nitrogen content in grains, but it was higher under 50 % RDN from vermicompost + 50 % RDN from urea in case of straw followed by 100 per cent RDN (Urea). The extent of increase in nitrogen content in grains under 50 % RDN from vermicompost + 50 % RDN from urea was to the tune of 42.2 per cent over control and 1.4 % over 100 per cent RDN (Urea) in pooled results. In case of straw, the magnitude of increase in nitrogen content under 50 % RDN from vermicompost + 50 % RDN from urea was observed to the tune of 44.2 per cent over control and 1.4 per cent over 100 per cent RDN (Urea) in pooled results. The per cent increase in nitrogen content by both grains and straw was low

under treatments supplemented with 75 % N from vermicompost (75 % RDN from vermicompost + 25 % RDN from urea, 56.25 % RDN from vermicompost + 18.75 % RDN from urea and 37.5 % RDN from vermicompost + 12.5 % RDN from urea) which might be due to slow mineralization and low availability of nitrogen during early growth period. The treatment supplemented with 50 % N from vermicompost and 50 % N from urea reflected higher nitrogen content compared to rest of treatments in pooled results, which might be due to benefit of residual effect of vermicompost applied to previous year.

The maximum phosphorus content in grains was recorded in control, followed by 37.5 % RDN from vermicompost + 12.5 % RDN from urea and 25 % from RDN vermicompost + 25 % RDN from urea on pooled basis. The per cent increase under control was to the tune of 6.2 over 100 % RDN either inorganic or integrated source of nitrogen. In case of straw, the extent of increase in phosphorus content was higher under 100 % RDN either integrated or inorganic source of nitrogen to the tune of 14.9-14.3 per cent over control in pooled results. The phosphorus content in grains at different levels of nitrogen [100 per cent RDN (Urea), 75 per cent RDN (Urea) and 50 per cent RDN (Urea)], which received urea as source of nitrogen was lower as compared with those treatments, which received 75 % nitrogen from vermicompost at same levels (75 % RDN from vermicompost + 25 % RDN from urea, 56.25 % RDN from vermicompost + 18.75 % RDN from urea and 37.5 % RDN from vermicompost + 12.5 % RDN from urea), which might be due to higher phosphorus content of vermicompost. The magnitude of increase under 50 % RDN from vermicompost + 50 % RDN from urea was to the tune of 49.7 and 0.9 per cent by grains and 67.3 and 1.3 per cent by straw over control and 100 per cent RDN (Urea) in pooled data, respectively.

The potassium content was higher in grains under 100 % RDN over control, whereas, in straw it was higher under control over 100 % RDN. In case of straw, increase in potassium content under control was to the tune of 17.0 per cent over 100 per cent RDN (Urea) and 16.6 per cent over 50 % RDN from vermicompost + 50 % RDN from urea in pooled results. In pooled results, the increase in grains and straw under 50 % RDN from vermicompost + 50 % RDN from urea was to the tune of 79.4 and 24.2 per cent over control and 1.6 and 0.6 per cent over 100 per cent RDN (Urea), respectively.

Nutrient uptake :

Application of nitrogen increased the uptake of N by grains and straw. The per cent increase in uptake under treatment 50 % RDN from vermicompost + 50 % RDN from urea recorded maximum 0.8 and 0.5 per cent over 100 per cent RDN (Urea) on pooled basis by grains and straw, respectively. The per cent increase in nitrogen uptake by both grains and straw was low under treatments supplemented with 75 % N from vermicompost (75 % RDN from vermicompost + 25 % RDN from urea, 56.25 % RDN from vermicompost + 18.75 % RDN from urea and 37.5 % RDN from vermicompost + 12.5 % RDN from urea), which might be due to slow mineralization and low availability of nitrogen during at growing period.

The extent of increase in phosphorus uptake under 50 % RDN from vermicompost + 50 % RDN from urea was to the tune of 49.7 per cent by grains and 67.3 per cent by straw over control in pooled data. While, it was 0.9 and 1.3 per cent higher in pooled results by grains and straw over 100 per cent RDN through Urea, respectively.

The per cent increase in potassium uptake under 50 % RDN from vermicompost + 50 % RDN from urea was to the tune of 12.5 per cent over control and 0.4 per cent over 100 per cent RDN through Urea in pooled results, respectively.

Effect of Bio- fertilizers :

Nutrient content :

Bio-fertilizers influenced significantly the nutrient contents by grains and straw in pooled data. The percentage increase in nutrient contents was higher under *Azotobactor* followed by *Azospirillun* seeds inoculation. On pooled basis, increase in nitrogen content (Table 2) due to bio- fertilizer was to the tune of 5.4 and 11.8 per cent over control by grains and straw, respectively. The percentage increase in phosphorus content by grains and straw due to *Azotobactor* was to the tune of 8.8 and 8.1 per cent over control, respectively, while marginal increase was observed over *Azospirillum* in pooled results. Increase in potassium content due to *Azotobactor* seed inoculation was 11.9 per cent higher over control

and 0.6 per cent over *Azospirillum* by grains on pooled basis, while it was not observed in straw.

Nutrient uptake :

Bio-fertilizers influenced the uptake by grains and straw in pooled data. On pooled basis increase in nitrogen uptake (Table 2) was improved by 24.9 and 29.5 per cent over control and 2.7 and 3.1 per cent over *Azospirillum* by grains and straw, respectively. The extent of increase in phosphorus uptake due to *Azotobactor* seed inoculation was to the tune of 27.7 and 23.5 per cent over control and 2.9 and 2.2 per cent over *Azospirillum* by grains and straw, respectively on pooled basis. The extent of increase in potassium uptake due to *Azotobactor* seed inoculation was to the tune of 32.0 and 12.4 per cent over control without bio-fertilizer and 2.7 and 0.4 per cent over *Azospirillum* inoculation by grains and straw, respectively on pooled basis.

Interaction :

Integrated source of nitrogen along with bio-fertilizers recorded highest nitrogen uptake by grains over 100 % RDN from urea. The nitrogen uptake by grains and straw was significantly higher under treatment combination of 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* followed by 100 per cent RDN (Urea) + *Azotobactor* in pooled results. The magnitude of increase in grain under 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* was to the tune of 181.9 per cent over control in pooled results. While the magnitude of increase in uptake by straw under 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* was to the tune of 187.5 and 172.3 per cent over control and 7.8 and 1.6 per cent over 100 per cent RDN (Urea) + *Azotobactor*, respectively. The per cent increase in nitrogen uptake under 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* might be due to residual synergistic effect of integrated sources of nitrogen. Higher phosphorus uptake was recorded by grains under treatment combination of 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* followed by 100 per cent RDN (Urea) + *Azotobactor*, while treatment combinations 50 % RDN from vermicompost + 50 % RDN from urea + *Azospirillum*, 75 % RDN from vermicompost + 25 % RDN from urea + *Azotobactor*, 100 per cent RDN (Urea) +*Azospirillum* and 75 % RDN from vermicompost + 25 % RDN from urea + *Azospirillum* did not exert any effect in phosphorus uptake in pooled results. The magnitude of increase in phosphorus uptake by grains under 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* was to the tune of 87.4 per cent over control and 2.5 per cent over 100 per cent RDN (Urea) + *Azotobactor* in pooled results. In case of straw, the highest phosphorus uptake recorded with treatment combination of 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* followed by 100 per cent RDN (Urea) + *Azotobactor*, 100 per cent RDN (Urea) +*Azospirillum* and 50 % RDN from vermicompost + 50 % RDN from urea + *Azospirillum* on pooled basis. The per cent increase in phosphorus uptake under 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* by straw was to the tune of 102.1 per cent over control and 0.5 per cent over 100 per cent RDN (Urea) + *Azotobactor* treatment combination. Organic acids formed during decomposition, might have enhanced the mobilization and availability of P_2O_5 by various mechanisms and promoted the root growth and ultimately uptake of phosphorus. Potassium uptake was higher under 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* followed by 100 per cent RDN (Urea) + *Azotobactor* by grains in pooled results. The magnitude of increase in potassium uptake by grains under 50 % RDN from vermicompost + 50 % RDN from urea + *Azotobactor* was to the tune of 128.8 per cent over control and 5.1 per cent over 100 per cent RDN (Urea) + *Azotobactor* in pooled results, respectively. The findings are in accordance with those reported by Khanda and Mohpatra (2001) in amaranth and Sharma *et al*. (2005) in wheat due to integrated source of nitrogen, while Shivankar *et al*. (2000) on maize crop due to bio-fertilizers. Singh and Totawat (2002) in maize and Parmar (2003) in amaranth observed increase in nutrient uptake due to integrated nitrogen management.

In view of the results obtained from the present investigation, it is inferred that crop should be fertilized @ 60 kg N ha^{-1} with integration of vermicompost and urea on 50:50 basis alongwith *Azotobactor* seed inoculation for getting higher yield as well as improving the soil health.

Table 1. Quantity of Urea, Vermicompost and SSP required for different treatments

Treatments detail	Urea (kg ha^{-1}) for both the year		Vermicompost (kg ha^{-1})		Single super phosphate (kg ha^{1})	
			2004 -05 N:2.07%, P_2O_5:1.26%	2005 -06 N:2.21%, P_2O_5:1.58%	2004 -05	2005 -06
	Basal	Split	Basal	Basal	Basal	Basal
N_1	0.0	0.0	00	00	250.0	250.0
N_2	65.2	65.2	00	00	250.0	250.0
N_3	48.9	48.9	00	00	250.0	250.0
N_4	32.6	32.6	00	00	250.0	250.0
N_5	0.0	65.2	1450	1357	135.8	116.0
N_6	0.0	32.6	2175	2036	78.8	48.9
N_7	0.0	48.9	1087	1018	164.4	149.5
N_8	0.0	24.4	1630	1527	121.6	99.2
N_9	0.0	32.6	725	679	192.9	182.9
N_{10}	0. 0	16.3	1087	1018	164.4	149.5

Table 2. Nutrient content and uptake as influenced by nitrogen management and bio-fertilizer (Pooled data of two years)

Nitrogen Management	Yield (kg ha^{-1})		Nutrient content (%) / Uptake (kg ha^{-1})											
			N content		N uptake		P content		P uptake		K content		K uptake	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
N_1 : Control	862	2778	1.80	0.52	15.49	14.63	0.687	0.168	5.93	4.65	0.486	1.953	4.18	54.24
N_2 : 100 per cent RDN (Urea)	1352	4015	2.56	0.74	34.80	30.08	0.647	0.192	8.80	7.69	0.545	1.669	7.38	67.00
N_3 : 75 per cent RDN (Urea)	169	3626	2.35	0.69	27.49	25.20	0.655	0.182	7.69	6.58	0.514	1.738	6.00	63.12
N_4 : 50 per cent RDN (Urea)	974	3090	2.24	0.60	21.82	18.79	0.662	0.175	6.46	5.39	0.500	1.878	4.88	58.17
N_5 : 50 % RDN from V.C. + 50 % RDN from urea	1366	4016	2.56	0.75	35.08	30.24	0.646	0.193	8.88	7.78	0.547	1.675	7.50	67.37
N_6 : 75 % RDN from V.C. + 25 % RDN from urea	1227	3794	2.42	0.70	29.85	26.69	0.652	0.190	8.04	7.13	0.536	1.711	6.60	65.00
N_7: 37.5 % RDN from V.C. + 37.5 % RDN from urea	1077	3378	2.27	0.63	24.57	21.43	0.658	0.181	7.12	6.11	0.512	1.801	5.51	60.93
N_8 : 56.25 % RDN from V.C. + 18.75 % RDN from urea	1000	3176	2.23	0.62	22.32	19.87	0.662	0.180	6.63	5.69	0.507	1.848	5.07	58.84
N_9 : 25 % RDN from V.C. + 25 % RDN from urea	935	2958	2.21	0.56	20.68	16.67	0.673	0.175	6.30	5.16	0.495	1.928	4.62	57.08
N_{10} : 37.5 % RDN from V.C. + 12.5 % RDN from urea	890	2841	2.13	0.55	19.02	15.67	0.678	0.172	6.05	4.90	0.496	1.941	4.43	55.09
S.Em. ±	19.2	41.7	0.03	0.01	0.54	0.43	0.005	0.003	0.15	0.11	0.007	0.028	0.13	1.20
CD at 5 %	54	117	0.08	0.03	1.51	1.19	0.014	0.007	0.42	0.31	0.020	0.077	0.36	3.35
Bio-fertilizer														
B_1: No bio - fertilizer	908	3084	2.20	0.59	21.73	18.52	0.627	0.172	6.13	5.32	0.477	1.832	4.67	56.12
B_2 : *Azotobactor*	1084	3537	2.32	0.66	27.16	23.99	0.682	0.186	7.83	6.57	0.534	1.794	6.17	63.10
B_3 : *Azospirillum*	1055	3481	2.31	0.66	26.44	23.27	0.677	0.183	7.61	6.43	0.531	1.818	6.01	62.83
SEm±	14.43	22.9	0.017	0.006	0.29	0.23	0.003	0.001	0.08	0.06	0.004	0.015	0.07	0.65
CD at 5 %	41	165	0.05	0.02	2.13	1.69	0.008	0.004	0.59	0.44	0.011	NS	0.51	NS
CV %	7.78	5.26	5.64	6.82	9.09	8.25	3.26	6.09	8.76	7.65	5.81	6.44	9.72	8.36
N X B	SIG	SIG	NS	NS	SIG	SIG	NS	NS	SIG	SIG	NS	NS	SIG	NS

V.C. = Vermicompost, RDN = Recommended dose of nitrogen

Table 3. Nutrient content and uptake as influenced by interaction of nitrogen management and bio-fertilizer

Nitrogen management	Bio-fertilizer														
	Nitrogen uptake by grain			Nitrogen uptake by straw			Phosphorus uptake by grain			Phosphorus uptake by straw			Potassium uptake by grain		
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
N_1 : Control	14.18	16.03	16.27	12.66	15.64	15.58	5.46	6.09	6.24	4.25	4.83	4.87	3.78	4.34	4.42
N_2 : 100 per cent RDN (Urea)	29.81	38.94	35.65	24.97	33.92	31.36	7.18	9.98	9.23	6.34	8.55	8.17	6.16	8.23	7.75
N_3 : 75 per cent RDN (Urea)	23.17	29.49	29.83	20.97	28.50	26.14	6.43	8.24	8.38	5.78	7.08	6.88	5.01	6.42	6.56
N_4 : 50 per cent RDN (Urea)	18.92	23.29	23.27	15.41	20.78	20.19	5.48	6.95	6.96	4.78	5.77	5.62	4.11	5.20	5.33
N_5 : 50 % RDN from V.C. + 50 % RDN from urea	29.05	39.97	36.21	25.33	34.47	30.93	7.19	10.20	9.22	6.67	8.59	8.09	5.98	8.65	7.87
N_6 : 75 % RDN from V.C. +25 % RDN from urea	24.81	32.37	32.38	23.44	28.64	28.00	6.58	9.00	8.54	6.50	7.45	7.43	5.15	7.34	7.30
N_7: 37.5 % RDN from V.C.+37.5% RDN from urea	21.46	25.85	26.40	17.90	22.78	23.63	6.06	7.62	7.66	5.27	6.46	6.59	4.63	5.98	5.93
N_8 :56.25 % RDN from V.C. +18.75% RDN from urea	20.02	24.19	22.75	17.04	20.78	21.78	5.91	7.23	6.76	5.00	6.14	5.92	4.20	5.78	5.23
N_9 : 25 % RDN from V.C+ 25 % RDN from urea	18.78	21.26	22.00	14.28	17.54	18.20	5.60	6.56	6.76	4.30	5.51	5.68	3.87	5.04	4.96
N_{10} : 37.5 % RDN from V.C. +12.5% RDN from urea	17.14	20.27	19.67	13.24	16.85	16.91	5.37	6.39	6.40	4.28	5.33	5.09	3.81	4.70	4.76
SEm ±		0.93			0.74			0.26			0.19			0.23	
CD at 5 %		2.61			2.07			0.72			0.53			0.62	
CV %		9.09			8.25			8.76			7.65			9.72	

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INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT ON NUTRIENT UPTAKE, FRUIT YIELD, QUALITY AND ECONOMIC ANALYSIS OF TOMATO (*Lycopersican esculentum* L.)

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ABSTRACT

A field experiment was conducted during *kharif* 2010 at college of Agriculture, Hyderabad (A.P.) to study the effects of integrated nutrient management on performance of tomato crop in terms of yield, nutrient uptake, quality and economics of tomato. The experiment was conducted in randomized block design with ten treatments replicated thrice. The treatments included, T_1- Control, T_2- 50% RDN through fertilizer + 50% RDN through vermicompost, T_3- 75% RDN through fertilizer + 25% RDN through vermicompost, T_4- 100% RDN through vermicompost, T_5- 100% RDN through fertilizer, T_6- 50% RDN through fertilizer + 50% RDN through poultry manure, T_7 - 75% RDN through fertilizer + 25% RDN through poultry manure, T_8 - 100% RDN through poultry manure, T_9 - 50% RDN through vermicompost + 50% RDN through poultry manure and T_{10} - 50% RDN through inorganic fertilizer + 25% RDN through vermicompost + 25% RDN through poultry manure. The N uptake (106.35 kg ha^{-1}) was the highest in 100% RDN through fertilizer. The highest P uptake (17.40 kg ha^{-1}) and K uptake (61.82 kg ha^{-1}) values were recorded in 75% RDN through fertilizer + 25% RDN through vermicompost. The highest yield (84.97 q ha^{-1}) was recorded in 75% RDN through fertilizer + 25% RDN through vermicompost and it was at par with 75% RDN through fertilizer + 25% RDN through poultry manure (84.06 q ha^{-1}) and 100% RDN through fertilizer (80.73 q ha^{-1}) treatments. The values pertaining to quality parameters of tomato revealed that the treatment receiving 50% RDN through Vermicompost + 50% RDN through Poultry manure recorded significantly highest ascorbic acid (30.83 mg 100g^{-1}) and lycopene (4.05 mg 100g^{-1}) contents. The highest net returns were obtained in 75% RDN through fertilizer + 25% RDN through poultry manure and B:C ratio (2.44) was the highest under 100 per cent inorganic fertilizer followed by 75% RDN through fertilizer + 25% RDN through poultry manure (2.14) and 75% RDN through fertilizer + 25% RDN through vermicompost (2.03), because of cost prohibitiveness of Vermicompost and Poultrymanure. However, combined use of 75% RDN through fertilizer + 25% of RDN through Vermicompost and Poultrymanure was the best for obtaining higher yield apart from maintaining soil fertility for longer period.

(Key words: Tomato, Integrated nutrient management, yield, nutrient uptake, quality and economics)

INTRODUCTION

The basic concept underlying the principles of integrated nutrient management is the maintenance and improvement of soil fertility for sustaining crop productivity on a long-term basis, which can be achieved through the combined use of various sources of nutrients and by managing them scientifically for optimum growth, yield and quality of different crops, suiting to local agro-ecological conditions. In vegetable production in Asian countries, farmers have been using organic manures for centuries, together in recent decades with chemical fertilizers, to meet the nutrient demands of crops. Integrated nutrient use has assumed great significance in recent years because the experimental results revealed that neither chemical fertilizers alone, nor organic sources used exclusively sustained the productivity of soils under highly intensive cropping systems (Singh and Yadav, 1992).

Vegetables constitute the potential cash crops as region's climate and edaphic suitability supports their cultivation almost round the year (Dass *et al*., 2002). In the recent years, there has been reduction in the usage of organic manures and increase in the use of inorganic fertilizers to obtain higher yields from hybrids and improved varieties. The production and productivity of vegetables stagnated over the years due to the deterioration in soil health. Continuous and indiscriminate use of high analysis fertilizers has resulted in acidity, alkalinity, micronutrient deficiencies and soil and water pollution (Chhonkar, 1995).

Tomato is the most popular vegetable crop widely grown worldwide under outdoor and indoor conditions and stands second to potato (Bose *et al*., 2002). According to National Horticultural Board (Anonymous, 2010), tomato is cultivated in 0.61 million hectares with a production of 11.97 million

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tonnes and productivity of 19.3 tonnes hectare^{-1}. In Andhra Pradesh, it is cultivated in 0.74 lakh hectares with production and productivity of 1.4 million tonnes and 19 tonnes hectare^{-1}, respectively.

Most of the vegetable crops in surrounding districts of Hyderabad viz., Rangareddy, Medak, Nalgonda and Mahaboobnagar are grown on light textured red soils, which are in general poor in fertility status and need optimum combination of inorganic and organic fertilizers not only to maintain soil fertility but also to increase the fertilizer use efficiency.

Nutrient and soil health management should be sound to sustain as well as to increase the productivity of crops. Among the several strategies for sustainable crop production, integrated nutrient management plays an important role through minimizing the chemical fertilizers and integrating with organic manures without affecting the quality of soil as it is an important resource for sustainable agriculture. Hence, keeping in view of the above facts, the present experiment was carried out.

MATERIALS AND METHODS

A field experiment was conducted on a sandy loam soil (Alfisol) at Students' Farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif* season of 2010 with a view to studying the effect of integrated nutrient management on yield, nutrient uptake and quality of tomato crop and also economics of those treatments. The farm is geographically situated at 77^{0}85' East longitude and 18^{0}59' North latitude and at an altitude of 542.6 m above mean sea level. The climate of Hyderabad is tropical semi-arid. The initial soil was sandy loam in texture. The physico-chemical properties revealed that the soil was slightly alkaline (7.9 pH) in reaction, non saline (0.13 dS m^{-1}) in nature and low in organic carbon (4.6 g kg^{-1}).With regard to soil fertility status,it was low in available nitrogen (230.7 kg N ha^{-1}), medium in available phosphorus (25.4 kg P_2O_5 ha^{-1}) and potassium (284.5 kg K_2O ha^{-1}). Experiment was laid out in Randomized Block Design with 3 replications and 10 treatments viz., T_1- Control, T_2- 50% RDN through fertilizer + 50% RDN through vermicompost, T_3- 75% RDN through fertilizer + 25% RDN through vermicompost, T_4- 100% RDN through vermicompost, T_5- 100% RDN through fertilizer, T_6- 50% RDN through fertilizer + 50% RDN through poultry manure, T_7- 75% RDN through fertilizer + 25% RDN through poultry manure, T_8 - 100% RDN through poultry manure, T_9 - 50% RDN through vermicompost + 50% RDN through poultry manure and T_{10} - 50% RDN through inorganic fertilizer + 25% RDN through vermicompost + 25% RDN through poultry manure. The recommended dose (100% RDN) of inorganic fertilizer was 150 N kg ha^{-1}, 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} to the tomato crop. In these fertilizers P_2O_5 and K_2O were applied uniformly to all the treatments and nitrogen was applied according to the treatments. The two organic sources used for the study *viz.,* vermicompost and poultry manure were analysed for their per cent N, P and K contents. The values found to be 1.5 per cent N, 0.94 per cent P, 0.72 per cent K (Vermicompost) and 1.0 per cent N, 1.12 per cent P, 1.66 per cent K (Poultry manure), respectively.

Tomato variety used was Arka Vikas and the thirty days old seedlings were transplanted at 30th August 2010 with a spacing of 60 cm x 45 cm. Vermicompost and poultry manure were applied one week before transplanting to the respective plots as per the treatment requirements and were incorporated into the soil. Nitrogen and potassium were applied in the form of urea and muriate of potash. Half of inorganic nitrogen and potassium (30 kg ha^{-1}) were applied as basal at the time of transplanting and the rest was applied at flowering stage. Entire dose of phosphorus (60 kg P_2O_5 ha^{-1}) was applied as basal in the form of single super phosphate.

Plant samples collected at final harvest were oven dried at 65^0 C. The dried samples were powdered and analyzed for per cent N, P and K contents by adopting the standard procedures *viz.,* Micro kjeldahl method, Vanado molybdo phosphoric yellow colour method [In diacid (9:4 Nitric acid : Perchloric acid) extract], Flame photometry (In diacid extract), (Piper, 1966) respectively. The dry matter production (kg ha^{-1}) was also recorded to compute nutrient uptake at final harvest.

$$\text{N uptake (kg ha}^{-1}) = \frac{\text{N content (\%) x Dry matter production (kg ha}^{-1})}{100}$$

$$\text{P uptake (kg ha}^{-1}) = \frac{\text{P content (\%) x Dry matter production (kg ha}^{-1})}{100}$$

$$\text{K uptake (kg ha}^{-1}) = \frac{\text{K content (\%) x Dry matter production (kg ha}^{-1})}{100}$$

Fruit analysis for quality :

Fresh tomato fruits were analyzed for quality parameters following standard procedures.

Lycopene content :

Lycopene content of tomato fruit was assessed as per the procedure given below and expressed in mg 100 g^{-1} (Ranganna, 1986).

Reagents : Acetone, Petroleum ether, 5 % Sodium sulphate : This was prepared by dissolving 5g Sodium sulphate in 100 ml of distilled water.

Procedure :

Ten grams of the tomato puree was taken and extracted repeatedly with acetone in a pestle and mortar until the residue is colorless. The acetone extract was transferred to a separating funnel containing 10 to 15 ml of petroleum ether and mixed gently. The carotenoid pigments were taken into the petroleum ether by diluting the acetone (lower phase) with water or water containing 5% sodium sulphate. The lower phase was transferred to another separating funnel and the petroleum ether extract containing carotenoid pigments was placed to an amber coloured bottle. Extraction of the carotenoid pigments from the acetone phase was repeated in the same manner with petroleum ether until it was colourless. The acetone phase was discarded. To the petroleum ether extract, a small quantity of anhydrous sodium sulphate was added, transferred to a 50 ml volumetric flask and diluted to the mark with petroleum ether and the colour was measured in a 1cm cell at 473 nm in a spectrophotometer using petroleum ether as blank (Ranganna, 1986).

Calculation :

Lycopene content of the sample was calculated as given below using the relationship that an optical density (OD) of 1.0 = 2.88 µg of lycopene ml^{-1}.

$$\text{mg of lycopene per 100 g} = \frac{2.88 \times \text{OD of sample} \times \text{volume made up to 50 ml} \times 100}{\text{Wt of the sample} \times 1000}$$

Ascorbic acid :

Ascorbic acid (vitamin C) content of tomato fruit was analyzed by dichlorophenol indophenol dye method as given below and expressed in mg 100 g^{-1} (Ranganna, 1986).

Reagents :

1. 3% Metaphosphoric acid: Prepared by dissolving 3 g of the sticks or pellets of metaphosphoric acid in 100 ml of distilled water.
2. Ascorbic acid standard: Accurately 100 mg of l-ascorbic acid was taken and made up to 100 ml with 3% metaphosphoric acid (1mg = 0.1 mg of ascorbic acid).
3. Dye solution: 50 mg of the sodium salt of 2, 6-dichlorophenol-indophenol was dissolved in approximately 150 ml of hot glass distilled water containing 42 mg of sodium bicarbonate. Cooled and diluted with glass distilled water to 200 ml.

Procedure :

Standardization of Dye :

5 ml of standard ascorbic acid solution was taken and 5 ml of HPO_3 was added. Microburette was filled with the dye and then titrated with the dye solution to a pink colour which should persist for 15 sec. Dye factor was determined, i.e. mg of ascorbic per ml of the dye, using the formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of sample :

10 g of the sample was taken, blended with 3% HPO_3 and made up to 100 ml with HPO_3. Filtered through filter paper.

Assay of the extract :

An aliquot (2-10 ml) of the HPO_3 extract of the sample was taken and titrated with the standard dye to a pink end-point which should persist for at least 15 sec. In the next determination, most of the dye required was added and then titrated accurately. The aliquot of sample taken should be such that the titre should not exceed 3 to 5 ml.

Calculation :

The ascorbic acid content of the sample was calculated from the following formula:

$$\text{mg of ascorbic acid per 100 g of the sample} = \frac{\text{Titre} \times \text{dye factor} \times \text{volume made up (100 ml)} \times 100}{\text{Aliquot of extract taken for estimation} \times \text{Wt of sample taken for estimation}}$$

Fresh tomato fruit yield was recorded treatment wise at 5 days intervals. In all 11 pickings were done. The benefit cost ratios were computed through partial budgeting technique by taking into consideration the additional cost incurred due to imposition of the treatments and the additional returns realized. The treatment wise details of expenditure and net returns and were calculated by using the formula

$$\text{Benefit : Cost Ratio} = \frac{\text{Net Returns (Rs ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs ha}^{-1}\text{)}}$$

RESULTS AND DISCUSSION

Nutrient Uptake :

The per cent nutrient contents of N, P and K and dry matter production values were used to compute nutrient uptake by plants at final harvest. The data on nutrient uptake with regard to N, P and K were presented in table 1.

The N uptake varied from 47.86 to 106.35 kg ha^{-1} at harvest stage. The lowest and the highest the N uptake values were recorded in control and 75% RDN through fertilizer + 25% RDN through Vermicompost, respectively. However, 75% RDN through fertilizer + 25% RDN through Vermicompost was at par with 100% RDN through fertilizer, 75% RDN through fertilizer + 25% RDN through poultry manure, 50% RDN through fertilizer + 50% RDN through poultry manure and 50% RDN through inorganic fertilizer + 25% RDN through vermicompost + 25% RDN through poultry manure indicating the importance of integrated use of organic and inorganic fertilizers in nutrient uptake. The phosphorous uptake by tomato plants also showed similar trends as that of N uptake, the lowest and highest values being recorded at control and 75% RDN through fertilizer + 25% RDN through Vermicompost treatments, respectively. With regard to K uptake by tomato, the K uptake varied from 24.53 to 61.82 kg ha^{-1}. The highest K uptake values were recorded in 75% RDN through fertilizer + 25% RDN through Vermicompost which was at par with 100% RDN through fertilizer and 75% RDN through fertilizer + 25% RDN through poultry manure and was significantly higher than all other remaining treatments.

The plant growth hormones, such as indole acetic acid (IAA), gibberellins and cytokinins and enzymes like cellulase, amylase, invertase, protease, peroxidase, urease, phosphatase and dehydrogenase are some of the byproducts of the increased microbial activities in vermicompost and poultry manure which were responsible for stimulating the growth and development of tomato plants, through their favourable effect in the root zone. This might have resulted in increased availability and uptake of nutrients by the plants. The results further support the hypothesis that the organic manures in the root rhizosphere release a number of enzymes which enhances the transformations and release of nutrients (Barani and Anburani, 2004).

Though the organic manures had positive effects, it was found that 100% organic manures application could not meet the nutrient requirement of plant, which was clear from nutrient contents and dry matter production values also. The lower uptake of N, P and K in organic manure treated plots alone might be attributed to the non-availability of adequate nutrients throughout the crop growth period, because of their low nutrient composition and slow release of nutrients (Reddy and Reddy, 2008). So, the combination of chemical fertilizers with any one of the organics is beneficial as compared to their individual applications.

Fruit Yield :

The total fruit yield of tomato recorded at different pickings are presented in table 2. The yield of tomato varied from 31.30 to 84.97 q ha^{-1} with a mean of 69.32 q ha^{-1}. The lowest and highest yields were recorded at control and 75% RDN through fertilizer + 25% RDN through Vermicompost, respectively. However, the fruit yield recorded at 75% RDN through fertilizer + 25% RDN through Vermicompost was at par with that recorded at 75% RDN through fertilizer + 25% RDN through poultry manure (84.06 q ha^{-1}) and 100% RDN through fertilizer (80.73 q ha^{-1}) and significantly superior over

per cent increase in yield of 75% RDN through fertilizer + 25% RDN through Vermicompost over the control, 100% RDN through vermicompost and 100% RDN through Poultry manure found to be 171.4, 37.6 and 39.4, respectively. Conjunctive use of different levels of chemical fertilizers with any one of the organics produced higher yields as compared to their individual applications. This was due to the direct availability of nutrients from inorganic fertilizers and also the vermicompost containing higher available N, P and K contents. The enrichment of biological activity and release of organic acids might have degraded and mobilized the occluded soil nutrients to available form. The plant growth hormones, such as indole acetic acid (IAA), gibberellins and cytokinins and enzymes like cellulase, amylase, invertase, protease, peroxidase, urease, phosphatase and dehydrogenase are some of the byproducts of the increased microbial activities in vermicompost and poultry manure which might have stimulated the growth and development of tomato plants. Thus, favourable effect of poultry manure and vermicompost in the root zone resulted in increased availability and uptake of nutrients by the plants (Bhardwaj *et al*., 2010).

Fruit quality :

The data on quality parameters are given in table 2. The ascorbic acid content varied from 23.83 to 30.83 with a mean value of 28.27 mg 100 g^{-1} of fruit, the highest value being recorded in 50% RDN through vermicompost + 50% RDN through poultry manure. However, the values were at par with 100% RDN through poultry manure and 100% RDN through Vermicompost. These treatments had significantly higher values than all other treatments. The lycopene content varied from 2.09 to 4.05 with a mean value of 3.63 mg 100 g^{-1} of fruit and showed similar trend as that of ascorbic acid content.

The increase in vitamin C and lycopene content with organic manures might be due to physiological influence of vermicompost and poultry manure on the activity of number of enzymes. The results are almost in agreement with the findings of Patil *et al*. (2004) who found that significantly highest ascorbic acid content (26.76 mg 100 g^{-1}) was recorded in 50% RDF+ 50% FYM and was on par with 50% RDF+ 50% vermicompost (26.53 mg 100 g^{-1}) and 100% organic treatment (25.97 mg 100 g^{-1}). The maximum vitamin C (56.73 mg 100^{-1} g of fruit) was recorded with 50% NPK + 50% FYM + biofertilizers. (Chumyani *et al*., 2012).

Effect of INM on Benefit : Cost ratio of tomato :

The data pertaining to the economics of INM in tomato are presented in table 3. Among the different treatment combinations, the highest yield (84.97 q ha^{-1}) was recorded with 75% RDN through fertilizer + 25% RDN through Vermicompost followed by 75% RDN through fertilizer + 25% RDN through poultry manure and 100% RDN through fertilizer.

Considering the cost of vermicompost, poultry manure and inorganic fertilizers, the highest monetary net returns were obtained from 75% RDN through fertilizer + 25% RDN through poultry manure was ₹ 57267.1 $hectare^{-1}$ followed by 100% RDN through fertilizer (₹ 57260.8) and 75% RDN through fertilizer + 25% RDN through Vermicompost (₹ 56918.7).

Whereas, considering the total cost of cultivation and net returns, the B:C ratio was the highest in treatment 100% RDN through fertilizer (2.44), followed by 75% RDN through fertilizer + 25% RDN through poultry manure (2.14) and 75% RDN through fertilizer + 25% RDN through Vermicompost(2.03).

From the above revelations, it is clear that the B:C ratio was less due to the high cost of manures. Hence, the farmers those who prepare vermicompost by themselves or those who have poultry farms can be benefited by integrated application of 75% RDN through fertilizers and 25% RDN through either vermicompost or poultry manure to set higher net returns with high B:C ratio. However, it should be taken into account that nutrient residues last longer in soil and benefit the crops grown subsequently. Hence, comparatively less B:C ratio should not become the cause of non use of organic manures.

Table 1. Effect of INM on total nutrient uptake (kg ha^{-1}) by tomato at final harvest

Tr. No.	Treatments	N Uptake (kg ha^{-1})	P Uptake (kg ha^{-1})	K Uptake (kg ha^{-1})
T_1	Control	47.86	6.80	24.53
T_2	50% RDN through fertilizers + 50% RDN through Vermicompost (VC)	90.01	16.08	53.41
T_3	75% RDN through fertilizers + 25% RDN through Vermicompost (VC)	103.76	17.40	61.82
T_4	100% RDN through Vermicompost (VC)	81.61	14.57	49.26
T_5	100% RDN through fertilizers	106.35	17.36	60.70
T_6	50% RDN through fertilizers + 50% RDN through Poultry manure	91.36	15.39	54.21
T_7	75% RDN through fertilizers + 25% RDN through Poultry manure	104.62	17.26	61.24
T_8	100% RDN through Poultry manure	82.16	14.46	51.46
T_9	50% RDN through Vermicompost (VC) + 50% RDN through Poultry manure	83.53	15.06	52.47
T_{10}	50% RDN through fertilizers + 25% RDN through Vermicompost (VC)+ 25% RDN through Poultry manure	90.01	15.95	56.15
	SE(d) ±	2.56	0.34	1.65
	CD (0.05)	5.43	0.73	3.49

Table 2. Effect of INM on fruit yield (q ha^{-1}) and fruit quality of tomato

Tr. No.	Treatments	Yield (q ha^{-1})	Ascorbic acid (mg 100 g^{-1} fruit)	Lycopene (mg 100 g^{-1} fruit)
T_1	Control	31.30	23.83	2.09
T_2	50% RDN through fertilizers + 50% RDN through Vermicompost (VC)	75.93	28.90	3.91
T_3	75% RDN through fertilizers + 25% RDN through Vermicompost (VC)	84.97	27.63	3.67
T_4	100% RDN through Vermicompost (VC)	61.73	30.60	4.03
T_5	100% RDN through fertilizers	80.73	25.57	3.09
T_6	50% RDN through fertilizers + 50% RDN through Poultry manure	74.77	28.43	3.90
T_7	75% RDN through fertilizers + 25% RDN through Poultry manure	84.06	27.60	3.65
T_8	100% RDN through Poultry manure	60.93	30.33	4.00
T_9	50% RDN through Vermicompost (VC) + 50% RDN through Poultry manure	62.77	30.83	4.05
T_{10}	50% RDN through fertilizers + 25% RDN through Vermicompost (VC)+ 25% RDN through Poultry manure	76.01	28.93	3.92
	SE(d) ±	3.08	0.66	0.05
	CD (0.05)	6.52	1.40	0.12

Table 3.Effect of INM on benefit cost ratio of tomato

Tr. No.	Treatment	yield (q ha^{-1})	Total cost of cultivation			Gross returns (ha^{-1}) `	Net returns (ha^{-1}) `	Benefit: cost ratio
			Fixed cost	Variable cost N fertilizer cost	Total cost `			
T_1	Control	31.30	21777.7	---	21777.7	31300.0	9522.3	0.44
T_2	50% RDN through fertilizers + 50% RDN through Vermicompost	75.93	21777.7	10844.4	32622.1	75933.3	43311.2	1.33
T_3	75% RDN through fertilizers + 25% RDN through Vermicompost	84.97	21777.7	6270.3	28048.0	84966.7	56918.7	2.03
T_4	100% RDN through Vermicompost (VC)	61.73	21777.7	20000.0	41777.7	61733.3	19955.6	0.48
T_5	100% RDN through fertilizers	80.73	21777.7	1694.8	23472.5	80733.3	57260.8	2.44
T_6	50% RDN through fertilizers + 50% RDN through poultry manure	74.77	21777.7	8344.4	30122.1	74766.7	44644.6	1.48
T_7	75% RDN through fertilizers + 25% RDN through poultry manure	84.06	21777.7	5018.5	26796.2	84063.3	57267.1	2.14
T_8	100% RDN through Poultry manure (PM)	60.93	21777.7	15000.0	36777.7	60933.3	24155.6	0.66
T_9	50% RDN through Vermicompost (VC) + 50% RDN through Poultry	62.77	21777.7	17500.0	39277.7	62766.7	23489.0	0.60
T_{10}	50% RDN through fertilizers + 25% VC + 25% RDN through Poultry	76.01	21777.7	9592.5	31370.2	76013.3	44643.1	1.42

Cost of tomatoes kg^{-1} = Rs.10.00 Cost of SSP 50 kg^{-1} = Rs.170
Cost of urea 50 kg^{-1} = Rs. 260 Cost of MOP 50 kg^{-1} = Rs 260
Cost of vermicompost kg^{-1} = Rs. 2 Cost of poultry manure kg^{-1} = Rs. 1

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SCREENING VARIETIES OF OKRA (*Abelmoschus esculentus* (L.) MOENCH) AGAINST *Earias vittella* (FABRICIUS) IN ALLAHABAD (U.P.), INDIA

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ABSTRACT

Field experiment was conducted in 2009-10 to screen 17 varieties of okra (*Abelmoschus esculentus* (L.) Moench) against shoot and fruit borer, *Earias vittella* (Fabricius) (Lepidoptera: Nolidae) infestation. The per cent shoot infestation by *E. vittella* was minimum in okra variety Bhendi Vaphy (10.00) and was found to be resistant. The lowest per cent fruit damage on number basis by *E. vittella* was recorded in EMS-8-1 (8.66) and Punjab Padmini (8.87) being at par with VRO-3 (9.07) and Bhendi Vaphy (10.27) as compared to all other varieties. These varieties are graded as moderately resistant varieties. On weight basis, the per cent fruit infestation on 17 okra varieties ranged between 8.18 and 22.06 per cent. Okra varieties viz., VRO-3, EMS-8-1 and IIVR-11 (8.18, 9.30 and 10.5%) showed significantly lower infestation and were at par with each others followed by Punjab Padmini, IIVR-10, Bhendi Vaphy, Kashi Pragati and EC-35638 (10.52, 10.73, 11.54, 14.92 and 15.68%, respectively). These are graded as moderately resistant varieties. However, the combined per cent shoot and fruit damage caused by *E. vittella* was significantly lower in the Okra varieties Bhendi Vaphy (20.27), IIVR-11 (23.66%), VRO-3 (22.40%) and EMS-8-1 (21.99%) followed by IIVR-10 (28.33%) and Punjab Padmini (28.87%) in comparison to all other varieties.

(Key words: *Abelmoschus esculentus*, okra, *Earias vittella*, screening for susceptibility)

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) belongs to the family Malvaceae and is commonly known as “bhendi” or “lady's finger” in most parts of India. This tropical vegetable is presumably a native of India (Zeven and Zherkovsky, 1975). It is distributed in Africa, Asia, southern Europe and America (Oyenuga, 1968; Hamon and Harmon, 1991; Ariyo, 1993; and Oyelade *et al*., 2003). Being an economically important vegetable crop, many okra varieties are widely grown in Mediterranean region as well as in the tropical and sub-tropical parts of the world (Zeven and Zherkovsky, 1975). Several biotic and abiotic factors are responsible for low yield in the okra crop. Out of these, infestation by insect pests is one of the crucial factors leading to severe economical losses (Anonymous, 2008). Various researchers (Fletcher, 1914; Nair, 1970; Butani and Jotwani, 1984; Singh and Misra, 1988; Gupta, 1990; David, 2001 and Sharma, 2011) suggested that the shoot and fruit borer or spotted bollworm, *Earias vittella* (Fabricius) (Lepidoptera: Nolidae) is a major pest of okra throughout India. In their peak activities on okra, the larvae of *E. vittella* alone could damage 8.5 per cent shoots and infest 41.25 per cent fruits (Shukla *et al*., 1997). Both the species of fruit borers such as spiny bollworm, *Earias insulana* (Boisduval) and *E. vittella* severely attack okra crop and their seasonal damage ranges between 20 to 51 per cent in various agro-climatic zones of India (Brar *et al.,* 1994; Verma *et al*., 1984 and Shukla *et al*., 1997). Among the various insect pests of okra, *E. vittella* and *E. insulana* together are capable of causing 57.10 per cent of fruit infestation and 54.04 per cent yield losses.

Headley (1979) predicted that chemical control may play a major role in the pest management until 1992; and thereafter, the use of non-chemical control methods will be increased. As per Headley's anticipation, we consider today's era as an era of IPM where integration of all the control measures is likely to be done to manage various insect pests. This measure involves growing insect resistant plants which, in turn, may offer an ideal prevention against insect damage, involving minimum cost of production and also eco-friendly. So, in vegetable crops, there is a great need for developing insect pest resistant varieties. The utility of insect resistant vegetable varieties has more importance in a country like India where a sizable area is under cultivation with different kinds of vegetables and has been constantly facing the problem of heavy insect pest

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infestations. In view of the importance of vegetable in Indian diet and the hazards involved in the use of chemical control, it has become imminent to seek for an in-built protection by way of varietal resistance to insect pest wherever possible. The use of resistant varieties is one of the most economical and effective control methods in IPM. Keeping in view the above facts, the present study was planned to screen some of the promising varieties of okra for their resistance to *E. vittella*.

MATERIALS AND METHODS

Field experiment was conducted in 2009-10 on the field of Department of Plant Protection, Sam Higginbottom Institutes of Technology and Sciences, Allahabad during *kharif* 2009 season. There were 17 varieties with diverse morphological characters collected from Indian Institute of Vegetable Research (IIVR), Varanasi. The experiment consisted of 17 treatments (varieties) having three replications were sown in first week of July, in Randomized Block Design keeping row to row and plant to plant spacing 45 and 60 cm, respectively. The recommended amount of N:P:K (40:20:20) was applied as per recommendation and weeding was done at fortnight interval and as and when required. In each plot, five plants were randomly selected and tagged for recording observations. As soon as the infestation of *E. vittella* was noticed on the plants, the first observations on shoot infestation were recorded; and thereafter weekly observations were taken till the starting of reproductive phase. Number of infested fruits and number of healthy fruits were counted from the five randomly selected plants and labelled these plants to work out the per cent fruit infestation at each picking. The weight of healthy and infested fruits from the same five plants was also recorded (Table 1). Per cent fruit infestation of each variety was calculated from the data obtained during the investigation and the varieties were categorized by adopting scale developed by Nath (1966) (Table 2) where germplasm with no damage are grouped as resistant. They formulated four grades Resistant (R), Moderately Resistant (MR), Moderately Susceptible (MS) and Susceptible (S) based on per cent damage to indicate different levels of fruit infestation (1-5%, 6-15%, 16-30% and 31-50%, respectively).

RESULTS AND DISCUSSION

Mean per cent infestation of *E. vittella* on shoot :

The data presented in table 1 revealed that the shoot infestation ranged between 10.00 to 33.33 per cent. Out of 17 okra varieties screened, significantly lowest shoot infestation by *E. vittella* was recorded on Bhendi Vaphy (10.00%) followed by IIVR-11 (13.33%), VRO-3 (13.33%) and EMS-8-1 (13.33%) (Table 1); and graded as moderately resistant (MR) varieties (Table 2). The varieties like Kashi Pragati (30%), Parbhani Kranti (26.66%), EC-316053 (26.66%), IC-140934 (23.33%), EC-35638 (23.33%), IC-282273 (30.00%), IC-282272 (26.66%), IIVR-10 (16.66%), Punjab Padmini (20.00%) and Pusa Sawani (26.66%) were found moderately susceptible. The infestation on these varieties was found statistically at par with each other; and graded as moderately susceptible (MS) varieties (Table 2). Significantly higher infestation was registered on three okra varieties viz., KS-410, VRO-4 and LORM-1 with 33.33 per cent of shoot infestation (Table 1); and graded as moderately susceptible (MS) (Table 2). However, Gupta and Yadav (1978) evaluated 60 germplasms for infestation for *Earias* spp. and none of the germplasm was found resistant against the attack of this pest. Some of the varieties/germplasms viz. 3325, 6327, 6701, 6901, 7177 and Kalyanpur were found to be moderately resistant and 6001, 6302, 6322 and 6902 were found to be susceptible. Similarly, Singh *et al.* (2005) also reported that none of the okra lines/varieties were immune.

Mean per cent infestation of *E. vittella* on fruit (number basis) :

The data on per cent mean infestation of fruits by *E. vittella* (Table 1) revealed that the mean per cent infestation ranged between 8.66 and 18.90 per cent. On number basis, the per cent fruit damage by *E. vittella* was the lowest in okra variety EMS-8-1 (8.66); and Punjab Padmini (17.26) being at par with VRO-3 (9.07) and Bhendi Vaphy (10.27) as compared to all other treatments (Table 1). These okra varieties were graded as moderately resistant (MR) varieties (Table 2). Out of all varieties tested, fruit infestation on number basis was significantly higher in LORM-1 (18.90), Pusa Sawani (18.38), EC-316053 (18.29), VRO-4 (18.17), IC-140934 (17.92) and KS-410

Table 1. Reaction of different varieties against important insect pests of okra during *kharif* 2009

Sr. No.	Varieties	Shoot damage (%) by *E. vittella*	Fruit damage (%) by *E. vittella*		Shoot and fruit damage (%) by *E. vittella*
			Number basis	Weight basis	
1	Kashi Pragati	30.00 (33.21)^{ab}	14.25 (22.14)^{bcde}	14.92 (22.71)^{cde}	44.25 (41.67)^{e}
2	Bhendi Vaphy	10.00 (18.44)^{a}	10.27 (18.63)^{abc}	11.54 (19.82)^{bcd}	20.27 (26.74)^{a}
3	VRO-4	33.33 (35.24)^{b}	18.17 (25.18)^{e}	18.61 (25.55)^{ef}	51.50 (45.84)^{f}
4	IIVR-11	13.33 (21.39)^{ab}	10.33 (18.72)^{abc}	10.05 (18.44)^{a}	23.66 (29.07)^{a}
5	Parbhani Kranti	26.66 (31.05)^{ab}	17.09 (21.35)^{abcde}	17.39 (24.58)^{ef}	43.75 (41.39)^{de}
6	EC-316053	26.66 (31.05)^{ab}	18.29 (25.25)^{e}	18.65 (25.55)^{ef}	44.95 (42.08)^{e}
7	IC-140934	23.33 (28.86)^{ab}	17.92 (25.03)^{e}	17.12 (24.43)^{ef}	41.25 (39.94)^{cd}
8	EC-35638	23.33 (28.56)^{ab}	15.35 (23.03)^{cde}	15.68 (23.26)^{cde}	38.68 (38.44)^{c}
9	IC-282273	30.00 (33.21)^{ab}	15.72 (23.34)^{de}	16.56 (23.97)^{def}	45.72 (42.52)^{e}
10	IC-282272	26.66 (31.05)^{ab}	15.93 (23.50)^{de}	18.73 (25.62)^{ef}	42.59 (40.71)^{cde}
11	VRO-3	13.33 (21.39)^{ab}	9.07 (17.46)^{ab}	8.18 (16.54)^{a}	22.40 (28.23)^{a}
12	IIVR-10	16.66 (24.04)^{ab}	11.67 (19.91)^{abcd}	10.73 (19.09)^{abc}	28.33 (32.14)^{b}
13	EMS-8-1	13.33 (21.39)^{ab}	8.66 (17.05)^{a}	9.30 (17.76)^{a}	21.99 (27.94)^{a}
14	Punjab Padmini	20.00 (26.56)^{ab}	8.87 (17.26)^{a}	10.52 (18.91)^{ab}	28.87 (32.48)^{b}
15	KS-410	33.33 (35.24)^{b}	17.89 (24.95)^{e}	22.06 (27.97)^{f}	51.22 (45.68)^{f}
16	LORM-1	33.33 (35.24)^{b}	18.90 (25.77)^{e}	21.59 (27.63)^{f}	52.23 (46.25)^{f}
	Pusa Sawani	26.66 (31.05)^{ab}	18.38 (25.33)^{e}	19.65 (26.28)^{ef}	45.04 (42.13)^{e}
	SE±	**7.884**	**2.353**	**2.066**	**1.798**
	CD 5%	**15.935**	**4.755**	**4.176**	**2.841**

Table 2. Grading of different okra varieties based on fruit infestation

Sr. No.	Category	Grade	Level of infestation (%)	Okra varieties (% fruit infestation)	
				Number basis	Weight basis
1	Resistant	R	1-5	None	None
2	Moderately resistant	MR	6-15	EMS-8-1 (8.66), Punjab Padmini (8.87), VRO-3 (9.07), Bhendi Vaphy (10.27), IIVR-11 (10.33), IIVR-10 (11.67), Kashi Pragati (14.25), EC-35638 (15.35)	VRO-3 (8.18), EMS-8-1 (9.30), IIVR-11 (10.5), Punjab Padmini (10.52), IIVR-10 (10.73), Bhendi Vaphy (11.54), Kashi Pragati (14.92)
3	Moderately susceptible	MS	16-30	IC-282273 (15.72), IC-282272 (15.93), LORM-1 (18.90), Pusa Sawani (18.38), EC-316053 (18.29), VRO-4 (18.17), IC-140934 (17.92), KS-410 (17.89), Parbhani Kranti (17.09)	EC-35638 (15.68), KS-410 (22.06), LORM-1 (21.59), Pusa Sawani (19.65), IC-282272 (18.73), EC-316053 (18.65), VRO-4 (18.61), Parbhani Kranti (17.39), IC-140934 (17.12), IC-282273 (16.56)
4	Susceptible	S	31-50	None	None

(17.89), respectively, as compared to all other treatments (Table 1); and graded as MS varieties (Table 2). None of the variety was found resistant.

Mean per cent infestation of *E. vittella* on fruit (weight basis) :

The per cent fruit infestation on different varieties of okra by *E. vittella* on fruit weight basis ranged between 8.18 and 22.06 per cent. Significantly lower infestation was found in the varieties VRO-3 (8.18%), EMS-8-1 (9.30%), IIVR-11 (10.5%) being at par with each others followed by Punjab Padmini (10.52%), IIVR-10 (10.73%), Bhendi Vaphy (11.54%), Kashi Pragati (14.92%) and EC-35638 (15.68%), respectively (Table 1); and graded as moderately resistant (MR) varieties (Table 2). The maximum infestation was registered in KS-410 (22.06%) and LORM-1 (21.59%) followed by Pusa Sawani (19.65%), IC-282272 (18.73%), EC-316053 (18.65%), VRO-4 (18.61%), Parbhani Kranti (17.39%), IC-140934 (17.12%) and IC-282273 (16.56%) and were found at par with each other (Table 1). Among the tested varieties against *E. vittella*, none of the varieties were found to be resistant/immune (Table 2). In contrary to the above findings 60 germplasms were screened against the infestations of spotted bollworm and none was found resistant whereas germplasm 5235, 6327, 6701, 6901, 6903 and Kalyanpur were found to be moderately resistant to the attack of borers (Gupta and Yadav, 1978). Similarly, Bhala *et al.* (1989) found no resistant/immune variety against the attack of *Earias* spp. However, in the present investigations none of the variety was found resistant against *E. vittella*, while VRO-3 and EMS-8-1 gave better performance (Table 2) and may be graded as moderately resistant.

Mean per cent infestation of *E. vittella* on shoot and fruit basis :

The per cent shoot and fruit damage together caused by *E. vittella* was significantly lower in the Okra varieties Bhendi Vaphy (20.27%), IIVR-11 (23.66%), VRO-3 (22.40%) and EMS-8-1 (21.99%) followed by IIVR-10 (28.33%) and Punjab Padmini (28.87%) in comparison to all other varieties. However, simultaneously higher damage was recorded in varieties VRO-4, KS-410 and LORM-1 (51.50%, 51.22% and 21.99%, respectively).

Present investigation showed that the per cent shoot infestation by *E. vittella* was minimum in Bhendi Vaphy variety, whereas the fruit infestation was minimum in EMS-8-1 and VRO-3 varieties. So these varieties may further be exploited for development of resistant variety in any okra breeding programme.

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STUDIES ON EFFECT OF FERTIGATION ON GROWTH AND YIELD-ATTRIBUTING CHARACTERS OF SWEET PEPPER (*Capsicum annuum* L.) UNDER BLACK POLYETHYLENE MULCH

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ABSTRACT

An experiment was carried out on Sweet Pepeer 'Indra' hybrid during the year 2010-11 in *rabi* season under Randomized Block Design (RBD) with five replications and five treatments of fertigation. Each treatment plot measured 160 m^2 with a spacing of 60 cm x 45 cm in between row and within row, respectively. Four week old healthy seedlings were transplanted in experimental plots. The plots were irrigated by using drip irrigation system as per water requirement of the crop.The use of 80 % RDF through fertigation with black polyethylene mulch was found effective for stem girth (cm), number of pickings, days to last picking, fruit length (cm), fruit girth (cm), fruit weight (g), number of fruits $plant^{-1}$, fruit weight $plant^{-1}$ (g), fruit yield $plot^{-1}$ (kg), fruit yield ha^{-1} (q) of Sweet Pepper. Whereas, 100% of RDF through fertigation with black polyethylene mulch was found moderately effective for plant height (cm), number of branches $plant^{-1}$ and fruit length (cm). While, the plants in respect of plant height (cm), number of branches $plant^{-1}$ were superior under 120% RDF through fertigation under black polyethylene mulch.

The maximum net income (Rs. 265070/-) was obtained under treatment 80% RDF (120:80:80 kg NPK ha^{-1}) through fertigation with black polyethylene mulch followed by 100% RDF (150:100:100 kg NPK ha^{-1}) through fertigation with black polyethylene mulch and 120% RDF (180:120:120 kg NPK ha^{-1}) through fertigation with black polyethylene mulch.

(Key words: Sweet pepper, fertigation, polyethylene mulch, growth, yield)

INTRODUCTION

Sweet Pepper is one of the important vegetables grown in India as well as in the world, because of its attractive fruits, nutritive value, flavour and colour. The fruit of *Capsicum annuum* belongs to longum group, which is popularly known as red pepper, paprika or capsicum. Sweet Pepper are generally non-pungent fruits which are eaten raw in salads, but more commonly cooked, fried or processed together with other foods.

Water stress, unbalanced nutrient management and weed problem during the critical stages of growth and development period reduces optimum production of Sweet Pepper. Plastic mulch reduces evaporation moisture loss from soil surface and prevents weed growth (Ravinder *et al.,* 1997).

Fertigation allows nutrient placement directly into root zone around the plants through a pipe network with the help of emitters near plants roots during critical periods of nutrient requirement (Imas *et al.*, 1997a and 1997b). Besides, mulching is the practice of covering the soil around plants to make conditions more favorable for growth, development and efficient crop production (Nagalakshmi *et al*., 1990).It was therefore, thought worthwhile to study the effect of fertigation of various levels of recommended dose of fertilizer on growth and yield attributing characters under Raipur condition.

MATERIALS AND METHODS

Field experiment was carried out during winter season of 2010-11 at Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment was laid out in Randomized Block Design (RBD) with five replications and five treatments *i.e.*, F_1 - 120% of RDF (180:120:120 kg NPK ha^{-1}) through fertigation, F_2 - 100% of RDF (150:100:100 kg NPK ha^{-1}) through fertigation, F_3 - 80% of RDF (120:80:80 kg NPK ha^{-1}) through fertigation, F_4 - 60% of RDF (90:60:60 kg NPK ha^{-1}) through fertigation and F_5 - RDF (150:100:100 kg NPK ha^{-1}) through soil application. Each treatment plot measured 160 m^2 with a spacing of 60 cm x 45 cm in between row and within row, respectively. Initially, field was ploughed by M.B.

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plough, then its preparation was done by tractor-drawn cultivator followed by two cross-harrowings to pulverise the soil and raised beds of 1.0 m x 5.0 m size were prepared. The seeds were sown in nursery on 1st October, 2010.

Healthy seedlings of 29 days old were transplanted in experimental plots on 28th October 2010. Transplanting was done at a spacing of 60 cm x 45 cm with one seedling hill^{-1}. The plots were irrigated by using drip irrigation system as per water requirement of the crop. The mulching was done on 30th October using black polyethylene mulch of 50 micron on all the experimental plots in between rows.

Crop water requirement was calculated daily with the help of meteorological data recorded by meteorological observatory of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The plants were irrigated daily by drip irrigation systems. The irrigation water requirement was estimated and irrigation schedule was developed by various methods. However, the most commonly adopted method was Pan "A" evaporation method where the daily water requirement was calculated

Daily water requirement (litre day^{-1} plant^{-1}) = A x B x C x D x E.

Where, A = Pan evaporation,
B = Pan Factor
C = Crop factor
D = Per cent wetted area
E = Spacing between row to row and plant to plant

Irrigation Scheduling :

The length of irrigation time was determined as follows:

$$\text{Irrigation time (in hours)} = \frac{\text{Water requirement (litre)}}{\text{Rate of application (litre)}}$$

Fertigation schedule of Capsicum : 150:100:100 kg NPK (Table 3)

For the control of leaf curl malathion (1ml liter $^{-1}$water) was sprayed at an interval of 15, 30, 45, and 60 days after transplanting (DAT) to protect crops. The weed was completely removed at the time of field preparation. At later growth stages, two hand weedings at 35 and 75 DAT were done to keep the plots free from weeds.

The pickings of fruits were done at green mature stage from each plot and fruits of five plants selected randomly were picked up separately for studying the various growth and yield-attributes. Observations were recorded during the experimentation for each plant at four directions randomly north, south, east and west for studying various characters *i.e.*, growth, flowering, fruit set, fruit growth and development and yield.

RESULTS AND DISCUSSION

Plant growth :

Data recorded on the effect of different levels of fertigation with black polyethylene mulch on various characters of Sweet Pepper are presented in table 1. Maximum plant height was found in 120% RDF (70.98 cm) which was *at par* with 100% RDF (69.69 cm), 80% RDF (67.61 cm), 60% RDF (66.95 cm) through fertigation and RDF through soil application (64.62 cm). While, non-significantly minimum plant height was obtained in RDF through soil application (64.62 cm). The maximum stem girth was found in 120% RDF (5.71 cm) followed by 80% RDF (5.26 cm), 100% RDF (4.68 cm) and RDF through soil application (4.57 cm) respectively. Whereas minimum stem girth was recorded in 60% RDF through fertigation (4.46 cm) under (90:60:60 kg NPK ha^{-1}).The maximum number of branches plant^{-1} was recorded in 120% RDF (3.97) followed by 100% RDF (3.57), 80% RDF (3.10) through fertigation, RDF through soil application (2.77) and 60% RDF (2.48) through fertigation. While, minimum number of branches plant^{-1} was obtained in 60% RDF (2.48) through fertigation. The treatments 120% RDF through fertigation and 100% RDF through fertigation were statistically *at par*. The significantly maximum numbers of days were taken to first flowering under the treatment 120% RDF (24.98) through fertigation followed by RDF through soil application (24.16), 60% RDF (22.99) and 100% RDF (22.98) through fertigation. While the significantly minimum number of days were taken to first flowering under the treatment 80% RDF (21.07) through fertigation. The present finding are in conformity with the findings of El Desouky *et al*. (2005), who reported that early flowering, high number of flowers, low percentage of flowers abscission and high number of fruits plant^{-1} were obtained in both tomato and sweet pepper with all applied mulch colours. The red mulch alone or over black mulch was the most effective treatment.

Table 1. Effect of different levels of fertigation with black polyethylene mulch on plant height of Sweet Pepper

Sr. No	Treatments	Plant height (cm)	Stem girth (cm)	Number of branches plant^{-1}	Days to first flowering	Days to first picking	Number of pickings	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Number of fruits plant^{-1}	Fruit weight plant^{-1} (g)	Fruit yield plot^{-1} (kg)
1.	**120% of RDF (180:120:120 kg NPK ha^{-1}) through fertigation**	70.98	5.71	3.97	24.98	54.28	12.15	11.81	7.98	175.70	5.33	912.34	178.19
2.	**100% of RDF (150:100:100 kg NPK ha^{-1}) through fertigation**	69.69	4.68	3.57	22.98	53.18	12.79	12.08	8.33	183.14	5.65	986.40	186.27
3.	**80% of RDF (120:80:80 kg NPK ha^{-1}) through fertigation**	67.61	5.26	3.10	21.07	51.05	13.32	13.55	10.17	201.87	5.78	1094.69	193.09
4.	**60% of RDF (90:60:60 kg NPK ha^{-1}) through fertigation**	66.95	4.46	2.48	22.99	52.14	12.08	10.97	7.62	169.06	4.92	837.98	138.23
5.	**RDF through soil application**	64.62	4.57	2.77	24.16	52.82	11.80	10.77	7.13	128.03	4.26	558.24	148.39
	SEm±	**1.35**	**0.30**	**0.21**	**0.67**	**0.47**	**0.31**	**0.42**	**0.34**	**1.53**	**0.33**	**1.24**	**0.62**
	CD at 5% level	**4.05**	**0.90**	**0.64**	**2.02**	**1.40**	**0.93**	**1.25**	**1.00**	**5.07**	**1.07**	**4.04**	**2.01**

Table 2. Economics analysis of different levels of fertigation with black polyethylene mulch on Sweet Pepper

Sr. No.	Treatments	Cost of cultivation (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	Benefit : Cost Ratio
1.	120% of RDF (180:120:120 kg NPK ha^{-1}) through fertigation	217146	428400	211254	0.972:1
2.	100% of RDF (150:100:100 kg NPK ha^{-1}) through fertigation	216217	449100	232883	1.070:1
3.	80% of RDF (120:80:80 kg NPK ha^{-1}) through fertigation	214930	480000	265070	1.233:1
4.	60% of RDF (90:60:60 kg NPK ha^{-1}) through fertigation	214001	339600	125699	0.587:1
5.	RDF through soil application	230146	357000	126854	0.551:1

Table 3. Application of fertilizers and its schedule

Fertilizer grade	Required qty. (kg h^{-1})	Quantity applied (kg ha^{-1} day^{-1})	Schedule of application
12:61:00 + Urea	5 + 10	5 + 10	7^{th} DAT
20: 10:10 + Urea	50 + 70	25 + 35	From 10 to 24 th day
19: 19:19 + Urea	50 + 70	25 + 35	From 25 to 40 thday
12:61:00 + Urea	126 + 70	18 + 10	From 41 to 90 thday
13:00:45	40	13.33	From 91 to 110 thday
00:00:50	115	28.75	From 111 to 140 thday
16:08:24	50	16.66	At 2 to 3 picking

The minimum days were taken to first picking under the treatment 80% RDF (51.05) followed by 60% RDF (52.14) through fertigation, RDF through soil application (52.82), 100% RDF (53.18) and 120% RDF through fertigation (54.28). Among the treatments 60% RDF through fertigation and RDF through soil application were found statistically *at par*.The maximum number of pickings was recorded in 80% RDF (13.32) followed by 100% RDF (12.79), 120% RDF (12.15), 60% RDF (12.08) through fertigation and RDF through soil application (11.80). Whereas, the minimum number of picking was obtained in RDF through soil application (11.80). The treatments 120% RDF and 100% RDF through fertigation were statistically *at par*. The significantly maximum fruit weight was recorded under the treatment 80% RDF (205.30 g) followed by 100% RDF (183.14 g), 120% RDF (175.70 g) and 60% RDF (169.06 g). While, significantly minimum fruit weight was observed under the treatment RDF through soil application (128.03 g). The treatment 80% RDF and 100% RDF through fertigation were statistically *at par*.

Yield analysis :

In case of fruits yield (Table 1) the significantly maximum number of fruits were found in 80% RDF (6.23) followed by 100% RDF (5.65), 120% RDF (5.33) and 60% RDF (4.92) through fertigation. The total fruit weight ranged from 558.24 g to 1091.69 g plant^{-1}. Significantly maximum fruit weight was recorded under the treatment 80%RDF (1091.69) followed by 100% RDF (986.40), 120% RDF (912.34) and 60% RDF (837.98) through fertigation. While significantly minimum fruit weight plant^{-1} was obtained in RDF through soil application (558.24 kg). Sasikala *et al.* (2007), found that in different growing media water-soluble fertilizer and mulching was the most effective in improving the growth, yield and quality of sweet pepper. The total fruit yield ranged from 121.02 to 92.74 q ha^{-1}. Significantly maximum fruit yield plot^{-1} was found in 80%RDF (121.02 ha^{-1}) followed by 100%RDF (116.41 ha^{-1}), 120%RDF (111.36 ha^{-1}) and RDF (92.74 ha^{-1}) through fertigation and the treatment 80% RDF and 100% RDF were statistically at par. Significantly minimum fruit yield hectare^{-1} was obtained in 60% RDF (87.26 ha^{-1}) through fertigation.

Economic analysis :

The cost of cultivation ha^{-1} ranged from Rs. 217146 to 214001 ha^{-1} (Table-2). The maximum net income (Rs. 265070/-) was obtained under treatment 80% RDF (120:80:80 kg NPK ha^{-1}) through fertigation with black polyethylene mulch followed by 100% RDF (150:100:100 kg NPK ha^{-1}) through fertigation with black polyethylene mulch and 120% RDF (180:120:120 kg NPK ha^{-1}) through fertigation with black polyethylene mulch. The highest benefit: cost ratio was obtained with the use of 80% RDF (120:80:80 kg NPK ha^{-1}) through fertigation with black polyethylene mulch and gave maximum profit for rupee^{-1} investment. The similar higher net return and economical feasibility of drip system was reported earlier by Patil and Patil (2009), who reported that treatment of drip irrigation with black plastic mulch of 50 µ thickness and water use efficiency was 59.2% higher than the lowest water use efficiency (6.9 kgha^{-1}mm^{-1}) observed in treatment of conventional irrigation methods with no mulch.

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EFFECT OF MOISTURE REGIMES, NPK AND ZINC LEVELS ON GROWTH, YIELD, QUALITY, NUTRIENT UPTAKE AND ECONOMICS OF MUSTARD (*Brassica juncea*)

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ABSTRACT

A field experiment to identify the effect of irrigation and fertility levels on growth, yield, nutrient uptake, WUE, quality and economics of Indian mustard [*Brassica juncea* (L.) Czernj and Cosson] was carried out on sandy loam soil at Morena (M.P.) during winter (*rabi*) season of 2007-08 and 2008-09. Two irrigation applied at flower initiation and siliqua formation stage registered significantly higher growth and yield attributes, WUE, production efficiency, nutrient uptake and oil production and resulted in 11.22% and 33.33% higher seed yield over one irrigation applied at flower initiation stage and siliqua formation stage, respectively. Among the fertility levels 125% (100N, 22 P, 20.7 K and 6.25 Zn kg ha^{-1}) RDF maintained significantly higher values of growth and yield contributory characters, WUE, production efficiency, nutrient uptake and quality components over 100% (80 N, 17.6 P, 16.6 K and 5.0 Zn kg ha^{-1}) RDF. Application of 125% RDF also achieved 19.94, 11.86 and 3.97% higher seed yield of mustard over 50, 75 and 100% RDF. The highest oil content was also recorded under 125% RDF treatment which was significantly superior to 50% RDF. The interaction effect among irrigation and fertility levels were not found significant. Maximum net monitory returns of Rs. 40441 ha^{-1} and 36916 ha^{-1} and benefit cost ratio of 4.37 and 3.82 were realized under two irrigations and 125% RDF, respectively.

(Key words: Moisture usage, monetary returns, nutrient uptake, production efficiency, quality, seed yield)

INTRODUCTION

The shortage of edible oils has become a chronic problem in India with increasing demographic pressure which has resulted in tremendous challenges for the agricultural research in the country to fulfill the demand for increasing population. Rapeseed- mustard is an important group of oilseed crops in the world. India ranks 2nd in acreage and 3rd in production with contribution of 21.7% and 10.7% to the estimated global area (30.74 million hectares) and production (59.93 million tones), respectively during 2009-10 (Anonymous,2010). The process of productivity of grain is now slowing down coupled with decline in soil fertility. Low and imbalance use of fertilizers one of the major reasons for low productivity. Coarse textured soils with low organic matter content of Indo-Gangetic alluvium plains are inherently low in available zinc status (Katyal and Rattan, 1993). In this context balanced nutrition is necessary, which means application of all the deficient plant nutrients in sufficient amount, in appropriate forms and ratios is necessary so that maximum benefit may be derived from the applied quantity of the nutrients (Roul *et al*., 2006). The adequate soil moisture is required for normal development of mustard at all the critical stages of crop growth, which can be created, by timely scheduling of irrigation (Panda *et al*., 2000 and Chauhan *et al*., 2002). Over the last 30 years, 50-55% improvement in crop productivity could be attributed to irrigation and fertilizers but their efficiency remained low (Wamjari *et al*., 2004). In cognizance of the above facts the present study was undertaken, to study the effect of moisture regimes and NPK and zinc levels on the growth, yield, quality, nutrient uptake and economics of mustard.

MATERIALS AND METHODS

The field experiment was conducted during winter season of 2007-08 and 2008-09 at Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Zonal Agricultural Research Station, Morena, Madhya Pradesh. The soil of experimental field was sandy loam having low in available nitrogen (134.5 kg ha^{-1}) and zinc (0.43 mg kg^{-1}), medium in available phosphorus (14.2 kg ha^{-1}) and potash (223 kg ha^{-1}) with pH 7.7. The available moisture at field capacity was 23.50%, bulk density 1.4 g cc^{-1}, permanent wilting point 7.2%, infiltration rate 14.5 mm hr^{-1} with electrical conductivity 0.32 d Sm^{-1}. No rainfall was

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received during crop growth period. The experiment was laid out in split-plot design with four replications. Twelve treatment combinations, comprising three irrigation schedules viz., one irrigation at flower initiation stage, one irrigation at siliquae formation stage and two irrigations at flower initiation and siliquae formation stage in main plots and four fertilizer levels of recommended doses of fertilizer (RDF) i.e. 50% (40:8.8:8.3), 75% (60:13.2:12.4), 100% (80:17.6:16.6) and 125% (100:22:20.7) of NPK kg ha^{-1} with four levels of Zn (2.50 , 3.75, 5.0 and 6.25 kg ha^{-1}) in sub plots. Half of the nitrogen and full dose of phosphorus, potash and zinc were applied through urea, diammonium phosphate, muriate of potash and zinc sulphate before sowing the seed. The remaining nitrogen was top dressed after first irrigation applied as per treatments. Mustard variety JM-4 was sown in 3rd week of October and harvested in 3rd week of February during both the years. The seed rate of 5 kg $ha^{-1}$was sown in lines maintaining row to row distance of 30 cm and plant to plant distance of 10 cm. Other operations were done as per recommended package of practices of the crop. The irrigation at a depth of 7 cm was applied as per treatment in addition to 8 cm as pre-sowing irrigation. Growth parameters like plant height, leaves $plant^{-1}$, branches $plant^{-1}$, siliquae $plant^{-1}$ and yield parameters such as seeds $siliqua^{-1}$, seed weight and 1000 seed weight were recorded at harvest stage by taking five random plant samples from each treatment. The water use efficiency (WUE) in kg ha^{-1} cm^{-1} was calculated by dividing the seed yield with total water applied to the crop. The production efficiency was computed by dividing the seed yield with total days of crop period. The nutrient use in kg of NPKZn in seed kg^{-1} was calculated by dividing the seed yield with quantity of NPKZn applied to the crop as per treatment. The data on various biometric characters were recorded and statistically analysed. Nitrogen content was determined by micro-kjeldahl method (Chopra and Kanwar, 1980), phosphorus content was determined in digested material colorimetrically by vanadomolybdate procedure laid down by Champan and Pratt (1961), potassium was determined in diacid by flame photometric method as described by Jackson (1973) and Zinc content was determined in digested material with the help of Atomic Absorption Spectrophotometer (Model Perkin Elemer AA 100).Oil was determined by extracting 2 g seed material by petroleum ether (B.P. 60-80°C) in a Soxhlet oil extractor glass apparatus for 8 hours at 60°C as per procedure described by AOAC (Anonymous, 1960). The economics of various treatments were calculated based on market price, which was Rs.2400 q^{-1} and Rs.50 q^{-1} for grain and straw of mustard respectively.

RESULTS AND DISCUSSION

Growth and yield :

Growth and yield attributing characters of mustard were significantly influenced by different irrigation regimes in both the years as well as in pooled analysis (Table 1). Among levels of irrigation, two irrigation applied at flower initiation and siliquae formation stage recorded significantly higher plant height, leaves $plant^{-1}$, branches $plant^{-1}$, siliquae $plant^{-1}$, seeds $siliquae^{-1}$, seed weight $plant^{-1}$ and 1000 seed weight over one irrigation applied either at flower initiation or siliquae formation stage. Such increase in growth and yield components were due to more soil moisture supplied with two irrigations providing congenial growth environment which improved the cell turgidity and opening of stomata to the sink (Chauhan *et al*., 2002). One irrigation applied at flower initiation stage also maintained significantly higher values of all the yield contributing characters over one irrigation at siliquae formation. All these characters progressively declined due to delay in irrigation at siliquae formation stage which resulted in water stress at grand growth stage and adversely affectd nutrient translocation, photosynthesis and metabolic activity in the plant system.

The progressive and significant increase in growth and yield components of mustard were noticed with the successive increase in fertilizer levels from 50% to 125% RDF (Table 1). Maximum values of growth and yield attributes were achieved under 125% RDF, which marked significant improvement over other fertilizer doses. The response of mustard to nutrient application may be attributed to the fact that addition of fertilizer improved the uptake of nutrients which might have favoured the plant growth and helped in improving yield attributing characters under125% RDF. On the other hand the lowest values of this these parameters were registered with 50% RDF. These findings are in

close conformity with those of Jain and Sharma (2000), who reported that application of nitrogen from 0 to 80 and 40 to 100 kg ha^{-1} significantly enhanced siliquae $plant^{-1}$, seed $siliquae^{-1}$, and test weight of Indian mustard. Reager *et al.* (2006) also reported that the application of increasing levels of nitrogen from 40 to 100 kg ha^{-1} significantly enhanced siliquae $plant^{-1}$, seed $siliquae^{-1}$, siliqua length and test weight of mustard. The interaction effect between irrigation and fertility levels were not found significant.

Seed and straw yields :

The seed and biological yield of mustard improved significantly due to irrigation schedules in both the years and pooled over two years (Table 2). Two irrigations applied at flower initiation plus siliquae formation stage showed the best performance in improving the seed yield (2.08 t ha^{-1}) and straw yield (4.80 t ha^{-1}) which was 11.22% and 33.33% higher in seed yield and 7.38% and 27.32% in straw production over one irrigation applied either at flower initiation and one at siliquae formation stage respectively. Increase in seed and straw yield was attributed to more vigorous growth and higher order of growth and yield components due to adequate supplies of the moisture to the crop at grand growth and reproductive phase under two irrigations as compared to one irrigation at flower initiation stage or at siliquae formation stage of mustard

The application of fertilizer significantly increased the seed yield as well as stover production of mustard with subsequent increase in fertilizer doses from 50% to 125% RDF (Table 2). The mean response gained due to 125% RDF was 17.15, 12.23 and 4.21% in seed yield and 19.94, 11.86 and 3.97% in stover yield over 50, 75 and 100% RDF, respectively. Fertilizer application provided better conducive condition for better uptake of nutrients and in turn helped the plant to boost their growth, leading to the development of yield attributes through supply of more photosynthates towards reproductive sink with the successive increase in nutrient doses. Reager *et al*. (2006) also reported that the application of increasing levels of nitrogen from 40 to 100 kg ha^{-1} significantly increased seed yield of mustard. Sarangthem *et al*. (2008) also made similar observations and reported that application of 60 kg N ha^{-1} produced the highest seed (1.18 t ha^{-1}) and straw (1.69 t ha^{-1}) yield of rapeseed.

Moisture usage :

Water use efficiency and production efficiency were improved significantly due to different moisture regimes (Table 3). The maximum production efficiency was recorded under two irrigation (17.38 kg $ha^{-1}day^{-1}$) followed by one irrigation applied at flower initiation stage (15.65 kg $ha^{-1}day^{-1}$). This might be attributed to higher seed yield under these treatments. Significantly more water use efficiency (125.3 kg ha^{-1}-cm^{-1}) was realized with one irrigation at flower initiation stage than one irrigation at siliquae stage. However, two irrigations also showed marked improvement in WUE over siliquae formation stage of irrigation. WUE in terms of seed yield was the highest with one irrigation at flower initiation stage as under such conditions plant would use available moisture most economically and thereby increase in WUE under this treatment as compared to two irrigations. The consumptive use of water was markedly higher under two irrigations than that of one irrigation. This might be due to the fact that under two irrigations, evaporation was at potential rate due to availability of more soil moisture than the crop irrigated only at one time (Panda *et al*., 2000 and Chauhan *et al*., 2002). Irrigation regimes brought about marked influence on the moisture extraction patterns of the crop. The maximum soil moisture depletion from 0-20 cm soil layers was registered under two irrigations which might have helped in better root development in upper profiles due to adequate availability of soil moisture. The lowest extraction was noticed under siliquae formation stage of irrigation. However, the reverse was true for 40-60 cm soil profile, where the maximum percentage of moisture was depleted under siliquae formation stage of irrigation. Under this treatment, the crop suffered from scarcity of water in upper layers, compelling the roots to go deeper in search of moisture.

Water use efficiency, consumptive use of water, soil moisture depletion and production efficiency increased appreciably due to increasing fertility levels (Table 3). The highest values of all these four parameters on an average were associated with 125% RDF, perhaps due to improved vegetative growth and extensive root system which enabled the

Table 1. Effect of irrigation and N, P, K and Zn levels on growth and yield attributes of mustard (Pooled over two years 2007-08 and 2008-09)

Treatments	Plant height (cm)	Leaves plant^{-1} (No.)	Branches plant^{-1} (No.)	Siliquae plant^{-1} (No.)	Seed Siliquae^{-1} (No.)	Seed weight plant^{-1} (g)	1000 seed weight (g)
Irrigation Schedules							
One at Flower initiation stage	176.4	17.28	8.44	281	10.77	11.56	4.64
One at Siliquae formation stage	172.5	16.28	7.62	245	10.16	10.81	4.20
Two- One at Flower initiation + another at Siliquae formation stage	181.3	19.40	8.89	290	12.15	12.32	4.81
SEm±	0.42	0.25	0.06	1.66	0.27	0.08	0.07
CD (P=0.05)	1.25	0.74	0.16	5.03	0.78	0.25	0.21
Levels of NPKZn (kg ha^{-1})							
40:8.8:8.3:2.50	173.5	17.17	7.69	252	10.34	10.79	4.41
60:13.2:12.4:3.75	176.9	17.76	8.12	266	10.96	11.25	4.48
80:17.6:16.6:5.0	178.8	18.68	8.78	288	11.61	12.14	4.73
100:22:20.7:6.25	180.2	18.75	8.88	295	11.94	12.29	4.83
SEm±	0.30	0.17	0.07	1.45	0.20	0.08	0.06
CD (P=0.05)	0.92	0.50	0.18	4.38	0.62	0.24	0.18

Table 2. Effect of irrigation and N, P, K and Zn levels on yield, quality and economics of mustard (Pooled over two years 2007-08 and 2008-09)

Treatments	Seed yield (t ha^{-1})			Stover production (t ha^{-1})	Harvest index (%)	Net returns (Rs. ha^{-1})	B:C ratio	Oil content (%)	Oil production (kg ha^{-1})
	2007-08	2008-09	Pooled						
Irrigation Schedules									
One at Flower initiation stage	1.69	2.05	1.87	4.47	29.5	35808	4.11	40.95	765
One at Siliquae formation stage	1.42	1.70	1.56	3.77	29.3	27997	3.43	41.10	641
Two- One at Flower initiation + another at Siliquae formation stage	1.98	2.18	2.08	4.80	30.2	40441	4.37	40.65	845
SEm±	0.02	0.02	0.01	0.11	--	--	--	0.07	18
CD (P=0.05)	0.08	0.05	0.05	0.30	--	--	--	0.23	51
Levels of NPKZn (kg ha^{-1})									
40:8.8:8.3:2.50	1.56	1.82	1.69	3.71	29.6	31085	3.68	40.53	686
60:13.2:12.4:3.75	1.65	1.92	1.78	3.98	29.6	32986	3.74	40.86	727
80:17.6:16.6:5.0	1.75	2.05	1.90	4.28	29.8	35477	3.82	41.05	782
100:22:20.7:6.25	1.84	2.13	1.98	4.45	29.9	36916	3.82	41.19	818
SEm±	0.03	0.01	0.01	0.05	--	--	--	0.16	9.0
CD (P=0.05)	0.09	0.03	0.04	0.15	--	--	--	0.45	24.0

Table 3. Effect of irrigation and N, P, K and Zn levels on production efficiency, consumptive use of water, water use efficiency and moisture extraction pattern of mustard (Pooled over two years 2007-08 and 2008-09)

Treatments	Production efficiency (kg ha^{-1} day^{-1})	Water applied (mm)	Consumptive use of water (mm)	Water use efficiency (kg ha^{-1} cm^{-1})	Moisture extraction pattern from different depths (%)		
					0-20 cm	20-40 cm	40-60 cm
Irrigation Schedules							
One at Flower initiation stage	15.65	150	210.8	125.3	47.5	31.5	18.4
One at Siliquae formation stage	13.06	150	180.0	104.5	39.6	24.2	21.3
Two- One at Flower initiation + another at Siliquae formation stage	17.38	220	265.6	115.8	54.9	36.3	15.1
SEm±	0.15	--	--	0.34	--	--	--
CD (P=0.05)	0.42	--	--	1.01	--	--	--
Levels of NPKZn (kg ha^{-1})							
40:8.8:8.3:2.50	14.11	173	175.2	105.9	41.3	25.6	15.7
60:13.2:12.4:3.75	14.89	173	195.4	111.6	45.5	29.5	17.0
80:17.6:16.6:5.0	15.90	173	245.6	119.1	49.3	32.4	19.4
100:22:20.7:6.25	16.64	173	259.3	124.1	53.1	35.2	20.9
SEm±	0.16	--	--	0.35	--	--	--
CD (P=0.05)	0.45	--	--	1.06	--	--	--

Table 4. Effect of irrigation and N, P, K and Zn levels on nutrient use efficiency, uptake of nutrients and nutrient status of mustard (Pooled over two years 2007-08 and 2008-09)

Treatments	Nutrient use efficiency (kg seed kg nutrient^{-1})				Total nutrient uptake (kg ha^{-1})				Available nutrient status			
	N	P	K	Zn	N	P	K	Zn	N	P	K	Zn
									(kg ha^{-1})			(mg kg^{-1})
Irrigation Schedules												
One at Flower initiation stage	29.4	58.8	117.7	471	97.3	15.5	77.6	0.531	129	13	221	0.40
One at Siliquae formation stage	24.8	49.6	99.3	394	81.1	12.9	64.8	0.443	130	14	222	0.42
Two- One at Flower initiation + another at Siliquae formation stage	32.6	65.2	130.5	522	108.0	17.2	86.2	0.732	128	13	220	0.38
SEm±	1.30	2.25	3.4	22.0	4.2	0.70	2.3	0.04	0.8	0.5	1.0	0.11
CD (P=0.05)	3.80	6.8	9.9	64.3	12.5	2.15	7.2	0.12	--	--	--	--
Levels of NPKZn (kg ha^{-1})												
40:8.8:8.3:2.50	42.3	84.6	169.4	677	87.7	14.0	70.0	0.480	128	13	220	0.37
60:13.2:12.4:3.75	29.7	59.5	119.1	474	92.5	14.8	73.9	0.505	129	13	220	0.39
80:17.6:16.6:5.0	23.8	47.6	95.4	380	98.8	15.8	78.9	0.539	129	14	222	0.41
100:22:20.7:6.25	19.8	39.7	79.5	316	102.9	16.4	82.1	0.512	130	14	223	0.43
SEm±	1.83	2.72	5.0	30.4	1.61	0.26	1.23	0.009	0.3	0.2	0.6	0.003
CD (P=0.05)	5.53	8.30	15.1	90.3	5.0	0.80	3.71	0.025	0.9	0.6	1.0	0.015

plants to utilize more nutrients with increased levels of fertilizer.

Nutrient use studies :

Application of irrigation showed significant positive responsive on the nutrient use efficiency (NUE) and total (NPKZn) uptake (Table 4). Maximum nutrient use efficiency and total nutrient NPKZn uptake was recorded under two irrigations at flower initiation and siliquae formation stage over one irrigation at flower initiation or siliquae formation stage of irrigation. One irrigation at flower initiation stage also registered significantly higher NUE and total nutrient uptake than one irrigation at siliquae formation stage. Higher availability of soil moisture under two irrigations might have improved the physiological and metabolic functions inside the plant and led to higher seed yield and biomass production. The available nutrient status at harvest of the crop remains unaffected due to moisture regimes.

The nutrient use efficiency, total NPKZn uptake and available nutrient status of soil improved significantly due to successive increase in fertility levels (Table 4). The highest NUE, total NPKZn uptake and available nutrient status were observed with 125% RDF. This might be owing to increased supply of nutrient sources to the crop. Roul *et al*. (2006) also reported that N uptake and N-use efficiency for mustard crop was higher under 100% recommended dose of nitrogen.

Quality character :

The irrigation and fertility levels had caused significant variations in quality of mustard (Table 2). One irrigation at siliquae formation stage recorded significantly higher oil content (41.10%) over other moisture regimes. Two irrigations also maintained significantly higher oil content over flower initiation stage of irrigation. Higher oil content at siliquae formation stage may be due to less supply of moisture at grand growth and reproductive phase resulted in low supply of nutrient especially the nitrogen which in turn increased the oil content under this treatment. Maximum oil production (845 kg ha^{-1}) was achieved under two irrigations, which might be owing to higher seed yield.

The oil content and oil production significantly and gradually increased with the increase in fertility levels and maximum oil content and oil production was obtained under 125% RDF (41.19% and 818 kg ha^{-1}). The highest oil content with increasing fertility levels might be due to increased availability of nutrient to the plants. Improvement in seed yield helped in increasing the oil production. Sarangthem *et al*. (2008) also reported that addition of nitrogen (60 kg ha^{-1}) significantly increased oil content in mustard seed.

Economics :

Irrigation and fertility levels brought about considerable variation in harvest index, net returns and B:C ratio (Table 2). However, two irrigations applied at flower initiation stage plus siliquae formation stage fetched the highest harvest index (30.2%), net monitory returns Rs. 40441 ha^{-1}) and the highest B:C ratio (4.37). Further, the maximum harvest index (29.97), net returns (Rs. 36916 ha^{-1}) and B:C ratio (3.82) were realized with 125% RDF. This might be due to higher seed yield in these treatments.

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SOIL FERTILITY STATUS, QUALITY PARAMETERS AND YIELD OF CLUSTERBEAN (*Cyamopsis tetragonoloba* L. Taubert) AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT

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ABSTRACT

A field experiment was conducted on loamy sand soil of Agronomy instructional farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif,* 2008 to study "Soil fertility status, quality parameters and yield of clusterbean (*Cyamopsis tetragonoloba* L. Taubert) as influenced by Integrated Nutrient Management". Among the different treatments, the application of 100 % RDN (20 kg) through Urea + *Rhizobium* + PSB significantly enhanced phosphorus and potash content (%) in plant and the uptake of nitrogen and potash by seeds of clusterbean. Clusterbean crop when fertilized with 100 % RDN through Urea + *Rhizobium* + PSB inoculation recorded significantly higher seed yield (910 kg ha^{-1}) and protein yield (223 kg ha^{-1}) over rest of the treatments. The highest net return (Rs. 9631 ha^{-1}) and BCR (2.13) were recorded with the application of 100 % RDN through Urea + *Rhizobium* + PSB, followed by application of 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium* + PSB (Rs. 7227 ha^{-1}) along with BCR value of 2.02. The lowest net realization (Rs. 2795 ha^{-1}) and BCR (1.29) was recorded with the application of 100 % RDN through FYM.

(Key words : Clusterbean integrated nutrient management)

INTRODUCTION

Pulses are important food grain crop because of higher nutritive value and occupy a unique position in ever known system of farming as a main, catch, cover, green manure and intercrop. Pulses have wide range of adaptability to various agro-ecological situations. Moreover, a pulse provides good soil health by reducing erosion and maintaining status of the soil, as well as fixing the atmospheric nitrogen in the soil. Among the different pulses, clusterbean locally known as *guar* considered as an important drought resistant crop. It is best suited to dry farming areas. In India, it is cultivated mainly in Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh and Maharashtra. The production of clusterbean can be increased by various agronomical practices one of them is nutrient management. There is a positive relationship between nutrient application and the productivity. The judicious use of fertilizer plays a vital role to achieve higher yield of clusterbean. Among different plant nutrients, nitrogen is the most important nutrient for plant growth and development. Nitrogen plays an important role in plant metabolism by the synthesis of chlorophyll as well as amino acid, which contributes to building the unit of protein and ultimately vigorous growth of the plant. Clusterbean, being a pulse crop, has the capacity to fix atmospheric nitrogen by its effective root nodules. The major part of nitrogen is met only by *Rhizobium* present in the root nodules, hence, crop does not require additional nitrogen for its initial growth and development stage of crop needs very small amount of nitrogen. The phosphorus is the second important plant nutrient. An application of phosphorus influences symbiotic nitrogen fixation, yield and quality of clusterbean pods. Evaluation of the role of biofertilizer including Phosphate Solubilizing Bacteria to harness their effect in enhancing crop yields will be the challenging task. Biofertilizers have become more essential and popular because of increasing cost of chemical fertilizer as well as their adverse effects on the global environment. The short supply and recent price hike in inorganic fertilizers encouraged the use of indigenous source like FYM as it supplies essential plant nutrients, improves the physical and chemical properties of the soil, increases water holding capacity and thereby increases the soil fertility and productivity too. Therefore, proper nutrient management is of prime importance. With this view in mind, this study was undertaken.

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MATERIALS AND METHODS

The experiment was laid out during *kharif* season of the year 2008 at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat State). The soil at the experimental site was loamy sand with low available nitrogen (172 kg ha^{-1}), medium in available phosphorus (41 kg ha^{-1}) and high in available potassium (285 kg ha^{-1}). The experiment was laid out in randomized block design with four replications. The gross and net plot size were 5.0 m x 4.5 m and 4.0 m x 2.7 m, respectively. The experiment comprised of sixteen treatments as given in table 1. The drought resistant clusterbean variety Gujarat Guar-2 was sown @ 18 kg seed ha^{-1} to a depth of 4 to 5 cm with 45 cm row spacing in the third week of July. The seeds were treated as per treatment with *Rhizobium* and PSB culture @ 250 g per 8 kg seeds and were dried under shade before sowing. Nitrogen fertilization was done @ 20 kg ha^{-1} N through urea for 100 % RDN and other treatments proportionate N was applied through urea. The gross quantity of FYM contains 0.5 % N, 0.25 % P and 0.5 % K applied for 100 % RDN through FYM was @ 4 tonnes ha^{-1}. Phosphorus 40 kg ha^{-1} was given as basal for common dose. The crop was irrigated as and when needed to maintain the optimum moisture level. Attempts were made to keep the experimental field weed free throughout the crop season. There was sucking pest attack on crop during early growth stage which was effectively controlled by spraying of dimethoate. Soil studies were carried out by taking soil samples from 0 to 15 cm and 15 to 30 cm depth at 20 different spots ascertained in a random manner. The samples were drawn before the application of fertilizers to the experimental field during the year of the study. Estimation of total nitrogen was done by modified Kjeldhal's method as described by Jackson (1973). Estimation of potassium was made from acid extract by flame photometric method as described by Jackson (1973). Total uptake of N, P and K by seeds was calculated by using following formula.

$$\text{Nutrient uptake by seeds} = \frac{\text{\% Nutrient content x Seed yield (kg ha}^{-1}\text{)}}{100}$$

The protein content of seed in percentage was calculated by multiplying total nitrogen by 6.25. From the protein content values protein yield was computed by using following formula.

$$\text{Protein yield (kg ha}^{-1}\text{)} = \frac{\text{Protein content (\%) x Seed yield (kg ha}^{-1}\text{)}}{100}$$

For the determination of gum content, seed samples were drawn separately from the produce of all the experimental plots. The gum was determined as described by Dubois *et al.* (1956). Gum yield was calculated by using following formula.

$$\text{Gum yield (kg ha}^{-1}\text{)} = \frac{\text{Gum content (\%) x Seed yield (kg ha}^{-1}\text{)}}{100}$$

Crop was harvested at maturity in the last week of November. Seed and straw yield were recorded at harvest and economics was worked out by privileging market price of crop and straw.

RESULTS AND DISCUSSION

Nitrogen content (%) :

Data presented in table 1 indicated that nitrogen content in plant was not significantly influenced due to different integrated nutrient management treatments. Numerically highest nitrogen content was recorded under the application of 100 % RDN through FYM + *Rhizobium* + PSB. These results are in close conformity with Tarafdar and Rao (2001). They reported that the *Rhizobium*, AMF inoculation with FYM improved the concentration of nitrogen.

Nitrogen uptake (kg ha^{-1}) :

100 % RDN through Urea + *Rhizobium* + PSB recorded significantly higher nitrogen uptake by seeds (44.13 kg ha^{-1}) than all other treatments, followed by treatment 100 % RDN through FYM + *Rhizobium* + PSB and 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium* + PSB. Treatment 100 % RDN through Urea lagged behind all other treatments by recording the lowest value of nitrogen uptake (24.36 kg ha^{-1}) by seeds. The increase in nitrogen uptake by seeds under the treatments 100 % RDN through Urea + *Rhizobium* + PSB, 100 % RDN through FYM + *Rhizobium* + PSB and 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium* + PSB was to the tune of 81.2, 78.4 and 73.8 per cent, respectively than that recorded under the treatment 100 % RDN through Urea. The marked

improvement in nitrogen uptake by seeds under these treatments may be due to greater availability of nitrogen released by the decomposition of organic matter from FYM incorporated in the soil and availability of atmospheric nitrogen, which was fixed by root nodules due to *Rhizobium* inoculation. Organic fertilizers also improved the soil environment, which ultimately increased nitrogen absorption by roots and their transportation towards foliage results in to increase in nutrient uptake by seed.

Phosphorus content (%) :

Application of 100 % RDN through Urea + *Rhizobium* + PSB recorded maximum value of phosphorus content in plant. The lowest phosphorus content in plant was registered under the treatment 75 % RDN through Urea + 25 % RDN through FYM (0.42 %).

Phosphorus uptake (kg ha^{-1}) :

Maximum phosphorus uptake by seeds was observed under the treatment 100 % RDN through Urea + *Rhizobium* + PSB. Treatment 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium* + PSB ranked second in recording phosphorus uptake by seeds. The magnitude of increase in phosphorus uptake by seeds under the treatment 100 % RDN through Urea + *Rhizobium* + PSB and 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium* + PSB was 63.7 and 61.5 per cent, respectively over application of 100 % RDN through Urea. The lower value of phosphorus uptake by seeds (4.22 kg ha^{-1}) was noticed under the treatment 75 % RDN through Urea + 25 % RDN through FYM. The higher phosphorus uptake by seeds under the treatment 100 % RDN through Urea + *Rhizobium* + PSB and 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium* + PSB may be ascribed to greater availability of phosphorus due to higher phosphorus content in organic acids released after decomposition of FYM and secreted by nodule bacteria increased the available soil phosphorus by dissolving the acid soluble phosphorus and ultimately resulted to higher uptake by seeds. These results are akin to those reported by Naagar and Meena (2004). They reported that seed inoculation with PSB significantly increased the total uptake of nitrogen and phosphorus over uninoculated control.

Potash content (%) :

Treatment 100 % RDN through Urea + *Rhizobium* + PSB recorded maximum value of potash content in plant. The lowest potash content in plant was registered under the treatment 50 % RDN through Urea + 50 % RDN through FYM (3.45 %). This was due to application of organic fertilizer and biofertilizer in combination with inorganic fertilizer, which might have helped in continuous availability of nutrient to the plant. These results are in close conformity with Tarafdar and Rao (2001). They reported that the *Rhizobium*, AMF inoculation with FYM improved the concentration of phosphorus.

Potash uptake (kg ha^{-1}) :

Application of 100 % RDN through Urea + *Rhizobium* + PSB recorded significantly higher potash uptake by seeds (55.97 kg ha^{-1}) than all other treatments, except treatment 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium* + PSB which registered second highest potash uptake by seeds. Treatment 100 % RDN through Urea lagged behind all other treatments by recording the lowest value of potash uptake (21.17 kg ha^{-1}) by seeds. The marked improvement in potash uptake by seeds under the treatment 100 % RDN through Urea + *Rhizobium* + PSB and 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium* + PSB may be described to greater availability of potash due to higher potash content in organic matter, which released organic acids after decomposition of FYM. These results are akin to those reported by Vikrant et *al.* (2004) in greengram. They reported that FYM play an important role for potash uptake.

Seed yield (kg ha^{-1}) :

Application of 100 % RDN through Urea + *Rhizobium* + PSB recorded significantly higher seed yield (910 kg ha^{-1}) than rest of treatments except treatments 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium* + PSB (910 kg ha^{-1} seed yield), 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium* + PSB (901 kg ha^{-1} seed yield) and 100 % RDN through FYM + *Rhizobium* + PSB (889 kg ha^{-1} seed yield) which was higher than the seed yield obtained by the application of 100 % RDN through Urea alone. The per cent increase in seed yield under the treatments 100 % RDN through

Table 1. Nitrogen, phosphorus and potash content (%) in plant and uptake (kg ha^{-1}) by seeds as influenced by different treatments of integrated nutrient management

Treatments	Nitrogen		Phosphorus		Potash	
	Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})
T_1 100 % RDN through Urea	3.85	24.36	0.78	4.93	5.15	32.59
T_2 100 % RDN through Urea + *Rhizobium*	4.55	36.63	0.79	6.37	4.45	35.81
T_3 100 % RDN through Urea + PSB	4.65	36.47	0.81	6.35	5.75	45.04
T_4 100 % RDN through Urea + *Rhizobium* + PSB	4.85	44.13	0.89	8.07	6.15	55.97
T_5 75 % RDN through Urea + 25 % RDN through FYM	4.35	31.19	0.42	4.22	5.05	35.21
T_6 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium*	4.45	34.18	0.66	5.19	4.95	38.84
T_7 75 % RDN through Urea + 25 % RDN through FYM + PSB	4.35	29.86	0.67	4.38	4.75	31.63
T_8 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium* + PSB	4.65	42.33	0.84	7.56	5.45	49.22
T_9 50 % RDN through Urea + 50 % RDN through FYM	4.05	27.19	0.76	4.79	3.45	21.71
T_{10} 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium*	4.65	36.55	0.88	6.92	5.65	44.35
T_{11} 50 % RDN through Urea + 50 % RDN through FYM + PSB	4.45	29.79	0.88	5.88	5.65	37.79
T_{12} 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium* + PSB	4.35	39.01	0.87	7.96	5.85	49.79
T_{13} 100 % RDN through FYM	4.55	28.89	0.88	5.45	4.85	30.58
T_{14} 100 % RDN through FYM + *Rhizobium*	4.45	33.47	0.85	6.39	4.05	30.45
T_{15} 100 % RDN through FYM + PSB	4.45	29.39	0.88	5.79	4.65	30.34
T_{16} 100 % RDN through FYM + *Rhizobium* + PSB	4.95	43.47	0.88	7.68	4.75	41.83
S Em ±	0.2	2.7	0.02	0.4	0.2	2.7
C D at 5 %	-	7.7	0.07	-	0.7	7.7
C V %	10.56	15.94	6.95	13.43	10.55	14.18

Note : 43.48 kg Urea ha^{-1} for 100 % RDN through urea and 4 tonnes FYM ha^{-1} for 100 % RDN through FYM was done

Rhizobium and PSB seed treatment was done @ 250 g 8 kg^{-1} seeds for both

Table 2. Economics, protein content (%), protein yield (kg ha^{-1}) and gum content (%) of seed as influenced by different treatments of integrated nutrient management

Treatments	Seed yield (kg ha^{-1})	Gross return (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	BCR	Protein content (%)	Protein yield (kg ha^{-1})	Gum content (%)
T_1 100 % RDN through Urea	632	12640	8531	4109	1.49	22.11	139	22.80
T_2 100 % RDN through Urea + *Rhizobium*	805	16100	8550	7550	1.89	22.29	180	23.35
T_3 100 % RDN through Urea + PSB	784	15680	8550	7130	1.84	21.82	167	23.45
T_4 100 % RDN through Urea + *Rhizobium* + PSB	910	18200	8569	9631	2.13	23.24	223	23.05
T_5 75 % RDN through Urea + 25 % RDN through FYM	705	14100	8819	5281	1.60	23.39	166	23.35
T_6 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium*	785	15700	8893	6807	1.77	23.44	184	22.85
T_7 75 % RDN through Urea + 25 % RDN through FYM + PSB	667	13340	8893	4447	1.50	24.21	159	23.15
T_8 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium* + PSB	901	18020	8912	9108	2.02	24.85	211	23.75
T_9 50 % RDN through Urea + 50 % RDN through FYM	630	12600	9218	3382	1.37	21.27	134	24.15
T_{10} 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium*	785	15700	9327	6463	1.70	23.41	184	23.95
T_{11} 50 % RDN through Urea + 50 % RDN through FYM + PSB	670	13400	9237	4163	1.45	23.36	156	24.85
T_{12} 50 % RDN through Urea + 50 % RDN through FYM + *Rhizobium* + PSB	897	17940	9256	8684	1.94	22.63	202	25.85
T_{13} 100 % RDN through FYM	635	12700	9905	2795	1.29	21.79	137	25.65
T_{14} 100 % RDN through FYM + *Rhizobium*	753	15060	9929	4136	1.52	23.31	175	25.05
T_{15} 100 % RDN through FYM + PSB	660	13200	9924	3276	1.33	24.26	160	24.15
T_{16} 100 % RDN through FYM + *Rhizobium* + PSB	889	17780	9943	7837	1.79	23.59	208	23.02
S Em ±	33.8	--	--	--	--	0.9	10.1	0.7
C D at 5 %	96.4	--	--	--	--	-	29.0	-
C V %	8.94	--	--	--	--	8.01	11.69	6.02

Urea 250 Rs. 50 kg^{-1} bag
FYM 400 Rs. tone^{-1}
PSB Rs.19 250 g^{-1} pocket
SSP 155 Rs. 50 kg^{-1} bag
Rhizobium Rs.19 250 g^{-1} pocket
Selling price 18 Rs. kg^{-1} seed and 0.5 Rs. kg^{-1} stover

Urea + *Rhizobium* + PSB and 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium* + PSB was to the extent of 43.8 and 42.3, respectively than that recorded under the treatment 100 % RDN through Urea. The higher seed yield under the treatments of integrated nutrient management as compared to sole application of chemical fertilizers might be due to improvement in physico-chemical and biological properties of soil and constant and optimum supply of nutrients by the soil which enhanced the growth and yield attributing characters. Tarafdar and Rao (2001) reported that application of FYM in conjunction with *Rhizobium* inoculation improved the seed yield of clusterbean on loamy sand soil of Jodhpur (Rajasthan). Moreover, Singh and Buttar (2012) reported that application of fertilizer @ of 20 kg N+40 kg P_2O_5 ha^{-1} increased the mean seed yield of clusterbean to the tune of 19.6% over the control and application of *Rhizobium* and PSB increased mean seed yield by 19.1% over control.

Economics :

The highest net return of Rs. 9361 ha^{-1} was recorded with application of 100 % RDN through Urea + *Rhizobium* + PSB with BCR value of 2.13. The second highest net return (Rs. 7227 ha^{-1}) was observed under the treatment 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium* + PSB with Benefit: Cost Ratio value of 2.02. The lowest net gain of Rs. 2795 ha^{-1} was noticed under the treatment 100 % RDN through FYM with the BCR value of 1.29. The highest net return under application of chemical fertilizer along with seed treatment of *Rhizobium* was only due to higher seed yield.

Protein content (%) :

Data presented in table 2 on protein content (%) did not reveal significant differences due to different integrated nutrient management treatments. Numerically the highest protein content was observed under the application of 75 % RDN through Urea + 25 % RDN through FYM + *Rhizobium* + PSB. The lowest protein content (21.27 %) was registered under the treatment 50 % RDN through Urea + 50 % RDN through FYM. These results are in agreement with the results of those reported by Singh and Singh (2006). They reported that the highest protein content in seed of clusterbean was obtained with FYM along with *Rhizobium* inoculation. Similar results were obtained by Baviskar *et al.* (2012). They observed that application of organic fertilizer registered significantly higher protein content and protein yield over control in clusterbean.

Protein yield (kg ha^{-1}) :

The protein yield (kg ha^{-1}) was significantly influenced due to various integrated nutrient management treatments, wherein, 100 % RDN through Urea + *Rhizobium* + PSB recorded maximum value of protein yield (223 kg ha^{-1}). The lowest protein yield (134 kg ha^{-1}) was registered under the treatment 50 % RDN through Urea + 50 % RDN through FYM. The increased in protein yield under the best treatment was to the tune of 59.3 per cent over the treatment 100 % RDN through Urea. This was due to application of inorganic fertilizer in combination with organic fertilizer and biofertilizer, which might have helped in continuous availability of nutrient, resulted in marked increase in seed yield of clusterbean and ultimately protein yield.

Gum content (%) :

The gum content of guar seed was non-significant due to different integrated nutrient management treatments. It means that different integrated nutrient management treatment did not have the positive relationship with gum content of the seed.

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A STUDY ON COMPARATIVE EFFICIENCY OF NEAR NEIGHBOR ANALYSIS ON ELEPHANT FOOT YAM IN GANGETIC ALLUVIAL REGION OF WEST BENGAL

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ABSTRACT

Near Neighbor (NN) analysis in agricultural crop experiments is known to have better efficiency over conventional Randomized Complete Block Design (RCBD), especially in cases of large block size with more than twelve plots. The present study on application of spatial analysis (NN models) in tuber crop Elephant Foot Yam (EFY) experiment, conducted at BCKV Farm, Mondouri, West Bengal, for three consecutive years of 2004, 2005 and 2006, has an optimistic result. The yields of twelve varieties of EFY tubers were analyzed using traditional RCBD, and three Near Neighbor analysis methods viz., Papadakis (1937), iterated Papadakis (Bartlett, 1978) and Wilkinson *et al.* (1983). It was observed that the plot errors of blocks had significant trend effects, so it was felt important to reduce the error mean square in order to get a reliable estimate of treatment parameter. After detrending using the NN models, the relative efficiency (RE %) over RCBD was the highest in case of Wilkinson's (1983) model (102.2% to 165%). Iterated Papadakis (Bartlett, 1978) method had RE ranging from 105.9% to149.3% while Papadakis had 100.09% to 135.36%. The treatment means of twelve varieties estimated after detrending showed changes in ranks.

(Key words: Elephant foot yam, near neighbor (NN), spatial, detrending, RE (%), ANCOVA, EMS, serial correlation lag.)

INTRODUCTION

The theory of experimental design is based on three basic principles, viz., replication, randomization and local control. The local control refers to the reduction of experimental errors by balancing, blocking and grouping of the experimental units or plots so as to make them homogenous, and thereby, making the experimental design more efficient. It serves the purpose well where fertility variations are smooth and well known, so that the experimental area can be divided into homogenous blocks or rows or columns. But, it has been found that there may be considerable variation among the experimental plots within a block with a comparatively larger number of treatments. Stroup *et al.* (1994) observed that spatial homogeneity within blocks of more than 8 to 12 plots seldom occurs in field trials. Traditional methods of blocking is found not suitable to address the problem of variability of slowly changing soil fertility over space in a block where it is likely that a selected block may actually increase the error variance instead of decreasing it. Stefanova *et al.* (2009) conducted a series of uniformity trials and showed the implications of presence of extraneous variation related to various agronomic practices.

To overcome the problem of local control involving larger blocks, the use of some more efficient alternative methods called spatial or nearest neighbor (NN) adjustment methods has been developed. Piepho *et al.* (2008) studied simple differencing methods, including first differences and the Papadakis (1937) method and utilized mixed model representations of these methods. Edme *et al*., (2007) used Moving Means (MM) and an autoregressive spatial (SP) method to adjust genotype values. The relative efficiency (RE) obtained with MM ranged from 4 to 188% and SP resulted gains in RE from 95 to 492%. But, Piepho *et al.* (2010) found that a baseline model, which included row and column effects only, minimized the Atkinson Information Criterion (AIC) in many cases in sugar beet trials.

The application of spatial analysis for tuber crop Elephant Foot Yam has been done in the study to validate its utility in wide spectrum of agricultural research. The Elephant Foot Yam (EFY) is a tropical and sub-tropical crop and is conducive in agro-climatic conditions, especially in humid warm weather. The tuber crop is cultivated on commercial scales in many states in India especially in Andhra Pradesh, Tamil Nadu, Kerala, Gujarat, Maharashtra, West Bengal, Bihar, Jharkhand, Chattisgarh and Goa. The studies on performance of varieties are carried out to provide the suitable high yielding varieties for cultivation by farmers.

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In this study, the three models (viz., Papadakis (1937), Iterated Papadakis (Bartlett, 1978) and Wilkinson *et al.* (1983)) of nearest neighbor (NN) adjustments are applied to the tuber yield of twelve varieties of Elephant Foot Yam (EFY) viz., BCA-1, BCA-2, BCA-3, NDA-4, NDA-5, NDA-9, Santraganchi, Midnapore Fine, Midnapore, Singur, Ranchi and Sree Padma. The yield values (kg) were analyzed and assessed by three NN adjustment models, and the relative efficiencies over Randomized Complete Block Design (RCBD) were calculated. The plot errors (before and after detrending by NN adjustments) of the above mentioned field trials were tested for normality by W-test (Shapiro and Wilks, 1965) and for randomness by Mann's test (Deshpande *et al.*, 1995) to prove the existence of trend effect in actual field data, and their elimination by using the proposed NN adjustments.

MATERIALS AND METHODS

The trials were conducted at BCKV Farm, Mondouri, West Bengal to compare twelve Elephant Foot Yam (*Amorphyllus campanulatus*) varieties in RCBD experimental layout with three blocks for three consecutive years (2004, 05, and 06). The tuber yield of the field experiments for three years, were analyzed using conventional RCBD and three NN analysis models (viz., Papadakis, 1937, iterated Papadakis (Bartlett, 1978) and Wilkinson *et al.,* 1983 model).

The baseline model of the Near Neighbor (NN) analysis is $Y_{ij} = \mu + \alpha_i + T_{ij} + e_{ij}$; where, $T_{ij} = \beta_j + bX_{ij}$ with X_{ij} is the trend effect of $(ij)^{th}$ plot with regression coefficient 'b'. For RCBD model, X_{ij} is zero. The notations μ, α_i and β_j are respectively, the general effect, effect of i^{th} variety in j^{th} block. The residual of $(ij)^{th}$ plot is e_{ij}, where $e_{ij} \sim$ IIDN $(0, \sigma^2)$.

In Papadakis (1937) NN model, the mean residuals for adjacent plots have been used to correct the neighbor effects as mentioned by Papadakis (1937). At first, e_{ij} has been calculated as $(Y_{ij} - Y_i)$, where Y_i be the mean of the i^{th} treatment allotted in $(ij)^{th}$ plot. Then X_{ij} be $0.5(e_{i-1,j} + e_{i+1,j})$. We analyzed the data using the X_{ij} as the covariate under RCBD analysis of covariance (ANCOVA) model.

In Iterated Papadakis (Bartlett, 1978) model, the NN analysis is the same as Papadakis (1937) and then considered the first iteration as Papadakis method. The method was repeated for second iteration by recalculating the plot error e_{ij}. Instead of the unadjusted treatment mean allotted to $(ij)^{th}$ plot, the adjusted treatment mean of the first iteration has been used for second iteration. The procedure of iteration was continued till the difference between the adjusted treatment mean of the two subsequent iterations was negligible.

In Wilkinson *et al.* (1983) model (Linear 1-D NN Analysis), let Y_i be i^{th} plot tuber yield, $i = 1, 2, \ldots, n$ where n is number of plots in a block. Then, $Y_i'(b) = Y_i - b\{0.5\,(Y_{i-1} + Y_{i+1})\} = Y_i - b\,\overline{Y}_{Ni}$ where, $\overline{Y}_{Ni} = \{0.5\,(Y_{i-1} + Y_{i+1})\}$. Initially at intra-NN analysis phase, $b = 1$. Therefore, $Y_i'(1) = Y_i - \{0.5\,(Y_{i-1} + Y_{i+1})\}$. Then, we calculated T' as the treatment totals from the plot yield Y_i'. The estimation of treatment parameter can be done by equating $B'\alpha = T'$. An explicit matrix representation of the above equation is $B'\alpha = (rI_v - (1/2)\,A)\,\alpha = T'$, where, α is the vector of treatment parameters of order (v x 1), and v is the number of treatments in the experiment. And A is the adjacency matrix of order (v x v), with entries a_{jk} is number of times treatment k being immediate neighbor of treatment j on an internal plot (treatments on border plots render A non-symmetric). The equations are then converted to $B''\alpha = T''$, where T'' is the total of the treatments of $Y_i'' = Y_i' - Y'_{Bi}$ where Y'_{Bi} is the mean of the block containing Y_i'. To simplify block sweep calculation, we defined $Q = I_v - (1_v 1_v^T)/v$, then we can get $T'' = QT'$ and $B'' = QB'$. The Q operation performed block sweeps on B' and T'. The vector of residuals $z'' = Y'' - \hat{E}\,(Y''; \acute{\alpha})$, where $\acute{\alpha}$ is the estimate of the treatment effects, was obtained. For simplicity, first we calculated $z_i = Y_i - \acute{\alpha}_i$ to develop the vector z, then transformed z by NN adjustment to z', and finally reduced z' to z'' with a sweep of its block means. The resulting expected value of the residual sum of squares is $E(z''^T z'') = E(z'^T z') - r\,(1 + 2\alpha_1\rho'_1 + 2\,\alpha_2\rho'_2)$, where, if each block has d rows or columns in the direction of NN adjustment, $\alpha_k = (d-k)/d$. Here, $\rho'_1 = -2/3$ and $\rho'_2 = 1/6$, as mentioned in Wilkinson *et al.,* (1983). Then, repeated the entire estimation process for optimal $b = b_{opt}$, where $b_{opt} = cov\,(Y_i, Y_{Ni})/V(Y_{Ni})$ for estimation of treatments.

The Relative Efficiency of the NN adjustments over

the RCBD design was evaluated by the formula, RE (%) = (RSS_{NN}/ RSS_{RCBD}) x 100 in percentage value (Stroup *et al.,* 1994), where RSS_{NN} is the residual sum of squares of NN designs, and RSS_{RCBD} is the residual sum of squares of RCBD design. For Wilkinson Method, the efficiency over RCBD is given by E = (1+ *w*) / {1+ (1-*b*) *w*} from the minimum variance formula where $w = \sigma^2_{Trend} / \sigma^2_e$. It is to be noted that RE (%) > 130% indicates the significant presence of neighboring effects (Stroup *et al.*, 1994).

RESULTS AND DISCUSSION

The plot errors of block 2 in 2004, and plot errors of block 3 in 2005 and 2006 were found to be non-normal by W-test (Table 1). The normality was observed when the plot errors were adjusted by the NN method of Wilkinson *et al.* (1983). The results of Mann's test for randomness of the plot errors of block 2 in 2004 and 2005, as well as the plot errors of block 3 in 2006 in RCBD were found non-random (Table 2). The randomness was observed when plot errors were adjusted by NN method of Wilkinson *et al.* (1983).

The three charts (Chart 1, 2 and 3) of serial correlations of the plot errors of the EFY for three years 2004, 05 and 06 respectively, showed before and after detrending using Wilkinson model (1983) for block 2 of all the three year trials. It was observed that after detrending, the randomness of serial correlation lag was obtained, otherwise it was following a trend, particularly for year 2005 and 2006.

The Wilkinson model (1983) had higher relative efficiency of 165% and 124% respectively for 2004 and 2005 (see Table 3). Papadakis model and iterated Papadakis model had RE of 100.09 - 135.36% and 105.90 - 149.93% respectively.

The adjustment of cultivar means after detrending may affect ranking of varieties. So, we compared NN model adjusted means with RCBD unadjusted means. In the year 2004 (Table 5), Wilkinson (1983) NN adjusted means showed a change in ranks of 6 out of 12 varieties. Major change was BCA-1, which became 11th from 8th rank of RCBD analysis. In the year 2005 (Table 6), in Wilkinson's NN adjustment, there was drastic change in seven out of twelve ranks. The 2006 dataset (Table 7) showed change in places of six ranks in Papadakis, six in Iterated Papadakis and only four ranks in Wilkinson. However, change in rank of top performing varieties viz., Singur, BCA-3, BCA-2, NDA-9 and Midnapore, but the 11th rank (Ranchi) and 12th ranking variety (Sree Padma) remains unchanged.

The NN adjustment provides substantial gains in accuracy of treatment effect estimation, which is important for selection of top yielding varieties. As per trial conducted by Terrance *et al*. (2008) and its spatial analysis using autoregressive error structures for growth traits of 275 Douglas-fir progeny trials, more than 97% of the data sets had shown significant model improvement with spatial analysis. Spatial analysis removed 14~34% of residual variance due to spatial heterogeneity. Also, they found spatial adjustment significant decreased the coefficient of variation.

The present study showed similar results in reduction of residual variances of NN analyses over RCBD and thus increased the efficiency of designs for almost all the experiments. Also, the study established the fact that any kind of NN adjustment with 8 to 12 plots/block will at least increase the efficiency over RCBD. The method as described by Wilkinson (1983) gave better results with higher relative efficiency. It was observed that, after detrending using the three NN models, the relative efficiency in case of Wilkinson model was in the range of 102.2% to 165%. Iterated Papadakis method helped in removing spatial trend in the field with relative efficiencies ranging from 105.9% to149.3%. Papadakis method showed a relative efficiency of 100.09% to 135.36%. Among all, Wilkinson model brought a major rearrangement of ranks, however, wide variation in ranks of top five varieties, viz., Singur, Midnapore, BCA-2, BCA-3, NDA-9, under trial was not observed in all of the three NN analyses models concerned within their respective years of observation.

Table 1. W-test for Normality

Year	RCBD			NN Wilkinson (1983)		
	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3
2004	0.953	**0.843***	0.931	0.979	0.938	0.916
2005	0.952	0.940	**0.823***	0.970	0.988	0.988
2006	0.902	0.928	**0.839***	0.924	0.949	0.926

Remarks : The asterisk (*) shows non- Normal data.

Table 2. Mann's test for Randomness

Year	RCBD			NN Wilkinson (1983)		
	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3
2004	1.94	**3.49***	1.552	1.358	0.194	0.776
2005	1.94	**2.91***	1.552	1.552	0.388	0.97
2006	0.388	0.776	**1.970***	1.358	1.164	0.194

Remarks : The asterisk (*) shows non- randomness.

Table 3. The relative efficiency (%) of NN analysis models

Year	(RE %)	Papadakis (RE %)	Iterated Papadakis (RE %)	Wilkinson (RE %)
2004	100.00	101.70	107.10	165.00
2005	100.00	100.09	105.90	124.00
2006	100.00	135.36	149.93	102.20

Table 4. The b_{opt}, Error Mean Squares (EMS) of Wilkinson model

Year	b	W	RCBD EMS	Wilkinson EMS
2004	0.69	1.32	111.47	47.98
2005	0.36	0.34	64.26	47.87
2006	0.18	0.98	8.31	7.34

Table 5. Comparison of actual yield (kg) and NN estimates (2004)

Variety	**RCBD**	**NNA $_{Pap.}$**	**NNA $_{Ited.}$**	**NNA $_{Wil.}$**
BCA -1	45.923 (8)	45.781 (8)	45.737 (8)	35.137 (11)
BCA -2	61.337 (3)	61.138 (3)	61.111 (3)	60.294 (3)
BCA -3	64.270 (2)	64.327 (2)	64.322 (2)	65.632 (2)
NDA -4	43.967 (9)	43.971 (9)	43.983 (9)	45.443 (9)
NDA -5	55.877 (6)	55.870 (6)	55.883 (6)	56.867 (5)
NDA -9	59.377 (4)	59.726 (4)	59.804 (4)	58.076 (4)
Santraganchi	52.917 (7)	53.119 (7)	53.127 (7)	48.482 (8)
Midnapore Fine	43.907 (10)	43.162 (10)	43.035 (10)	48.861 (7)
Midnapore	56.637 (5)	56.970 (5)	57.013 (5)	56.471 (6)
Singur	65.003 (1)	64.721 (1)	64.657 (1)	67.667 (1)
Ranchi	40.767 (11)	40.780 (11)	40.798 (11)	43.404 (10)
Sree Padma	32.117 (12)	32.592 (12)	32.687 (12)	30.248 (12)

Note: Figures in parenthesis represents ranks of the variety.

Table 6. Comparison of actual yield (kg) and NN estimates (2005)

Variety	RCBD	$NNA_{Pap.}$	$NNA_{Ited.}$	$NNA_{Wil.}$
BCA-1	45.503 (8)	45.504 (8)	45.503 (8)	40.023 (11)
BCA-2	59.550 (3)	59.555 (3)	49.555 (6)	60.317 (3)
BCA-3	62.337 (1)	62.341 (1)	62.341 (1)	63.577 (1)
NDA-4	40.587 (10)	40.613 (10)	40.616 (10)	41.147 (9)
NDA-5	54.513 (6)	54.529 (6)	54.526 (5)	55.029 (5)
NDA-9	57.713 (4)	57.706 (4)	57.705 (3)	55.927 (4)
Santraganchi	42.243 (9)	42.227 (9)	42.225 (9)	44.177 (8)
Midnapore Fine	46.457 (7)	46.500 (7)	46.506 (7)	47.320 (7)
Midnapore	54.750 (5)	54.718 (5)	54.714 (4)	54.586 (6)
Singur	60.260 (2)	60.276 (2)	60.278 (2)	61.641 (2)
Ranchi	38.573 (11)	38.569 (11)	38.569 (11)	40.183 (10)
Sree Padma	30.573 (12)	30.526 (12)	30.520 (12)	29.133 (12)

Note: Figures in parenthesis represents ranks of the variety.

Table 7. Comparison of actual and NN yield (kg) estimates (2006)

Variety	RCBD	$NNA_{Pap.}$	$NNA_{Itertd.}$	$NNA_{Wilk.}$
BCA-1	52.437 (6)	52.183 (7)	51.592 (7)	49.995 (7)
BCA-2	53.923 (5)	54.287 (4)	55.030 (4)	54.413 (5)
BCA-3	54.573 (4)	54.101 (5)	53.403 (5)	55.379 (4)
NDA-4	41.477 (10)	42.361 (10)	42.714 (10)	41.963 (10)
NDA-5	52.023 (7)	52.656 (6)	53.032 (6)	52.575 (6)
NDA-9	57.180 (2)	57.065 (3)	56.260 (3)	56.419 (2)
Santraganchi	46.397 (8)	46.363 (8)	47.147 (8)	47.138 (9)
Midnapore Fine	46.337 (9)	44.848 (9)	44.284 (9)	47.458 (8)
Midnapore	56.530 (3)	57.268 (2)	57.547 (2)	55.791 (3)
Singur	59.673 (1)	59.420 (1)	59.450 (1)	60.477 (1)
Ranchi	40.647 (11)	40.580 (11)	40.785 (11)	41.279 (11)
Sree Padma	31.520 (12)	31.584 (12)	31.474 (12)	29.829 (12)

Note: Figures in parenthesis represents ranks of the variety.

Chart 1. Randomness before and after detrending, for year 2004

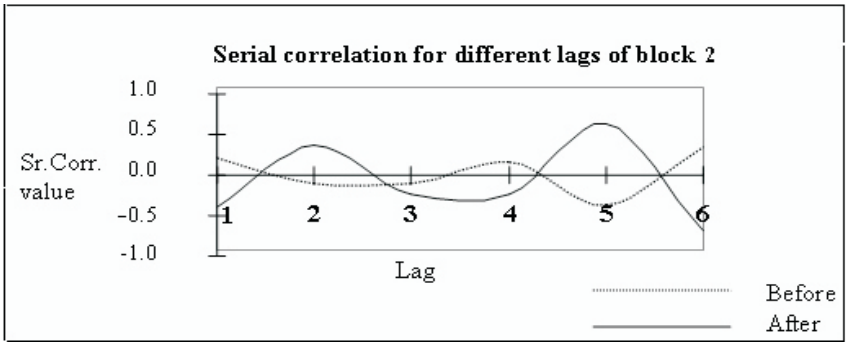


Chart 2. Randomness before and after detrending, for year 2005

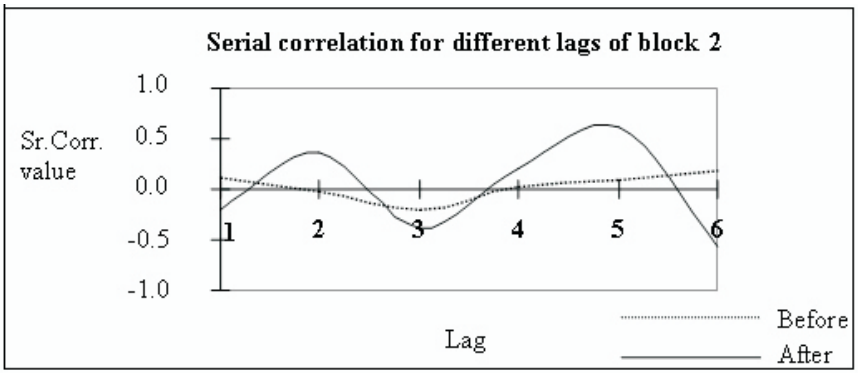
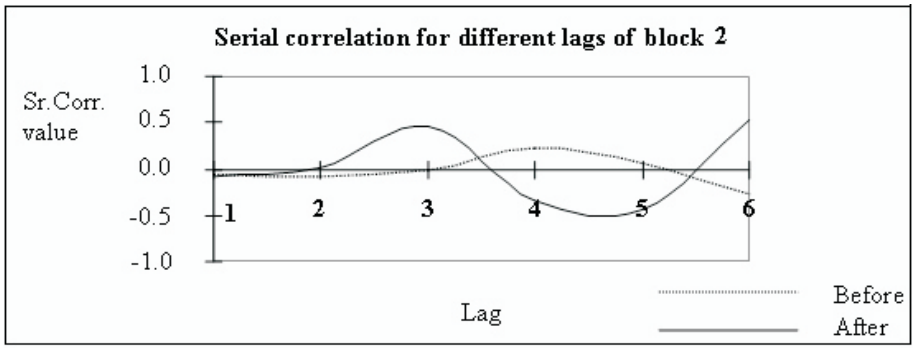


Chart 3. Randomness before and after detrending, for year 2006



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EFFECT OF IRRIGATION AND FERTILIZERS ON SPECTRAL BEHAVIOUR, GROWTH AND YIELD OF SOYBEAN (*Glycine max* L.*)* CROP

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ABSTRACT

A field experiment was conducted at Research Farm, Marathwada Agricultural University, Parbhani, during monsoon 2009-2010 on Mixed Montmorillonitic Hyperthermic Typic Haplusterts to find out the effect of crop management practices on spectral parameters, growth and yield of soybean crop. The experiment was laid out in split plot design with sixteen treatment combinations comprising two irrigation treatments I_1 (No irrigation),I_2 (Irrigation as and when required),two levels of plant protection D_1 (No spraying for pest and disease control),D_2 (Spraying for pest and disease control) and four levels of fertilizers F_1(No N and P application),F_2 (Recommended N application and no P application), F_3(Recommended P application and no N application) and F_4 (Recommended N and P application) were replicated three times. Growth attributes like leaf area, total bio-mass and chlorophyll content and spectral indices RVI (Relative Vegetation Index) and NDVI (Normalized Difference Vegetation Index) were calculated from the reflectance measured in IR and NIR bands of Multiband Ground Truth Radiometer. The study revealed that the highest leaf area index, total biomass and chlorophyll content and P concentration in leaf and grain yield of soybean was obtained with the treatment including irrigation level (I_2),plant protection level (D_2) and fertilizer level (F_4) at all the stages of observations. Interactions between IxD, DxF and IxDxF were additive to increase the leaf area index, total biomass and chlorophyll content of soybean crop. The irrigation, plant protection measures and application of N and P fertilizers had relatively high RVI and NDVI than no irrigation, no plant protection measures and unfertilized treatments. Total chlorophyll and N concentration in soybean leaf established significant and positive relationship with RVI whereas NDVI positively correlated with LAI and total biomass.

(Key words: Soybean, irrigation, fertilizer, Spectral reflectance, RVI, NDVI, growth attributes, yield)

INTRODUCTION

Crop growth and development which decide the economic value of crop is usually affected due to climatic and soil conditions. Therefore, knowledge of leaf canopy spectral response affected by the environmental and cultural factors which alter crop development is important one. Accurate assessment of growth and radiation from spectral measurement will require further understanding of relationship between canopy development and spectral response. (Leamer *et al., 1973* and Daughtry *et al.,* 1980). Differences in Leaf Area Index (LAI) are useful for spectrally separating healthy from stressed crop canopies (Knipling, 1970). Spectral parameters have been used to estimate important crop canopy variables such as LAI, chlorophyll content and biomass of crop species (Kamat *et al.,* 1983 and Verma *et al.*, 2002). With the rapid improvements taking place in sensor technology and space platforms, remote sensing is going to provide advance information on water stress and adverse effects of pest and diseases so as to take appropriate remedial measures.Hence, the present study was carried to find out the effect of irrigation, plant protection and fertilizers on spectral behavior, growth and yield of soybean crop.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* season 2009-10 at Research farm, Department of Agricultural Chemistry and Soil Science, Marathwada Agricultural University, Parbhani. The initial status of experimental soil was clay in texture, (55.1%), alkaline in reaction (pH 8.36) and safe in total soluble salt concentration ($EC_{2.5}$ – 0.4 dSm^{-1}). Among the fertility constituents, organic carbon was 4.4 g kg^{-1}, available nitrogen, phosphorus and potassium contents were 212, 22 and 640 kg ha^{-1}, respectively.

Field experiment was laid out in split plot design on soybean (var. PK472) during *kharif* season. There were 16 treatment combinations consisting of two irrigation treatments I_1 (No irrigation),I_2 (Irrigation as and when required),two levels of plant protection D_1 (No spraying for pest and disease control),D_2 (Spraying for pest and disease control) and four levels of fertilizers F_1(No N and P application),F_2 (Recommended N application and no P application), F_3 (Recommended P application and no N application) and F_4 (Recommended N and P application) were replicated three times. The size of each plot was 5.4 m x 3.6 m . The recommended

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fertilizer dose for soybean crop was 30:60:00 kg N, P_2O_5 and K_2O ha^{-1}. The N and P was applied through urea and single super phosphate. As per the level of N, 15 kg N was applied at the time of sowing and 15 kg N was top dressed after one month of sowing. The soybean crop was sown on 23 rd July 2009 and harvested on 25th November2009.Soybean crop irrigated twice in 37th and 44th meteorological week and three sprayings were given for pest and disease control during the growth cycle. The first spraying of 0.04% carbaryl was given at 22 days after sowing, second spraying of 0.04 % monocrotophos (36 EC) and 0.3 % bavistin was given at 20 days after first spraying and third spraying of 0.05 % quiolphos (20 EC) was given at 15 days after second spraying. The observations were recorded during the growth period of soybean (15, 30,47,76,90 and 107 DAS) on cloud free days. The biometric parameters like leaf area index, total biomass, total chlorophyll content, and nitrogen and phosphorus concentration in leaf and grain yield were also recorded. The leaf samples were dried and processed for estimation of N and P concentration as per the methods described by Jackson (1973). The total chlorophyll was also estimated on spectrophotometer as per the method outlined by Arnon (1949). The correlation and stepwise multiple regression was also worked out.The radiometric measurements were carried out using four-band Optomech Multiband Ground Truth Radiometer on cloud free days throughout growing season. The spectral reflectance observations were taken from a height of 1 m on cloud free days between 11.00 and 13.00 hrs. above the crop canopy and also on $BaSO_4$ calibration plate before and after taking the measurement of canopy. From spectral reflectance data absolute values of various vegetation indices were calculated using following formulae:

Relative vegetation index (RVI) = NIR /R

Normalized difference vegetation index (NDVI) = NIR – R / NIR + R

It is revealed that during the growth period of soybean total rainfall of 931 mm was received in 12 rainy weeks. Its distribution during the month of July, August, September and October was 448,937,613 and 381.4 mm, respectively. There were no rains in the month of November.

RESULTS AND DISCUSSION

Leaf Area Index (LAI):

It was evidenced from table 1 that on 15 and 30 days after sowing (DAS), there was no significant increase in LAI due to irrigation treatment. However, further, scrutiny of data revealed that the LAI significantly increased from 47 DAS to 90 DAS due to need based irrigation treatment. At 107 DAS both treatments viz., no irrigation and irrigation were statistically at par. The non-significant effect of irrigation treatment might be because of sufficient soil moisture present in the soil due to heavy rains received in 40th meteorological week.

The effect of plant protection (Table 1) on LAI over no plant protection was seen at all observations. Protecting the plant against pests and diseases significantly increased LAI over no plant protection at all observations except 90 and 107 DAS. Application of only nitrogen and only phosphorus and their combination showed increase in LAI of soybean. The minimum LAI (1.47) was observed in control treatment (No N and P application). While maximum LAI (3.10) was recorded at 107 DAS in the treatment consisting both nitrogen and phosphorus. Among N and P nutrients, application of nitrogen had more influence on LAI than P application. Patil and Kolte (2002) found that the plant protection measures and application of N,N and P nutrients were superior to increase LAI in soybean over no plant protection and only P application, respectively.

Total Biomass:

The total biomass produced by soybean crop on 15 DAS was 14.53 g $plant^{-1}$ which increased upto 50.28 g $plant^{-1}$ in last observation (107 DAS). The total biomass produced by soybean crop was not affected due to irrigation treatments upto 76 DAS (Table 1). The non-significant results were recorded upto 47 days between no irrigation and irrigation treatments, because of sufficient rain moisture. However, after 90 and 107 DAS, application of irrigation increased the biomass production significantly. This was due to optimum moisture availability after 76 days onward in need based irrigation treatment. The effect of plant protection measures against no plant protection on biomass production was significant at all growth stages except 15 DAS.Among the fertilizer application treatments,

N and P application alone and N in combination with P application significantly increased the biomass production than no nutrient application at 15 and 30 DAS. From 47th day onward, application of N and N + P had significant increase in biomass production. Application of P increased the biomass plant^{-1}, however, it could not reach to the level of significance. Similarly application of nitrogen and phosphorus singly produced non significant results with respect to biomass production plant^{-1}.

Total Chlorophyll Content:

It was evidenced that chlorophyll content (Table 1) of soybean was found to be increased from 15 to 76 DAS (0.34 – 0.54 mg g^{-1}), thereafter chlorophyll content decreased. Effect of irrigation on chlorophyll content was not observed upto 30 days as that of other growth parameters. However, on 47 and 76 DAS chlorophyll content increased from 0.34 mg g^{-1} to 0.40 mg g^{-1} and 0.48 mg g^{-1} to 0.52 mg g^{-1}due to need based irrigation. The maximum chlorophyll content in the leaf of soybean was recorded on 76th DAS and thereafter, chlorophyll content declined upto 107 days. However, irrigation treatment showed significantly higher chlorophyll content than no irrigation treatment at both the observations. The effect of plant protection on chlorophyll content was not seen during the complete growth of soybean crop. The application of nitrogen, phosphorus alone and N + P tended to increase the chlorophyll content of soybean. During grand growth period of soybean i.e. 47 to 90 DAS, N + P treatment found to be superior over rest of the fertilizer treatments. Next to N + P treatment, application of only nitrogen increased more chlorophyll content. The improvement in chlorophyll concentration was attributed to the role of nitrogen in chlorophyll synthesis. Similar line of work was also reported by Patil and Kolte (2002) and Gole *et al.* (2008) who observed a significant increase in total chlorophyll content due to application of need based irrigation and application of N and P fertilizer over control, whereas plant protection measures did not showed significant effect to increase total chlorophyll content.

Nitrogen concentration in leaf:

The nitrogen concentration of leaf samples of soybean on 76, 90 and 107 DAS was determined and the relevant data are presented in table 3. It was observed that N concentration of leaf was increased as growth proceeds. The application of irrigations found to increase the nitrogen concentration in the leaves at all growth stages, however, it could not reach to the level of significance. This might be because of the crop grown during the monsoon season and there was sufficient moisture available throughout the growth period except 32nd and 44th meteorological week. In these weeks, irrigations were applied and there was numerical increase in nitrogen concentration in leaf of soybean.Further, it was observed that plant protection measures did not show significant difference for nitrogen concentration in soybean. The application of nitrogen at the rate of 30 kg ha^{-1} significantly increased leaf N concentration.Further,significant increase in N concentration of leaves was recorded when nitrogen (30 kg Nha^{-1}) was applied @ 60 kg phosphorus (recommended N+P dose).

Phosphorus concentration in leaf:

The phosphorus concentration in leaf was numerically increased due to application of irrigation over no irrigation on 76 and 90 DAS.Whereas no increase in phosphorus concentration in leaf was found on 107 DAS. The adoption of plant protection measures to soybean was found to be ineffective in influencing the P concentration of leaves. The application of nitrogen had synergistic effect on leaf phosphorus concentration of soybean. There was increase in phosphorus concentration when nitrogen was applied to soybean. The application of phosphorus @ 60 kg ha^{-1} and 30 kg N + 60 kg P ha^{-1} found to increase phosphorus concentration at all growth stages over control.

Grain yield:

The data on grain yield of soybean presented in table 3 showed that moisture level did not influence the grain yield of soybean significantly. However, there was significant increase in grain yield of soybean due to spraying against pest and diseases over no plant protection measures. Among the four fertilizer application treatments, maximum grain yield to the extent of 965.09 kg ha^{-1} was obtained with recommended dose of N+P and was significantly superior over rest of the treatments.

Spectral parameters :

Relative Vegetation Index (RVI):

RVI is a good indicator of crop growth and its status (Printer *et al.,* 1981) and it has been successfully used by Ajai (1984) for estimation

of grain yield and biomass production in wheat. The infra red /red reflectance ratio (RVI) has been shown to be related to variations in moisture levels (Table 2). The effect of irrigation treatment was non-significant upto 47 days. Thereafter, irrigated soybean crop showed signficicantly higher RVI upto last observation. Increasing relative vegetative index due to irrigation treatment over unirrigated soybean at 76, 90,107 days were 2.08, 2.32 and 0.82, respectively. The data presented on effect of plant protection over control (Table 2) revealed that due to plant protection treatment, there was numerical increase in RVI at all growth stages. However, the differences were statistically non significant except for 90 DAS. At 90 DAS, RVI was significantly superior in plant protection treatment against pest and diseases over no plant protection. The effect of nitrogen, phosphorus and N + P application indicated that nutrient deficient soybean crop (no nitrogen, no phosphorus i.e. control) had much lower Near Infra Red/Red ratio compared to the fertilized one. This may be because of higher red reflectance and lower IR reflectance for N and P deficient crop. Among the fertility treatments application of N + P treatment showed significantly higher values of RVI over control treatment. It was also observed that application of nitrogen to soybean had relatively higher RVI values than P application. The RVI values were progressively increased upto grand growth period of soybean i.e. upto 76 DAS and thereafter there was progressive decrease in RVI in all fertility level treatments (Table 2).

Normalized Difference Vegetative Index (NDVI):

There was significant variation observed in NDVI due to irrigated and unirrigated soybean (Table 2). The treatment differences were found significant only after 47 DAS. Whereas, before 47 DAS, no significant variation was recorded due to irrigation treatment. After receiving irrigation during 32nd and 44th meteorological week, the growth parameters were improved. The improved growth parameters had significant influence on NDVI of soybean. The adoption of plant protection measures improved the NDVI values throughout the growth of soybean crop. Eventhough differences between no plant protection and plant protection treatments were at par upto 47 days, thereafter plant protection treatment showed significantly higher value of NDVI than no plant protection.

It was observed (Table 2) that nutrient deficient soybean crop had much lower NDVI values compared to fertilized one. Nitrogen received treatment had relatively high NDVI than P applied. Higher values of NDVI in N fertilized soybean plants are due to higher LAI, chlorophyll content and total biomass over complete growth cycle for N fertilized soybean plants. NDVI values progressively increased upto grand growth period of soybean. Thereafter, there was progressive decrease in RVI and NDVI. Nutrient deficient soybean had much lower IR/red ratio compared to the fertilized one. This may be because of higher red reflectance and lower reflectance in NIR for nitrogen deficient crop. Changes in red and NIR reflectance have been attributed to LAI, total chlorophyll and total biomass (Patil and Kolte, 2002 and Gole *et al*., 2008).

Relationship (r –values) between RVI and physiological parameters and leaf nutrient concentration:

Correlation coefficients ('r' values) were worked out to determine the relationship between Relative Vegetation Index (RVI) and other parameters (Table 4). It was observed that leaf area index, total biomass, total chlorophyll, leaf nitrogen and leaf phosphorus had positive correlation with RVI. Further, it was observed that total chlorophyll and nitrogen content of soybean established significant and positive relationship with RVI confirming prominent role of nitrogen in chlorophyll synthesis. RVI showed highly significant correlation with plant nitrogen content and very poor relationship with plant phosphorus.

The relationship of NDVI with leaf area index, total biomass, total chlorophyll, leaf nitrogen and leaf phosphorus was positive (Table 4). However, NDVI had highly significant positive relationship with total biomass production followed by LAI.

The 'r' values presented in table 4 showed positive relationship of grain yield with Relative Vegetation Index and Normalized Difference Vegetation Index. Even though the correlation was statistically non significant, NDVI established more close association (r = 0.484) than RVI(r = 0.271). This suggests that NDVI is better index for predicting the grain yield of soybean (Table 4).

Table 1. Effect of soil moisture, plant protection and soil fertility levels on leaf area index, total biomass production and chlorophyll content

Treatments	Leaf area index DAS						Total biomass production (g plant $^{-1}$)						Chlorophyll (mg g^{-1})					
	15	30	47	76	90	107	15	30	47	76	90	107	15	30	47	76	90	107
Moisture levels																		
I_1	1.90	1.04	1.94	1.83	1.86	2.06	14.43	38.06	39.62	50.35	47.81	47.50	0.34	0.35	0.34	0.48	0.40	0.32
I_2	1.99	2.18	2.38	2.15	2.12	2.57	14.62	38.18	42.56	52.18	55.56	54.06	0.34	0.36	0.40	0.52	0.49	0.35
SE ±	0.118	0.118	0.114	0.125	0.06	0.27	1.15	0.32	1.29	1.94	2.03	20.9	0.004	0.007	0.01	0.010	0.004	0.01
CD at 5%	0.365	0.34	0.350	0.384	0.20	0.85	-	-	-	5.82	6.10	6.24	-	-	0.032	0.036	0.013	0.033
Plant protection levels																		
D_1	1.78	1.84	1.98	1.75	1.94	2.04	13.31	35.93	37.50	46.91	47.81	48.47	0.34	0.32	0.37	0.49	0.44	0.33
D_2	2.17	2.28	2.36	2.23	2.04	2.68	15.75	40.31	44.68	55.62	55.56	54.68	0.34	0.37	0.37	0.52	0.44	0.34
SE ±	0.118	0.113	0.114	0.125	0.06	0.27	1.15	0.32	1.29	1.94	2.03	2.09	0.004	0.007	0.010	0.010	0.004	0.010
CD at 5%	0.365	0.349	0.350	0.384	0.20	0.85	3.98	1.13	4.48	5.83	6.09	6.24	-	0.022	-	0.036	-	-
Fertility levels																		
F_1	1.47	1.57	1.67	1.48	1.35	1.60	13.00	35.12	37.50	48.91	47.50	48.12	0.31	0.33	0.34	0.48	0.40	0.32
F_2	1.58	2.12	2.22	2.05	2.04	2.36	13.75	36.75	40.50	50.41	50.00	49.37	0.35	0.35	0.38	0.52	0.45	0.33
F_3	1.76	1.94	2.04	1.95	1.86	2.19	14.12	37.25	42.37	51.25	52.62	54.37	0.34	0.34	0.36	0.49	0.44	0.33
F_4	1.98	2.61	2.71	2.48	2.72	3.10	17.25	43.37	46.00	54.50	56.62	61.25	0.36	0.36	0.40	0.52	0.48	0.35
SE ±	0.11	0.10	0.110	0.117	0.07	0.15	1.15	1.31	1.20	0.90	1.18	1.26	0.012	0.016	0.013	0.010	0.013	0.014
CD at 5%	0.317	0.314	0.320	0.342	0.20	0.45	3.35	3.82	3.52	2.57	3.54	3.78	0.037	-	0.040	0.032	0.038	-
Interactions																		
I x D																		
SE ±	0.16	0.16	0.161	0.17	0.09	0.39	1.62	0.46	1.83	3.40	2.29	2.24	0.00	0.01	0.01	0.01	0.00	0.01
CD at 5%	-	0.49	0.49	0.54	0.28	1.20	-	-	-	10.20	6.82	6.70	-	-	-	0.05	0.02	0.04
D x F																		
SE ±	0.154	0.15	0.15	0.166	0.09	0.22	1.62	1.85	1.70	2.70	2.51	2.61	0.02	0.02	0.02	0.01	0.02	0.02
CD at 5%	-	0.44	0.45	0.484	0.28	0.64	4.75	5.41	4.97	7.88	7.61	7.83	-	-	0.05	0.04	0.06	0.06
I x D x F																		
SE ±	0.12	0.215	0.219	0.235	0.14	0.31	2.30	2.62	2.41	3.81	2.97	4.53	0.03	0.30	0.02	0.02	0.03	0.03
CD at 5%	0.63	0.62	0.61	0.685	0.40	0.91	6.71	7.65	7.04	11.14	7.51	13.72	0.08	0.10	0.08	0.06	0.09	0.08
Grand Mean	1.95	2.06	2.08	2.21	2.09	2.31	14.53	38.12	41.09	51.27	51.68	50.78	0.34	0.35	0.37	0.50	0.44	0.33

Table 2. Effect of soil moisture, plant protection and soil fertility levels on relative vegetative index (RVI) and normalized difference vegetative index (NDVI)

Treatments	RVI						NDVI					
	15	30	47	76	90	107	15	30	47	76	90	107
Moisture levels												
I_1	7.77	7.70	8.97	8.11	6.61	4.79	0.64	0.71	0.70	0.77	0.70	0.77
I_2	7.12	8.07	9.97	10.19	8.92	5.61	0.65	0.73	0.75	0.83	0.78	0.80
SE ±	0.28	0.06	0.32	0.38	0.30	0.17	0.006	0.009	0.01	0.008	0.01	0.005
CD at 5%	-	-	1.13	1.34	1.05	0.62	-	-	0.03	0.02	0.03	0.01
Plant protection levels												
D_1	7.70	7.84	9.39	8.86	7.14	5.14	0.64	0.72	0.71	0.77	0.72	0.77
D_2	7.18	7.92	9.51	9.44	8.39	5.26	0.65	0.73	0.74	0.83	0.76	0.80
SE ±	0.28	0.06	0.32	0.38	0.30	0.17	0.006	0.009	0.01	0.008	0.01	0.005
CD at 5%	-	-	-	-	1.05	-	-	-	0.03	0.03	0.03	0.01
Fertility levels												
F_1	5.57	6.12	8.43	8.09	6.56	4.64	0.61	0.67	0.69	0.67	0.70	0.75
F_2	7.55	8.05	9.79	9.68	6.95	4.80	0.66	0.68	0.70	0.73	0.73	0.80
F_3	7.48	7.84	9.28	9.05	7.50	5.53	0.62	0.79	0.73	0.74	0.76	0.79
F_4	9.22	10.31	10.75	9.78	9.05	5.83	0.67	0.76	0.78	0.81	0.78	0.78
SE ±	0.68	0.65	0.45	0.46	0.34	0.20	0.01	0.01	0.01	0.02	0.01	0.01
CD at 5%	2.11	1.91	1.31	1.34	0.99	0.58	0.03	0.03	0.02	0.06	0.03	0.03
Interactions I x D												
SE ±	0.39	0.08	0.46	0.55	0.43	0.25	0.008	0.01	0.01	0.01	0.01	0.007
CD at 5%	-	-	1.59	1.90	1.49	0.87	-	-	-	-	-	-
D x F												
SE ±	0.83	0.92	0.63	0.65	0.48	0.28	0.01	0.02	0.02	0.03	0.02	0.019
CD at 5%	-	-	1.85	1.90	1.41	0.82	-	-	-	0.09	0.04	0.05
I x D x F												
SE ±	1.17	1.31	0.89	0.92	0.68	0.40	0.02	0.02	0.03	0.04	0.02	0.02
CD at 5%	3.43	3.83	2.62	2.69	1.99	1.16	-	-	-	0.13	0.06	0.07
Grand Mean	7.44	7.88	9.45	9.15	7.76	5.20	0.64	0.72	0.73	0.81	0.74	0.79

Table 3. Effect of irrigation, plant protection and soil fertility levels on nitrogen and phosphorus concentration in leaf at various growth stages of soybean

Treatments	Leaf N concentration (per cent)			Leaf P concentration (Per cent)			Yield (kg ha^{-1})
	76 DAS	90 DAS	107 DAS	76 DAS	90 DAS	107 DAS	
Moisture levels							
I_1	0.611	1.168	2.18	0.170	0.176	0.183	809.45
I_2	0.777	1.229	2.31	0.180	0186	0.194	835.68
SE ±	0.025	0.280	0.078	0.003	0.001	0.001	9.22
CD at 5%	-	-	-	0.005	0.005	0.004	-
Plant protection levels							
D_1	0.662	1.140	2.26	0.176	0.180	0.188	789.52
D_2	0.657	1.250	2.23	0.176	0.182	0.199	855.61
SE ±	0.025	0.028	0.078	0.003	0.001	0.001	9.22
CD at 5%	-	-	-	-	-	-	29.05
Fertility levels							
F_1	0616	0.877	1.77	0.147	0.147	0.145	659.60
F_2	0.657	1.277	2.21	0.152	0.152	0.150	844.30
F_3	0.688	1.115	2.30	0.209	0.209	0.245	821.27
F_4	0.815	1.526	2.70	0.215	0.215	0.233	965.09
SE ±	0.034	0.055	0.112	0.002	0.002	0.002	12.54
CD at 5%	0.100	0.158	0.322	0.006	0.006	0.007	38.66

Table 4. Correlation coefficient ('r' values) between Spectral indices and growth parameters and yield

Parameters correlated	'r' value	
	RVI	NDVI
LAI	0.150	0.555*
Total biomass	0.321	0.813*
Total chlorophyll	0.550*	0.380
Leaf nitrogen	0.821*	0.349
Leaf phosphorus	0.171	0.457
Grain yield	0.271	0484
Significant at 5%		

Multiple regression equations between RVI and growth parameters, NDVI and growth parameters and grain yield and spectral indices (RVI and NDVI):

Multiple regression equation of spectral indices and other parameters are

RVI = 0.413 + 1.20 LAI – 0.0596 total biomass + 19.04 total chlorophyll – 1.56 Leaf N + 2.56 Leaf P (R^2 = 0.445) ---- I

NDVI = 0.524 + 0.042 LAI + 0.003 total biomass – 0.015 Total chlorophyll + 1.10 Leaf N + 0.012 Leaf P (R^2 = 0.738) ----------II

Y= -616.58 + 33.37RVI + 159.97 NDVI (R^2= 0.424)----------III

The statistical relationship between RVI and NDVI with physiological parameters and leaf nutrients concentration were established by multiple regression equation of type $Y = a + b_1x_1 + b_2x_2 \ldots b_nx_n$, x_n where 'a' is an intercept and b_n to x_n are regression coefficients of x_1 to x_n, respectively.

The equation I have R^2 value 0.445 which showed relative contribution of various growth parameters and leaf nutrient concentration to the extent of 44 per cent in RVI of soybean. RVI of soybean found to be influenced nearly 1.20, -0.0596, 19.04, -1.56 and 2.58 units with one unit change in LAI, biomass, chlorophyll, and plant nitrogen and plant phosphorus, respectively.

Equation II developed for NDVI showed nearly 74 per cent contribution of studied growth parameters and plant nutrients in influencing NDVI (R^2 =0.738). It was observed that all studied parameters had influenced NDVI.

Grain yield of soybean (Y = predicted grain yield) was found to be influenced more due to NDVI than RVI and the adaptability of this equation (equation number III) was 42%. Among various parameters, total chlorophyll and leaf nitrogen content established significant and positive relationship with RVI and this was obvious because nitrogen plays very important role in chlorophyll synthesis and red radiance is more sensitive to chlorophyll pigment because chlorophyll bands are in centre of blue to red region (0.45 to 065 µm). Similar observations were recorded by Patil and Kolte (2002). NDVI showed highly significant positive relationship with total biomass production followed by LAI. The multiple regression equations indicated the relative contribution of various growth parameters and plant nutrient concentrations to the extent of 44 per cent in RVI and 74 per cent in NDVI.

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GENETIC ANALYSIS OF YIELD AND YIELD CONTRIBUTING CHARACTERS IN LINSEED (*Linum usitatissimum* L.)

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ABSTRACT

In the present study genetic analysis of yield and yield components in linseed (*Linum usitatissimum* L.) comprises of thirty nine F_1 crosses. These were obtained by crossing three females with thirteen males. These crosses were grown in Randomized complete block design and replicated twice at college of Agriculture, Nagpur during *rabi* 2011-12. These were used to asses the genetics of yield and yield contributing characters. The analysis of variance for the experimental design showed that, the mean squares due to between families were highly significant for all ten characters days to 50% flowering, plant height (cm), number of capsules plant^{-1}, number of branches plant^{-1}, days to maturity, 1000 seed weight (g), seed yield plant^{-1} (g), budfly infestation percentage, Alternaria blight percentage, and powdery mildew under study indicating substantial genetic variability. The analysis of variance for sums (L1i+L2i) and differences (L1i - L2i) and estimates of additive (D) and dominace (H1) components indicated that, the mean squares due to sums (L1i + L2i) were significant for all the characters, except plant height. The mean squares due to differences (L1i – L2i) were significant for all the characters except days to maturity and budfly infestation percentage. Additive (D), dominance (H_1) and epistasis components of genetic variation played an important role in the inheritance of characters under study including seed yield. The parents RLC-92, Nagarkot, Mukta and Sheela with high additive genetic variation will be useful for improvement of economic characters and may be utilized in hybridization programme.

(Key words: Genetic analysis , yield components , linseed)

INTRODUCTION

The assessment of magnitude of gene action for quantitative character is helpful in deciding the most efficient breeding procedure. In linseed, generation means, line x tester and diallel analysis has been used to asses the magnitude of gene action for quantitative characters. It has been also used to estimate additive and dominance components. These procedures are based on the assumption of absence of epistasis, which is known to be of wide occurrence in almost all the crop plants. For detecting epistasis there is a need of mating designs which detect epistasis and precisely estimate additive and dominance components. The triple test cross analysis detect epistasis and estimate additive and dominance components of genetic variation in self-pollinating crops. In spite of their simplicity, greater precision and their application in autogamous crop, particularly in linseed it has limited application. This analysis and its modifications are available since 1968.on

MATERIALS AND METHODS

The experimental material comprised of thirteen donor parents viz., Laxmi, T-397, Jeevan, Kiran, Mukta, Parvathi, Sheela, Heera, RLC92, Deepika, Nagarkot, Himani, Neela crossed with NL-97, Karthika, Padmini. This complete set of material under study consisting of 13 male parents and 3 female parents and 39 crosses were be grown in randomized complete block design with two replications in *rabi* 2011. The row to row spacing was 30 cm. The plants were spaced 30 cm between rows and plants. NL-97 as border plants was grown on all sides of the block to avoid border effect. Three seeds initially sown in each hill were subsequently thinned to one plant hill^{-1}, when the plants had established properly. Recommended package of practices were followed to raise a good crop. Data were recorded for all the plants of each family for the following characters. viz., days to maturity, plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1},budfly infestation (%), alternaria blight infestation (%), powdery mildew, 1000 seed weight (g) and seed yield plant^{-1} (g) except days to 50% flowering for which observations were recorded on plot basis. The data were subjected to the statistical and biometrical analysis as per the methodology suggested by Panse and Sukhatme (1954) for analysis of variance and Jinks *et al.*(1969) for estimation of additive, dominance and epistatic components of variation.

RESULTS AND DISCUSSION

The analysis of variance for the experimental

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Table 1. Analysis of variance for the experimental design

Source of variation	Degrees of freedom	Days to 50 % flowering	Plant height (cm)	Number of capsules plant^{-1}	Number of branches plant^{-1}	Days to maturity	1000 seed weight (g)	Seed yield plant^{-1} (g)	Budfly (%)	Alternaria blight (%)
Replication	1	2.88	16.40	0.05	0.88	35.47	0.27	0.12	4.19	2.28
Crosses	38	6.85**	58.42**	771.11**	2.34**	14.35**	0.74**	1.05**	15.59**	4.06**
Error	38	1.60	6.95	37.28	0.25	5.83	0.11	0.16	1.63	0.33

*, ** = significant at 5% and 1% level respectively

Table 2. Test of epistasis for different characters

		Mean squares								
Source of variation	**Degrees of freedom**	**Days to 50 % flowering**	**Plant height (cm)**	**Number of capsules plant^{-1}**	**Number of branches plant^{-1}**	**Days to maturity**	**1000 seed weight (g)**	**Seed yield plant^{-1} (g)**	**Budfly (%)**	**Alternaria blight (%)**
Epistasis $\overline{L_{1i}}+\overline{L_{2i}}-\overline{P_i}$	12	4.78	11.24	130.74**	1.58**	16*	0.55**	0.34**	6.04**	3.14**
Error	12	6.16	10.13	21.76	0.26	24.82	0.08	0.05	0.77	0.60

*, ** = significant at 5% and 1% level respectively

Table3. Estimation of individual line ($\overline{Pi}$) contribution to the epistasis comparison $\overline{L}_{1i}+\overline{L}_{2i}-\overline{P}_i$ for different characters

Sr. No.	Parents (Pi)	Days to 50 % flowering	Plant height (cm)	Number of capsules plant^{-1}	Number of branches plant^{-1}	Days to maturity	1000 seed weight (g)	Seed yield plant^{-1} (g)	Budfly (%)	Alternaria blight (%)
1	Lakshmi	52.0	51.15	83.45	7.1	97.5	4.60	3.48	12.72	7.42
2	T-397	52.5	48.10	96.95	6.7	107.0	6.15	3.79	17.94*	7.14
3	Jeevan	55.0	49.69	109.03	6.6	98.5	7.05	4.37	8.14	8.02
4	Kiran	58*	49.02	88.45	3.9	102.5	4.65	3.54	13.03	11.50
5	Mukta	52.5	44.78	101.45	7.5	100.0	6.40	4.30	15.22	5.81
6	Parvati	53.5	44.27	90.30	7.6	105.0	6.45	3.61	8.43	12.25*
7	Sheela	49.5	44.98	69.65	4.7	92.50	7.15	2.28	11.96	8.50
8	RLC-92	52.5	41.99	117.75*	8.9*	95.0	7.00	5.18*	11.76	6.79
9	Deepika	54.5	47.45	84.79	5.3	107*	7.45*	3.73	11.45	5.47
10	Nagarkot	50.0	41.28	90.50	5.7	107.0	7.00	3.58	15.45	8.22
11	Himani	54.5	43.70	85.00	7.5	104.0	6.10	3.09	9.20	6.84
12	Neela	47.5	50.98	78.72	7.5	96.0	5.85	3.34	11.8	6.21
13	Heera	52.0	55.47*	69.90	4.0	101.0	5.75	2.92	8.28	4.90

Table 4. Analysis of variance for the sums and differences for different characters

		Mean squares								
Source of variation	**Degrees of freedom**	**Days to 50 % flowering**	**Plant height (cm)**	**Number of capsules plant^{-1}**	**Number of branches plant^{-1}**	**Days to maturity**	**1000 seed weight (g)**	**Seed yield plant^{-1} (g)**	**Budfly (%)**	**Alternaria blight (%)**
Sums $\overline{L}_{1i}+\overline{L}_{2i}$	12	7.80**	8.30	157.68**	2.0**	16.77**	0.45**	0.42**	7.25**	4.72**
Error	12	0.72	10.45	16.13	0.21	3.81	0.08	0.05	0.68	0.35
Differences $\overline{L}_{1i}-\overline{L}_{2i}$	12	7.25**	30.54**	923.49**	2.56**	12.51	0.82**	0.95**	5.39	2.59**
Error	12	1.16	5.62	34.85	0.30	6.85	0.07	0.07	2.06	0.27
Components of genetic variation										
D		7.08	–	141.55	1.79	12.96	0.37	0.37	6.57	4.37
H_1		6.09	24.92	888.64	2.26	_	0.75	0.88	_	2.32
		0.92	_	2.50	1.12	_	1.42	1.54	_	0.72
$\sqrt{\frac{H}{D}}$										

Table 5. Estimation of individual line (Pi) contribution to the (1) Additive comparison ($L_{1i}+L_{2i}$) and (2) Dominance comparison ($L_{1i}-L_{2i}$) for different characters

Sr. No.	Parents (Pi)	Number of capsules plant^{-1}		Number of branches plant^{-1}		Days to maturity		1000 seed weight (g)		Seed yield plant^{-1} (g)		Budfly (%)		Alternaria blight (%)	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(2)	(2)
1	Lakshmi	130.0	-41	9.90	-0.50	199.50	-0.5	11.25	-0.25	5.185	-1.515	32.85	3.92	12.41	-0.31
2	T-397	141.60	-17.2	9.80	0.40	206.0	2	11.85	0.05	5.530	-1.010	35.67	-1.12	15.66	-3.07
3	Jeevan	152.33	29.73	10.20	-1.20	197.50	1.5	12.70	0.00	6.160	0.800	31.64	1.04	16.07	-2.64
4	Kiran	139.80	-64.8	8.15	-0.65	203.0	0	10.50	1.10	5.465	-2.105	37.26	0.57	17.56	-2.51
5	Mukta	141.35	8.95	12.30	1.90	200.50	0.5	13.0*	1.80	6.085	0.115	37.28	-3.18	15.56	-2.41
6	Parvati	137.00	-29.4	11.20	-0.80	206.0	-1.0	12.40	-0.50	5.275	-1.185	33.76	-0.78	19.85	-2.87
7	Sheela	135.30	-25.5	9.70	1.70	197.50	4.5	12.15	0.25	4.995	-0.685	38.59	2.10	20.22*	0.49
8	RLC-92	167.7*	-39.3	12.4*	-0.20	193.50	-3.5	12.50	-0.40	7.125*	-1.215	37.03	0.57	15.70	-1.61
9	Deepika	137.29	32.09*	10.0	4.0*	204.0	-5.0	12.15	2.15*	5.935	0.735	36.10	-1.29	15.44	-0.85
10	Nagarkot	136.10	-32.9	9.50	-2.10	208.5*	-7.5	12.25	-0.35	5.225	-1.285	42.02*	5.58*	16.95	1.4*
11	Himani	128.20	-34.2	10.70	-0.3	203.0	2.0	11.75	-0.45	4.805	-1.215	37.43	1.47	17.51	0.84
12	Neela	126.07	17.43	10.30	1.30	202.0	5*	12.15	-0.15	5.160	0.8*	38.35	-1.12	5.35	-0.05
13	Heera	116.45	-39.65	7.30	-0.10	201.0	0.0	11.30	-0.70	4.820	-1.350	35.41	0.77	13.65	0.77

design has been presented in table1. The mean squares due to between families were highly significant for all characters under study indicating substantial genetic variability. The test of epistasis for different characters has been presented in the table 2. It indicatated that the presence of epistasis for all characters, except days to 50% flowering and plant height. Epistasis ($\bar{L}_{1i} + \bar{L}_{2i} - P_i$) is an important component in the inheritance of quantitative traits in linseed for all traits under study. Epistasis for yield and its components has been reported in linseed by Tak and Gupta (1989), Sood *et al.* (2007), Savita *et al.* (2011) and Jadhv *et al*. (2011). In the present study, the estimates of individual line contribution to the epistatic comparison ($\bar{L}_{1i} + \bar{L}_{2i}$-$p_i$) have been presented in table 3. The parent Kiran contributed maximum epistatic variation for days to 50% flowering, Heera showed maximum epistatic variation for plant height, RLC-92 showed maximum epistatic variation for number of capsule plant^{-1}, branches plant^{-1} and seed yield plant^{-1}, for days to maturity and budfly infestation percentage parent T-397 exhibited maximum epistatic variation, Deepika recorded maximum epistatic variation for 1000 seed weight and Parvati contributed maximum epistatic variation for the alternaria blight percentage.

The analysis of variance for sums ($\bar{L}_{1i} + \bar{L}_{2i}$) and differences ($\bar{L}_{1i} + \bar{L}_{2i}$) and estimates of additive (D) and dominace (H_1) components (Table 4) indicated that, the mean squares due to sums ($\bar{L}_{1i} + \bar{L}_{2i}$) were significant for all the characters, except plant height. The mean squares due to differences ($\bar{L}_{1i} + \bar{L}_{2i}$) were significant for all the characters except days to maturity and budfly infestation percentage. The additive (D) and dominance (H_1) components were estimated for different characters under epistatic model and have been presented in table 5. The additive (D) components were predominant for all the characters. This was also reported by Pillai (1991), Reddy (2008), Mane (2009) and Jadhv *et al.* (2011).

The additive genetic variation is predominantly exploited in varietal improvement programme in linseed. Therefore, the parents with high additive genetic variation may be utilized in linseed breeding programme. The parent RLC-92 showed high additive genetic variation for number of capsules plant^{-1}, number of branches plant^{-1} and seed yield plant^{-1}, Nagarkot for the days to maturity, 1000 seed weight, and budfly infestation percentage, Mukta for 1000 seed weight , number of capsules plant^{-1}, days to maturity and seed yield plant^{-1} and Sheela exhibited additive genetic variation for alternaria blight, budfly infestation percentage and 1000 seed weight.

In the present study, both additive (D) and dominance (H_1) components of genetic variation play an important role in the inheritance of characters under study. Therefore, RLC-92, Nagarkot, Mukta and Sheela with high additive genetic variation will be useful for improvement of economic traits and may be utilized in hybridization programme.

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PHYSICO CHEMICAL STUDY OF KHOA SOLD IN NAGPUR CITY

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ABSTRACT

The present investigation was carried at Animal Husbandry and Dairying section, College of Agriculture, Nagpur during the year 2011-12 to study the physico-chemical and sensory quality of khoa sold in Nagpur city. The market khoa samples were collected from four sources viz., East, West, North and South region of Nagpur city. It was found that East, West, North and South region khoa samples had on an average moisture content of 29.21, 27.38, 28.98, and 30.44 per cent, fat 30.39, 25.19, 24.26, and 22.65 per cent, protein 18.70, 16.06, 16.90, and 16.91 per cent, ash 3.39, 4.20, 4.04, 3.94 per cent and total solids 70.99, 72.61, 71.60, and 69.04 per cent respectively. The overall sensory quality score of East, West, North and South Nagpur khoa were 86.97, 82.31, 83.13 and 81.57out of 100, respectively. The khoa produced and marketed in West region of Nagpur city had better physico-chemical quality than East, North and South Nagpur khoa which were fair but far below the Bureau of Indian Standards (Anonymous, 1968) and showed acidic and burnt flavour with mealy to gritty texture, presence of visible foreign matter and slightly mouldy appearance.

(Key words: Physico-chemical quality, sensory attributes and khoa)

INTRODUCTION

Khoa is a concentrated milk product. It is very rich in total solids and hence, highly nutritious food in the diet of human beings. According to Bureau of Indian Standards (Anonymous, 1968) khoa shall not contain moisture more than 28 per cent and fat not less than 26 per cent on dry matter basis. India is now the largest producer of milk in the world with annual production over 121.08 million tones in 2010-11, while in Maharashtra state, the total milk production has been increased significantly and was 9.7 million tonnes during 2010 (Anonymous, 2011).

Khoa is obtained by rapidly evaporating milk in shallow pans to total solid content of about 70 per cent. The product could be preserved for several days and is also used as base for different kinds of sweet like Pedha, Burfi, Gulabjamun, Kalakand etc. Naturally, there is a considerable demand for this product in big cities. Unfortunately, the manner in which this product is prepared, packed and transported is in very unhygienic conditions.

The demand for milk and milk products of Nagpur city is high and increasing day by day rapidly. In the city, wholesalers, halwai, hoteliers etc. prepare khoa by purchasing milk from milkmen of different areas. While others purchase readymade khoa from markets of surrounding areas i.e. Sitabuildi, Medical square, Sadar. The main business of purchase of khoa at Nagpur is in the hands of few wholesale dealers and retailers.

By considering nutritional significance and economical importance of khoa, it become essential to find out the percentage of chemical ingredients that are present in it. According to BIS (Anonymous, 1968) khoa shall not contain moisture more than 28 per cent and the fat content of it shall not be less than 20 per cent on dry matter basis.

The conventional methods used by halwais for the manufacture of khoa, suffer from several inherent limitations such as wide variation in chemical, microbial and sensory qualities from batch to batch, poor packaging and also limited shelf life of the product.The traditional dairy product sector will play a vital role in value added utilization of rapidly increasing milk production in the country. (Aneja *et al*., 2002). Now a days value and demand of khoa increasing rapidly. There are very few systematic studies conducted on physico-chemical aspects of marketed khoa. Keeping these facts in mind, present paper was focused on physico-chemical aspects of khoa sold in various areas of Nagpur city.

MATERIALS AND METHODS

The study of physico-chemical and sensory qualities of khoa sold in Nagpur city was conducted during 2011-12 at Animal Husbandry and Dairying Section, College of Agriculture, Nagpur. The samples were collected from the four localities of Nagpur city viz., (A) Eastern area (East), (B)Western area (West), (C) Northern area (North) ,(D)Southern area (South). 5 samples were collected from each region at a time

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i.e.20 samples were collected during one visit. Likewise subsequently same number of samples were collected twice at forthnightly interval. Thus, collection of samples was replicated thrice. The samples were collected in suitable containers and stored in refrigerator till the samples were used forsensory evaluation and physico-chemical analysis viz., moisture, protein, fat, ash and total solids. Fat content was determined by Soxhlet extraction method (Anonymous, 1990). Total solid was estimated by hot oven method and moisture content in khoa sample was determined by subtracting the total solids content from 100 in the sample.

$$\text{Moisture} = 100 - \text{Total solids}$$

Protein content of khoa samples were determined by kjeldahals method described by Aggrawal and Sharma (1961). Ash content of khoa samples were determined as per procedure prescribed by Bureau of Indian Standards, IS-1165 (Anonymous, 1967) as per equation given bellow.

$$\% \text{ of Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

The collected samples of khoa were subjected to sensory evaluation in respect of flavour, body, and texture, and colour and appearance of each sample and score was given with the help of 100 point numeric scale of scores prescribed by Pal and Gupta (1985) as stated bellow for various sensory attributes.

1. Flavour	-	45
2. Body and Texture	-	35
3. Colour and Appearance	-	20
Total	-	100

Data were statistically analyzed by using analysis of variance – two way classifications. Critical difference was calculated to determine the significance.

RESULTS AND DISCUSSION

The results on chemical composition of khoa samples collected from four localities of Nagpur city viz., East, West, North and South regions are presented in table1.

Moisture:

The moisture content of khoa samples collected from four different localities i.e. East, West, North and South area of Nagpur city was recorded as 29.21, 27.38, 28.97 and 30.44 per cent respectively. Moisture content of khoa sources showed significant differences. However, the maximum average moisture content was recorded in South Nagpur khoa and minimum in West Nagpur khoa. West Nagpur khoa was significantly superior followed by North, East and South Nagpur khoa in respect of moisture content. So, West Nagpur khoa samples meet the BIS specification (Anonymous, 1968) in respect of moisture content (28.00 per cent maximum).

Moisture level in dairy product like khoa is deciding factor so far as yield and profit is concerned. It appears from the results that South Nagpur khoa contained more moisture. Kurand *et al.* (2011) noticed that khoa sold in Washim was significantly superior (27.20) over Karanga and Risod khoa in respect of moisture content. These observations are in line with the results of present investigation. Similarly, Katole (2002) also noticed moisture content of 26.94% in khoa prepared by traditional method.

Fat:

It was observed from table 1 that the fat percentage of khoa sold in Nagpur city ranged from 22.65 to 30.39 per cent in which mean values of fat content of East, West, North and South Nagpur khoa recorded were 30.39, 25.19, 24.26 and 22.65 per cent respectively for this attribute. These differences were found to be significant for fat content. However, the maximum fat content was recorded in East Nagpur khoa from the khoa samples collected from East Nagpur followed by West, North and South Nagpur khoa. The fat content of East khoa was significantly superior over West, North and South Nagpur khoa. However, West, North and South Nagpur khoa which contained less per cent of fat in khoa were conformed to BIS specification (Anonymous, 1968) in respect of fat (20.00 per cent minimum).

Sharma (2006) and Kurand *et al.* (2011) reported fat content of khoa in the range of 19 to 27.70 per cent. These observation are supportive to present trends.

Protein:

The protein content of khoa samples collected from four different localities i.e. East, West, North and South regions of Nagpur city was recorded

as 18.70, 16.06, 16.90 and 16.91 per cent respectively. The maximum average protein content of market khoa recorded by East Nagpur khoa followed by West, North and South Nagpur khoa. East Nagpur khoa samples were significantly superior over West, North and South Nagpur khoa in respect of protein content.These results are in line with the results of Kurand *et al.* (2011). They found protein content of khoa in the range of 17.26 to 18.89 per cent.

Ash:

The ash content of khoa samples collected from four different localities i.e. East, West, North and South regions of Nagpur city was observed as 3.39, 4.20, 4.04 and 3.94 per cent respectively. These differences were found to be significant in respect of ash content. The maximum percentage of ash was recorded by West Nagpur while minimum ash content obtained in East, North and South Nagpur khoa. The findings of present investigation are in accordance with the findings of Katole (2002) and Kurand *et al.* (2011). They also noticed ash content of khoa in the range of 3.70 to 4.06 per cent.

Total-solids:

The total solid content of khoa samples collected from four different localities i.e. East, West, North and South area of Nagpur city was found as 70.99, 72.61, 71.60 and 69.04 per cent, respectively. It was noticed that West Nagpur khoa recorded maximum percentage of total solids followed by North, East and South Nagpur khoa. West Nagpur khoa was significantly superior over East, West and South Nagpur khoa in respect of total solids contents.

These results are in line with the results of Kurand *et al.* (2011). They reported total solids content of khoa in the range of 69.89 to 72.80 per cent.

Sensory quality of khoa

The results on the organoleptic quality of Khoa collected from Nagpur city are presented in table 2.

Flavour:

The flavour score (out of 45) of khoa samples collected from four different localities of Nagpur city i.e. East, West, North and South regions of Nagpur city were observed as 40.58(90.17%), 38.84(86.31%), 37.62(83.60%) and 36.27(80.60%) respectively. These differences were found to be significant for flavour scores. However, maximum average flavour score was contributed by East Nagpur khoa whereas, the lowest contributed by West Nagpur khoa. East Nagpur khoa was significantly superior over West, North and South Nagpur khoa for average flavour scores. Out of four sources North and South Nagpur khoa, received adverse comments for flavor, which was most inferior with slightly acidic flavor.

Kulkarni and Hembade (2010) reported that the flavour score of Ambajogai, Dharur, Wadwani, khoa samples showed significantly more than other taluka khoa samples. Typical mild cooked flavour similar to the prescribed from the boiled milk is more acceptable. Similarly, Kurand *et al*. (2011) reported that out of three sources of khoa which was sold in Washim city, Karanja and Risod received adverse comments, which was most inferior with slightly acidic flavour due to long storage period and also slight burnt flavour. The present findings support these results.

Body and texture:

The score for body and texture (out of 35) of khoa samples collected from East, West, North and South regions of Nagpur was observed 30.40 (86.85%), 25.37(72.48%), 29.24(83.54%) and 27.58(78.80%) respectively. It was noticed that minimum and maximum average body and texture was exhibited in East Nagpur khoa and West Nagpur khoa, respectively. These differences were found to be significant for body and texture scores. So East Nagpur khoa was significantly superior over West, North and, South Nagpur khoa in respect of body and texture scores, North, West and South Nagpur khoa were found to be mealy to gritty in texture.

Kurand *et al.* (2011) noticed that the average body and texture scores of Washim districts khoa ranged from 29.17 to 32.18. They noticed that minimum and maximum average body and texture was exhihibited in Risod khoa and Washim khoa, respectively. They further noticed that there was variation in average score of body and texture of khoa samples collected from Washim, Karanja and Risod in first, second and third fortnight.These results are in conformity with the findings of present study.

Colour and appearance score:

The score for colour and appearance (out of 35) of khoa samples collected from East, West, North

Table 1.Chemical composition of Khoa Sample **(mean of 15 samples)**

Source	Moisture%	Fat%	Protein%	Ash%	Total solids %
A (East)	29.21[b]	30.99[a]	18.70[a]	3.39[d]	70.99[c]
B (West)	27.38[d]	25.19[b]	16.06[d]	4.20[a]	72.61[a]
C (North)	28.97[c]	24.26[c]	16.90[c]	4.04[b]	71.60[b]
D (South)	30.44[a]	22.65[d]	16.91[b]	3.94[c]	69.04[d]
S E (m) ±	0.23	1.49	0.68	0.22	0.79
C D at 5%	0.57	3.66	1.66	3.94	1.95

Table 2. The overall score of khoa samples collected from Nagpur city (out of 100)

(mean of 15 samples)

Sources	Flavour(45)	Body and texture(35)	Colour and Appeaence(20)	Overall acceptiblity Score(100)
A (East)	40.58[a] (90.17)	30.40[a] (86.85)	16.12[c] (80.60)	86.97[a]
B (West)	38.84[b] (86.31)	25.37[d] (72.48)	15.89[d] (79.45)	82.31[b]
C (North)	37.62[c] (83.60)	29.24[b] (83.54)	16.25[b] (81.25)	83.13[b]
D (South)	36.27[d] (80.60)	27.58[c] (78.80)	17.05[a] (85.25)	81.57[b]
S E (m)±	0.49	1.32	0.23	0.99
C D at 5%	119	3.23	0.58	2.43

N.B. figures in parentheses indicate percentages

and South area of Nagpur city were observed as 16.12(80.60%), 15.89(79.45%), 16.25(81.25%) and 17.05(85.25%) respectively. The maximum score recorded by South Nagpur khoa followed by North, East and West Nagpur khoa. The average scores obtained for colour and appearance of market khoa differed significantly. South Nagpur Khoa was found to be significantly superior over West, North and South Nagpur khoa samples in respect of average colour and appearance score. The samples from East, West and North Nagpur khoa showed slightly brown and black speaks burnt spots.

Kurand *et al.* (2011) reported that the average scores obtained for colour and appearance of Washim district khoa (from three sources) differed significantly. Washim khoa was found to be significantly superior over Karanja khoa and Risod khoa in respect of colour and appearance score. The samples from Risod and Karanja khoa showed slightly brown and black speaks of burnt spots, slightly moldy and there appeared visible foreign matter like news paper pieces which influenced the scores for this sensory attribute.

Overall acceptability:

It was observed from table 2 that the average overall acceptability of khoa sold in Nagpur city ranged from 81.57 to 86.97. However, the mean values of overall acceptability scores of khoa samples collected from East, West, North and South region of Nagpur khoa recorded 86.97, 82.31, 83.13 and 81.57 per cent respectively. The highest score was recorded in East Nagpur khoa while the lowest score was recorded in South Nagpur khoa. Out of 100, the differences of score obtained for khoa sources were

found to be significant. East Nagpur khoa was found to be significantly superior over West, North and South Nagpur khoa in respect of overall acceptability.

The average overall acceptability of Washim district khoa ranged from 82.22 to 90.26. The differences of score obtained for khoa sources were found to be significantly superior over Karanja and Risod khoa in respect of overall acceptability (Kurand *et al.*, 2011).

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EFFECT OF DEFICIENCIES OF VARIOUS MINERAL ELEMENTS ON MORPHO-PHYSIOLOGICAL PARAMETERS OF GREENGRAM

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ABSTRACT

The investigation was carried out at Botany section, College of Agriculture, Nagpur during *kharif* 2011-2012 in CRD with three replications and eight treatments viz., N, P, K, S, Mg, Fe, Zn and control. Morpho-physiological characters such as plant height, internodal length, shoot dry weight, root dry weight, total dry weight of plant, root: shoot ratio and root volume were significantly declined in plant deficient in any of the essential nutrients mentioned above when compared with control. Significant reduction in plant height was recorded in Fe (37.45%), Mg (30.18%), K (25.78%), N (23.99%), Zn (22.41%), S (22.41%) and P (20.52%) deficiencies over control. Internodal length was significantly reduced in Mg (63.73%) and Fe (62.18%) followed by S (56.19%), Zn (48.52%), K (38.62%), P (31.56%) and N (27.13%) deficiencies over control. Shoot dry weight was reduced significantly in deficiency of Fe (78.65%) followed by Mg (69.10%), S (62.92%), K (60.11%), N (57.30%), Zn (54.49%) and P (54.49%) when compared with control. Root dry weight was reduced significantly in deficiency of Fe (85.71%) followed by Mg (79.59%), S (75.51%), Zn (65.31%), N (63.26%), K (61.22%) and P (61.22%) when compared with control. Total dry weight decreased significantly in deficiency of Fe (79.74%) followed by Mg (71.81%), K (60.35%), S (65.64%), N (59.03%), Zn (56.39%) and P (55.95%) over control. The root to shoot ratio was reduced significantly in deficiency of Mg (35.71%), S (35.71%), Fe (32.14%), Zn (25.00%), N (21.42%), P (17.85%) and K (07.14%) when compared with control. Root volume decreased significantly in deficiency of Fe (62.03%) followed by Mg (51.31%), S (47.71%), P (24.05%), Zn (22.78%), K (21.42%) and N (20.15%) when compared with control.

(Key words: Greengram, deficiency of essential mineral elements, morpho-physiological parameters)

INTRODUCTION

Green gram is one of the important pulse crops in India. It belongs to family leguminoceae and sub family Papilionaceae with chromosome number (2n= 24). Green gram is a protein rich staple food. It contains about 25% protein, which is almost three times more than that of cereals. N, P and K are three major or primary nutrients which are to be made available in larger quantities. Ca, Mg and S are three major or secondary nutrients and Fe and Zn are minor or micronutrients which are to be made available in smaller quantities as compared to primary nutrient (Jain, 2010). Hence, the present investigation was undertaken to know the abnormalities in physiology, growth and development of greengram due to nutrient deficiencies.

MATERIALS AND METHODS

Pot culture experiment was carried out in glass house of Botany Section, College of Agriculture, Nagpur during 2011-2012 with cultivar PKV mung 8802 in CRD with three replications and eight treatments. Sowing was done on 14th July 2011. Seedlings were transplanted in Hoagland solution after 20 days in glass jar having silica sand. Three pots were allotted for each treatment in each replication. There were 24 pots in each replication. Initially stock solutions using analar grade chemicals (KNO_3, K_2SO_4, Ca $(No_3)_2$, CaH $(PO_4)_2$, $CaSO_4$, $MgSO_4$, KH_2PO_4, $MgNO_3$) were prepared. From this stock solution required quantity of various chemicals were taken and prepared deficient culture solutions of N, P, K, Mg, S, Fe and Zn with control (Dhopte and Livera, 1989). The pH was adjusted to 6.5. Data on morpho-physiological observations such as plant height were recorded at 30 and 45 DAT. Internodal length, shoot dry weight, root dry weight, total dry weight, root to shoot ratio and root volume were recorded once at physiological maturity of the experiment.

RESULTS AND DISCUSSION

Plant height:

At 30 DAT, maximum reduction in plant height was noticed in deficiency of Fe (29.88%) followed by K (23.94), Mg (22.28%), N (19.09%), P (15.64%) and S (14.11%) deficiencies in a descending manner. Similarly at 45 DAT, significant reduction in plant height was recorded in all deficiencies viz., Fe (37.45%), Mg (30.18%), K (25.78%), N (23.99%), Zn (22.41%), S (22.41%) and P (20.52%). Considerable reduction in plant height due to Fe, Mg, N, S, Zn, P and K deficiencies was observed by Paliwal *et al*. (2003) in soybean. Deotale

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and Dhopte (2005) also observed stunted growth in mustard due to N, P, K, S, Mg and Zn deficiencies. Nitrogen is necessary for cell division and cell elongation. Deficiency of nitrogen restricted the plant growth and plant became stunted. This might be reason for decreasing plant height in N deficient plants in the present study (Jain, 2010).

Internodal length:

Drastic reduction in internodal length was noticed in Mg (63.73%) and Fe (62.18%) followed by S (56.19%), Zn (48.52%), K (38.62%), P (31.56%) and N (27.13%). The above observations are agreement with the finding of Paliwal *et al*. (2003). They reported that Fe, Zn, S, N, Mg, P and K deficiency in soybean resulted in drastic reduction in internodal length. Smith *et al.* (1993) reported that zinc deficiency in peanut resulted in reduction in internodal length. The internodal length in severe zinc deficiency became so short that all leaves appear to come from the same point and termed as "Rosetting" (Tondan, 1995).

Shoot dry weight:

Shoot dry weight was reduced significantly in deficiency of Fe (78.65%) followed by Mg (69.10%), S (62.92%), K (60.11%), N (57.30%), Zn (54.49%) and P (54.49%) deficiencies when compared with control. Nenova (2006) observed maximum reduction in dry matter of leaves and stems in Fe deficient pea plant. Zocchi *et al*. (2007) observed that iron deficiency in soybean resulted in decreasing growth rate at shoot and root level. Paliwal *et al*. (2003) also noted significant reduction in shoot dry weight in soybean due to N, Fe, Mg, P, S, K and Zn deficiencies in a descending manner. Schulze and Dervon (2005) also reported less shoot dry weight in P deficient alfalfa plant than P sufficient alfalfa plant.

Root dry weight:

Maximum reduction in root dry weight was observed in deficiency of Fe (85.71%) followed by Mg (79.59%), S (75.51%), Zn (65.31%), N (63.26%), K (61.22%) and P (61.22%) over control. Zocchi *et al*. (2007) observed that iron deficiency in soybean resulted in decreasing growth rate at shoot and root level. Paliwal *et al*. (2003) also noted significant reduction in root dry weight in soybean due to Zn, N, S, Fe, Mg, K and P deficiencies in a descending manner. Sulphur is necessary for formation of new cells. Deficiency of sulphur restricted root development. Similarly potassium deficiency decreases translocation of amino acids, organic acids and sugars to roots. These were considered to be the reason for reduction in root dry weight plant^{-1} as reported by Smith *et al.* (1993) in peanut. Zhao *et al.* (2005) reported that N deficiency reduced root dry weight in sorghum.

Total dry weight:

Maximum reduction in total dry weight was observed in deficiency of Fe (79.74%) followed by Mg (71.81%), K (60.35%), S (65.64%), N (59.03%), P (55.95%) and Zn (56.39%) in a decreasing manner when compared with control. The present findings are in agreement with the results obtained by Miranda *et al*. (2010) in cowpea. They noted that cowpea seedling affected their growth due to N, P, K, Mg, S, and Fe deficiencies and also recorded drastic reduction in total biomass production. Likewise, Zocchi *et al*. (2007) observed that iron deficiency in soybean resulted in decreasing growth rate at shoot and root level. Paliwal *et al*. (2003) also reported maximum dry weight reduction in N deficient plants followed by Fe (78.45%) and Mg (74.68%) deficient plants when compared with control. Zhao *et al.* (2005) recorded that nitrogen deficiency in sorghum reduced biomass production in plant. The reduction of biomass production was due to the less leaf area, chlorophyll and photosynthetic rate of plant.

Root : Shoot ratio:

The root to shoot ratio decreased significantly in deficiencies of Mg (35.71%) and S (35.71%) followed by Fe (32.14%), Zn (25.00%), N (21.42%), P (17.85%) and K (07.14%) when compared with control. Paliwal *et al*. (2003) also observed significant reduction of root to shoot ratio in soybean plant due to deficiencies of Zn, S, K, Mg, Fe, P and N. Cakmak (1994) observed that shoot and root growth was quite differently affected by low supply of P, K and Mg in bean plant. They also noted that the concentration of reducing sugars, sucrose and starch were also differently affected by low nutrient supply. In primary leaves under K deficiency and particularly Mg deficiency, the concentration of sucrose and reducing sugars were much higher than in control and P deficient plants. Mg deficiency also distinctly increased the starch concentration in the primary leaves. In contrast in roots, the lowest concentration of sucrose, reducing sugars and starch were found in

Table 1. Effect of mineral nutrient deficiencies on morpho-physiological parameters of greengram

Treatments	Plant height (cm)				Internodal length (cm)		Shoot dry weight (g)		Root dry weight (g)		Total dry weight (g)		Root to shoot ratio (g)		Root volume (cm^3)	
	30 DAT	Reduction (%)	45 DAT	Reduction (%)	At maturity	Reduction (%)	At maturity	Reduction (%)	At maturity	Reduction (%)	At maturity	Reduction (%)	At maturity	Reduction (%)	At maturity	Reduction (%)
Control	24.10	--	27.93	--	21.23	--	1.78	--	0.49	--	2.27	--	0.28	--	10.27	--
-N	19.50	19.09	21.23	23.99	15.47	27.13	0.76	57.30	0.18	63.26	0.93	59.03	0.22	21.42	08.20	20.15
-P	20.33	15.64	22.20	20.52	14.53	31.56	0.81	54.49	0.19	61.22	1.00	55.95	0.23	17.85	07.80	24.05
-K	18.33	23.94	20.73	25.78	13.03	38.62	0.71	60.11	0.19	61.22	0.90	60.35	0.26	07.14	08.07	21.42
-S	20.70	14.11	21.67	22.41	09.30	56.19	0.66	62.92	0.12	75.51	0.78	65.64	0.18	35.71	05.37	47.71
-Mg	18.73	22.28	19.50	30.18	07.70	63.73	0.55	69.10	0.10	79.59	0.64	71.81	0.18	35.71	05.00	51.31
-Zn	20.77	13.82	21.67	22.41	10.93	48.52	0.81	54.49	0.17	65.31	0.99	56.39	0.21	25.00	07.93	22.78
-Fe	16.90	29.88	17.47	37.45	08.03	62.18	0.38	78.65	0.07	85.71	0.46	79.74	0.19	32.14	03.90	62.03
SE(M)±	0.39		0.43		0.36		0.026		0.006		0.027		0.014		0.20	
CD at 5%	1.15		1.26		1.06		0.076		0.017		0.079		0.040		0.60	

Mg deficient plants, where as the concentrations of sucrose and starch were particularly high in P deficient plants. There was close relationship between shoot/root dry weight ratios and relative distributions of total carbohydrate in shoot and roots. Schulze and Drevan (2005) reported that P deficiency caused lower root to shoot ratio in alfalfa plant

Root volume:

Root volume was recorded once at physiological maturity. Root volume decreased significantly in deficiency of Fe (62.03%) followed by Mg (51.31%) and S (47.71%) over control. But root volume was moderately affected in deficiencies of P (24.05%), Zn (22.78%), K (21.42%) and N (20.15%) when compared with control. Zocchi *et al*. (2007) observed that iron deficiency in soybean resulted in decreasing growth rate at root and shoot level. Paliwal *et al*. (2003) reported that N, Mg, Fe, Zn, S, P and K deficiencies reduced root volume over control. Rajan (1992) noted that nitrogen deficiency inhibit cell division, cell enlargement and rate of respiration. Thus, plant remains stunted with reduced foliage. At early stages of growth root surface development was influenced by mineral nutrient and at later stages by photosynthesis. This might also be the reasons for decreasing root volume in nitrogen deficient plant in the presence study.

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EVALUATION OF ANTIFUNGAL PROPERTIES OF MEDICINAL AND AROMATIC PLANTS AGAINST CHICKPEA WILT COMPLEX PATHOGENS

Sireesha Yeturi[1], S.R. Potdukhe [2] and D.D. Guldekar [3]

ABSTRACT

The present study was carried out during the year 2011-2012 for evaluating five Medicinal and four Aromatic plants viz., *Withania somnifera, Andrographis paniculata, Allium vineale, Catharanthus roseus, Bixa orellana, Cymbopogan martini, C. flexuosus, C. winterianus* and *Ocimum sanctum in vitro* against chickpea wilt complex pathogens at 15% concentration. Data indicated significant differences on radial mycelial growth over uninoculated control. Thiram treatment arrested 100% growth against all the three pathogens. *In vitro* evaluation of medicinal plants viz., *Catharanthus roseus, Bixa orellana* and *Withania somnifera* were found significantly superior against *Fusarium oxysporum* f. sp. ciceri, *Rhizoctonia bataticola* and *Sclerotium rolfsii* with 86.30%, 84.10% and 78.52% per cent inhibition respectively. Among aromatic plants, *Ocimum sanctum* was found most effective in restricting radial mycelial growth of *Fusarium oxysporum* f. sp. ciceri, *Rhizoctonia bataticola and Sclerotium rolfsii* by 81.48%, 87.78% and 75.20% respectively.

(Key words : Antifungal, medicinal, chickpea, wilt)

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an ancient leguminous pulse crop that has been grown in India, Middle East and part of Africa for many years. Much of the world's chickpea supply (80 to 90%) comes from India. It is the third most important legume crop in world after beans and peas. In India chickpea occupies 9.21 million hectares area with the production of 8.25 million tonnes. In Maharashtra, it is grown as a *rabi* pulse crop, as an irrigated and also as a rainfed crop in black soils in an area of 1.43 million ha with an average productivity of 904 kg ha^{-1}. Vidarbha region with rich black cotton soils has an area of nearly 0.16 million hectares accounting a total production of 0.12 million tonnes with an average productivity of 768 kg ha^{-1}(Anonymous, 2011). It is grown in a diversified area and hence, it succumbs to many fungal, bacterial and viral diseases. Among the various fungal diseases wilt (*Fusarium oxysporum* f. sp. ciceri), dry root rot (*Rhizoctonia bataticola) and* collar rot (*Sclerotium rolfsii)* and stunt are the important diseases constitutes the chickpea wilt complex which causes serious threat to chickpea cultivation. As fungicidal treatment has hazardous nature and its non-judicious use relates to pollution in the soil disturbing the natural ecological balance, under such circumstances biological control of plant diseases aims at reduction in inoculum density or pathogen activity. Its a broad use specifying the usage of medicinal and aromatic plants in the ecofriendly management of chickpea wilt complex pathogens (Punetha, 2010).

MATERIALS AND METHODS

Medicinal plants such as *Withania somnifera* (Aswagandha), *Andrographis paniculata* (Kalamegh), *Allium vineale* (Wild garlic), *Catharanthus roseus* (Sadaphuli), *Bixa orellana* (Annatto) using different parts with aqueous extracts and aromatic plants with oil based extracts viz., *Cymbopogan martini* (Indian geranium), *Cymbopogan flexuosus* (East Indian Lemon grass), *Cymbopogan winterianus* (Citronella grass) and *Ocimum sanctum* (Tulasi) were collected from Medicinal and Aromatic Plants Unit, Nagarjun Garden, Dr. P. D. K. V., Akola during the year 2011-2012 and tested for their evaluation against the pathogens of chickpea at 15% concentration. Infected roots and stems of chickpea plants were used for isolation of pathogens and the pure cultures were prepared. The preparation of aqueous plant extracts was carried out by placing selected plant leaves in $HgCl_2$ (0.1%) solution for 2 minutes and thoroughly washed them with sterilized distilled water by three times. Equal weight of plant parts and equal volume of water was grinded in mortar and pestle, then filtered through double layered muslin cloth to remove fibrous and suspended material. Thus, filtrate prepared was treated as 100 per cent concentration. From this extracts, 15% concentration of botanicals was prepared by adding sterilized distilled water for aqueous extracts and by adding alcohol for oil based

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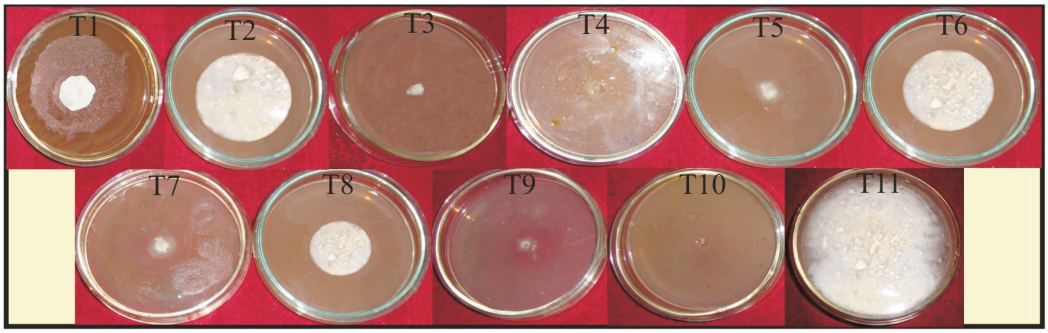

Plate 1 (A) : Evaluation of Medicinal and Aromatic Plants against *Fusarium oxysporum*

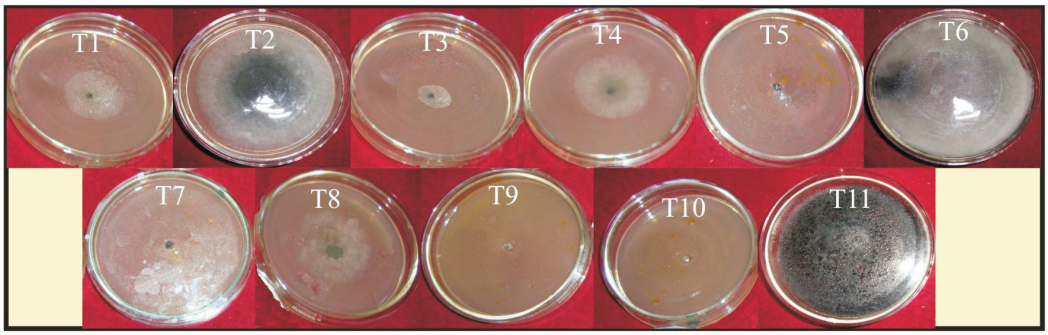

Plate 1 (B) : Evaluation of Medicinal and Aromatic Plants against *Rhizoctonia bataticola*

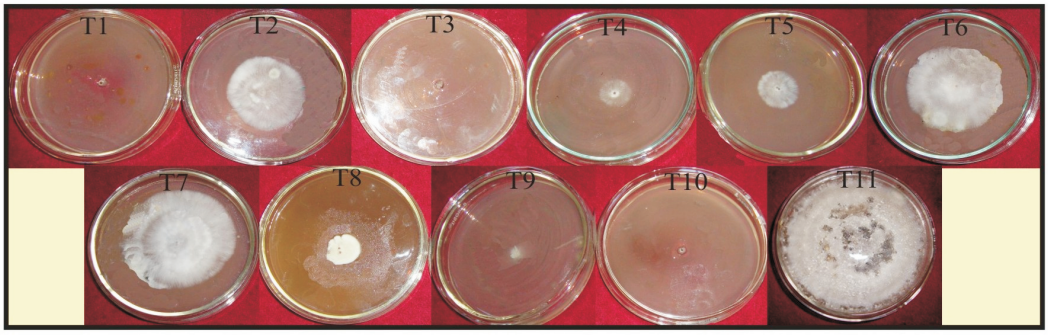

Plate 1 (C) : Evaluation of Medicinal and Aromatic Plants against *Sclerotium rolfsii*

extracts as solvents. The required quantity of plant extracts were added in autoclaved melted PDA separately and 15% concentration was obtained.

Treatment details :

Medicinal plants (T_1 to T_5) :	**Chickpea seeds soaked in 15% concentration**
T_1 *Withania somnifera*	root extract
T_2 *Andrographis paniculata*	leaf extract
T_3 *Allium vineale*	stem extract
T_4 *Catharanthus roseus*	flower and root extract
T_5 *Bixa orellana*	flower extract
Aromatic plants(T_6 toT_9):	
T_6 *Cymbopogan martini*	Oil based extract
T_7 *Cymbopogan flexuosus*	Oil based extract
T_8 *Cymbopogan winterianus*	Oil based extract
T_9 *Ocimum sanctum*	Oil based extract
T_{10} Thiram 80% WP	3 g kg^{-1}
T_{11} Control	

About 20 ml of melted poisoned PDA poured in each sterilized petriplate and after solidification, inoculated by test organism. Each treatment replicated three times. Five mm disc of old fungal culture transferred aseptically in the centre of each petriplate containing poisoned medium. The PDA without plant extract served as control. The plates were then incubated at room temperature (28± 2ºC) and observations regarding mycelial growth were recorded and compared with control treatment. The growth inhibition percentage was calculated by the following formula.

$$I = \frac{C - T}{C} \times 100$$

Where I = Per cent inhibition of growth
C = Growth of fungus in control
T = Growth of fungus in treatment

RESULTS AND DISCUSSION

It is evident from the data presented in the table 1 and plate 1 (A) indicated the significant differences due to medicinal and aromatic plant treatments against chickpea wilt complex pathogens at 15% concentration on PDA at 8th Day After Inoculation (DAI). Thiram treatment arrested 100% growth against all the three pathogens. For the inhibition of *Fusarium oxysporum* f. sp. ciceri, among the medicinal and aromatic plants treatments, minimum mycelial growth was recorded with *Catharanthus roseus* giving highest inhibition (86.30%) followed by *Ocimum sanctum* with 81.48% inhibition. Unamended control treatment recorded 90 mm radial mycelial growth. The inhibited growth of *Fusarium oxysporum* f. sp. ciceri might be due to the application of medicinal and aromatic plant extracts which attributed the diffusable substances secreted by the plant metabolites. The inhibition may probably due to the presence of antifungal compounds or ingradients in plant extracts of medicinal and aromatic plants. The findings of the present investigation are in consonance with Sahani and Saxena (2009) who obtained 90% toxicity against *Fusarium oxysporum* f. sp. pisi. The data in the table 1 and plate 1(B) indicated the evaluation of treatments against *Rhizoctonia bataticola* at 8th Day After Inoculation (DAI) on PDA at 15% concentration. Among the medicinal and aromatic plants treatments, minimum mycelial growth was recorded with *Ocimum sanctum* giving highest inhibition (87.78%) followed by *Bixa orellana* (81.48%). Thiram treatment was found significantly superior to all other treatments recording no growth (100%) inhibition. The complete inhibition is attributed due to chemical constituent contained in thiram i.e., tetra ethyl thiram disulphide which might have completely inhibited the growth. Control of these pathogens has been reported by Mandhare and Suryawanshi (2009) who acquired the inhibition of chickpea wilt complex pathogens by the extracts of *Azadirachta and Allium sativum.* The results regarding *Sclerotium rolfsii* are presented in the table 1 and plate 1(C). The data revealed significant differences in various treatments on radial mycelial growth of *Sclerotium rolfsii* at 15% concentration. Among the medicinal and aromatic plants, *Withania somnifera* treatment recorded minimum radial mycelial growth (19.33 mm) at 8th DAI with maximum inhibition (74.44%). This treatment was found significantly superior over all other treatments followed by *Ocimum sanctum* (75.20%). The results of the present investigation are in confirmity with the report of Gautham and Chauhan (2004), Tripathi *et al.* (2006) who obtained the inhibition of *Sclerotium rolfsii* on chickpea by *Withania somnifera* and *Ocimum sanctum*. Antifungal properties of medicinal plant extracts against *Sclerotium rolfsii* have been reported by Haralpatil and Raut (2008).

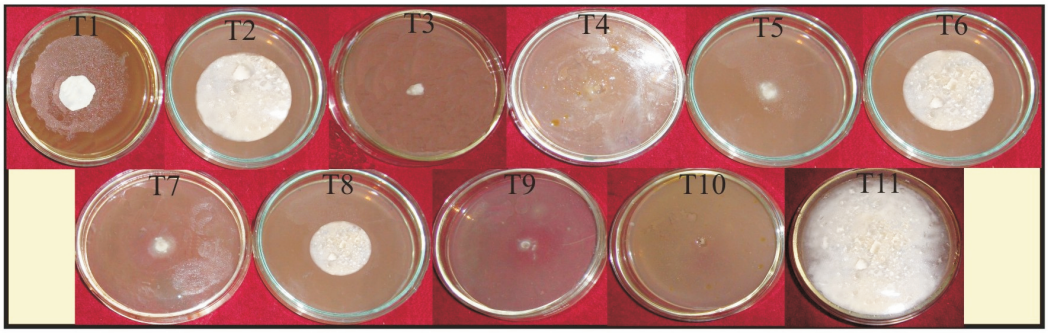

Plate 1 (A) : Evaluation of Medicinal and Aromatic Plants against *Fusarium oxysporum*

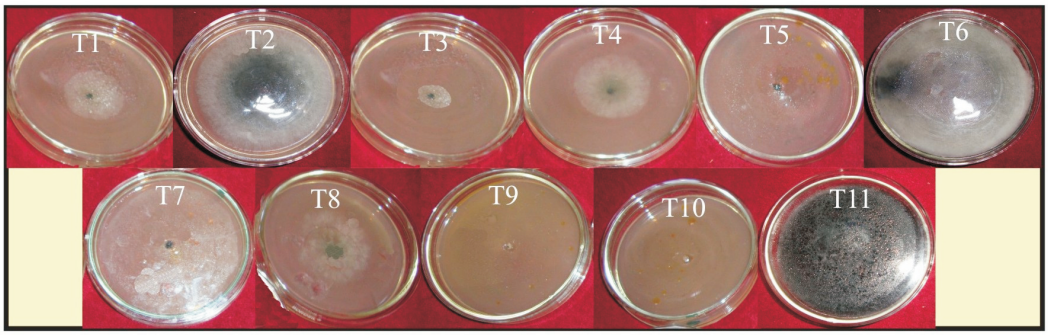

Plate 1 (B) : Evaluation of Medicinal and Aromatic Plants against *Rhizoctonia bataticola*

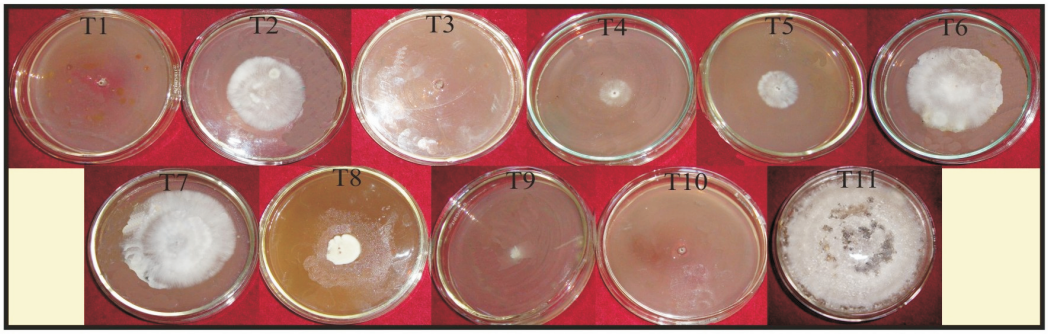

Plate 1 (C) : Evaluation of Medicinal and Aromatic Plants against *Sclerotium rolfsii*

Table 1. Evaluation of medicinal and aromatic plants against chickpea wilt complex pathogens at 8th DAI on PDA

Treatments	15% Concentration					
	Fusarium oxysporum		*Rhizoctonia bataticola*		*Sclerotium rolfsii*	
	Radial Mycelial Growth (mm)	Per cent Inhibition	Radial Mycelial Growth (mm)	Per cent Inhibition	Radial Mycelial Growth (mm)	Per cent Inhibition
Withania somnifera	29.67	67.03	22.67	74.81	19.33	78.52
Andrographis paniculata	65.67	27.03	35.00	61.11	48.67	45.92
Allium vineale	20.67	77.03	18.33	79.63	23.33	74.10
Catharanthus roseus	12.33	86.30	25.67	71.48	25.33	71.86
Bixa orellana	26.00	71.11	14.33	84.10	27.00	70.00
Cymbopogan martini	49.00	45.56	54.67	39.26	64.33	28.52
Cymbopogan flexuosus	22.33	75.19	15.67	82.59	75.67	15.92
Cymbopogan winterianus	39.67	55.92	23.67	73.70	38.00	57.78
Ocimum sanctum	16.67	81.48	11.00	87.78	22.33	75.20
Thiram 80% WP	0.00	100.00	0.00	100.00	0.00	100.00
Control	90.00		90.00		90.00	
SE± (M)	0.99		0.93		1.36	
CD(P= 0.01)	3.95		3.69		5.44	

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HETEROSIS STUDIES FOR YIELD AND YIELD COMPONENT CHARACTERS IN MAIZE (*Zea mays* L.)

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ABSTRACT

An investigation was carried out at Department of Genetics and Plant Breeding, Anand Agricultural University, Anand during the year 2010-11 to assess extent of heterosis over standard check (HM-5) for grain yield plant $^{-1}$ and yield contributing characters in maize (*Zea mays* L.). Fourty-five crosses obtained by crossing fifteen lines with three testers were raised in Randomized Block design with three replications. Parents and check (HM-5) were also raised adjacent to the crosses. The data were recorded on days to 50% tasselling, days to 50% silking, plant height, ear height, number of fresh harvested ears, length of ear, width of ear, number of kernel rows ear $^{-1}$, number of kernels row $^{-1}$, shelling percent, grain yield plant $^{-1}$ and 1000-kernel weight. Considerable variability existed among the genotypes for all the characters studied as observed from the significant mean squares due to genotypes. The crosses I-07-10-1 × HKI-163, I-07-8-6 × CLQ-30 and I-07-7-4 × CLQ-30 had high mean performance for grain yield plant $^{-1}$. The mean squares due to interaction effects of parents vs. crosses were found to be significant for ear height, width of ear, shelling pe rcent, grain yield plant $^{-1}$ and 1000-kernel weight indicating the choice of exploitation of heterosis. Three crosses I-07-10-1 × HKI-163, I-07-8-6 × CLQ-30 and I-07-7-4 × CLQ-30 were identified as promising crosses as they exhibited significant standard heterosis for grain yield plant $^{-1}$. These crosses also had significant *per se* performance for their respective characters. Thus, these crosses possess high heterosis, in future could be exploited commercially for higher yield in maize.

(Key words: Maize, standard heterosis, grain yield plant $^{-1}$)

INTRODUCTION

Maize (*Zea mays* L.) is the third most important crop of India belonging to the family Poaceae and tribe Maydeae. It has assumed greater significance due to its demand for food, feed and industrial utilization. Nearly 49 % of the maize produce is being utilized as a raw material in the poultry feed industry. Maize has wide adaptability, as it can be grown from MSL to 3000 M above and from 58^0 N to 40^0 S latitude. Maize being a C-4 plant and fertilizer responsive, has very high yielding ability coupled with higher amount of cross pollination. Hence, offers tremendous scope for the plant breeders for genetic improvement and exploitation of hybrid vigor. Already this phenomenon has been successfully exploited and still there is tremendous potential to develop several high yielding hybrids and composites. Hence, an attempt was made to assess the heterosis among the various hybrids produced through line x tester analysis.

MATERIALS AND METHODS

Fifteen lines viz., L_1 (I-07-7-1), L_2 (I-07-7-4), L_3 (I-07-7-11), L_4 (I-07-8-4), L_5 (I-07-8-5), L_6 (I-07-8-6), L_7 (I-07-9-9), L_8 (I-07-10-1), L_9 (I-07-13-1), L_{10} (I-07-54-1), L_{11} (I-07-56-4), L_{12} (I-07-56-7), L_{13} (I-07-56-8), L_{14} (I-07-57-5), L_{15} (I-07-57-6) were crossed with three testers T_1 (HKI-163), T_2 (CLQ-30), T_3 (CLQ-47) by following line x tester mating design to produce 45 crosses in *rabi* 2009. The fourty-five crosses and eighteen parents with standard check cross Harayana Maize-5 (HM-5) were evaluated in *kharif* 2010 by raising the experimental material in Randomized Block design with three replications with spacing of 60 cm x 20 cm. Recommended package of practices were followed to raise a good crop. The data were recorded on five randomly selected plants from each genotype on twelve characters viz., days to 50% tasselling, days to 50% silking, plant height, ear height, number of fresh harvested ears, length of ear, width of ear, number of kernel rows ear $^{-1}$, number of kernels row $^{-1}$, shelling per cent, grain yield plant $^{-1}$ and 1000- kernel weight. Line x Tester mating design given by Kempthorne (1957) with fixed effect model (Model I) of Eisenhart (1947) was used. The analysis of variance for the experimental design was analysed by the method given by Panse and Sukhatme (1954). The magnitude of standard heterosis was calculated as by increase of mean F_1 performance over that of mean performance of the standard variety.

RESULTS AND DISCUSSION

The results of analysis of variance are presented in table 1.Considerable variability existed among the genotypes for all the characters studied as observed

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from the significant mean squares due to genotypes. The mean squares due to parents and crosses were highly significant for all the characters except number of kernels row $^{-1}$ in case of parents. The mean squares due to parents vs. crosses was found to be significant for ear height, width of ear, shelling per cent, grain yield plant $^{-1}$ and 1000-kernel weight which indicated that the parents chosen were diverse and with a different genetic background and also indicated the presence of average heterosis due to the significant differences in the mean performance of crosses and parents. Similarly, mean squares due to check vs. crosses were significant for days to 50% tasselling, days to 50% silking, plant height, ear height and shelling per cent. These results were in confirmation with the results of Hemavathy and Balaji (2008), Premlatha *et al.* (2011) and Sundararajan and Shenthil (2011) who also reported the occurance of heterosis due to differences in the performance of crosses and parents in maize.

On the basis of *per se* performance (Table 2) studied for grain yield plant $^{-1}$ and yield contributing characters among 45 crosses, the cross I-07-10-1 × HKI-163 was identified as superior cross as it performed significantly superior over check HM-5 for grain yield plant $^{-1}$ (148.4 g) and plant height (129 cm). While hybrid I-07-8-6 × CLQ-30 and I-07-7-4 × CLQ-30 which performed significantly superior over check HM-5 for only grain yield plant $^{-1}$ (145.3 g and 143.0 g). These three crosses were identified as potential crosses for exploiting heterosis on the basis of *per se* performance.

Considerable amount of heterosis was observed for all the characters under study however, the magnitude varied with characters (Table 2). In the present investigation one cross recorded significant negative standard heterosis for days to 50% tasselling. The cross I-07-8-4 × HKI-163 (-4.03%) recorded maximum negative significant standard heterosis for this trait. Two crosses I-07-7-1 × HKI-163 (-5.03%) and I-07-8-4 x HKI-163 (-4.40%) recorded significantly negative standard heterosis for days to 50% silking. Cross I-07 - 10-1 × HKI -163 (-32.69%) recorded maximum significantly negative standard heterosis for plant height. Cross I-07-57-6 × CLQ-47 (-20.51%) recorded highest significantly negative standard heterosis for ear height.

Two crosses namely I-07-7-4 × HKI-163 (15.57%) and I-07-56-7 x CLQ-47 (15.57%) recorded maximum significantly positive standard heterosis for number of fresh harvested ears. For length of ear, cross I-07-10-1 × CLQ-30 (42.31%) recorded maximum positive and significant standard heterosis. For number of kernel rows ear $^{-1}$, two crosses I-07-7-11 × HKI-163 (8.40%) and I-07-56-8 x CLQ-30 (7.99%) recorded positive and significant standard heterosis. Cross I-07-10-1 × CLQ-30 (36.83%) recorded highest significant and positive standard heterosis for number of kernels row $^{-1}$. For width of ear and shelling per cent no one cross showed positive significant standard heterosis. For 1000-kernel weight, cross I-07-54-1 × HKI-163 (18.54%) recorded maximum positive and significant standard heterosis.

Among fourty-five crosses, three crosses namely I-07-10-1× HKI-163 (22.97%), I-07-8-6 × CLQ-30 (20.44%) and I-07-7-4 × CLQ-30 (18.50%) were identified as superior cross as it recorded maximum, significant and positive standard heterosis for grain yield plant $^{-1}$. The level of heterosis observed in these crosses justified the development of commercial crosses in maize. Such potential of maize crosses for commercial exploitation of heterosis have been reported by many maize breeders like Hemavathy and Balaji (2008), Saidaiah *et al.* (2008), Singh and Gupta (2009), Premlatha and Kalamani (2010), Premlatha *et al.* (2011) and Sundararajan *et al*. (2011) in maize.

The overall study of heterosis and *per se* performance indicated that the cross combinations like I-07-10-1× HKI-163, I-07-8-6 × CLQ-30 and I-07-7-4 × CLQ-30 were found to be outstanding in respect of grain yield plant $^{-1}$. These may be exploited commercially after critical evaluation for its superiority in performance with stability across the location over years.

Table 1. Analysis of variance for heterosis

Source of variation	d.f.	Days to 50% tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)	No. of fresh harvested ears	Length of ear (cm)	Width of ear (cm)	No. of kernel rows ear^{-1}	No. of kernels row $^{-1}$	Shelling per cent	Grain yield plant $^{-1}$ (g)	1000-kernel weight (g)
Replications	2	0.47	1.24	30.26	71.65	0.03	0.73	0.11	0.04	0.10	13.25	23.25	18.91
Genotypes	65	34.63**	42.43**	2362.73**	628.25**	0.16**	5.31**	2.52**	6.20**	8.45**	208.66**	375.32**	1923.95**
Parents	17	20.19**	22.12**	2940.00**	1286.69**	0.21**	3.38*	1.84**	8.85**	2.73	230.75**	298.74**	917.97**
Crosses	44	40.30**	49.13**	1810.31**	291.29**	0.15**	6.30**	2.90**	5.56**	8.77**	188.80**	391.31**	2440.05**
Parents vs. Crosses	1	0.04	0.75	10.25	1299.09**	0.04	0.28	3.20*	0.47	2.64	180.37**	2040.6**	1278.00**
Checks vs. Crosses	1	104.45**	204.11**	21847.8**	2947.00**	1.85	0.97	0.15	1.09	13.96	909.15**	1.24	198.13
Error	130	1.16	1.79	27.60	23.46	0.01	1.68	0.80	0.61	4.26	11.29	122.75	60.14

*, ** indicate level of significance at 5 % and 1 %, respectively

Table 2. Performance of crosses for mean and standard heterosis (SH)

Crosses	Days to 50 % tasselling		Days to 50 % silking		Plant height (cm)		Ear height (cm)	
	Mean	**SH**	**Mean**	**SH**	**Mean**	**SH**	**Mean**	**SH**
$L_1 \times T_1$	48.7	-2.01	50.3	-5.03*	234	22.58**	105	-1.77
$L_1 \times T_2$	58.7	18.12**	62.7	18.24**	230	20.31**	113	5.51
$L_1 \times T_3$	51.3	3.36	54.3	2.52	227	18.52**	94	-12.32**
$L_2 \times T_1$	54.7	10.07**	59.7	12.58**	226	18.05**	93	-12.85**
$L_2 \times T_2$	58.0	16.78**	61.0	15.09**	220	15.12**	103	-3.64
$L_2 \times T_3$	60.7	22.15**	65.3	23.27**	243	27.32**	111	3.70
$L_3 \times T_1$	50.0	0.67	51.3	-3.14	238	24.32**	110	2.93
$L_3 \times T_2$	57.0	14.77**	59.0	11.32**	231	20.98**	98	-8.81*
$L_3 \times T_3$	55.3	11.41**	59.0	11.32**	183	-4.03	102	-4.76
$L_4 \times T_1$	47.7	-4.03**	50.7	-4.40*	240	25.58**	98	-8.59*
$L_4 \times T_2$	60.3	21.48**	61.7	16.35**	237	23.96**	108	1.06
$L_4 \times T_3$	54.7	10.07**	59.0	11.32**	176	-7.93**	96	-10.05**
$L_5 \times T_1$	52.0	4.70**	54.0	1.89	210	10.03**	103	-4.23
$L_5 \times T_2$	53.3	7.38**	57.0	7.55**	233	21.92**	92	-13.73**
$L_5 \times T_3$	50.7	2.01**	55.0	3.77	205	7.31**	110	2.83
$L_6 \times T_1$	52.3	5.37	56.7	6.92**	189	-1.13	110	2.58
$L_6 \times T_2$	55.0	10.74**	60.0	13.21**	236	23.68**	105	-1.53
$L_6 \times T_3$	59.3	19.46**	64.0	20.75**	240	25.39**	102	-5.01
$L_7 \times T_1$	49.0	-1.34	53.0	0.00	239	24.76**	94	-11.98**
$L_7 \times T_2$	52.0	4.70**	58.0	9.43**	234	22.58**	92	-13.66**
$L_7 \times T_3$	50.7	2.01	56.3	6.29**	232	21.19**	101	-5.63
$L_8 \times T_1$	54.0	8.72**	59.0	11.32**	129	-32.69**	124	15.62**
$L_8 \times T_2$	52.3	5.37**	58.0	9.43**	178	-7.06**	132	23.25**
$L_8 \times T_3$	53.0	6.71**	58.0	9.43**	243	27.15**	111	3.64
$L_9 \times T_1$	56.0	12.75**	60.0	13.21**	234	22.62**	115	7.00
$L_9 \times T_2$	57.7	16.11**	62.7	18.24**	242	26.40**	93	-13.29**
$L_9 \times T_3$	50.0	0.67	51.0	-3.77	216	12.99**	89	-16.62**
$L_{10} \times T_1$	55.0	10.74**	58.0	9.43**	233	22.11**	95	-11.48**
$L_{10} \times T_2$	56.7	14.09**	60.7	14.47**	225	17.63**	95	-11.58**
$L_{10} \times T_3$	49.3	-0.67	54.7	3.14	198	3.40	114	6.22
$L_{11} \times T_1$	52.0	4.70**	56.7	6.92**	232	21.59**	107	-0.44
$L_{11} \times T_2$	56.0	12.75**	59.0	11.32**	238	24.39**	100	-6.72
$L_{11} \times T_3$	49.0	-1.34	53.3	0.63	241	26.19**	111	3.77
$L_{12} \times T_1$	62.7	26.17**	66.7	25.79**	220	14.93**	110	2.40
$L_{12} \times T_2$	57.0	14.77**	60.7	14.47**	227	18.81**	95	-10.92**
$L_{12} \times T_3$	51.0	2.68	54.3	2.52	215	12.71**	112	4.42
$L_{13} \times T_1$	54.7	10.07**	58.7	10.69**	192	0.33	95	-11.73**
$L_{13} \times T_2$	57.3	15.44**	63.3	19.50**	223	16.60**	92	-13.85**
$L_{13} \times T_3$	56.3	13.42**	60.0	13.21**	173	-9.29**	122	13.91**
$L_{14} \times T_1$	51.0	2.68	56.3	6.29**	245	28.11**	102	-4.76
$L_{14} \times T_2$	56.7	14.09**	59.7	12.58**	234	22.27**	96	-10.12**
$L_{14} \times T_3$	53.3	7.38**	58.3	10.06**	220	15.24**	106	-1.34
$L_{15} \times T_1$	49.0	-1.34	51.0	-3.77	233	21.97**	98	-8.50*
$L_{15} \times T_2$	59.0	18.79**	65.0	22.64**	255	33.39**	93	-13.48**
$L_{15} \times T_3$	53.0	6.71**	58.3	10.06**	239	25.21**	85	-20.51**
S Ed (±)	**0.62**	**0.88**	**0.77**	**1.10**	**3.03**	**4.35**	**2.80**	**4.02**

*, ** indicate level of significance at 5 % and 1 %, respectively

Table 2 Contd…

Crosses	No. of fresh harvested ears		Length of ear (cm)		Width of ear (cm)		No. of kernel rows ear^{-1}	
	Mean	**SH**	**Mean**	**SH**	**Mean**	**SH**	**Mean**	**SH**
L_1 x T_1	1.73	3.59	13.3	-14.53*	14.6	-3.31	14	-12.30**
L_1 x T_2	1.33	-20.36**	15.1	-2.99	14.0	-7.28	16	-3.89
L_1 x T_3	1.20	-28.14**	17.7	13.25*	14.5	-3.75	16	-3.07
L_2 x T_1	1.93	15.57**	16.7	7.26	14.3	-5.52	15	-5.94
L_2 x T_2	1.07	-35.93**	14.5	-6.84	14.5	-3.75	15	-5.53
L_2 x T_3	1.13	-32.34**	17.0	8.97	14.7	-2.65	15	-5.53
L_3 x T_1	1.13	-32.34**	18.1	16.24*	16.3	7.95	18	8.40*
L_3 x T_2	1.33	-20.36**	17.1	9.62	13.5	-10.60*	14	-12.30**
L_3 x T_3	1.07	-35.93**	14.4	-7.91	12.0	-20.31**	14	-11.07**
L_4 x T_1	1.53	-8.38	15.7	0.43	13.1	-13.25**	14	-11.48**
L_4 x T_2	1.33	-20.36**	14.8	-5.13	14.4	-4.86	15	-9.84*
L_4 x T_3	1.07	-35.93**	15.0	-3.85	14.1	-6.84	13	-23.16**
L_5 x T_1	1.07	-35.93**	17.2	10.26	14.5	-3.75	14	-12.30**
L_5 x T_2	1.67	0.00	17.1	9.62	14.4	-4.86	15	-6.76
L_5 x T_3	1.47	-11.98*	14.5	-7.26	15.3	1.10	15	-6.56
L_6 x T_1	1.47	-11.98*	15.9	1.92	13.6	-10.15*	13	-18.65**
L_6 x T_2	1.53	-8.38	17.1	9.83	15.5	2.43	17	7.17
L_6 x T_3	1.27	-23.95**	15.6	-0.21	14.4	-4.42	14	-12.91**
L_7 x T_1	1.13	-32.34**	16.6	6.20	13.6	-10.15*	14	-12.30**
L_7 x T_2	1.53	-8.38	17.2	10.04	15.2	0.66	14	-11.68**
L_7 x T_3	1.47	-11.98*	17.4	11.75	15.3	1.55	16	0.00
L_8 x T_1	1.33	-20.36**	16.3	4.70	14.4	-4.42	15	-9.22*
L_8 x T_2	1.33	-20.36**	22.2	42.31**	14.3	-5.30	14	-13.52**
L_8 x T_3	1.27	-23.95**	16.3	4.70	13.5	-10.60*	14	-12.30**
L_9 x T_1	1.33	-20.36**	14.8	-5.13	13.3	-11.70*	13	-22.34**
L_9 x T_2	1.20	-28.14**	17.4	11.54	12.2	-18.98**	14	-13.11**
L_9 x T_3	1.53	-8.38	16.4	5.13	13.8	-8.61	15	-7.99*
L_{10} x T_1	1.60	-4.19	13.6	-12.61	14.9	-1.32	17	1.64
L_{10} x T_2	1.40	-16.17**	16.3	4.70	13.6	-10.15*	15	-8.40*
L_{10} x T_3	1.67	0.00	16.3	4.70	13.9	-7.73	14	-16.39**
L_{11} x T_1	1.33	-20.36**	14.7	-5.56	14.4	-4.86	16	-4.30
L_{11} x T_2	1.20	-28.14**	16.8	7.91	13.4	-11.48*	14	-15.37**
L_{11} x T_3	1.73	3.59	15.5	-0.85	14.5	-4.19	16	-4.51
L_{12} x T_1	1.33	-20.36**	16.9	8.12	13.8	-8.83	13	-17.21**
L_{12} x T_2	1.27	-23.95**	16.3	4.49	14.3	-5.30	13	-19.06**
L_{12} x T_3	1.93	15.57**	16.2	3.63	15.3	1.32	17	3.48
L_{13} x T_1	1.27	-23.95**	15.0	-3.85	15.2	0.88	15	-9.02*
L_{13} x T_2	1.33	-20.36**	16.8	7.48	15.7	3.97	18	7.99*
L_{13} x T_3	1.27	-23.95**	14.2	-9.19	12.5	-17.00**	13	-22.95**
L_{14} x T_1	1.53	-8.38	15.4	-1.28	16.1	6.40	17	6.56
L_{14} x T_2	1.60	-4.19	15.6	0.00	14.0	-7.28	17	5.94
L_{14} x T_3	1.13	-32.34**	16.8	7.69	15.2	0.66	16	-1.02
L_{15} x T_1	1.40	-16.17**	16.1	2.99	14.9	-1.10	13	-18.44**
L_{15} x T_2	1.07	-35.93**	16.5	5.77	16.4	8.83	16	0.00
L_{15} x T_3	1.53	-8.38	15.8	1.50	15.5	2.87	15	-4.92
S Ed (±)	**0.07**	**0.09**	**0.75**	**1.03**	**0.52**	**0.72**	**0.45**	**0.64**

*, ** indicate level of significance at 5 % and 1 %, respectively

Table 2 Contd…

Crosses	No. of kernels row $^{-1}$		Shelling per cent		Grain yield plant $^{-1}$ (g)		1000-kernel weight (g)	
	Mean	**SH**	**Mean**	**SH**	**Mean**	**SH**	**Mean**	**SH**
L_1 x T_1	29	8.36	67.1	-23.46**	124.8	3.45	179.0	-21.61**
L_1 x T_2	28	6.12	65.2	-25.70**	134.9	11.82	255.7	11.97**
L_1 x T_3	28	5.87	72.7	-17.16**	123.2	2.12	212.3	-7.01*
L_2 x T_1	29	9.99	76.4	-12.95**	102.7	-14.93	230.3	0.88
L_2 x T_2	28	6.12	71.7	-18.30**	143.0	18.50*	193.3	-15.33**
L_2 x T_3	29	8.86	82.3	-6.14*	113.4	-6.04	228.3	0.00
L_3 x T_1	29	6.87	79.4	-9.47**	128.4	6.37	217.0	-4.96
L_3 x T_2	28	3.12	56.8	-35.27**	129.2	7.04	180.3	-21.02**
L_3 x T_3	27	-0.50	81.1	-7.53*	127.0	5.23	247.7	8.47**
L_4 x T_1	29	8.61	68.5	-21.92**	121.7	0.84	220.0	-3.65
L_4 x T_2	27	2.50	65.5	-25.31**	124.6	3.28	226.3	-0.88
L_4 x T_3	33	21.85**	85.1	-2.97	134.8	11.71	188.0	-17.66**
L_5 x T_1	29	7.37	72.7	-17.15**	112.8	-6.49	201.3	-11.82**
L_5 x T_2	30	10.49	82.5	-5.99*	115.1	-4.65	224.0	-1.90
L_5 x T_3	26	-2.87	78.2	-10.81**	117.4	-2.70	177.0	-22.48**
L_6 x T_1	27	2.75	71.5	-18.55**	105.5	-12.61	254.0	11.24**
L_6 x T_2	28	5.49	66.4	-24.36**	145.3	20.44**	203.3	-10.95**
L_6 x T_3	29	8.24	68.1	-22.41**	121.7	0.87	163.7	-28.32**
L_7 x T_1	28	4.00	65.1	-25.74**	119.5	-0.98	236.7	3.65
L_7 x T_2	28	6.62	74.1	-15.48**	131.3	8.84	204.3	-10.51**
L_7 x T_3	29	9.86	68.1	-22.33**	117.2	-2.91	255.9	12.07**
L_8 x T_1	28	3.62	71.4	-18.62**	148.4	22.97**	239.3	4.82
L_8 x T_2	37	36.83**	75.7	-13.66**	133.6	10.75	224.3	-1.75
L_8 x T_3	33	21.85**	76.1	-13.25**	129.4	7.22	167.3	-26.72**
L_9 x T_1	28	4.87	73.5	-16.18**	133.8	10.91	256.5	12.32**
L_9 x T_2	28	6.62	61.3	-30.15**	137.2	13.71	214.7	-5.99*
L_9 x T_3	27	2.87	82.9	-5.53	105.4	-12.64	188.7	-17.37**
L_{10} x T_1	29	8.86	77.2	-12.02**	115.4	-4.36	270.7	18.54**
L_{10} x T_2	29	9.36	69.9	-20.30**	134.4	11.41	200.0	-12.41**
L_{10} x T_3	28	4.00	86.5	-1.39	123.8	2.63	184.7	-19.12**
L_{11} x T_1	27	2.75	73.3	-16.44**	134.9	11.83	182.7	-20.00**
L_{11} x T_2	29	7.12	69.8	-20.39**	124.3	2.97	226.3	-0.88
L_{11} x T_3	29	9.86	79.0	-9.91**	133.0	10.22	194.4	-14.86**
L_{12} x T_1	28	6.62	64.9	-26.01**	110.7	-8.27	186.7	-18.25**
L_{12} x T_2	29	8.36	68.8	-21.53**	124.4	3.13	243.3	6.57*
L_{12} x T_3	29	10.11	62.7	-28.48**	134.6	11.56	224.2	-1.82
L_{13} x T_1	27	2.62	77.4	-11.81**	117.9	-2.30	170.3	-25.40**
L_{13} x T_2	27	1.12	82.2	-6.25*	103.3	-14.43	210.7	-7.74**
L_{13} x T_3	27	2.00	80.4	-8.30**	111.0	-8.04	256.7	12.41**
L_{14} x T_1	28	5.87	59.0	-32.77**	135.7	12.46	184.3	-19.27**
L_{14} x T_2	28	4.37	70.3	-19.88**	112.4	-6.88	219.7	-3.80
L_{14} x T_3	30	13.23*	71.5	-18.49**	117.4	-2.67	192.7	-15.62**
L_{15} x T_1	28	5.87	55.5	-36.70**	115.2	-4.54	200.0	-12.41**
L_{15} x T_2	28	5.99	87.7	-0.03	110.6	-8.38	255.0	11.68**
L_{15} x T_3	29	9.24	61.3	-30.12**	112.2	-7.00	240.3	5.26
S Ed (±)	**1.19**	**1.68**	**1.94**	**2.63**	**6.39**	**9.20**	**4.48**	**6.42**

*, ** indicate level of significance at 5 % and 1 %, respectively

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EVALUATION OF LOCAL MUSTARD GENOTYPES FOR MORPHO-PHYSIOLOGICAL YIELD AND YIELD CONTRIBUTING TRAITS

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ABSTRACT

The experiment to study the morpho-physiological and yield contributing characters using 12 mustard local collections viz., ACNM10-1, ACNM10-2, ACNM10-3, ACNM10-4, ACNM10-5, ACNM10-6, ACNM10-10, ACNM10-11, ACNM10-15, ACNM10-17, ACNM10-21, ACNM10-22 and two popular varieties ACN-9 and Pusa bold was conducted during *rabi* 2011-2012. Observations on plant height, number of primary branches, leaf area, and total dry matter production plant^{-1} were recorded at 25, 45 and 65 days after sowing to assess their growth performance. Relative growth rate (RGR) and net assimilation rate (NAR) were also calculated at above stages 45-25 and 65-45 DAS. At maturity number of siliqua plant^{-1}, 1000-seed weight, seed yield plot^{-1} and ha^{-1} were recorded. The fourteen genotypes of mustard showed significant variation among them for all the characters studied. Pusa bold ranked first followed by ACN-9 for above characters studied. Similarly next to above two genotypes two local genotypes i.e., ACNM10-6 and ACNM10-5 were also identified as superior over remaining ten genotypes under study. Hence, these two genotypes were also recommended for breeding programme and testing in yield trial.

(Key words: Mustard, morpho-physiological traits and yield contributing traits)

INTRODUCTION

Mustard (*Brassica juncea*) is a second important oil seed crop in India after groundnut in area and production. It belongs to family Crucifereae with chromosome number 2n = 36. The average productivity in India is low in comparison to that of the developed countries. There is direct need to develop high yielding varieties of *Brassica* to further enhance its productivity in country (Khan *et al*., 2005). In India, area under mustard cultivation is 6.50 million hectares producing about 7.67 million tones of seeds with average productivity of 1179 kg ha^{-1} (Anonymous, 2010a). During the year 2010-11, 8000 ha area was under cultivation in Maharashtra having production of 3000 tones and productivity of 375 kg ha^{-1} (Anonymous, 2010b) and 865 ha area was under cultivation in Vidarbha region having production of 330 tones and productivity of 380 kg ha^{-1} (Anonymous, 2011). Therefore, the present study with 14 genotypes (12 local collections + 2 varieties) of *Brassica juncea* was planned to study the morpho-physiological and yield contributing parameters to identify promising genotypes for cultivation.

MATERIALS AND METHODS

This field experiment was conducted to study the morpho-physiological and yield contributing characters in mustard during *rabi* 2011-2012 at the farm of Agricultural Botany Section, College of Agriculture, Nagpur. The experimental material consisted of 14 mustard genotypes (ACNM10-1, ACNM10-2, ACNM10-3, ACNM10-4, ACNM10-5, ACNM10-6, ACNM10-10, ACNM10-11, ACNM10-15, ACNM10-17, ACNM10-21, ACNM10-22, ACN-9 and Pusa bold) with three replications. The plot size of experiment was 2.25 m x 3.30 m with the spacing of 45 cm x 15 cm.

Plant height, number of primary branches, dry matter production and leaf area were recorded at three different stages viz., 25, 45 and 65 DAS. Relative growth rate and net assimilation rate were also calculated by the following formula proposed by Fisher (1971) and Williams (1946) respectively. The crop was harvested at physiological maturity and observations on the yield and yield contributing characters like number of siliqua plant^{-1}, 1000-seed weight and seed yield plant^{-1} and plot^{-1} were also recorded. The data collected were subjected to statistical analysis suggested by Panse and Sukatme (1954).

RESULTS AND DISCUSSION

The perusal of data establishes that significant differences exist among the genotypes in terms of all the parameters studied (Tables 1-2).

Morpho-physiological parameters :

Plant height :

The data recorded about the plant height were subjected to statistically significant. At 25 DAS

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significantly maximum plant height was recorded in Pusa bold, followed by ACN-9. Genotypes ACNM10-6 and ACNM10-5 also recorded maximum plant height as compared to rest of the genotypes. Similarly genotypes ACNM10-21, ACNM10-3, ACNM10-22, ACNM10-11, and ACNM10-15 recorded moderate plant height in a descending manner and genotypes ACNM10-2, ACNM10-10, ACNM10-4 and ACNM10-1 recorded minimum plant height. Genotype ACNM10-17 recorded least plant height at this stage of observation. All above genotypes were superior over ACNM10-17. At 45 DAS significantly highest plant height was recorded in genotype pusa bold followed by ACN-9. Genotypes ACNM10-6 and ACNM10-5 also recorded maximum plant height as compared to rest of the genotypes. Similarly genotypes ACNM10-21, ACNM10-3, ACNM10-22, and ACNM10-11 recorded moderate plant height in a descending manner and genotypes ACNM10-15, ACNM10-2, ACNM10-10, ACNM10-4 and ACNM10-1 recorded minimum plant height. Genotype ACNM10-17 recorded least plant height at this stage of observation. All above genotypes were superior over ACNM10-17.At 65 DAS significantly highest plant height was recorded in genotype Pusa bold followed by ACN-9, ACNM10-6, ACNM10-5, ACNM10-21, ACNM10-3, and ACNM10-22 in a descending manner. Similarly genotypes ACNM10-11, ACNM10-15, ACNM10-2, ACNM10-10, ACNM10-4, and ACNM10-1 recorded moderate plant height in a descending manner and genotype ACNM10-17 recorded least plant height.

The data showed that plant height was increased with the age till its maturity. Malek *et al*. (2012) revealed that plant height increased with the age till 95 DAS in soybean.In present study genotypes with high yielding capacity recorded more plant height and low yielding genotypes showed minimum plant height. These results are in confirmatory with the findings of Channappagoudar *et al*. (2007) in little millet. They reported that genotypes with high yielding capacity were found taller, medium and low yielding ones were shorter.

Number of primary branches plant^{-1}:

At 25 DAS no primary branches were observed. Pandey and Sinha (1972) reported that at initial stage during the phase of cell formation the growth rate increases slowly hence, plant grows slowly. This might be one of the reason for no branches at 25 DAS.

At 45 DAS significantly highest number of primary branches plant $^{-1}$ was recorded in genotype Pusa bold followed by ACN-9. Genotypes ACNM10-6, ACNM10-5, ACNM10-21, ACNM10-3 also recorded maximum number of primary branches plant $^{-1}$ when compared with remaining genotypes. Similarly, genotypes ACNM10-22, ACNM10-11, ACNM10-15, ACNM10-2, recorded moderate number of primary branches plant^{-1} in a descending manner and genotypes ACNM10-10, ACNM10-4 and ACNM10-1 and ACNM10-17 recorded minimum number of primary branches plant $^{-1}$. At 65 DAS significantly highest number of primary branches plant^{-1} was recorded in genotype ACNM10-6 followed by ACNM10-5, Pusa bold, ACN-9, ACNM10-21 and ACNM10-3. Genotypes viz., ACNM10-22, ACNM10-11, ACNM10-15, ACNM10-2, ACNM10-10, and ACNM10-4 recorded moderate number of primary branches plant^{-1} as compared to rest of the genotypes in a descending manner. Similarly minimum number of primary branches plant^{-1} recorded by ACNM10-1 and ACNM10 -17. Data showed that number of primary branches was increased with the age till its maturity. Malek *et al.* (2012) revealed that number of primary branches increased with the age till 95 DAS in soybean.

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and ACNM10-1 and ACNM10-17 recorded minimum number of primary branches plant^{-1}. At 65 DAS significantly highest number of primary branches plant^{-1} was recorded in genotype ACNM10-6 followed by ACNM10-5, Pusa bold, ACN-9, ACNM10-21 and ACNM10-3. Genotypes viz., ACNM10-22, ACNM10-11, ACNM10-15, ACNM10-2, ACNM10-10, and ACNM10-4 recorded moderate number of primary branches plant^{-1} as compared to rest of the genotypes in a descending manner. Similarly minimum number of primary branches plant $^{-1}$ recorded by ACNM10-1 and ACNM10-17. Data showed that number of primary branches was increased with the age till its maturity. Malek *et al.* (2012) revealed that number of primary branches increased with the age till 95 DAS in soybean.

Dry matter production :

At 25 DAS significantly maximum dry matter production was recorded in Pusa bold, followed by ACN-9, ACNM10-6, ACNM10-5, ACNM10-21, ACNM10-3, ACNM10-22, ACNM10-11 and ACNM10-15. Similarly genotypes ACNM10-2, ACNM10-10, ACNM10-4 and ACNM10-1 recorded moderate dry matter production in a descending manner. Genotype ACNM10-17 recorded least dry matter production at this stage of observation.

The data recorded about the dry matter production were found statistically significant at 45 DAS. Significantly highest dry matter production was recorded in genotype Pusa bold followed by ACN - 9, ACNM10 - 6, and ACNM10-5. Genotypes ACNM10-21, ACNM10-3, ACNM10-22, and ACNM10-11 also recorded maximum dry matter production when compared with rest of the genotypes. Similarly genotypes ACNM10-15 ACNM10-2, and ACNM10-10 recorded moderate dry matter production in a descending manner and genotypes ACNM10-4 and ACNM10-1 recorded minimum dry matter production. Genotype ACNM10-17 recorded least dry matter production at this stage of observation. At 65 DAS significantly highest dry matter was recorded in genotypes Pusa bold and ACN-9. Genotypes ACNM10-6, ACNM10-5 and ACNM10-21 also recorded more dry matter production as compared to rest of the genotypes. Similarly genotypes ACNM10-3, ACNM10-22, ACNM10-11, ACNM10-15, ACNM10-2, ACNM10-10 and ACNM10-4 recorded moderate dry matter production in a descending manner. Genotypes ACNM10-1 and ACNM10-17 recorded least dry matter production at this stage of observation.

Hassan *et al*. (2005) recorded highest dry matter accumulation m^{-2} at the time of maturity in sunflower. Channappagoudar *et al*. (2007) reported that photosynthetic rate also differed significantly among the genotypes leading to significant variation in total dry mater accumulation in little millet. In soybean relatively smaller portion of total dry mass (TDM) was produced before flower initiation and the bulk of it after anthesis (Malek *et al.,* 2012). These might be the reasons for variation in total dry matter production at different stages among all the genotypes in the present investigation.

Leaf area :

At 25 DAS significantly maximum leaf area was recorded in Pusa bold, followed by ACN-9, ACNM10-6, ACNM10-5, ACNM10-21, ACNM10-3, ACNM10-22, and ACNM10-11 in a descending manner. Genotypes ACNM10-15, ACNM10-2, ACNM10-10 and ACNM10-4 recorded moderate leaf area in a descending manner. Genotypes ACNM10-1 and ACNM10-17 recorded least leaf area at this stage of observation. At 45 DAS significantly highest leaf area was recorded in genotype Pusa bold followed by ACN-9, ACNM10-6, ACNM10-5, ACNM10-21, as compared to remaining genotypes in a descending manner. Similarly genotypes ACNM10-3 and ACNM10-22 recorded moderate leaf area and rest of genotypes ACNM10-11 ACNM10-15, ACNM10-2, ACNM10-10 ACNM10-4 and ACNM10-1 showed minimum leaf area. Genotype ACNM10-17 recorded least leaf area at this stage of observation. At 65 DAS significantly maximum leaf area was recorded in Pusa bold, followed by ACN-9. Genotypes ACNM10-6, ACNM10-5 and ACNM10-21 also showed maximum leaf area when compared with rest of the genotypes. ACNM10-3, ACNM10-22, ACNM10-11, ACNM10-15, ACNM10-2 and ACNM10-10 recorded moderate leaf area in a descending manner. Genotype ACNM10-4 and ACNM10-1 showed minimum leaf area, while it was least in ACNM10-17.

Leaf area increased gradually from first to second stage (25-45 DAS) but somewhat rapid increase in leaf area was evidenced at third stage (65 DAS) in all the genotypes studied. Malek *et al*. (2012) also reported that leaf area increased gradually with the age till 80 DAS in Soybean.

Growth analysis :

Growth analysis is one of the measures for accessing the seed yield of the plant. The physiological basis of yield difference can measured through an evaluation of difference in growth parameters and their impact on yield. The productivity of crop may be related with the parameters such as RGR, NAR and partitioning of total photosynthates into economic and non-economic sink.

Relative growth rate (RGR) :

At first stage i.e. 45-25 DAS significantly maximum RGR was observed in genotype Pusa bold, followed by ACN-9. Genotypes ACNM10-6, ACNM10-5, ACNM10-21, ACNM10-3 and ACNM10-22 also recorded more RGR as compared to rest of the genotypes. Similarly genotypes ACNM10-11, ACNM10-15, ACNM10-2, ACNM10-10, ACNM10-4 and ACNM10-1 recorded moderate RGR in a descending manner. Genotype ACNM10-17 recorded least RGR at this stage of observation.

At second stage i.e. 65-45 DAS significantly maximum RGR was observed in genotype Pusa bold, followed by ACN-9,ACNM10-6,ACNM10-5, ACNM10-21, and ACNM10-3 as compared to rest of the genotypes. Similarly genotypes ACNM10-22, ACNM10-11, ACNM10-15, ACNM10-2, ACNM10-10, ACNM10-4 and ACNM10-1 recorded moderate RGR in a descending manner. Genotype ACNM10-17 recorded least RGR at this stage of observation.

Net assimilation rate (NAR) :

At first stage i.e. 45-25 DAS significantly maximum NAR was observed in genotype Pusa bold followed by ACN-9, ACNM10-6, ACNM10-5, ACNM10-21, ACNM10-3, ACNM10-22 and ACNM10-11 as compared to rest of the genotypes. Similarly genotypes ACNM10-15, ACNM10-2, ACNM10-10, and ACNM10-4 recorded moderate NAR in a descending manner. Genotype ACNM10-1 recorded minimum NAR. ACNM10-17 recorded least NAR.

At second stage i.e. 65-45 DAS significantly maximum NAR was observed in Pusa bold, followed by ACN-9, ACNM10-6, ACNM10-5 and ACNM10-21.Genotypes ACNM10-3, ACNM10-22 and ACNM10-11 also recorded more NAR as compared to rest of the genotypes. Similarly genotypes ACNM10-15, ACNM10-2, ACNM10-10 and ACNM10-4 recorded moderate NAR in a descending manner. Genotype ACNM10-1 and ACNM10-17 recorded minimum NAR at this stage of observation.

Yield and yield contributing parameters :
Number of siliqua plant^{-1}

Significantly maximum numbers of siliqua plant^{-1} were recorded by ACNM10-6 followed by ACNM10-5, ACNM10-21, ACNM10-3, Pusa bold, ACNM10-22, ACN-9, ACNM10-11, ACNM10-15, and lowest in ACNM10-17. Genotypes ACNM10-2, ACNM10-10, ACNM10-4 and ACNM10-1 produced moderate number of siliqua plant^{-1}.

1000 seed weight :

The 1000 seed weight (test weight) mainly depends on grain filling capacity. The maximum 1000 seed weight was recorded by Pusa bold and ACN-9 followed by ACNM10-6, ACNM10-5 and ACNM10-21. The genotypes ACNM10-3, ACNM10-22 and ACNM10-11 gave significantly moderate 1000 seed weight. ACNM10-15, ACNM10-2 and ACNM10-10 recorded minimum 1000 seed weight in descending manner. While the genotypes ACNM10-4, ACNM10-1 and ACNM10-17 showed the lowest 1000 seed weight.

Seed yield plot^{-1}(kg) and ha^{-1} (q) :

Data recorded for seed yield plot^{-1}, ha^{-1} were showed significant variation. Pusa bold and ACN-9 showed maximum seed yield followed by ACNM10-6, ACNM10-5, ACNM10-21 and ACNM10-3. The genotypes ACNM10-22, ACNM10-11 and ACNM10-15 were showed moderate seed yield while, minimum seed yield was recorded by genotypes ACNM10-2, ACNM10-10 and ACNM10-4. However, genotypes ACNM10-1 and ACNM10-17 gave the lowest seed yield.

Table 1. Evaluation of mustard genotypes for morphophysiological traits

Genotypes	Plant height (cm)			Number of primary branches			Total dry matter of plant (g)			Leaf area of plant (dm^2)		
	25 DAS	45 DAS	65 DAS	25 DAS	45 DAS	65 DAS	25 DAS	45 DAS	65 DAS	25 DAS	45 DAS	65 DAS
ACNM10-1	3.31	41.34	119.21	0.00	3.00	4.13	1.24	2.70	10.74	1.05	2.13	3.47
ACNM10-2	4.16	49.99	123.54	0.00	3.85	4.33	1.38	3.17	15.18	1.14	2.35	4.68
ACNM10-3	5.74	66.96	129.23	0.00	4.27	5.53	1.56	4.16	24.03	1.25	3.21	4.93
ACNM10-4	3.50	45.92	122.64	0.00	3.08	4.30	1.31	2.92	12.71	1.06	3.16	3.55
ACNM10-5	6.83	84.99	130.07	0.00	4.60	5.96	1.62	4.37	26.64	1.27	3.29	5.25
ACNM10-6	7.30	88.26	132.64	0.00	4.73	6.32	1.64	4.50	28.62	1.28	3.41	5.41
ACNM10-10	3.66	46.29	122.75	0.00	3.13	4.27	1.36	3.07	14.22	1.11	2.17	4.46
ACNM10-11	4.87	62.19	126.39	0.00	3.87	4.90	1.47	3.70	19.08	1.24	2.38	4.81
ACNM10-15	4.76	50.75	125.97	0.00	3.87	4.80	1.42	3.46	17.45	1.14	2.38	4.80
ACNM10-17	2.65	39.20	90.70	0.00	2.96	3.93	0.97	1.93	7.74	1.01	1.86	2.92
ACNM10-21	5.76	68.94	129.24	0.00	4.60	5.60	1.59	4.26	26.28	1.25	3.28	5.19
ACNM10-22	5.58	66.20	127.65	0.00	4.13	5.20	1.50	3.84	20.95	1.25	2.48	4.92
ACN- 9	11.87	104.09	141.53	0.00	4.73	5.70	1.66	4.82	31.64	1.31	3.34	6.30
Pusa bold	12.86	129.75	152.17	0.00	4.93	5.93	1.68	4.95	34.62	1.32	3.50	7.18
SE(m) ±	0.40	4.85	8.45	-	0.25	0.33	0.09	0.22	1.12	0.04	0.10	0.15
CD at 5%	1.15	14.14	24.63	-	0.72	0.95	0.27	0.64	3.26	0.12	0.31	0.45

Table 2. Evaluation of mustard genotypes for RGR , NAR, yield and yield contributing traits

Genotypes	RGR (g g^{-1} day^{-1})		NAR (g dm^{-2} day^{-1})		Yield contributing traits			
	45-25 DAS	65-45 DAS	45-25 DAS	65-45 DAS	No. of siliqua $plant^{-1}$	1000 seed weight (g)	Yield $plot^{-1}$ (kg)	Yield ha^{-1} (q)
ACNM10-1	0.039	0.082	0.048	0.146	152.07	2.07	0.25	3.79
ACNM10-2	0.042	0.089	0.054	0.178	187.13	2.42	0.35	5.21
ACNM10-3	0.049	0.096	0.063	0.245	209.93	2.74	0.50	7.45
ACNM10-4	0.040	0.086	0.052	0.175	163.80	2.10	0.32	4.76
ACNM10-5	0.049	0.098	0.065	0.266	217.87	3.16	0.55	8.19
ACNM10-6	0.050	0.100	0.066	0.278	225.64	3.18	0.56	8.40
ACNM10-10	0.040	0.088	0.054	0.176	167.27	2.41	0.34	5.05
ACNM10-11	0.046	0.091	0.065	0.223	199.60	2.64	0.40	5.94
ACNM10-15	0.044	0.091	0.060	0.203	191.00	2.43	0.38	5.70
ACNM10-17	0.034	0.089	0.035	0.123	105.60	2.04	0.14	2.09
ACNM10-21	0.049	0.097	0.064	0.265	215.27	3.01	0.51	7.68
ACNM10-22	0.047	0.094	0.065	0.240	203.00	2.65	0.44	6.64
ACN- 9	0.054	0.101	0.073	0.288	200.10	3.35	0.59	8.81
Pusa bold	0.054	0.104	0.073	0.290	205.67	3.54	0.65	9.72
SE(m) ±	0.003	0.004	0.004	0.014	11.93	0.09	0.03	0.44
CD at 5%	0.008	0.011	0.011	0.042	34.76	0.27	0.09	1.29

The supply of photosynthates to developing seeds results in the development of seeds in a pod. The number of seeds pod^{-1} is controlled by genetical phenomenon. However, number of filled seeds pod^{-1} is a physiologically controlled phenomenon, which depends upon the availability of dry matter and its translocation to developing seeds (partitioning efficiency). Test weight is affected by supply of photosynthates and well development of seed. Since, a strong competition for photosynthates occurs between vegetative and reproductive organs during seed development phase, cultivation with high photosynthetic efficiency and efficient dry matter translocation mechanism will results in development of bolder seeds (higher test weight). In the present investigation the test weight showed significant genotypic differences.

The study on the performance of mustard genotypes for morphological, physiological at various growth stages and yield contributing characters revealed that fourteen genotypes of mustard showed significant variation among them for all the characters studied, which allowed the selection of superior performing genotypes. Out of the fourteen genotypes Pusa bold and ACN-9 were found to be superior when compared to other genotypes. Similarly next to these two genotypes two local genotypes i.e., ACNM10-6 and ACNM10-5 were also identified as superior over remaining ten genotypes under study. Hence, these two genotypes can also be beneficial for cultivation. In accordance to this study, significant variation among the genotypes of mustard for different yield and yield contributing characters were reported by Ilmulwar *et al.* (2003) and Khan *et al.* (2005) in mustard.

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STUDY OF PHYSICO CHEMICAL AND SENSORY QUALITY OF DAHI (CURD) SOLD IN NAGPUR CITY

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ABSTRACT

The present investigation was undertaken during the year 2011 to study the physico chemical and sensory quality of dahi (curd) sold in Nagpur city. Five samples each from viz., East, West, North and South area of Nagpur were collected at the same time and same number of samples were collected two times at forthnightly interval i.e. replicated thrice and judged for sensory quality and chemical composition. From the results, it was evident that the samples of dahi sold by West Napur region were higher in fat (6.10%), T.S. (13.62%),protein (3.87%),moisture (86.38%) and titratable acidity (0.67% lactic acid) content,while the North region was lower in fat (5.42%), T.S. (12.13%) and protein content (3.38%) and higher in moisture (87.87%) and titratable acidity (1.02% lactic acid) content . It was noted that the dahi sold by West Nagpur was better in quality than the dahi sold by East,North and South area of Nagpur city.The overall sensory score of dahi sold by West was (94.07) which was the higest followed by East(40.79),North(39.62)and South(38.93).

(Key words: Physico-chemical and sensory quality of dahi (curd),different areas of Nagpur)

INTRODUCTION

Fermented milks are known throughout the world for their better taste, nutritive values and therapeutic properties than milk.Though there is no increase in fat and protein content during fermentation,dahi has the highest digestibility than milk production of dahi is largely confined to household only.However,as a result of expantion of dairy industry ,dahi is prepered at local level without any quality control.It is packed in teen container and sold in nearby cities.Most of the cases scientificaly prepared culture is not used and dahi itself is used as culture for fermenting the milk for dahi production. The milk used for dahi production may not have same quality and hence, the quality of dahi produced will be different and will have different physico-chemical properties. The chemical composition of dahi has been reported as fat content ranging from 5-8 %, protein 3.3 – 3.4%, lactose 3.5 to 4.5 and 0.5 – 1.1% lactic acidity (Garg, 1988).Dey *et al.* (2011) studied the acidity of dahi available in Sylhet (Bangladesh). Acidity of dahi samples of Fulkoli, Banaful, Mohanlal, Madhuban and Shad Sweetmeat shops were found to have 0.77 $\pm$ 0.05, 0.68 $\pm$ 0.04, 0.81 $\pm$ 0.10 , 0.76 $\pm$ 0.03 and 0.79 $\pm$0.03, respectively.The highest acidity was that of Mohanlal brand dahi at 0.81 $\pm$ 0.10 % and the lowest acidity was that of Banaful brand dahi at 0.68 $\pm$ 0.04 %.The highest acidity of Mohanlal brand dahi might be due to uncontrolled incubation, postproduction handling and prolonged storage.

The good quality milk is a must for preparing good quality dahi. Total milk production in India is about 121.50 million tons (Anonymous,2011). Out of total milk production about 46% is utilized or sold in market/industry as such and remaining 54% is utilised for preparation of different dairy products like curd (28%), khoa and paneer (12%) and butter (7%) while hardly 7% milk goes into the production of western product like milk powder, processed product, processed cheese and ice cream (Anonymous, 2011).Fermented dairy products are manufactured using a wide range of microorganisms incorporated in starter culture. Quality of fermented dairy product is influenced by conversion of milk components during the fermentation. Metabolic activity of starter culture contribute to different physico-chemical and sensory characteristics of fermented dairy products (Tamime and Robinson, 2004).Considering these facts,an attempt was made to assess the physic-chemical and sensory qualities of dahi sold in various areas of Nagpur city.

MATERIALS AND METHODS

The study of physico chemical and sensory qualities of dahi sold in Nagpur city was conducted during 2011-12 at Animal Hasbandary And Dairing Section,College of Agriculture,Nagpur.The samples were collected from the four localities of Nagpur city viz., (A) Eastern area (East),(B)Western area (West), (C)Northern area (North) and (D)Southern area (South).5 samples were collected from each region at

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a time i.e.20 samples were collected during one visit.Likewise subsequently same number of samples were collected twice at forthnightly interval .Thus,collection of samples was replicated thrice.The samples were collected in suitable containers and stored in refrigerator till the samples were used for judging, sensory evaluation and physico chemical analysis viz., fat, protein, moisture, total solids, ash and acidity. Fat content was determined by Gerber method(Anonymous,1977).Total solid was estimated by hot oven method and acidity was estimated by titration method (Anonymous,1981).Moisture content in dahi sample was determined by subtracting the total solids content from 100 in the sample.

Moisture = 100 – Total solids

The protein content of dahi was determined as per the semi-micro Kjeldahls method (Anonymous,1961). Ash content of dahi samples was determined by using muffle furnes (Anonymous, 1961) as per equation given bellow.

$$\% \text{ of Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

The collected samples of dahi were subjected to sensory evaluation in respect of flavour,body, and texture and colour and appearance of each sample and score was given with the help of 100 point numeric scale of scores prescribed by Pal and Gupta (1985) as stated bellow for various sensory attributes.

1. Flavour - 45
2. Body and Texture- 35
3. Colour and Appearance- 20

Total- 100

Data were statistically analyzed by using analysis of variance – two way classifications. Critical difference was calculated to determine the significance. (Panse and Sukhatme,1978).

RESULTS AND DISCUSSION

The results on chemical composition of dahi samples collected from four localities of Nagpur city viz., East,West,North and South regions are presented in table1.

Fat Content :

The average fat content of dahi samples collected from four different localities i.e. East, West, North and South area of Nagpur city was observed as 5.34, 6.10, 5.42 and 5.46 per cent respectively.

The average content of fat in dahi from West Nagpur was higher than East, North and South. It seems that the fat content in dahi samples collected from West Nagpur was superior over East, North and South regions of Nagpur. It can also be noticed that lower fat percentage (5.34 per cent) was observed in dahi collected from East region which slightly differed from fat percentage of dahi samples collected from other regions.Soomro (2003) recorded that the highest fat content of indigenous dahi was observed from the sample C with an average of 5.071 $\pm$ 0.123364, whereas the lowest fat percentage was recorded from sample A with an average of 2.48 $\pm$ 0.0504891.On contrary, Salunkhe *et al.* (2008) recorded the fat content in dahi as 4.80 and 1.23 per cent in hotel and vender samples respectively collected from different localities of Nagpur city.

Total Solids :

The total solid content of dahi samples collected from four different localities i.e. East, West, North and South area of Nagpur city was found as 11.99, 14.91, 12.13 and 13.62 per cent respectively. The total solid content of dahi samples from East Nagpur was lower than the total solid content of dahi samples of North, South and West Nagpur.The higher total solid percentage was observed in West region (14.91 per cent) than other regions viz., South, North and East and differed significantly. The difference in between total solid content of dahi sample was mainly due to non standardization of milk in these area,Soomro *et.al.* (2003), recorded the highest total solid content of indigenous dahi from the sample C with an average of 13.8 $\pm$ 0.Thus finding of present investigation agree with these observations for total solids.

Moisture :

The moisture content of dahi samples collected from four different localities i.e. East,West,North and South area of Nagpur city was found as 88.01, 85.09, 87.87 and 86.38 per cent respectively and showed significant difference amongst them.The moisture content of dahi samples from West Nagpur was lower than the moisture content of dahi samples of East,North and South Nagpur.The higher moisture percentage was observed in East Nagpur(88.01 per cent) than other area of Nagpur and differed significantly.Salunkhe *et. al.* (2008) recorded that the average moisture content of dahi samples collected from hotel in East, West,

North and South region of Nagpur was found as 86.68, 86.15, 86.52 and 87.12 per cent respectively. Thus,results of present studies agree with his results.

Titratable Acidity :

The titratable acidity of dahi samples collected from four different localities i. e. East, West, North and South area of Nagpur city was observed as 0.74, 0.67, 1.02 and 1.01, per cent, respectively with significant difference between them. The titratable acidity of North Nagpur samples (1.02 per cent) was higher than the titratable acidity of East, West and South Nagpur samples.The West Nagpur samples had lower acidity of 0.67 per cent.Salunkhe *et al.*(2008) noticed that the acidity content of dahi samples collected from hotel and venders of four different localities of Nagpur city was in the range of 0.81 to 2.45 per cent.Thus, result of present study conform in the acidity of different samples recorded earliers.

Protein:

The protein content of dahi samples collected from four different localities i.e. East, West, North and South regions of Nagpur city was recorded as 3.41, 3.87, 3.38 and 3.40 per cent, respectively. The protein content in dahi sample of West region was significantly higher (3.87 per cent) than the protein per cent of East, West and North Nagpur samples.The dahi samples of North had lower protein (3.38 per cent) than that of other dahi samples.Though there was significant difference in protein content of dahi samples collected from different regions i.e. East, West, North and South but the values of protein content was significantly more in West Nagpur (3.87 per cent). Variation in protein content of dahi samples collected from different localities of Nagpur city might be due to progress of storage period.

Ash:

The ash content of dahi samples collected from four different localities i.e. East, West, North and South regions of Nagpur city were observed as 0.70, 0.77, 0.72 and 0.71 per cent, respectively. The ash content of West sample was significantly higher (0.77 per cent) than the protein per cent of North, South and East respectively.The East region samples had lowest ash content (0.70 per cent). Ash content of dahi samples varied non-standardised quality of milk.On the contrary, Dey *et al.* (2011) recorded the average percentage of ash of Fulkoli, Banaful, Mohanlal, Madhuban and Shad Sweetmeat shops made dahi were 0.93 ± 0.06, 1.03 ± 0.17, 1.22 ± 0.07, 1.16 ± 0.21 and 1.42 ± 0.06 respectively.These values are much higher that the values of ash content recorded in the present study.

Sensory quality of Dahi :

The overall scores of dahi collected from Nagpur city after sensory evaluation are presensted in table 2.

Flavour:

The flavour score of dahi samples collected from four different localities of Nagpur city i.e. East, West, North and South regions were observed 40.79, 42.99, 39.62 and 38.93, per cent respectively. It was noticed that there was significant difference in flavour score of dahi samples from East, West, North and South. The highest score of dahi samples for flavour was observed in West region (42.99 per cent) and differed significantly. Salunkhe *et al*.(2008) recorded the average flavour score of dahi samples collected from hotels and vendors of four localities were 41.51 and 36.27, respectively.

Body and texture :

The score for body and texture of dahi samples collected from East, West, North and South regions was observed 31.16, 32.29, 29.93 and 29.67 per cent respectively. Highest score was observed in West samples (32.29).It is evident from the data that there was significant difference in body and texture score of dahi samples collected from different area of Nagpur city.West Nagpur samples had firm, solid uniform and smooth body and texture, however,East Nagpur samples also possessed the same quality while North and South samples had little whey in them. These results are in line with the results of Singh and Sinha (2000). They noticed that the body and texture of dahi had firm solid body and texture with negligible whey separation.

Colour and apperance score :

The score for colour and appearance of dahi samples collected from East, West, North and South area of Nagpur was observed as 18.09, 18.78, 17.46 and 17.12,per cent respectively. Highest score was observed in West samples (18.78). It is found that there was significant difference in colour and appearance score of dahi samples collected from different localities of Nagpur city.West samples showed clean, velvety, smooth appearance while East, North and South samples showed gas holes and

Table 1.Chemical composition of dahi sample(mean of 15 samples)

Source	Fat %	Moisture %	Total solid%	Protein%	Acidity %	Ash%
A (East)	5.34^{d}	88.01^{a}	11.99^{d}	3.41^{b}	0.74^{c}	0.70^{d}
B (West)	6.10^{a}	85.09^{d}	14.91^{b}	3.87^{a}	0.67^{d}	0.77^{a}
C (North)	5.42^{c}	87.87^{b}	12.13^{c}	3.38^{d}	1.02^{a}	0.72^{b}
D (South)	5.46^{b}	86.38^{c}	13.62^{a}	3.40^{c}	1.01^{b}	0.71^{c}
SE(m) $\pm$	0.1315	0.3339	0.3193	0.0237	0.0336	0.0039
CD(0.05)	0.390	0.991	0.948	0.070	0.099	0.011

Table 2. The overall score of dahi samples collected from Nagpur city (out of 1) (mean of 15 samples)

Source	Flavour(45)	Body and texture (35)	Colour and appeaence(20)	Overall acceptiblity score(100)
A (East)	40.79^{b}	31.16^{b}	18.09^{b}	90.05^{b}
B (West)	42.99^{a}	32.29^{a}	18.78^{a}	94.07^{a}
C (North)	39.62^{c}	29.93^{c}	17.46^{c}	87.01^{c}
D (South)	38.93^{d}	29.67^{d}	17.12^{d}	85.73^{d}
SE(m) $\pm$	0.2726	0.2726	0.2713	0.3265
CD at 5%	0.809	0.809	0.806	0.969

watery appearance. These results are in accordance with the findings of Dorai *et.al.* (2009). He recorded the appearance score of goat milk dahi as 8.50 ± 0.036 per cent against the control scores of 7.83 ± 0.005 per cent for colour and appearance.While Salunkhe *et al.*(2008) recorded the average score of dahi sample of hotels and vendors was 8.29 and 6.20 per cent respectively on 9 point hedonic scale.

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GENETIC DIVERGENCE FOR SELECTION OF PARENTS FOR HYBRIDIZATION IN MAIZE

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ABSTRACT

Thirty three genotypes were evaluated in *rabi* 2011 in the farm of Agricultural Botany Section, College of Agriculture, Nagpur for genetic divergence to identify the desirable and potential parents for maize breeding programme aimed at yield and earliness improvement. Genetic divergence was studied for nine characters like days to 50% tassling, days to 50% silking, days to maturity, plant height (cm), cob length, cob girth, number of grain cob^{-1}, 100 grain weight (g) and grain yield^{-1}. Mahalanobis generalized distance for characters was used in this study for computing genetic divergence. The analysis of dispersion for nine correlated variables using Wilk's criterion, revealed highly significant difference between genotypes for aggregate of the nine characters. The 33 genotypes were grouped into six clusters by Tocher's method. The maximum inter cluster distance was recorded between cluster IV and cluster VI (62.538). The canonical analysis indicated that number of grains cob^{-1}, days to 50% tasseling, grain yield plant^{-1} 100 grain weight, cob length and days to 50% silking were the important source of variation in vector I. In vector II plant height, days to maturity, days to 50% tasseling and number of grains cob^{-1} were important source of variation. In vector III cob length, number of grains cob^{-1} and days to 50% tasseling were important. In vector IV 100 grain weight, cob girth, days to 50% tasseling and plant height were important. In vector V days to 50% tasseling, number of grains cob^{-1} and days to 50% silking were important. The canonical analysis and cluster mean study together revealed the importance of days to 50% tasseling, number of grains cob^{-1}, days to 50% silking and plant height as contributors to the total divergence. The genotypes belonging to distant cluster and exhibiting high performance in the desirable direction for days to 50% tasseling, number of grains cob^{-1}, days to 50% silking and plant height were identified as the potential parents for hybridization programme. Genotypes NM-098, NM-093, NM-0918, NM-0991, NM-0911, GP-87, NM-0923, NM-0924, NM-0955, NM-0912, NM-0921, NM-097, NM-0915(W), NM-0959, GP-93, NM-0992 and GP-92 were identified as diverse parents to be crossed with either PKVM-Shatak or Maharaja.

(Key words : Maize hybrid, genetic divergence)

INTRODUCTION

Maize occupies a pride place among coarse cereal crops in India. It is grown in area of 7.27 million ha with the production of 15.86 million tonnes and average productivity of 2181 kg ha^{-1} (Anonymous, 2011). Among the major maize producing states, Karnataka tops the list with a contribution of 18.02% to the total Indian maize production. Other states are Andhra Pradesh (16.02%), Maharashtra (10.93%) Bihar (8.84%), Rajasthan (6.85%), Tamil Nadu (6.84%) and Madhya Pradesh (6.25%). The study of genetic divergence among the set of available genotypes will be useful to plan hybridization programme, because success of hybridization programme depends upon selection of suitable parents of diverse origin. Availability of sufficient genetic diversity in the germplasm collection is the basis for choice of suitable parents for hybridization programme. Genetic diversity plays a huge role in survival and adaptability of a species. A species that has large degree of genetic diversity among its population will have more variation from which choosing the fit alleles become possible.

MATERIALS AND METHODS

Thirty three genotypes of diverse eco-geographical background including thirty one genotypes and two checks, one single cross hybrid Maharaja and one composite PKVM-Shatak were grown in randomized complete block design with two replications during *rabi* 2011 in the farm of Agril. Botany Section, College of Agriculture, Nagpur. Each genotype was grown in single row plot with inter and intra row spacing of 60 cm and 20 cm. The recommended cultural practices were followed to raise good crop. The data were recorded on five randomly selected plants from each genotype on following six characters viz, plant height, cob length, cob girth, number of grains cob^{-1}, 100 grain weight and grain yield plant^{-1} except days to 50 % tasseling, days to 50% silking and days to maturity which were recorded on plot basis. The data were subjected to the statistical and biometrical analysis. In order to assess the genetic diversity among distinct genotypes, the D^2 statistics developed by Mahalanobis (1930) were utilized. Grouping of genotypes into different clusters and canonical analysis were done by using Tocher's

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method described by Rao (1952). Selection of parents for hybridization from different clusters was done on the basis of mean statistical distance as suggested by Bhatt (1970).

RESULTS AND DISCUSSION

The mean squares due to genotypes were highly significant for all the nine characters studied i.e. days to 50% tasseling, days to 50% silking, days to maturity, plant height, cob length, cob girth, number of grains cob^{-1}, 100 grain weight and grain yield plant^{-1}. Analysis of variance for the experimental design thus indicated the presence of substantial genetic variability among the genotypes which allows the further estimation in the experimental material. The wide variability for yield plant^{-1} and yield contributing characters in maize were also observed by Gautam *et al.* (2002), Alom *et al*. (2003), Marker and Krupakar (2009), Ganesan *et al*. (2010). The *per se* performance of 33 genotypes studied for nine characters (Table 1) revealed that the genotypes NM-093, NM-098, NM-0918, NM-0931, NM-0991 and NM-0912 were found to be promising as they showed superior performance for grain yield plant^{-1} and yield contributing traits like 100 grain weight, number of grains cob^{-1}, cob girth and cob length. These genotypes were either significantly superior or at par with check Maharaja and PKVM-Shatak. The analysis of dispersion for the test of significance of differences in the mean values based on Wilk's criterion indicated highly significant differences between the genotypes for the aggregate of nine characters (X^2 = 4.1436+02 at 288 d.f.). Therefore the data were further evaluated for D^2 and cluster analysis. The data regarding contribution of each character towards genetic divergence are presented in table 2. The contribution of number of grains cob^{-1} to the total genetic divergence was maximum (28.41%) followed by cob girth (23.48%), plant height (12.69%), 100 grain weight (9.85%), cob length (7.95%) and days to 50% tasseling (7.39%). Relatively days to maturity (5.30%), days to 50% silking (2.46%) and grain yield plant^{-1} (2.46%) contributed less towards genetic divergence. In agreement with present result Marker and Krupakar (2009) studied the contribution of individual character towards total divergence and suggested that per cent contribution was highest for protein content (80.00) followed by ear girth (5.83), harvest index (4.17), days to 50 per cent tasseling (2.50), number of grains row^{-1} (2.50), ear height (1.67), grain yield plant^{-1} (1.67), plant height (0.83) and number of grains row^{-1} (0.83).

The groupings of 33 genotypes are presented in table 3. The entire genotypes on the basis of D^2 statistics were grouped into six clusters. Cluster III was the largest comprising of 9 genotypes. The next largest cluster was cluster II which included 8 genotypes, cluster I and cluster IV included 7 genotypes each. Cluster V and cluster VI included only one genotype each. The promising check Maharaja and PKVM-Shatak were found to fall each in separate cluster. All other 31 genotypes were distributed in four clusters. This indicates that the genotypes are highly diverse from the check and hence offers good scope for improvement.

The values of first five canonical vectors and canonical roots are presented in table 4 and table 5. The first three canonical roots accounted for 63.59% of the observed variability in material(λ_1= 28.482%, λ_2=21.819% and λ_3=13.291%). The overall contribution of the five canonical roots to total variability among 33 genotypes was 83.156% suggesting the completion of major portion of differentiation in first five phases. This indicated that differentiation for nine characters among 33 genotypes was nearly completed in five phases. Further the coefficients in the first five canonical vectors indicate that out of nine quantitative characters number of grains cob^{-1}, days to 50% tasseling, grain yield plant^{-1}, 100 grain weight, cob length and days to 50% silking were important characters in the first vectors which was major access of differentiation accounting for 28.482% of total variation. Plant height, days to maturity, days to 50% tasseling and number of grains cob^{-1} were important characters in secondary access of differentiation which accounted for 21.819% of variation. Important characters in vector III were cob length, number of grains cob^{-1} and days to 50% tasseling accounting to 13.291% of variation. 100 grain weight, cob girth, days to 50% tasseling and plant height were important characters in vector IV which accounted for 11.195% and days to 50% tasseling, number of grains cob^{-1} and days to 50% silking were important source of variation in vector V accounting to 8.369% of variation. This suggested that parents selected on

basis of characters like days to 50% tasseling, number of grains cob^{-1}, days to 50% silking,plant height and cob length may be expected to be genetically diverse. Average intra and inter cluster distance among nine characters were worked out from divergence analysis and are presented in table 6. The inter cluster distance in most of the cases was larger than the intra cluster distance. The intra cluster variation ranged from 0.00 to 17.64. Cluster IV passed highest intra cluster distance (D=17.647) followed by cluster III (D=11.766) and cluster II (D=7.134). The average inter cluster distance was maximum between cluster IV and cluster VI (D=62.538) followed by cluster V and cluster VI (D=59.815), cluster III and cluster V (D=49.155), cluster II and cluster VI (D=46.145) and cluster IV and cluster V (D=43.322) suggesting more variability in genetic make up of genotypes included in these cluster. The inter cluster distance was found to be minimum between cluster I and cluster II (D=8.551). Somayagullu *et al*. (1970) reported that the clustering showed instability due to relatively lesser divergence, where as the widely diverged cluster remained distinct in different environment. The clusters which are highly diverge would be more stable. Therefore, the genotypes belonging to the distant cluster may be used in hybridization programme for obtaining a wide spectrum of variation among the segregates. These findings are in conformity with the finding of Alom *et al.* (2003) and Marker and Krupakar (2009).

Overall study for cluster means (Table 7) considering all the characters indicated that cluster V possessed the highest cluster mean for days to maturity, plant height and cob length. Cluster IV showed maximum mean for days to 50% silking, number of grains cob^{-1} and grain yield plant^{-1}. Cluster III showed maximum mean for cob girth and 100 grain weight. Cluster II showed maximum mean for days to 50 % tasseling. The variance of cluster means for all the characters indicated that the maximum variation was accounted by number of grains cob^{-1} (783.87) followed by plant height (76.89), grain yield plant^{-1} (29.79), days to 50 % silking (10.28) and days to 50% tasseling (9.70). The variance was lowest for cob girth (0.20). Cluster means based on correlated data are used to know relative importance of characters in causing genetic divergence. In the present study the results on variance of cluster mean indicated that number of grains cob^{-1}, plant height, grain yield plant^{-1}, days to 50% silking and days to 50% tasseling were important source of variation which suggest that these characters were highly responsible for genetic divergence in the present material. This observation is slightly deviating from results obtained on the basis of canonical method. However, four characters days to 50% tasseling, number of grains cob^{-1}, days to 50% silking and plant height are important source of variation as observed from both the method studied. Hence it is suggested that the selection of parent for hybridization and subsequent genetic improvement may be made on the basis of the characters exhibiting maximum variation and expected to be genetically diverse. Thus, from this study it can be reported that the parent may be selected for hybridization on the basis of the above four characters namely days to 50 % tasseling, number of grains cob^{-1}, days to 50 % silking and plant height. Alom *et al*. (2003), Showemimo (2004) and Hemavathy *et al*. (2006) also observed the importance of above four characters for genetic divergence in maize.

According to Bhatt (1970) the mean statistical distance may be considered arbitrarily as a guide line and crosses between parents belonging to different clusters having same or higher inter-cluster distance than the mean statistical distance may be attempted. The crosses should be chosen from widely separate cluster. In the present study all possible combinations beyond the mean inter cluster distance (D=23.21) formed from different clusters have been arranged in descending order of magnitude of genetic distance and promising nine cluster combinations are presented in table 8. Other practical considerations like grain yield plant^{-1}, number of grains cob^{-1}, days to 50% tasseling, days to 50 % silking and plant height were also taken into account while choosing the genotypes from the selected cluster combination. The present study projected the importance of NM-098, NM-093, NM-0918, NM-0991, NM-0911, GP-87, NM-0923, NM-0924, NM-0955, NM-0912, NM-0921, NM-097, NM-0915(W), NM-0959, GP-93, NM-0992 and GP-92 as one of the parents and either PKVM-Shatak or Maharaja as another parent for getting high heterotic cross in F_1.

Table 1. Mean performance of genotypes for different characters

Sr. No.	Genotypes	Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	100 grain weight (g)	Grain yield plant^{-1} (g)
1	NM-093	56.00	66.50	96.50	123.70	11.99	12.31	246.40	22.86	55.45
2	NM-096	55.00	65.00	93.00	117.90	10.40	10.41	182.30	20.49	38.32
3	NM-097	54.50	66.50	96.50	117.60	10.30	11.65	208.00	21.38	47.43
4	NM-098	56.00	66.50	97.00	127.60	10.65	12.66	226.20	23.24	60.28
5	NM-0911	54.50	64.50	94.50	119.70	12.55	12.88	230.90	21.05	49.01
6	NM-0912	56.50	67.00	96.00	112.60	11.44	12.01	255.60	19.50	54.42
7	NM-0913	54.50	65.50	95.00	122.40	11.90	11.60	204.90	19.82	43.00
8	NM-0915 (W)	53.50	66.50	94.50	117.20	11.47	11.84	194.80	21.04	45.46
9	NM-0915 (Y)	57.00	66.50	96.00	120.00	12.62	9.95	170.50	19.43	36.69
10	NM-0918	57.00	66.50	96.50	120.60	12.90	11.55	228.00	22.60	55.48
11	NM-0921	56.00	65.50	96.00	120.10	12.51	11.99	204.80	21.92	48.01
12	NM-0923	56.50	67.00	96.50	121.30	13.51	11.53	199.40	20.82	47.49
13	NM-0924	55.00	66.00	96.50	126.90	14.18	12.57	218.10	20.15	46.72
14	NM-0931	57.00	67.00	95.00	129.80	14.11	11.85	227.60	21.21	51.89
15	NM-0932	57.50	67.00	95.50	124.40	12.30	10.75	186.70	17.61	35.78
16	NM-0946	56.00	67.00	97.00	113.60	11.35	11.84	188.60	21.13	40.00
17	NM-0955	56.00	66.50	96.50	118.40	9.70	10.20	162.30	21.72	40.45
18	NM-0959	55.00	67.50	96.50	114.60	10.46	12.10	176.60	22.59	42.95
19	NM-0960	54.50	65.50	96.00	132.30	10.55	10.26	175.10	18.81	38.13
20	NM-0986	54.00	65.00	95.50	116.30	9.66	10.79	146.50	24.74	41.76

Table 1. Cont...

Sr. No.	Genotypes	Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	100 grain weight (g)	Grain yield plant^{-1} (g)
21	NM-0991	51.00	63.50	94.00	124.10	13.21	13.49	163.00	27.01	51.85
22	NM-0992	55.50	66.00	95.00	129.60	12.02	11.46	174.40	21.25	37.79
23	NM-0993	54.50	65.00	94.50	118.90	9.85	11.84	176.20	18.80	36.60
24	GP-86	54.50	65.50	95.50	105.80	9.96	10.92	143.70	22.85	32.34
25	GP-87	52.50	64.50	94.00	117.50	12.66	11.91	193.50	23.85	45.19
26	GP-89	54.00	64.50	95.50	115.50	8.66	11.71	132.20	23.58	33.95
27	GP-90	57.00	66.00	96.00	126.30	11.58	11.94	181.00	23.85	41.70
28	GP-91	54.50	64.00	94.00	126.30	11.90	10.37	175.00	19.38	38.22
29	GP-92	53.50	64.50	94.00	118.40	13.21	12.54	168.80	24.26	43.66
30	GP-93	53.50	65.50	94.50	115.10	11.10	11.00	158.80	21.76	39.14
31	GP-0111	53.50	65.50	96.50	106.10	9.77	9.22	165.20	18.20	33.02
32	PKVM SHATAK	53.50	65.00	100.00	140.50	12.50	11.01	213.00	19.46	42.78
33	MAHARAJA	47.50	58.00	91.50	118.60	11.05	10.95	142.20	22.97	32.99
	Grand Mean	54.75	65.53	95.50	120.59	11.57	11.48	188.49	21.49	43.27
	S E (m) ±	1.00	1.03	0.89	3.49	0.87	0.50	15.22	1.20	4.45
	C V (%)	2.58	2.23	1.32	4.09	10.69	6.26	11.41	7.89	14.54
	CD (5%)	2.88	2.98	2.57	10.06	2.52	1.46	43.84	3.45	12.82

Table 2. Contribution of individual character to divergence

Sr. No.	Source	Time ranked Ist	Contribution %
1.	Days to 50% tasseling	39	7.39
2.	Days to 50% silking	13	2.46
3.	Days to maturity	28	5.30
4.	Plant height (cm)	67	12.69
5.	Cob length (cm)	42	7.95
6.	Cob girth (cm)	124	23.48
7.	Number of grains cob^{-1}	150	28.41
8.	100 grain weight (g)	52	9.85
9.	Grain yield plant^{-1} (g)	13	2.46
	Total	528	100

Table 3. Grouping of 33 genotypes of maize in different clusters

Cluster	Total no. of Genotypes	Genotypes
I	7	NM-0921, NM-0946, NM-097, NM-0913, NM-0959, NM-0915 (W), GP-93
II	8	NM-0915(Y), NM-0932, NM-0923, GP-91, NM-0924, NM-0992, NM-0955, NM-096
III	9	GP-87, GP-92, GP-86, NM-0986, GP-89, NM-0993, NM-0911, GP-90, NM-0991
IV	7	NM-093, NM-0918, NM-0931, NM-098, NM-0912, NM-0960, GP-0111
V	1	PKVM SHATAK
VI	1	MAHARAJA

Table 4. The value of first five canonical vectors and canonical roots

Vector	Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	100 grain weight (g)	Grain yield plant^{-1} (g)
I	0.513	0.199	-0.072	0.044	0.268	-0.009	0.514	0.329	0.495
II	0.214	-0.048	0.487	0.528	-0.267	-0.574	0.115	-0.126	-0.080
III	0.179	-0.757	-0.352	0.086	0.336	-0.144	0.210	-0.102	-0.275
IV	0.175	-0.296	0.070	0.124	-0.393	0.267	-0.180	0.759	-0.163
V	0.286	0.116	-0.406	-0.437	-0.625	-0.267	0.212	-0.126	-0.165

Table 5. Value of five canonical root and their contribution expressed as per cent of the total variation

Root	Value	Contribution (%)
1	2.563	28.482
2	1.964	21.819
3	1.196	13.291
4	1.008	11.195
5	0.753	8.369
Total	6.711	83.156
Sum of all canonical root	8.061	-
Residual	1.35	16.844

Table 6. Average intra and inter-cluster distance by Tocher's method

Cluster	I	II	III	IV	V	VI
I	**4.433**	8.551	9.966	12.900	41.451	39.033
II		**7.134**	16.198	13.229	32.895	46.145
III			**11.766**	22.964	49.155	30.471
IV				**17.647**	43.322	62.538
V					**0.000**	59.815
VI						**0.000**

$\overline{D}$ **= 23.26**

Figures in bold indicates intra cluster distance.

Table 7. Cluster means for nine characters in maize

Sr. No.	Cluster	Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	100 grain weight (g)	Grain yield $plant^{-1}$ (g)
1	I	54.71	66.28	95.71	117.22	11.29	11.71	190.92	21.37	43.71
2	II	55.87	66.00	95.37	123.10	12.07	10.90	183.58	20.10	40.18
3	III	53.94	64.77	94.83	118.05	11.26	12.00	170.64	23.33	41.78
4	IV	55.78	66.35	96.21	121.81	11.63	11.40	217.72	20.91	49.81
5	V	53.50	65.00	100.00	140.50	12.50	11.01	213.00	19.46	42.78
6	VI	47.50	58.00	91.50	118.60	11.05	10.95	142.20	22.97	32.99
	S. D.	3.11	3.20	2.72	8.76	0.55	0.45	27.99	1.54	5.45
	Variance	9.70	10.28	7.43	76.89	0.30	0.20	783.87	2.37	29.79

Table 8. Selection of cluster combinations, potential parents and cross combination on the basis of genetic diversity

Sr. No.	Cluster combination	Average inter-cluster distance	Cross combination	Traits
1	IV × VI	62.538	NM-098 NM-093 NM-0918 x MAHARAJA	100 grain weight
2	V × VI	59.815	PKVM SHATAK x MAHARAJA	Cob girth
3	III × V	49.155	NM-0991 NM-0911 GP-87 x PKVM SHATAK	Grain yield plant^{-1}
4	II × VI	46.145	NM-0923 NM-0924 NM-0955 x MAHARAJA	Grain yield plant^{-1}
5	IV × V	43.322	NM-0912 NM-093 NM-0918 x PKVM SHATAK	Number of grains cob^{-1}
6	I × V	41.451	NM-0921 NM-097 NM-0915 (W) x PKVM SHATAK	Grain yield plant^{-1}
7	I × VI	39.033	NM-0959 NM-0921 GP-93 x MAHARAJA	100 grain weight
8	II × V	32.895	NM-0955 NM-0992 NM-0923 x PKVM SHATAK	100 grain weight
9	III x VI	30.471	NM-0991 NM-0986 GP-92 x MAHARAJA	100 grain weight

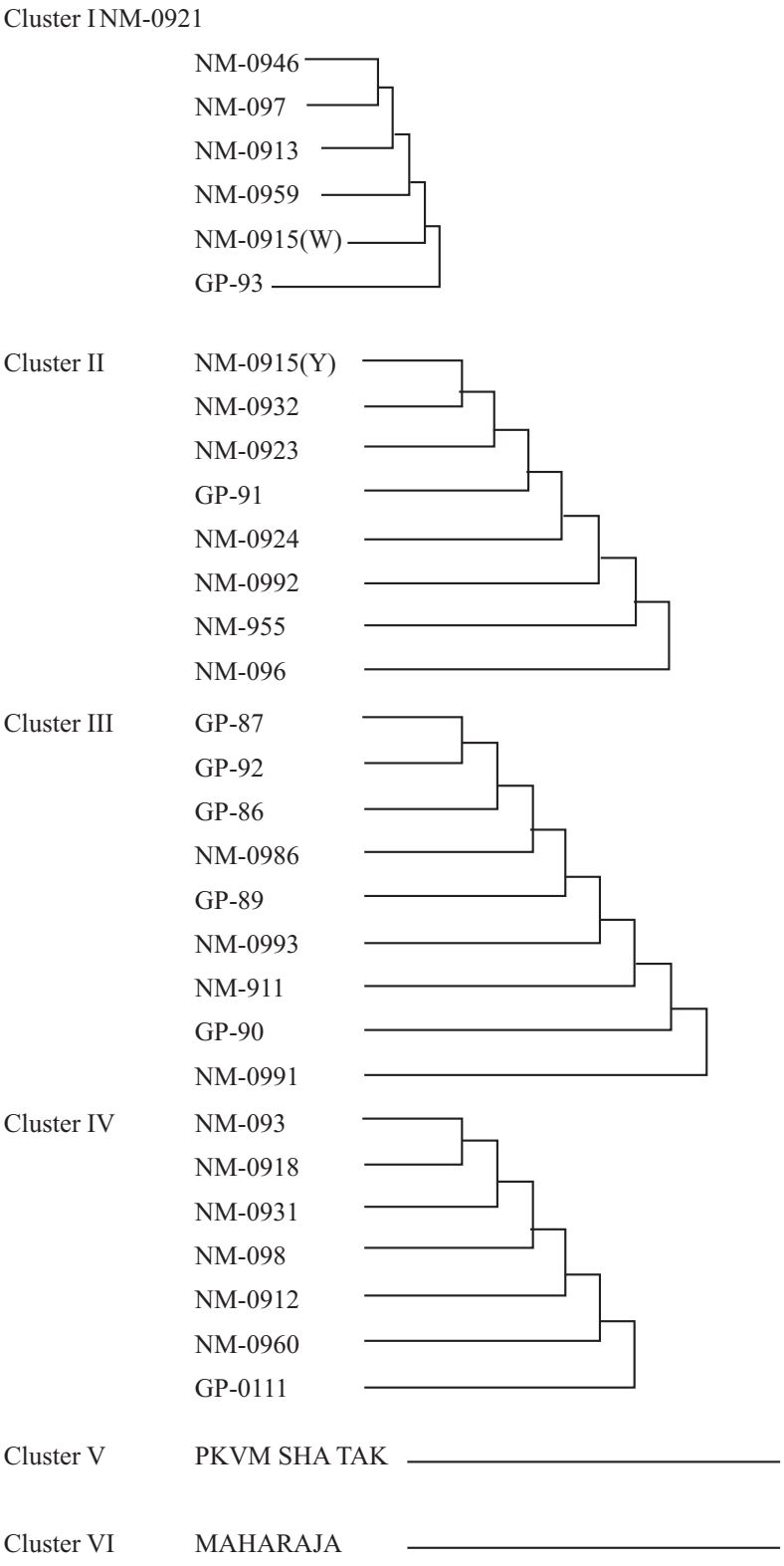

Fig. 1 Dendrogram showing clustering by Tocher's methods

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EFFECT OF IBA ON ROOTSTOCK AND TIME OF BUDDING AND IT'S SUCCESS IN ROSE

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ABSTRACT

Studies were conducted to observe the effect of IBA on rootstock and time of budding and it's success in rose at Horticulture Section, College of Agriculture, Nagpur during, 2011. The experiment was laid out in Factorial Complete Randomized Design (FCRD). Twenty treatment combinations were tested in three replications. The experiment comprised of four levels of IBA viz., control (T_1), 500 ppm IBA (T_2), 1000 ppm IBA (T_3) and 1500 ppm IBA (T_4) and five times of budding i.e. 3rd week of November (B_1), 1st week of December (B_2), 3rd week of December (B_3), 1st week of January (B_4) and 3rd week of January (B_5) and their combitions. It is evident from the results that, the treatment of IBA 1000 ppm was proved to be significantly superior than other levels of IBA and control in respect of days required for budsprouting, budsprouting percentage, height of bud graft, number of leaves budsprout^{-1} as well as branches budsprout^{-1} and final budding success. Among different time of budding 1st week of January showed significant effect on days required for budsprouting after budding, budsprouting percentage, number of branches as well as leaves budspout^{-1}, height of bud graft and final budding success. Interactions were found non-significant in every character studied.

(Key words: IBA, budding time, rootstock, rose propagation)

INTRODUCTION

The rose is one of the nature's beautiful creations and is universally acclaimed as the Queen of flowers. The roses are generally propagated by vegetative method. In this, firstly cuttings of root stock are planted and then they are budded with the desired variety. But success rate through cuttings is limited in most of rose varieties due to failure in root formation.

This problem can be overcome by use of growth regulators. Plant growth regulators could promote rooting in many ornamental plants including roses (Pande and Sinha, 1977). Now a day, growth substance is being used in the commercial propagation of different crops. Budding is the most popular and successful method for multiplying roses. Budding method can obtained considerable success with the use of plant growth regulators (Kuppuswami, 1957 and Singh *et al.,* 1976). The time of budding varies from place to place and the right stage of budding is when plants have good sap flow and the cambium tissue is highly active. The best time to budding in a roses in Eastern India is from January to March (Bose and Mukherjee, 1977), while in Northern India it is from December to February (Swarup, 1980).

MATERIALS AND METHODS

The experiment was conducted in Horticulture Section, College of Agriculture, Nagpur during 2011. The experiment was carried out in Factorial Complete Randomized Design (FCRD) with twenty treatment combinations and three replications. The twenty treatment combinations comprised of different levels of IBA viz., control (T_1), 500 ppm IBA (T_2), 1000 ppm IBA (T_3) and 1500 ppm IBA (T_4) and five times of budding i.e. 3rd week of November (B_1), 1st week of December (B_2), 3rd week of December (B_3), 1st week of January (B_4) and 3rd week of January (B_5). The semihard wood cuttings of 20 cm length and 0.6 to 0.7 cm diameter having good swollen buds were taken from the rootstock of rose i.e. *Rosa indica* Odorata. The solutions of different concentrations of IBA were prepared as per the treatments. The lower portion of the cutting was treated with different concentrations of IBA for 20 minutes by dipping method. However, the untreated cuttings (control) were placed in distilled water for the same period. After treating with IBA cuttings were planted in pre arranged polybag containing mixture of well decomposed FYM, sand and soil in the proportion of 1:1:1. Immediately after planting the cuttings were watered. The plumpy and dormant buds were removed from the bud sticks of Toro variety and budded on the root stock of *Rosa indica var*. Odorata in the month of November, December, and January. The data were collected fortnightly on various growth and development indices. The plants were allowed to grow and data on their growth performance regarding days required for budsprouting, budsprouting

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percentage, height of bud graft, number of leaves budsprout^{-1}, number of branches budsprout^{-1}, final budding success were recorded and statistically analyzed by the method given by Panse and Sukhatme (1954).

Days required for sprouting of buds :

The data regarding days required for budsprouting are presented in table1. IBA treatments showed significant variation on days required for budsprouting. The treatment 1000 ppm IBA induced earliest budsprouting (20.77 days) followed by treatments 1500 ppm IBA (22.82 days), 500 ppm IBA (24.24 days) when compared with control treatment T_1 (25.76 days). The above result was in agreement with the finding of Ulemale *et al.* (2004) who found that, IBA at 1000 ppm resulted in the lowest number of days required (18.23 days) for budsprouting. Among time of budding showed significant effect on days required for budsprouting. 1st week of January (22.53 days) required minimum number of days for sprouting. 1st week of January was significantly superior over all other treatments which was followed by 3rd week of January (22.95 days), 3rd week of December (23.45 days), 1st week of December (23.83 days) and 3rd week of November (24.23 days) but time of budding 3rd week of December (23.45 days) and 1st week of December (23.83 days) and 3rd week of November (24.23 days) were at par with each other. These results were correlated with the findings of Pandey *et al*. (1991), Nanjan and Kumar (1983) for early budsprouting of rose in 1st week of January. Interaction effects due to time of budding and treatment IBA were found to be non-significant (Table 1).

Bud sprouting percentage :

It was evident from the table 2 that, IBA treatments showed significant effect on budsprouting percentage. The treatment of 1000 ppm IBA (91.33 %) gave significantly maximum percentage of budsprouting over remaining treatments and significantly superior over all of the other treatments. This treatment was followed by the treatments of 1500 ppm IBA (79.33 %), 500 ppm IBA (69.33 %). The minimum percentage of sprouting was observed in control treatment (65.33 %). Similar result was also reported by Ulemale *et al.* (2004), who found that, IBA at 1000 ppm gave highest budsprouting percentage (85.55 %) in rose. This might be due to more nutrient uptake and enhanced cell differentiation and formation of graft union. From table 2 it is seen that, time of budding showed significant effect on budsprouting percentage in rose.The maximum budsprouting percentage of cuttings was observed in time of budding 1st week of January (84.16 %) and significantly superior over other time of budding but It was at par with time of budding 3rd week of January (80.83 %), while 3rd week of January (80.83 %) was also at par with 3rd week of December (77.50 %). Minimum budsprouting percentage was observed in time of budding 3rd week of November (67.50 %). Similar results were also reported by Pandey *et al*. (1991), Nanjan and Kumar (1983), and Malik *et al*. (2007), who found maximum budsprouting percentage of roses in January. Interaction effects of sprouting percentage of cuttings due to time of budding and treatment with IBA were found to be non-significant.

Height of bud graft :

It is clear from the table 3 that, IBA treatments showed significant effect on height of bud graft. The cuttings treated with 1000 ppm IBA gave significantly maximum height of bud graft (38.44 cm) followed by the treatments of 1500 ppm IBA (36.45 cm), and 500 ppm IBA (33.64 cm). The minimum height of bud graft (31.52 cm) was recorded in control treatment. From table 3 it is seen that time of budding showed significant effect on height of bud graft. The maximum height of bud graft was observed in time of budding 1st week of January (35.89 cm) which was found significantly superior over other time of buddings. Time of budding 1st week of January was at par with time of budding 3rd week of January (35.21 cm), next to these two treatments budding at 3rd week of December (34.99 cm) and 1st week of December (34.70 cm) were also found significantly superior over budding at 3rd week of November in respect of height of bud graft. Interaction effects due to time of budding and treatment with IBA were found to be non-significant.

Number of leaves budsprout^{-1} :

It is obviously clear from data that, the IBA induced significant effect on number of leaves budsprout^{-1}. Treatment of 1000 ppm IBA produced maximum number of leaves (8.08) budsprout^{-1}. This treatment was found to be significantly superior over all other treatments followed by treatments of

1500 ppm IBA (6.85), and 500 ppm IBA (6.33). The minimum number of leaves was recorded in control treatment (5.26). Similar result was reported by Ulemale *et al.* (2004), who found that IBA at 1000 ppm resulted in maximum number of leaves budgraft^{-1} (5.13) in rose. Singh *et al*. (1976) also reported that scion shoot number and growth was in proportionate with root growth of rootstock cutting in rose bud. From data it is seen that time of budding showed significant effect on number of leaves budsprout^{-1}. The maximum number of leaves budsprout^{-1} was observed in time of budding 1st week of January (7.25) which was superior over all other treatments but at par with time of budding 3rd week of January (6.93) followed by time of budding 3rd week of December (6.51), 1st week of December (6.23) and 3rd week of November (6.13). These results were in agreement with the findings of Pande *et al*. (1991), Nanjan and Kumar (1983). They found maximum number of leaves budgraft^{-1} of rose sp. in January. Interaction effects due to time of budding and treatment with IBA were found to be non-significant.

Number of branches budsprout^{-1} :

From the table 5 it is revealed that, the IBA induced significant effect on number of branches budsprout^{-1}. The cuttings treated with treatment of 1000 ppm IBA produced maximum number of branches budsprout^{-1} (1.90) over other treatments. This treatment was followed by the treatments of 1500 ppm IBA (1.73), and 500 ppm IBA (1.57). The minimum number of branches budsprout^{-1} (1.38) was recorded in control treatment. Similar result was reported by Ulemale *et al.* (2004), who found that, IBA at 1000 ppm resulted in maximum number of branches bud graft^{-1} (2.13) in rose. The treatment of IBA 1000 ppm produced more and profused roots. Due to stimulation of IBA 1000 ppm treatment, more root primordia originated which lead to formation of more number of active adventitious roots. Due to regular and more absorption of major and minor nutritive elements, the cuttings established properly and thereafter produced more shoots. From the data it is revealed that, time of budding showed significant effect on number of branches budsprout $^{-1}$. The maximum number of branches budsprout^{-1} was observed in time of budding 1st week of January (1.80) which was superior over all other time of budding but at par with time of budding 3rd week of January (1.70). Next to these were time of budding 3rd week of December (1.66), 1st week of December (1.60) and 3rd week of November (1.48), but time of budding 3rd week of December (1.66), 1st week of December (1.60) and 3rd week of November (1.48) were found at par with each other. This result was in agreement with the finding of Malik *et al.* (2007), who concluded that maximum number of leaves plant^{-1} was recorded in plants budded on 1st week of January in variety Montezuma. Interaction effects due to time of budding and treatment with IBA were found to be non-significant (Table 5).

Final budding success :

It is evident from the table 6 that, IBA treatments showed significant effect on final budding success. The treatment of 1000 ppm IBA (81.33 %) gave significantly maximum percentage of budding success over remaining treatments. Next to this treatment, treatments were 1500 ppm IBA (72.66 %) and 500 ppm IBA (64.00 %). The minimum percentage of budding success was observed in control treatment (50.67 %). The result was in agreement with the result of Ulemale *et al.* (2004) who found that, IBA at 1000 ppm resulted in maximum budding success (72.0%) in rose. From table 6 it is revealed that, time of budding showed significant effect on final budding success. The maximum final budding success in budding was showed in time of budding 1st week of January (79.16 %). This budding treatment was significantly and statistically superior over all other time of budding treatments followed by time of budding 3rd week of January (72.50 %), 3rd week of December (68.33 %), and 1st week of December (62.50 %). The minimum percentage of budding success was observed in time of budding 3rd week of November (53.33 %). The results were in agreement with the results of Malik (2007), Nanjan and Kumar (1983) and Pande *et al*. (1991), who found final budding success of rose in January. Interaction effects due to time of budding and treatment with IBA were found to be non-significant (Table 6).

As regard the budding success in rose 1000 ppm IBA with budding during 1st week of January were found significantly superior to enhance bud sprouting percentage, total number of branches and leaves budsprout^{-1}, height of bud graft, and highest final budding success. However, it decreased days required for sprouting of scion bud.

Table 1. Days required for sprouting of buds as influenced by IBA and time of budding

Treatments / IBA Concentration	Days required for budsprouting — Time of Budding					
	3rd week of Nov. (B_1)	1st week of Dec. (B_2)	3rd Week of Dec. (B_3)	1st week of Jan. (B_4)	3rd week of Jan. (B_5)	Mean
Control (T_1)	26.60	26.20	25.87	25.13	25.00	25.76
IBA 500 ppm (T_2)	24.73	24.80	24.26	23.33	24.06	24.24
IBA 1000 ppm (T_3)	22.06	21.33	20.93	19.46	20.06	20.77
IBA 1500 ppm (T_4)	23.53	23.00	22.73	22.20	22.66	22.82
Mean	24.23	23.83	23.45	22.53	22.95	
		Factor A		Factor B		Interaction
		T		B		T x B
SE (m) ±		0.12		0.14		0.28
CD at 5%		0.36		0.41		---

Table 2. Budsprouting percentage as influenced by IBA and time of budding

Treatments / IBA Concentration	Budsprouting percentage — Time of Budding					
	3rd week of Nov. (B1)	1st week of Dec. (B2)	3rd week of Dec. (B3)	1st week of Jan. (B4)	3rd week of Jan. (B5)	Mean
Control (T1)	56.66 (48.84)	63.33 (52.77)	66.66 (54.78)	73.33 (59.00)	66.66 (54.78)	65.33 (54.03)
IBA 500 ppm (T2)	60.00 (50.85)	60.00 (50.85)	70.00 (56.99)	80.00 (69.93)	76.66 (61.21)	69.33 (56.77)
IBA 1000 ppm (T3)	83.33 (66.14)	86.66 (68.85)	93.33 (77.71)	96.66 (83.85)	96.66 (83.85)	91.33 (76.08)
IBA 1500 ppm (T4)	70.00 (56.99)	76.66 (61.21)	80.00 (63.93)	86.66 (68.85)	83.33 (68.85)	79.33 (63.97)
Mean	67.50 (55.71)	71.66 (58.22)	77.50 (63.35)	84.16 (68.91)	80.83 (67.17)	
		Factor A		Factor B		Interaction
		T		B		T x B
SE (m) ±		1.61		1.80		3.60
CD at 5%		4.60		5.15		---

(Note- Arc sin value given in bracket)

Table 3. Height of bud graft as influenced by IBA and time of budding

Treatments IBA Concentration	Height of bud graft (cm)					
	Time of Budding					
	3rd week of Nov. (B_1)	1st week of Dec. (B_2)	3rd week of Dec. (B_3)	1st week of Jan. (B_4)	3rd week of Jan.(B_5)	Mean
Control (T_1)	30.66	31.40	31.46	32.53	31.53	31.52
IBA 500 ppm (T_2)	33.10	33.26	33.60	34.26	34.00	33.64
IBA 1000 ppm(T_3)	37.61	38.16	38.30	39.59	38.55	38.44
IBA 1500 ppm (T_4)	35.72	35.98	36.62	37.16	36.77	36.45
Mean	34.27	34.70	34.99	35.89	35.21	
		Factor A		Factor B	Interaction	
		T		B	T x B	
SE (m) ±		0.20		0.22	0.45	
CD at 5%		0.57		0.64	---	

Table 4. Number of leaves budsprout^{-1} as influenced by IBA and time of budding

Treatments IBA Concentration	Number of leaves budsprout^{-1}					
	Time of Budding					
	3rd week of Nov. (B_1)	1st week of Dec. (B_2)	3rd week of Dec. (B_3)	1st week of Jan. (B_4)	3rd week of Jan. (B_5)	Mean
Control (T_1)	4.80	4.80	5.00	5.93	5.80	5.26
IBA 500 ppm (T_2)	6.20	6.20	6.20	6.66	6.40	6.33
IBA 1000 ppm (T_3)	7.33	7.53	8.06	8.73	8.33	8.08
IBA 1500 ppm (T_4)	6.20	6.40	6.80	7.66	7.20	6.85
Mean	6.13	6.23	6.51	7.25	6.93	
		Factor A		Factor B	Interaction	
		T		B	T x B	
SE (m) ±		0.10		0.11	0.23	
CD at 5%		0.30		0.33	---	

Table 5. Number of branches budsprout^{-1} as influenced by IBA and time of budding

Treatments	Number of branches budsprout^{-1}					
	Time of Budding					
IBA Concentration	3rd week of Nov. (B_1)	1st week of Dec. (B_2)	3rd week of Dec. (B_3)	1st week of Jan. (B_4)	3rd week of Jan. (B_5)	Mean
Control (T_1)	1.20	1.33	1.40	1.53	1.46	1.38
IBA 500 ppm (T_2)	1.40	1.53	1.60	1.73	1.60	1.57
IBA 1000 ppm (T_3)	1.80	1.86	1.93	2.00	1.93	1.90
IBA 1500 ppm (T_4)	1.53	1.66	1.73	1.93	1.80	1.73
Mean	1.48	1.60	1.66	1.80	1.70	
		Factor A		Factor B		Interaction
		T		B		T x B
SE (m) ±		0.03		0.03		0.07
CD at 5%		0.09		0.10		---

Table 6. Final budding success as influenced by IBA and time of budding

Treatments	Final budding success (%)					
	Time of Budding					
IBA Concentration	3rd week of Nov. (B_1)	1st week of Dec. (B_2)	3rd week of Dec. (B_3)	1st week of Jan. (B_4)	3rd week of Jan.(B_5)	Mean
Control (T_1)	43.33 (41.15)	46.66 (43.07)	50.00 (46.66)	60.00 (50.85)	53.33 (46.92)	50.67 (45.73)
IBA 500 ppm (T_2)	50.00 (45.00)	56.66 (48.84)	63.33 (52.77)	76.66 (61.21)	73.33 (59.00)	64.00 (53.36)
IBA 1000 ppm (T_3)	70.00 (56.79)	76.66 (61.21)	83.33 (66.14)	90.00 (71.57)	86.66 (68.85)	81.33 (64.91)
IBA 1500 ppm (T_4)	50.00 (45.00)	70.00 (56.99)	76.66 (61.21)	90.00 (71.57)	76.00 (61.21)	72.66 (59.20)
Mean	53.33 (46.98)	62.50 (52.53)	68.33 (56.70)	79.16 (63.80)	72.50 (59.00)	
		Factor A		Factor B		Interaction
		T		B		T x B
SE (m) ±		1.08		1.21		2.42
CD at 5%		3.10		3.46		---

(Note-Arc sin value given in bracket)

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EVALUATION OF NEWLY DEVELOPED INBRED LINES FOR COMBINING ABILITY IN MAIZE

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ABSTRACT

Evaluation of newly developed inbred lines for combining ability in maize (*Zea mays* L.)" was undertaken to study the general and specific combining ability of parents and crosses respectively and to identify superior parents and crosses. Ten lines and three testers were crossed in line x tester fashion to secure thirty cross combinations which were raised in Randomised Complete Block design with two replications. Parents and two checks (Maharaja and PKVM-Shatak) were also raised in two replications adjacent to the crosses with a spacing of 60 cm x 20 cm. The data were recorded on days to 50 % tasseling, days to 50 % silking , days to maturity, plant height, cob length, cob girth, number of grains cob^{-1}, 100 grain weight and grain yield plant $^{-1}$ (g). Considerable variability existed among the genotypes for all the characters studied as observed from the significant mean squares due to genotypes. The mean squares of lines were significant for days to 50 % tasseling, days to 50 % silking, cob girth, number of grains cob^{-1}, 100 grain weight and grain yield plant^{-1} ,while of tester for plant height, cob length, cob girth, number of grains cob^{-1}, 100 grains weight and grain yield plant^{-1} and of line x tester for days to 50% tasseling, cob length, cob girth, number of grains cob^{-1}, 100 grain weight and grain yield pant^{-1}. Out of thirty crosses studied two crosses namely NM-094 x NM-0969 and NM-0985 x NM-0969 were identified as the most potential crosses for hybrid production based on high *per se* performance and high significant sca effects and hence it is suggested that these two crosses can be used directly for heterosis breeding in maize.

(Key words: Maize, inbred lines, gca effects, sca effects, combining ability)

INTRODUCTION

Maize being a highly cross-pollinated crop there is wide scope for the development of stable hybrids and varieties. The invention of heterosis phenomenon, the development of hybrid breeding technology and successful commercial exploitation of heterosis in maize are considered to be significant achievements and land marks in the history of biological sciences during the past century. Maize being a versatile crop, in order to harness its yield potential, several genetic and agro-technique improvement strategies have been used in the past and present viz., single crosses, three way crosses, double crosses, varietal hybrids, multiple hybrids, composites, synthetics, pools, populations etc. The recent trend even in the developing and developed countries is to go for single crosses than for the double and three way crosses. Moreover, seed production in single crosses involves less cost than the double crosses. The initial selection of suitable parents is stated to be of immense importance by all workers for utilization of heterosis to its maximum extent. Keeping these in view, an attempt was made to develop single crosses and to evaluate them for mean and combining ability analysis in maize.

MATERIALS AND METHODS

Ten lines were crossed with three testers by following Line x Tester mating design to produce 30 crosses in *rabi* 2010-11.These 30 crosses were grown in Randomized Complete Block design in two replications with the spacing of 60 cm x 20 cm accommodating 15 plants in each row for the estimation of combining ability analysis in *kharif* 2011-12. Thirteen parents and two checks viz. one single cross hybrid Maharaja and one composite PKVM-Shatak were also raised in two replications adjacent to the crosses. Recommended package of practices were followed to raise a good crop. The data were recorded on five randomly selected plants from each genotype on following six characters except days to 50 % tasseling, days to 50% silking and days to maturity. The analysis of variance for the experimental design was analysed by the method given by Panse and Sukhatme (1954) and the combining ability analysis was carried out by following the methodology of Kempthorne (1957) with fixed effect model (Model I) of Eisenhart (1947).

RESULTS AND DISCUSSION

The data regarding analyses of variance for nine characters studied are presented in table 1. The mean squares due to genotypes were highly significant for all the nine characters studied i.e. days to 50% tasseling, days to 50% silking, days to maturity, plant height, cob length, cob girth, number

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of grains cob^{-1}, 100 grain weight and grain yield plant^{-1}. This indicates the presence of wide genetic variation among the genotypes (parents, crosses and check) for all the nine characters. The wide variability for yield plant^{-1} and yield contributing characters in maize were also observed by Iqbal *et al.*(2010), Dubey *et al.*(2009), Singh and Gupta (2009), Fan *et al.*(2010), and Dadheech and Joshi (2007).

The analysis of variance for combining ability for different characters are presented in table 2. The variation between crosses was partitioned into different components representing the mean square due to lines, testers and line x tester interaction. The mean squares due to lines were significant for days to 50% tasseling, days to 50% silking, cob girth, number of grains cob^{-1}, 100 grain weight and grain yield plant^{-1}. The mean squares due to testers were significant for plant height, cob length, cob girth, number of grains cob^{-1}, 100 grain weight, and grain yield plant^{-1}. Line x tester interaction mean square was found to be significant for the characters days to 50% tasseling, cob length, cob girth, number of grains cob^{-1}, 100 grain weight and grain yield plant^{-1}. These significant mean squares due to lines, testers and line x tester interaction indicated the presence of significant variances among them. Such type of significant mean squares for lines, testers and line x tester interaction were also observed by Joshi *et al.*(2002), Krishna *et al.*(2003), Todkar and Navale (2006), Atanaw *et al.*(2006) and Ali *et al.*(2007) for yield and yield component in maize. The fixed effect model adopted in the present study does not provide the estimate of variance components and thus it was not possible to know precisely the relative importance of additive and dominance component in the control of different characters. However in this model an idea about relative importance of gca and sca in determining progeny performance can be obtained by calculating the general predictability ratio on the basis of gca and sca mean squares (Baker, 1978). The predictability ratio in the study ranged from 0.97 for grain yield plant^{-1} to 0.69 for days to maturity. The estimates of this ratio indicated that for most of the characters except days to maturity, the predictability ratio was observed to be closer to unity which indicated the predominance of additive genetic component. Under such situation the performance of progeny can be judged/ predicted on the basis of general combining ability. Joshi *et al*.(2002), Iqbal *et. al.* (2007) and Legesse *et al*.(2009) also explained that gca of the parents involve in the crosses should be given emphasis for recovering superior segregants.

The data regarding analyses of variance for nine characters studied are presented in table 3. The results on *per se* performance of parents and crosses revealed that most of the crosses were either at par with check or lower in performance than the check for yield and yield contributing characters. Very few crosses were found to be significantly superior. Similar to these results Wali *et al*. (2010) also reported that the mean performance of all the test hybrids were at par with the mean of the check hybrid. The mean performance of thirty crosses when compared with single cross hybrid Maharaja and composite PKVM-Shatak, the crosses NM-094 x NM-0969 and NM-0985 x NM-0969 were identified as superior crosses as they performed significantly superior over the single cross hybrid check Maharaja for grain yield plant^{-1}, number of grains cob^{-1} (65.08 and 276.50 respectively). The cross NM-094 x NM-0969 also recorded significant superiority over check PKVM-Shatak composite for the above traits. Therefore these two crosses NM-094 x NM-0969 and NM-0985 x NM-0969 were identified as potential crosses for exploiting heterosis on the basis of *per se* performance.

Estimates of gca and sca effects among the parents and crosses showed wide variation in the level of significance for different characters. None of the parents nor crosses had high and significant gca and sca effects in the desirable direction for all the characters studied. The significant gca and sca effects were also reported by Kumari *et al.* (2008), Legesse *et al.* (2009), Singh and Gupta (2009), Senthil and Bharathi (2009) and Fan *et al.* (2010) in maize. The estimates of gca effects showed that among the lines NM-094 was found to be the best general combiner as it recorded significant positive gca effect for grain yield plant^{-1}, number of grains cob^{-1} and cob girth. Lines NM-0985 and NM-0979 were also identified as a good general combiner as they exhibited significant positive gca effect for grain yield plant^{-1} and number of grains cob^{-1}. Among the testers NM-0969 was identified as good general combiner as it recorded significant positive gca effect for grain yield plant^{-1}, number of grains cob^{-1}, cob girth and cob length. From this study of combining ability four parents

Table 1. Analysis of variance for various characters in maize

Source of variation	Degrees of freedom	Mean squares								
		Days to 50 % tasseling	Days to 50 % silking	Days to maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	100 grain weight (g)	Grain yield plant^{-1} (g)
Replication	1	6.4	0.17	0.9	7.07	14.12	2.80	1607.82	0.36	55.03
Genotypes	44	13.04**	15.87**	26.35**	119.21*	5.01**	1.54**	5114.62**	14.65**	276.08**
Error	44	5.49	6.33	4.12	59.11	1.41	0.45	555.439	2.23	21.22

*, ** = Significant at 5% and 1% level respectively

Table 2. Analysis of variance for combining ability

Source of variation	Degrees of freedom	Mean squares								
		Days to 50 % tasseling	Days to 50 % silking	Days to maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	100 grain weight (g)	Grain yield plant^{-1} (g)
Lines (l)	9	12.71**	15.85*	4.04	94.59	5.11	1.41*	5781.82**	19.82**	157.86**
Testers (t)	2	6.65	1.51	4.71	760.27**	9.78**	3.55**	23141.28**	83.94**	2380.77**
Lines X Testers	18	9.20*	10.55	5.62	73.29	4.01*	1.18*	2686.10**	28.80**	81.27**
Error	29	4.066	6.22	3.77	63.55	1.57	0.59	658.644	1.95	22.08
GCA vs. SCA		0.78	0.75	0.69	0.93	0.83	0.84	0.93	0.81	0.97

*, ** = Significant at 5% and 1% level respectively

Table 3. General combining ability of parents

Sr. No.	Genotypes	Das to 50 % tasseling	Days to 50 % silking	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	100 grain wt. (g)	Grain yield plant^{-1} (g)
1	NM-094	-1.90	-1.73	-	-	0.83**	20.31	1.58	7.30**
2	NM-0914	2.27*	2.60*	-	-	-0.26	-0.31	3.91*	-0.03
3	NM-0919	-2.40*	-2.57*	-	-	0.17	17.95	-0.10	1.38
4	NM-0926	0.10	-0.57	-	-	-0.12	-49.11**	0.43	-7.49**
5	NM-0929	-0.07	-0.57	-	-	0.65*	-19.68	0.37	-0.30
6	NM-0952	1.10	0.77	-	-	-0.15	17.25	-1.74	2.39
7	NM-0971	0.77	1.93	-	-	-0.80**	-19.48	-1.78	-4.75*
8	NM-0979	1.27	0.60	-	-	0.07	31.35**	-1.28	4.50*
9	NM-0981	-0.07	0.77	-	-	-0.47	-40.85**	0.88	-7.50**
10	NM-0985	-1.07	-1.23	-	-	0.06	42.58**	-1.39	4.51*
	SE (gi)	**0.9746**	**1.0393**	**-**	**-**	**0.2756**	**9.7791**	**1.5385**	**1.8981**
1	NM-0969	-	-	-1.43	0.79**	0.43**	38.04**	1.61	12.31**
2	NM-0978	-	-	6.75**	-0.29	-0.01	-10.57	0.68	-3.84**
3	NM-0988	-	-	-5.32**	-0.50	-0.41**	-27.47**	-2.30*	-8.47**
	SE (gj)	**-**	**-**	**1.7449**	**0.2719**	**0.1509**	**5.3563**	**0.8427**	**1.0396**

*, ** = Significant at 5% and 1% level respectively

Note: GCA effect of lines for days to maturity, plant height, cob length and testers for days to 50% tasseling, days to 50% silking and days to maturity were not calculated as their respective mean squares were non-significant.

Table 4. Specific combining ability of crosses

Sr. No.	Genotypes	Days to 50 % tasseling	Cob length (cm)	Cob girth (cm)	Number of grain cob^{-1}	100 grain wt. (g)	Grain yield plant^{-1}(g)
	Crosses						
1	NM-094 X NM-0969	1.15	2.07*	-0.86	73.15**	-3.05	6.96*
2	NM-094 X NM-0978	-0.95	1.15	1.39**	-9.43	0.63	5.07
3	NM-094 X NM-0988	-0.20	-2.23*	-0.53	-63.73**	2.42	-7.04*
4	NM-0914 X NM-0969	-2.51	-0.34	0.60	6.79	-6.21*	-4.37
5	NM-0914 X NM-0978	-2.11	0.37	-0.21	-1.09	10.28**	3.16
6	NM-0914X NM-0988	4.63*	-0.02	-0.39	-5.69	-4.08	1.20
7	NM-0919 X NM-0969	0.65	0.49	0.71	-1.08	-0.37	-3.11
8	NM-0919 X NM-0978	1.05	0.58	0.49	46.44*	0.21	10.81**
9	NM-0919 X NM-0988	-1.70	-2.06	-1.19*	-45.36*	0.16	-7.70*
10	NM-0926 X NM-0969	0.15	1.11	0.69	-0.21	1.48	-1.51
11	NM-0926 X NM-0978	0.05	-1.57	-0.77	-29.49	-1.01	-4.73
12	NM-0926 X NM-0988	-0.20	0.45	0.07	29.70	-0.47	1.24
13	NM-0929 X NM-0969	1.31	-0.06	-0.67	-18.75	1.35	-4.60
14	NM-0929 X NM-0978	-1.28	0.20	-0.36	8.07	-2.13	2.73
15	NM-0929 X NM-0988	-0.03	-0.13	1.03*	10.67	0.77	0.87
16	NM-0952 X NM-0969	1.15	0.16	-0.21	-7.28	1.43	4.88
17	NM-0952 X NM-0978	-1.45	-0.94	0.06	-10.76	-0.76	-3.67
18	NM-0952 X NM-0988	0.30	0.77	0.15	18.04	-0.67	-1.21
19	NM-0971 X NM-0969	-2.01	-0.74	-0.16	-28.95	-0.08	-3.74
20	NM-0971 X NM-0978	3.88*	1.04	0.11	23.07	-0.02	-4.53
21	NM-0971 X NM-0988	-1.87	-0.29	0.05	5.87	-0.10	-0.79
22	NM-0979 X NM-0969	0.48	-2.53*	-0.81	-15.18	-0.08	-1.37
23	NM-0979 X NM-0978	1.88	0.75	0.43	12.44	-2.31	-1.13
24	NM-0979 X NM-0988	-2.37	1.78*	0.38	2.74	2.40	2.50
25	NM-0981 X NM-0969	-1.18	0.18	0.54	27.12	-0.40	1.83
26	NM-0981 X NM-0978	0.21	-1.48	-0.83	-50.36*	-0.63	-10.22**
27	NM-0981 X NM-0988	0.97	1.29	0.29	23.24	1.03	4.40
28	NM-0985 X NM-0969	0.81	-0.34	0.17	-35.61*	5.93*	9.02*
29	NM-0985 X NM-0978	-1.28	-0.11	-0.31	11.11	-4.26	-7.55*
30	NM-0985 X NM-0988	0.46	0.45	0.14	24.51	-1.67	1.53
	SE (Sij)	**1.6880**	**0.8599**	**0.4773**	**16.9380**	**2.6648**	**3.2876**

*, ** = Significant at 5% and 1% level respectively

Note: SCA effect of crosses for days to 50% silking, days to maturity, plant height were not calculated as its respective mean square was non-significant.

NM-094, NM-0979, NM-0985 and NM-0969 were identified as best general combiner for either only yield or yield with other yield contributing characters.

The significant sca effect observed in different crosses for different characters had the combination of either high x high, high x low, low x high or low x low combining parents. It is important to note that among the crosses showing significant sca in desirable direction in respect to all the traits either involved or did not involved one or both the parents as good general combiner for the concerned trait. This indicated that nonadditive type gene action, which are non-fixable were involved in these crosses. It was also inferred that all the crosses which exhibited high mean did not necessarily have significant sca effect indicating the non-correspondence between *per se* performance and sca effects, but in few case correspondence between *per se* performance and sca effect were observed.

Out of the thirty crosses studied crosses NM-094 x NM-0969 and NM-0985 x NM-0969 which were identified as superior crosses on the basis of *per se* performance were also observed to exhibit positive significant sca effects for yield and yield contributing characters like number of grains cob^{-1} or 100 grain weight. The superiority of these crosses having high sca effect involved high x high, combiner as parents. This could explain on the basis of interaction between the positive alleles from two good combiner parents. The high performance of such crosses is due to non-fixable dominant gene action and thus could be exploited for heterosis breeding (Iqbal *et al.,* 2007). Therefore, these two crosses NM-094 x NM-0969 and NM-0985 x NM-0969 were identified to be suitable for direct use in hybrid production instead of going for selecting segregants in advance generation.

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VARIABILITY STUDIES FOR GRAIN YIELD AND YIELD CONTRIBUTING CHARACTERS IN UPLAND RICE (*Oryza sativa* L.)

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ABSTRACT

Genetic variability was estimated among twenty four genotypes of upland rice during *kharif* 2011. Observations were recorded on grain yield and yield contributing characters viz., plant height, number of effective tillers plant^{-1}, number of effective tillers metre^{-1} length, days to 50% flowering, days to maturity, panicle length, number of grains panicle^{-1}, 1000 grain weight and grain yield plant^{-1}. Analysis of variance indicated highly significant differences among the genotypes for all the characters studied. The material for the present study comprises of genotypes which were selected on the basis of performance for grain yield and yield contributing characters in the previous season and was derived from different crosses, which were in F_6 and F_7 generations. The genotype PBNR 04-28 had recorded maximum number of tillers plant^{-1} and maximum grain yield plant^{-1}. The genotype PBNR 08-05 had recorded highest panicle length and maximum number of grains panicle^{-1}.

High values of phenotypic and genotypic coefficient of variation was recorded for grain yield plant^{-1} followed by number of effective tillers plant^{-1} which indicated the presence of ample amount of variation for these characters. High values of heritability coupled with high expected genetic advance was observed for the characters viz., grain yield plant^{-1}, number of effective tillers plant^{-1} and number of grains panicle^{-1} suggesting the presence of additive gene action, thus there is scope for selection.

(Key words: Upland rice, variability, PCV, GCV, heritability)

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for over half the world's population including India, providing 43% of caloric requirement for more than 70% of Indian population. Indian population is growing at high rate and according to a report by Anonymous (2003) the demand for rice in India is projected at 128 million tones for the year 2012. Thus there is need to increase production and productivity by increasing the yield of rice to meet the food requirement of growing population.

Yield is a complex character which mainly depends upon several component characters, so that selection of genotypes based on yield component is not effective but based on component character is more effective. Thus, variability in genotypes for yield and yield contributing characters forms the basic factor to be considered while making selection of parents since estimate of genetic parameters are useful to breeder for designing an effective breeding programme. Hence, present investigation was undertaken to know the GCV, PCV, heritability and genetic advance for various yield contributing characters.

MATERIALS AND METHODS

The experimental material consisted of twenty two promising genotypes which were selected on the basis of performance for grain yield and yield contributing characters were derived from different crosses, which were in F_6 and F_7 generations of upland rice along with two checks viz., 'Parag' and 'Avishkar'. The experiment was conducted using Randomized Block Design with three replications on experimental field at Upland Paddy Research Scheme, MKV, Parbhani, during *kharif* season of 2011. A plot of 4.5x 3m^2 was assigned to each genotype with 30 cm spacing between two rows. The recommended agronomic practices were adopted timely to raise the healthy crop. Five randomly selected plants of each genotype in each replication were used for recording observations on nine quantitative traits viz., plant height, days to 50% flowering, days to maturity, number of effective tillers plant^{-1}, effective tillers metre^{-1} length, panicle length, number of grains panicle^{-1}, 1000 grain weight and grain yield^{-1}. The analysis was done according to Burton (1952) and Hanson *et al.* (1956).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences for all characters suggesting the presence of high genetic variability among the genotypes assessed (Table 1). These results are in conformity with the findings of Chand *et al.* (2004)

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who reported that all genotypes differed significantly with respect to plant height, days to maturity, panicle length, filled grains panicle^{-1}, 1000 grain weight, effective tillers plant^{-1}, grain length, grain breadth and grain yield plant^{-1} and Adeyemi (2011) also observed that highly significant differences in 25 upland rice cultivars for plant height and 1000 grain weight.

The genotypes were selected on the basis of mean performance of genotypes for different quantitative characters i.e. plant height, the range for plant height was from 71 to 123 cm, the genotype PBNR 08-01 (123.00 cm) had recorded highly significant plant height followed by PBNR 08-05 (104.00 cm) over check Parag (78.33 cm), for number of effective tillers plant^{-1} the genotypes PBNR 04-28 (9.33), PBNR 08-07 (9.00) had recorded significantly superior effective tillers plant^{-1} over check Parag (7.66), for the effective tillers metre^{-1} length the genotype PBNR 08-02 (52.83) had recorded significantly superior number of effective tillers metre^{-1} length followed by PBNR 08-07 (51.66) as compared to check Avishkar (35.75) (Table 2).

For days to 50 % flowering genotype PBNR 04-28 (76.33 days) was early in flowering followed by PBNR 04-24 (77.33 days), for days to maturity the genotype PBNR 08-01 (105.33 days) was early in maturity followed by PBNR 08-02 (105.67 days) than the check Parag (115.67 days), for the panicle length among the genotypes only one genotype PBNR 08-05 (29.00 cm) had recorded significantly superior panicle length over the check Parag (25.00 cm), for number of grains panicle^{-1} the maximum number of grains panicle^{-1} were recorded by the check Avishkar (186.33) followed by PBNR 08-05 (182.33), for grain yield plant^{-1} significantly superior grain yield plant^{-1} was recorded by PBNR 04-28 (42.93g), PBNR 08-07 (41.86g) and PBNR 03-07 (40.73g) over the check Parag (30.50g) (Table 2).

Phenotypic coefficient of variation (PCV) was higher in magnitude than that of genotypic coefficient of variation (GCV) for grain yield plant^{-1} (40.27 and 39.61) followed by number of effective tillers plant^{-1} (31.81 and 30.62) indicating the substantial modifying effect of environment in the expression of these traits (Table 3). Similar to these results Panwar and Mathur (2007) also observed that estimates of GCV was smaller than that of PCV suggesting influence of environment on them and Selvaraj *et al.* (2011) recorded that PCV was slightly greater than GCV for number of tillers plant^{-1} followed by plant height and grain yield plant^{-1} indicating influence of environment on them.

Heritability is the index of transmissibility of characters from parents; need to be studied in order to determine extent to which the observed variation is inherited. High heritability estimates were observed for grain yield plant^{-1} (96.77), number of effective tillers plant^{-1} (92.66) and number of grains panicle^{-1} (84.11), such characters are govern by additive gene effects thus, there is scope for improvement through individual plant selection.

Number of effective tillers plant^{-1} and grain yield plant^{-1} showed high estimates of heritability with high genetic advance indicated the role of additive gene effects in the inheritance of these traits. These results are in conformity with the findings of Kumari *et al*. (2003) who observed that high heritability with high genetic advance for number of effective tillers plant^{-1}, number of grains panicle^{-1}, plant height, panicle length and 1000 grain weight which indicated the role of additive gene effects in the inheritance of these traits and Padmaja *et al.* (2008) also recorded that, the heritability and genetic advance were high for characters like effective tillers plant^{-1}, number of grains panicle^{-1}, plant height and 1000 grain weight indicating the involvement of additive type of gene action in controlling these characters (Table 3). Thus, the genotypes PBNR 04-28 and PBNR 08-07 were found to be promising for number of effective tillers plant^{-1} and grain yield plant^{-1}, the genotype PBNR 08-01 was found superior as it was early in maturity, the genotype PBNR 08-05 was found to be superior for panicle length and number of grains panicle^{-1}.

Table 1. Analysis of variance for yield and yield contributing characters in upland rice

Sources of variation	d. f.	Plant height (cm)	Days to 50% flowering	Days to maturity	Effective tillers plant^{-1}	Effective tillers metre^{-1}	Panicle length (cm)	1000 grain weight (g)	Grains panicle^{-1}	Grain yield plant^{-1}
Replication	2	3.8750	13.1667	9.0417	0.0556	6.711	6.3750	55.5417	4.4666	5.1017
Genotypes	23	438.298**	19.7391**	82.5018**	11.1787**	123.51**	9.8062**	1569.137**	6.9638**	328.566**
Error	46	91.5272	9.3406	34.2880	0.2874	2.215	3.3170	92.91	1.2174	3.6147

*, ** = significant at 5% and 1% level respectively

Table 2. Mean values of twenty four genotypes for yield and yield contributing characters

Genotypes	Plant height (cm)	Effective tillers plant^{-1}	Effective tillers metre length^{-1}	Days to 50% flowering	Days to maturity	Panicle length (cm)	Grains panicle^{-1}	1000 grain weight (g)	Grain yield plant^{-1} (g)
PBNR 03-02	89.66	5.00	46.00**	78.33	114.33	25.66	134.67	24.66	30.00
PBNR 03-07	103.33**	8.66**	47.41**	83.66**	123.67	26.66	155.67	26.33	40.73**
PBNR 03-10	92.66	7.33	38.00	82.33**	121.00	25.66	125.00	25.33	29.33
PBNR 03-11	90.1	5.66	33.75	83.33**	116.33	25.00	132.33	26.66	23.23
PBNR 03-19	88.33	4.33	38.08	80.33	111.33	23.00	107.33	26.66	16.46
PBNR 03-20	91.33	4.66	45.16**	81.66**	112.67	23.66	118.00	24.66	17.73
PBNR 04-23	71.66	8.00	46.91**	82.33**	122.33	24.33	141.67	24.66	39.20**
PBNR 04-24	102.33**	4.00	31.00	77.33	110.33	23.66	98.33	24.33	15.60
PBNR 04-26	98.66**	6.00	38.00	81.33**	115.33	25.00	128.67	24.66	22.80
PBNR 04-27	98.66**	7.33	40.08	78.66	120.33	26.33	119.33	26.33	23.70
PBNR 04-28	77.00	9.33**	45.91**	76.33	124.33	20.66	154.33	25.33	42.93**
PBNR 04-30	97.33**	6.66	43.33**	84.66**	118.00	23.33	111.33	26.33	22.90
PBNR 04-32	80.00	6.33	41.83**	82.66**	117.33	22.00	125.67	25.33	22.83
PBNR 04-36	81.33	7.66	38.16	82.33**	121.67	24.00	117.33	24.33	24.26
PBNR 04-37	86.00	5.33	35.33	81.33**	114.67	23.33	121.0	24.66	21.40
PBNR 08-01	123.00**	3.33	46.25**	80.33	105.33	25.33	135.33	24.00	11.66
PBNR 08-02	94.66**	4.33	52.83**	78.33	105.67	25.00	151.67	25.00	22.96
PBNR 08-03	75.66	4.00	48.91**	79.33	110.33	25.33	125.00	25.00	14.30
PBNR 08-04	80.66	3.66	49.55**	80.33	114.33	26.00	137.33	23.66	12.16
PBNR 08-05	104.00**	8.66**	49.83**	84.66**	117.00	29.00**	182.33**	24.33	40.66**
PBNR 08-06	90.33	4.00	34.16	78.66	120.00	25.00	153.00	24.00	15.16
PBNR 08-07	94.66**	9.00**	51.66**	80.00	121.67	23.33	143.67	24.66	41.86**
Parag (ch)	78.33	7.66	34.25	75.66	115.67	25.00	175.33	29.66	30.50
Avishkar (ch)	71.00	8.33	35.75	81.33	119.33	28.33	186.33**	29.33	40.96

*, ** = significant at 5% and 1% level respectively

Table 3. Range, mean and estimates of genetic parameters in upland rice

Characters	Range	Mean	SE ±	Phenotypic variance (σ^2p)	Genotypic variance (σ^2g)	PCV	GCV	Heritability (%) (Broad sense)	EGA (%)
Plant height (cm)	71.00-123.00	90.04	5.52	207.11	115.59	15.98	11.94	55.80	81.37
Number of effective tillers plant^{-1}	3.33-9.33	6.22	0.30	3.91	3.63	31.81	30.62	92.66	60.72
Number of effective tillers metre^{-1} length	31.00-52.83	42.17	1.76	47.56	38.22	16.35	14.65	80.36	27.078
Days to 50% flowering	75.66-84.66	80.50	1.76	12.80	3.46	4.44	2.31	27.06	2.47
Days to maturity	105.33-124.33	116.37	3.38	50.35	16.07	6.09	3.44	31.91	4.00
Panicle length (cm)	20.66-29.00	24.70	1.05	5.48	2.16	9.47	5.95	39.47	7.70
Number of grains panicle^{-1}	107.33-186.33	136.75	5.56	584.99	492.07	17.68	16.22	84.11	30.64
1000 grain weight (g)	23.66-29.66	25.41	0.63	3.13	1.91	6.916	5.44	61.14	8.77
Grain yield plant^{1} (g)	11.66-42.93	26.27	1.09	111.93	108.31	40.27	39.61	96.77	80.28

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EFFECT OF *IN VITRO* DROUGHT STRESS ON LOCAL COLLECTIONS OF MUSTARD

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ABSTRACT

Study of *in vitro* drought stress effect through mannitol on local collections of mustard was carried out during 2011-2012 at tissue culture laboratory, Botany Section, College of Agriculture, Nagpur with the objective to study the variation in the regeneration ability among the *Brassica* genotypes under different *in vitro* drought stress levels and to identify the drought tolerant *Brassica* genotypes. Axillary bud of 10-15 days old seedling was used as explants and MS media + BAP (2.5 mg l^{-1}) + IAA (1.0 mg l^{-1}) + Kinetin (0.5 mg l^{-1}) + Sucrose (2%) + Agar (1%) was used for shoot initiation and ½ MS media + IBA (0.01 mg l^{-1}) + Sucrose (2%) + Agar (1%) was used for root initiation. Mannitol at 0, 4, 6 and 10% concentration were used in the shoot differentiation media to induce stress condition. The culture condition throughout the experiment was maintained at 25 ± 2 °C and 16 hrs light and 8hrs photoperiod. The shoot of 2 cm length was then transferred for root differentiation. Observations on response to shoot initiation, number of days for shoot initiation, number of shoot bud initiated, number of shoot elongated, shoot length, response to root initiation, number of days for root initiation and root length were recorded on the ten cultures. The mean values of five cultures in two replications were used for statistical analysis in Factorial Randomized Block Design (FRBD).Significant variation for mannitol concentration, *Brassica* genotypes and mannitol concentration × *Brassica* genotypes interaction were observed for all the characters related to shoot and root differentiation studied. The regeneration capacity in terms of traits related to shoot and root differentiation were found to decrease with an increase in concentration of mannitol except root length. Regeneration ability was totally inhibited in 10% mannitol concentration which indicated that *Brassica* genotypes can tolerate stress due to osmoticum only up to 6% concentration. Eight local collections, one drought tolerant donor (RH 819) and promising variety ACN 9 when evaluated for drought tolerance in *in vitro* condition resulted in the identification of ACNM 10/5 and ACN 9 along with drought tolerant genotype RH 819 to show high regeneration efficiency under *in vitro* stress condition. Hence, ACNM 10/ 5, ACN 9 and RH 819 were identified as drought tolerant genotypes from this study.

(Key words : Sugarcane, INM, yield, nutrient uptake, soil characteristics)

INTRODUCTION

Brassica is a very important oilseed crop of the Indian subcontinent. Salinity and drought are two major environmental stresses that limits plant growth and productivity (Gangopadhyay *et al.,*1997). In India mustard is grown on light textured soil with conserved moisture from monsoon rain and thus if invariably suffers from moisture stress during the reproductive phase of growth. Drought is thus a major factor that limits the area under cultivation and yield of the crops. Drought is also observed in the irrigated areas due to insufficient supply of water and canal closer. In response to water stress, plant faces physiological changes, including loss of cell turgour, closing of stomata, cell enlargement and reduced leaf surface area. All these abnormality ultimately decreases photosynthesis and respiration and as a result overall production of crop is reduced. Therefore, the need for identification and cultivation of plant varieties adapted to drought situation is urgent.

Many producers have been employed to screen and evaluate plant accessions for their tolerance to drought condition (Rajashekar *et al.,*1995). Breeding for water stress tolerance by traditional method is a time consuming and a troublesome procedure. *In vitro* cultures may be used to obtain drought tolerant plants assuming that there is a correlation between cellular and *in vivo* plant response. This alternative system used for induction of water stress in green house test and laboratory tests involve the use of mannitol. Mannitol has been used extensively by researchers because it mimics a drought stress situation when added to a nutrient solution and it does not produce phytotoxic effects. These studies demonstrated a general decrease in shoot growth with increase in the concentration of mannitol in media. The harmful effect of osmotic stress agent occurred in both shoot proliferation and rooting stages. Regeneration of plant displaying an increased tolerance to environmental stress (mannitol) is an important goal for biotechnological improvement of many plant species. Therefore, the aim of this study was to select drought (mannitol) tolerant genotypes. The regeneration capacity, shoot length and root lenght of *Brassica* genotypes in different concentrations of mannitol were considered for identification of drought tolerant genotypes in this study.

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MATERIALS AND METHODS

The work on effect of *in vitro* drought stress on local collections of mustard was carried out during 2011-12 in the tissue culture laboratory of Botany Section, College of Agriculture, Nagpur. The experimental material comprised of axillary bud explants of eight local collections of mustard ACNM 10/1, ACNM 10/2, ACNM 10/3, ACNM 10/4, ACNM 10/5, ACNM 10/10, ACNM 10/15, ACNM 10/17 and one drought tolerant genotype RH 819 and a check variety ACN 9. The explants were washed under running tap water for 4-5 minutes followed by 3-4 times washing with distilled water. All further operations were carried out in aseptic conditions the axillary bud explants were surface sterilized with 0.1% $HgCl_2$ solution for 5 mintues and immediately rinsed with sterile distilled water, so as to remove all traces of $HgCl_2$. Axillary bud explants were trimmed aseptically in the laminar airflow cabinet to optimum size and used for inoculation immediately.

The surface sterilized cut explants were inoculated on shoot induction media supplemented with different concentrations of mannitol by working in laminar airflow cabinet. To evaluate the *Brassica* genotypes for its tolerability to drought condition. Mannitol at 0, 4,6 and 10% concentrations were used in the shot differentiation media of MS + BAP (2.5 mg l^{-1}) + IAA (1.0 mg l^{-1}) + kinetin (0.5 mg l^{-1}) + sucrose (2%) + Agar (1%). The culture conditions to throughout the experiment was maintained at 25± 2ºC and 16 hrs light and 8 hrs dark photoperiod. The shoot of 3-4 cm length was then transferred for root differentiation in ½ MS + IBA (0.01 mg l^{-1}) + sucrose (2%) + Agar (1%). Observations on response to shoot initiation (%), number of days for shoot initiation, number of shoot bud initiated, number of shoots elongated, shoot length (cm), response to root initiation (%), number of days for root initiation and root length (cm) were recorded under different levels of mannitol concentrations. The experiment for all the traits was conducted in FRBD and the mean values of five cultures were used in duplex for statistical analysis (Panse and Sukatame, 1954).

RESULTS AND DISCUSSION

Axillary bud of eight *Brassica* local collections viz., ACNM 10/1, ACNM 10/2, ACNM 10/3, ACNM 10/4, ACNM 10/5, ACNM 10/10, ACNM 10/15, ACNM 10/17 along with RH 819 (drought tolerant donor) and ACN – 9 were inoculated in MS + BAP (2.5 mg^{-1}) + IAA (1.0mg^{-1}) + Kinetin (0.5 mg^{-1}) + Sucrose (2%) + Agar (1%) fortified with 0%, 4%, 6% and 10% mannitol with an aim to identify the suitability of mustard genotypes towards stress condition. After inoculation the cultures when given the cultural condition of 25± 2ºC temperature and the photoperiod of 16 hrs light and 8 hrs dark, within 2-3 days of culture the explants showed swelling over the surface and small protrution initiated which became prominent within 3-4 days. The structure gradually turned green and developed into shoot within 2-3 weeks. The FRBD analysis done for the traits related to shoot regeneration indicated the significance of F-test for genotypes, stress treatment and their interaction for all five characters related to shoot regeneration viz., response to shoot initiation, number of days for shoot initiation, number of shoot bud initiated, number of shoot elongated and shoot length. (Table 1 to 5). This indicated the presence of significant variation among the different *Brassica* genotypes, different stress treatments and their interaction for shoot regeneration. Similar to this result Jaya *et al.* (2012) also reported significance of mean squares for mannitol treatment, *Brassica* species and mannitol x *Brassica* species interaction for the characters related to shoot initiation (%), number of days for shoot bud initiation, number of shoot bud initiated and number of shoot elongated.

The data on different characters related to shoot and root differentiated at different concentrations of mannitol in *Brassica* genotypes are presented in table 1 to 8. The results on different characters related to shoot and root differentiation as influenced by 0, 4, 6 and 10% mannitol in *Brassica* genotypes, ACNM 10/1, ACNM 10/2, ACNM 10/3, ACNM 10/4, ACNM 10/5, ACNM 10/10, ACNM 10/15, ACNM 10/17, RH 819 and ACN 9 indicated that there were sharp decreased with the increasing mannitol concentrations in all the shoot and root differentiating traits, although there were significant differences in the responses among the genotypes. These results indicated that there were marked genetic effect on shoot and root differentiation capacity. The different traits related to shoot and root differentiation showed decreasing trend with the increase in mannitol concentration and totally

inhibited at 10% concentration. 10% mannitol treatment did not allow the cultures to produce shoot and root in all 10 genotypes while 6% mannitol allowed shoot and root differentiation in some genotypes viz., ACNM 10/2, ACNM 10/4, RH 819 and ACN-9.

The data on response to shoot initiation revealed that increase in the concentration of mannitol in the media highly affected shoot initiation, decrease in response to shoot initiation was observed to occur linearly with the increase in the mannitol concentration. Similar to this result Jaya *et al.* (2012) and Errabii *et al.*(2006) also observed decrease in response to shoot initiation as the concentration of mannitol in the media were increased in *Brassica* . Response was also highly specific to genotypes used in the experiment which indicates that large number of genotypes can be screened by the *in vitro* techniques to identify the superior performing genotypes. In accordance to this results Hassanein and Dorion (2006) in *Pelargonium* species and Jaya *et al.* (2012) in *Brassica* species also came to the same conclusion that shoot initiation is highly specific to the genotypes and variation were reported in response to shoot initiation among the genotypes. Debnath (2008) also reported that growth response in mannitol was different in different genotypes. These results revealed that tissue growth was more impaired due to the effect of an ionic osmoticum in mannitol.

The data on number of days for shoot initiation presented above revealed that under stress condition days taken for shoot initiation was more than days under normal condition. Similar to this result Jaya *et al.* (2012) also reported delay in shoot initiation under stress condition as compared to normal condition. This might be due to reduced rate of growth of tissue in stressful media which is a usual phenomenon (Debnath, 2008) and it has been interpreted that a metabolism is channeled to resist the stress. Some of the genotypes were not able to initiate shoot even after keeping the cultures for 15 days under stress which indicated that different genotypes performed differently in stress condition.

It is inferred from the results that ACNM 10/5 and RH 819 were able to produce the maximum number of shoots in all the levels of mannitol. All the genotypes except ACNM 10/1 showed shoot organogenesis in media without mannitol. No shoot development was observed at 10% mannitol concentration in all the ten genotypes. In accordance with this result Jaya *et al.* (2012) also found that the number of shoots produced in different *Brassica* species ranged from 3.17 to 3.72 shoot buds culture and at 10% mannitol none of *Brassica* speices were able to produce shoot buds. Morphological differentiation shuffled from shoot organogenesis to root formation with an increase in mannitol concentration. Debnath (2008) also reported that with the increase in the concentration of mannitol number of shoots produced by the cultures reduced. At 8% mannitol he observed 4-5 shoot buds culture^{-1}. The trend of number of shoots elongated was found to be similar to that of number of shoot bud initiated for mannitol concentration, genotypes and their interaction.

Shoot length decreased significantly in different osmotic stress levels when compared to control. The length of shoot was also observed to be differing in different genotypes. Similar to this result Hassanein and Dorion (2006) also noticed significant decrease in shoot length with the increase in osmotic stress in Pelargonium and also difference in shoot length in different species of *Pelargonium*. This reduction in shoot length might to due to the reasons that plantlets decreased their turgidity under water deficit condition, then the cells become unable to multiply, divide and expand or absorb essential materials for their normal growth and development (Abu-Shama *et al.*, 2005).

The elongated and well developed shoots with 2 cm length of *Brassica* genotypes obtained from 0%, 4%, 6% and 10% mannitol treatments were transferred for root differentiation in ½ MS + IBA (0.01 mg/l) + sucrose (2%) + Agar (1%). The results on response to root initiation, days required for root differentiation and root length are presented in table 6, 7, 8 . The F test for the genotypes, stress treatment and their interaction were found to be significant for the above three characters indicating the presence of significant variation among the different genotypes, different stress treatments and their interaction for traits related to root regeneration. In accordance with the result Jaya *et al.* (2012) also reported significance of mean squares for mannitol treatment, *Brassica* species and mannitol x *Brassica* species interaction for the different characters related to root differentiation.

Table 1. Response to shoot initiation (%) at different concentrations of mannitol in Brassica genotypes

Genotypes	0% mannitol	4% mannitol	6% mannitol	10% mannitol	Mean A
ACNM 10/1	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)	0.00 (0.701)
ACNM 10/2	90.00 (8.753)	73.33 (7.716)	66.66 (7.426)	0.00 (0.701)	76.66(6.159)
ACNM 10/3	70.00 (7.579)	0.00 (0.701)	0.00 (0.701)	0.00(0.701)	70.00(2.428)
ACNM 10/4	90.00(8.753)	83.33(8.474)	83.33(8.474)	0.00(0.701)	85.55(6.600)
ACNM 10/5	100.00(9.511)	95.00(9.002)	80.00(7.996)	0.00(0.701)	91.66(6.802)
ACNM 10/10	80.00(7.996)	0.00(0.701)	0.00(0.701)	0.00(0.701)	80.00(2.522)
ACNM 10/15	100.0(9.511)	0.00(0.701)	0.00(0.701)	0.00(0.701)	100.0(2.906)
ACNM 10/17	70.00(7.579)	0.00(0.701)	0.00(0.701)	0.00(0.701)	70.00(2.428)
RH 819	100.00(9.511)	90.00(8.753)	80.00(7.996)	0.00(0.701)	90.00(6.745)
ACN 9	70.00(7.560)	68.33(7.493)	63.33(7.299)	0.00(0.701)	67.22(5.766)
Mean B	85.55(7.745)	81.99(4.494)	74.66(4.272)	0.00(0.701)	
Factor A SE (d)	**0.230**	**CD 5%**	**0.473**		
Factor B SE (d)	**0.146**	**CD 5%**	**0.299**		
Interaction SE (d)	**0.461**	**CD 5%**	**0.947**		

Table 2. Number of days for shoot initiation at different concentrations of mannitol in *Brassica* genotypes

Genotypes	0% mannitol	4% mannitol	6% mannitol	10% mannitol	Mean A
ACNM 10/1	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)
ACNM 10/2	7.20(2.778)	8.66(3.025)	10.99(3.390)	0.00(0.701)	8.95(2.476)
ACNM 10/3	7.30(2.797)	0.00(0.701)	0.00(0.701)	0.00(0.701)	7.30(1.225)
ACNM 10/4	7.30(2.797)	10.49(3.314)	12.83(3.653)	0.00(0.701)	10.20(2.619)
ACNM 10/5	7.30(2.797)	11.49(3.462)	13.16(3.695)	0.00(0.701)	10.65(2.669)
ACNM 10/10	7.20(2.779)	0.00(0.701)	0.00(0.701)	0.00(0.701)	7.20(1.228)
ACNM 10/15	7.30(2.797)	0.00(0.701)	0.00(0.701)	0.00(0.701)	7.30(1.225)
ACNM 10/17	7.40(2.814)	0.00(0.701)	0.00(0.701)	0.00(0.701)	7.40(1.239)
RH 819	7.40(2.814)	9.83(3.214)	13.33(3.716)	0.00(0.701)	10.18(2.619)
ACN 9	7.50(2.823)	11.49(3.462)	13.44(3.735)	0.00(0.701)	10.81(2.680)
Mean B	7.32(2.586)	10.39(2.003)	12.75(2.174)	0.00(0.701)	
Factor A SE (d)	**0.041**	**CD 5%**	**0.084**		
Factor B SE (d)	**0.026**	**CD 5%**	**0.053**		
Interaction SE (d)	**0.083**	**CD 5%**	**0.169**		

Table 3. No. of shoot bud initiated at different concentrations of mannitol in *Brassica* genotypes

Genotypes	0% mannitol	4% mannitol	6% mannitol	10% mannitol	Mean A
ACNM 10/1	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)
ACNM 10/2	2.84(1.825)	2.67(1.784)	2.33(1.682)	0.00(0.701)	2.61(1.493)
ACNM 10/3	3.16(1.919)	0.00(0.701)	0.00(0.701)	0.00(0.701)	3.16(1.008)
ACNM 10/4	3.50(1.998)	2.55(1.741)	2.16(1.636)	0.00(0.701)	2.73(1.521)
ACNM 10/5	4.15(2.151)	3.16(1.919)	2.70(1.786)	0.00(0.701)	3.33(1.644)
ACNM 10/10	2.40(1.709)	0.00(0.701)	0.00(0.701)	0.00(0.701)	2.40(0.958)
ACNM 10/15	2.80(1.815)	0.00(0.701)	0.00(0.701)	0.00(0.701)	2.80(0.984)
ACNM 10/17	2.10(1.611)	0.00(0.701)	0.00(0.701)	0.00(0.701)	2.10(0.933)
RH 819	3.83(2.073)	3.70(2.042)	2.33(1.682)	0.00(0.701)	3.28(1.629)
ACN 9	3.00(1.878)	2.60(1.757)	2.30(1.673)	0.00(0.701)	2.63(1.507)
Mean B	3.08(1.763)	2.93(1.275)	2.36(1.193)	0.00(0.701)	
Factor A SE (d)	**0.230**	**CD 5%**	**0.466**		
Factor B SE (d)	**0.020**	**CD 5%**	**0.040**		
Interaction SE (d)	**0.063**	**CD 5%**	**0.127**		

Note: -1) The data were subjected to square root transformation and then analysed as there were many zero. The value in the parenthesis are the square root transformed value

2) Mean A and Mean B were calculated excluding the treatment and species showing zero values

Table 4. Number of shoot elongated at different concentrations of mannitol in *Brassica* genotypes

Genotypes	0% mannitol	4% mannitol	6% mannitol	10% mannitol	Mean A
ACNM 10/1	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)
ACNM 10/2	1.84(1.526)	1.67(1.470)	1.33(1.357)	0.00(0.701)	1.61(1.266)
ACNM 10/3	2.16(1.636)	0.00(0.701)	0.00(0.701)	0.00(0.701)	2.16(0.932)
ACNM 10/4	2.50(1.738)	1.55(1.432)	1.16(1.287)	0.00(0.701)	1.73(1.287)
ACNM 10/5	3.15(1.910)	2.16(1.636)	1.70(1.488)	0.00(0.701)	2.33(1.439)
ACNM 10/10	1.40(1.374)	0.00(0.701)	0.00(0.701)	0.00(0.701)	1.40(0.874)
ACNM 10/15	1.80(1.515)	0.00(0.701)	0.00(0.701)	0.00(0.701)	1.80(0.904)
ACNM 10/17	1.10(1.262)	0.00(0.701)	0.00(0.701)	0.00(0.701)	1.10(0.844)
RH 819	2.83(1.816)	2.70(1.786)	1.33(1.357)	0.00(0.701)	2.28(1.410)
ACN 9	2.00(1.581)	1.60(1.444)	1.30(1.346)	0.00(0.701)	1.63(1.263)
Mean B	2.08(1.508)	1.93(1.137)	1.36(1.034)	0.00(0.701)	
Factor A SE (d)	**0.023**	**CD 5%**	**0.048**		
Factor B SE (d)	**0.015**	**CD 5%**	**0.030**		
Interaction SE (d)	**0.047**	**CD 5%**	**0.096**		

Table 5. Shoot length (cm) at different concentrations of mannitol in *Brassica* genotypes

Genotypes	0% mannitol	4% mannitol	6% mannitol	10% mannitol	Mean A
ACNM 10/1	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)
ACNM 10/2	1.48(1.404)	1.19(1.308)	0.99(1.226)	0.00(0.701)	1.22(1.150)
ACNM 10/3	1.25(1.324)	0.00(0.701)	0.00(0.701)	0.00(0.701)	1.25(0.864)
ACNM 10/4	1.76(1.493)	1.73(1.640)	1.46(1.392)	0.00(0.701)	1.65(1.278)
ACNM 10/5	2.22(1.640)	1.98(1.577)	1.55(1.421)	0.00(0.701)	1.91(1.340)
ACNM 0/10	1.25(1.328)	0.00(0.701)	0.00(0.701)	0.00(0.701)	1.25(0.860)
ACNM10/15	1.79(1.512)	0.00(0.701)	0.00(0.701)	0.00(0.701)	1.79(0.906)
ACNM10/17	1.15(1.288)	0.00(0.701)	0.00(0.701)	0.00(0.701)	1.15(0.852)
RH 819	2.49(1.735)	2.10(1.611)	1.86(1.538)	0.00(0.701)	2.15(1.399)
ACN 9	2.22(1.657)	1.90(1.548)	1.69(1.477)	0.00(0.701)	1.93(1.346)
Mean B	1.73(1.408)	1.78(1.103)	1.51(1.062)	0.00(0.701)	
Factor A SE (d)	**0.035**	**CD 5%**	**0.071**		
Factor B SE (d)	**0.022**	**CD 5%**	**0.045**		
Interaction SE (d)	**0.070**	**CD 5%**	**0.143**		

Table 6. Response to root initiation (%) at different concentrations of mannitol in *Brassica* genotypes

Genotypes	0% mannitol	4% mannitol	6% mannitol	10% mannitol	Mean A
ACNM 10/1	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)
ACNM 10/2	50.00(6.737)	66.66(7.426)	49.99(6.704)	0.00(0.701)	55.55(5.394)
ACNM 10/3	50.00(6.737)	0.00(0.701)	0.00(0.701)	0.00(0.701)	50.00(2.212)
ACNM 10/4	68.33(7.493)	63.33(7.299)	45.00(6.522)	0.00(0.701)	58.88(5.504)
ACNM 10/5	85.00(8.245)	65.00(7.366)	50.00(6.743)	0.00(0.701)	66.66(5.769)
ACNM10/10	40.00(6.301)	0.00(0.701)	0.00(0.701)	0.00(0.701)	40.00(2.101)
ACNM10/15	50.00(6.737)	0.00(0.701)	0.00(0.701)	0.00(0.701)	50.00(2.212)
ACNM10/17	50.00(6.737)	0.00(0.701)	0.00(0.701)	0.00(0.701)	50.00(2.212)
RH 819	90.00(8.753)	68.33(7.493)	50.00(6.737)	0.00(0.701)	69.44(5.921)
ACN 9	73.33(7.716)	60.00(7.163)	40.00(6.310)	0.00(0.701)	57.75(5.472)
Mean B	61.85(6.610)	64.66(4.024)	46.99(3.659)	0.00(0.701)	
Factor A SE (d)	**0.155**	**CD 5%**	**0.313**		
Factor B SE (d)	**0.098**	**CD 5%**	**0.198**		
Interaction SE (d)	**0.310**	**CD 5%**	**0.627**		

Note: -1) The data were subjected to square root transformation and then analysed as there were many zero. The value in the parenthesis are the square root transformed value

2) Mean A and Mean B were calculated excluding the treatment and species showing zero values

Table 7. Number of days for root initiation at different concentrations of mannitol in *Brassica* genotypes

Genotypes	0% mannitol	4% mannitol	6% mannitol	10% mannitol	Mean A
ACNM 10/1	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)
ACNM 10/2	5.40(2.426)	9.16(3.107)	8.33(2.914)	0.00(0.701)	7.63(2.289)
ACNM 10/3	5.90(2.527)	0.00(0.701)	0.00(0.701)	0.00(0.701)	5.90(1.167)
ACNM 10/4	5.20(2.384)	8.99(3.079)	10.31(3.286)	0.00(0.701)	8.17(2.360)
ACNM 10/5	4.80(2.305)	7.50(2.820)	7.00(2.736)	0.00(0.701)	6.43(2.143)
ACNM 10/10	3.51(1.998)	0.00(0.701)	0.00(0.701)	0.00(0.701)	3.50(1.032)
ACNM 10/15	3.50(1.998)	0.00(0.701)	0.00(0.701)	0.00(0.701)	3.50(1.032)
ACNM 10/17	4.60(2.243)	0.00(0.701)	0.00(0.701)	0.00(0.701)	4.60(1.091)
RH 819	4.60(2.243)	7.50(2.820)	10.00(3.243)	0.00(0.701)	7.36(2.254)
ACN 9	5.60(2.468)	9.66(3.185)	11.00(3.389)	0.00(0.701)	8.75(2.438)
Mean B	4.78(2.137)	8.56(1.851)	9.32(1.916)	0.00(0.701)	
Factor A SE (d)		**0.045**	**CD 5%**	**0.092**	
Factor B SE (d)		**0.028**	**CD 5%**	**0.058**	
Interaction SE (d)		**0.091**	**CD 5%**	**0.184**	

Table 8. Root length (cm) at different concentrations of mannitol in *Brassica* genotypes

Genotypes	0% mannitol	4% mannitol	6% mannitol	10% mannitol	Mean A
ACNM 10/1	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.00(0.701)
ACNM 10/2	0.24(0.859)	0.30(0.891)	0.33(0.918)	0.00(0.701)	0.29(0.847)
ACNM 10/3	0.27(0.874)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.27(0.746)
ACNM 10/4	0.29(0.888)	0.36(0.923)	0.38(0.931)	0.00(0.701)	0.34(0.860)
ACNM 10/5	0.37(0.937)	0.45(0.973)	0.79(1.137)	0.00(0.701)	0.53(0.934)
ACNM 10/10	0.40(0.942)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.40(0.761)
ACNM 10/15	0.41(0.959)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.41(0.768)
ACNM 10/17	0.29(0.886)	0.00(0.701)	0.00(0.701)	0.00(0.701)	0.29(0.759)
RH 819	0.38(0.937)	0.47(0.988)	0.70(1.096)	0.00(0.701)	0.51(0.933)
ACN 9	0.28(0.887)	0.28(0.887)	0.34(0.912)	0.00(0.701)	0.30(0.847)
Mean B	0.32(0.887)	0.37(0.825)	0.50(0.849)	0.00(0.701)	
Factor A SE (d)		**0.016**	**CD 5%**	**0.033**	
Factor B SE (d)		**0.010**	**CD 5%**	**0.020**	
Interaction SE (d)		**0.032**	**CD 5%**	**0.066**	

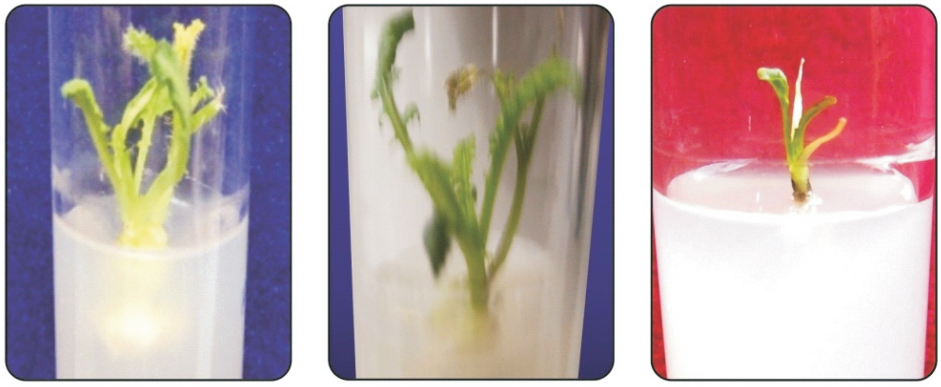
Note: -1) The data were subjected to square root transformation and then analysed as there were many zero. The value in the parenthesis are the square root transformed value.
2) Mean A and Mean B were calculated excluding the treatment and species showing zero values

Plate 1 : Shoot regneration at different concentrations of mannitol in selected genotypes

ACNM 10/5

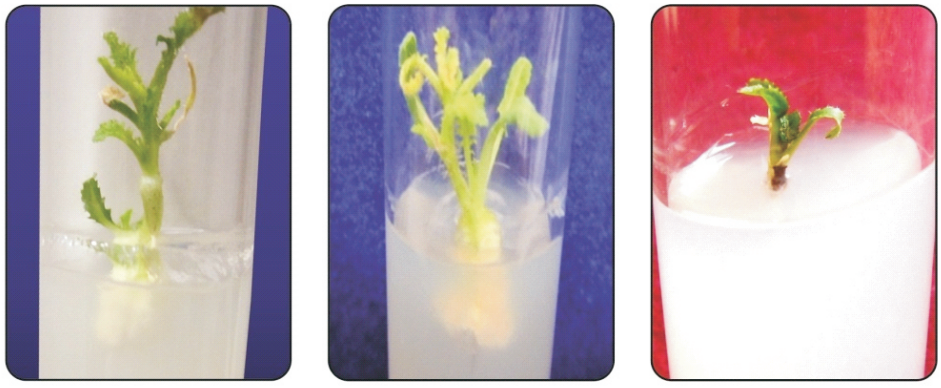
0% MANNITOL | 4% MANNITOL | 6% MANNITOL

RH 819



0% MANNITOL | 4% MANNITOL | 6% MANNITOL

ACN 9



0% MANNITOL | 4% MANNITOL | 6% MANNITOL

Plate 2 : Root regneration at different concentrations of mannitol in selected genotypes

ACNM 10/5

0% MANNITOL | 4% MANNITOL | 6% MANNITOL

RH 819

0% MANNITOL | 4% MANNITOL | 6% MANNITOL

ACN 9

0% MANNITOL | 4% MANNITOL | 6% MANNITOL

Response to rooting was affected with the increase in mannitol and also the genotype under study. Days required for root initiation was found to be less in shoot obtained from 0% mannitol and it increased with the increase in mannitol concentration. Days for root initiation was also affected by the genotype. Delay in root initiation due to mannitol was also reported by Jaya *et al.* (2012) in *Brassica* species, Ehsanpour and Amini (2003) in Alfalfa. This might be due to the reason that the plantlet tried to establish itself in the media with mannitol and struggled for their sustainability under osmotic stress condition (Abu-shama *et al.*, 2005). Root length was found to increase with the increase in mannitol concentration in all the genotypes studied. One of the mechanism to drought stress tolerance in plants is increase in root length which indicates that the genotype with maximum root length can tolerate drought as it can grow deep into the soil in search of moisture. Increase in root length in higher mannitol concentration was also reported by Ehsanpour and Amini (2003) in Alfalfa, Debnath (2008) in *Bacopa monnieri* and Abu-shama *et al.*(2005) in tomato.

To summarize variability was found in osmotic stress tolerance among the tested *Brassica* genotypes as they showed difference in response to regeneration under *in vitro* condition. The genotypes RH 819, ACNM 10/5 and ACN -9 were observed to exhibit superior performance for all the characters related to shoot and root differentiation in 0%, 4% and 6% mannitol concentrations in the desirable direction (Plate 1 and Plate 2). This indicates that these three genotypes RH 819, ACNM 10/5 and ACN 9 were found to exhibit superior regeneration capacity under stress condition as compared to all other species. RH 819 being drought tolerant donor is expected to perform superior in different osmoticum stress condition. However, ACNM 5 a local collection and ACN 9 promising variety of *Brassica* were found to be at par with RH 819 for most of the characters studied. Hence, RH 819, ACNM 10/5 and ACN 9 were identified to be tolerant to drought from this study.

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ASSESSMENT OF HETEROSIS AND COMBINING ABILITY FOR BIOCHEMICAL COMPONENTS IN CROSSES AMONG HIGH QUALITY PROTEIN MAIZE (*Zea mays* L.)

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ABSTRACT

Studies on heterosis and combining ability analysis in maize (*Zea mays* L.) was undertaken to assess the possibility of estimating the extent of heterosis for quality parameters, to study the general and specific combining ability of parents and crosses respectively and to identify superior parents and crosses. Fourty-five hybrids obtained by crossing fifteen lines with three testers were raised in Randomized Block design with three replications. Parents and checks (HM-5, GM-2) were also raised adjacent to the crosses. The data were recorded on grain moisture, protein content, lysine in protein, tryptophan in protein, starch content and oil content. Considerable variability existed among the genotypes for all the characters studied as observed from the significant mean squares due to genotypes. The mean squares due to interaction effects of parents vs. crosses were found to be significant for grain moisture, protein content, lysine in protein and tryptophan in protein, indicating the choice of exploitation of heterosis. Top three crosses namely I-07-7-4 x CLQ-30, I-07-56-7 x CLQ-30 and I-07-9-9 x CLQ-30 were identified as promising crosses as they exhibited significant standard heterosis for protein content over both checks. These crosses also had significant *per se* performance for this characters. The mean squares for lines were significant for only grain moisture content. The higher magnitude of variance in line x tester interaction suggested the presence of greater variability among the crosses than among the parents. The gca estimates of lines and testers emphasized the importance of five parents I-07-7-4, I-07-9-9, I-07-10-1, I-07-56-4 and CLQ-30 for their use as a good general combiner for protein content. These parents could be utilised for the development of either the synthetic variety or an elite breeding population. Out of fourty-five crosses studied the top four crosses namely I-07-56-8 x CLQ-47, I-07-8-6 x HKI-163, I-07-57-5 x CLQ-47 and I-07-9-9 x CLQ-30 was identified as a high significant sca effects for protein content. However, out of them only one cross I-07-9-9 x CLQ-30 were found to be the best cross based on high *per se* performance and high significant standard heterosis over both the checks in addition to significant sca effects and hence it is suggested that this cross can be used directly for heterosis breeding in quality protein maize.

(Key words: Quality protein maize (QPM), standard heterosis and combining ability)

INTRODUCTION

Maize lacks two amino acids: lysine and tryptophan, which are essential for protein synthesis in humans and monogastric animals. The discovery of nutritional value of the *opaque2* mutation in maize was a significant breakthrough as it was found to alter the amino acid composition of the endosperm protein, resulting in enhanced concentration of lysine and tryptophan (Mertz *et al.,* 1964). The QPM contains twice the usual lysine and tryptophan as compared to the normal maize in addition to that it contains more balanced amino acids that greatly enhances its overall nutritive value.

QPM has similar agronomic performance parameters, appearance and taste as the normal maize. It has reduced prolamin fraction (25-30%) but has elevated levels of other fractions such as glutelins, albumins and globulins. The two-fold increase in the levels of lysine and tryptophan results in high digestibility and enhances biological value. The QPM has a balanced leucine-isoleucine ratio that enhances the production of niacin, which helps overcome pellagra in humans (Prasanna *et al*., 2001). Several countries in Asia, Africa and Latin America, including India have active QPM breeding programmes. The present study had the objective of assessing standard heterosis and combining ability for biochemical traits viz., grain moisture content, protein content, lysine in protein, tryptophan in protein, starch content and oil content.

MATERIALS AND METHODS

The present investigation was carried out at Department of Genetics and Plant Breeding, Anand Agriculture University, Anand (Gujarat), India. Fifteen lines viz., L_1 (I-07-7-1), L_2 (I-07-7-4), L_3 (I-07-7-11), L_4 (I-07-8-4), L_5 (I-07-8-5), L_6 (I-07-8-6), L_7 (I-07-9-9), L_8 (I-07-10-1), L_9 (I-07-13-1), L_{10} (I-07-54-1), L_{11} (I-07-56-4), L_{12} (I-07-56-7), L_{13} (I-07-56-8), L_{14} (I-07-57-5), L_{15} (I-07-57-6) were crossed with three testers T_1 (HKI-163), T_2 (CLQ-30), T_3 (CLQ-47) in *rabi* 2009. The fourty-five hybrids and eighteen parents with two standard checks Harayana Maize-5

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(HM-5) and Gujarat Makai-2 (GM-2) were evaluated in *kharif* 2010 by raising the experimental material in Randomized Block design with three replications with spacing of 60 cm x 20 cm. Recommended package of practices were followed to raise a good crop.

The data were recorded on five randomly selected plants from each genotype on six characters viz., grain moisture content, protein content, lysine in protein, tryptophan in protein, starch content and oil content. The analysis of variance for the experimental design was analysed by the method given by Panse and Sukhatme (1954) and the combining ability analysis was carried out by following the methodology of Kempthorne (1957) with fixed effect model (Model I) of Eisenhart (1947). Grain moisture content was estimated by using oven dry method, protein content by Micro-kjeldahl's method given by Hawk (1951), lysine and tryptophan in protein by calorimetric method given by Tsai *et al.* (1972), starch content by Anthrone reagent method given by Clegg (1956) and oil content by Soxhlet method (Anonymous, 1965). The magnitude of standard heterosis was calculated as by increase of mean F_1 performance over that of mean performance of the standard variety.

RESULTS AND DISCUSSION

The results of analysis of variance are presented in table 1. Considerable variability existed among the genotypes for all the characters studied as observed from the significant mean squares due to genotypes. The mean squares due to parents and crosses were found to be highly significant for all the characters. The mean squares due to parents vs. crosses was found to be significant for grain moisture content, protein content, lysine in protein and tryptophan in protein which indicated that the parents chosen were diverse and with a different genetic background and also indicated the presence of average heterosis due to the significant differences in the mean performance of hybrids and parents. Mean squares due to checks vs. crosses were significant for grain moisture content, protein content, lysine in protein while mean squares between checks were significant for grain moisture content, tryptophan in protein, starch content and oil content. These results were in confirmation with the results of Hemavathy and Balaji (2008), Dubey *et al.* (2009) and Premlatha *et al.* (2011) who also reported the occurance of heterosis due to differences in the performance of crosses and parents in maize.

The results on the analysis of variance for combining ability for different characters are presented in table 2. The variation between crosses was partitioned into different components representing the mean squares due to lines, testers and line x tester interaction. The mean squares due to lines were significant for only grain moisture content. However, mean squares for line x tester interaction was found to be significant for all the characters studied. The higher estimates of dominance variance as compared to additive variance for all the six characters were probably due to predominance of non-additive gene action suggesting the scope of improvement of these characters through heterosis breeding. Similar to the above result Hemavathy and Balaji (2008) and Premlatha *et al.* (2011) also reported non-additive gene action in quality protein maize.

On the basis of *per se* performance (Table 4) studied for protein content and other biochemical characters among 45 crosses along with both checks HM-5 and GM-2, the cross I-07-56-7 x CLQ-30 was identified as superior cross as it which performed significantly superior over the checks HM-5 and GM-2 for protein content (9.08%), grain moisture content (12.1%) over check GM-2, tryptophan in protein (0.85%) over both the checks and starch content (64.46%) over check GM-2. This was followed by the cross I-07-7-4 x CLQ-30 which performed significantly superior over the checks HM-5 and GM-2 for protein content (9.31%), grain moisture content (10.6%) over both the checks, lysine in protein (3.23%) over check HM-5, tryptophan in protein (0.77%) over both the checks, starch content (61.57%) over check GM-2 and oil content (4.87%) over both the checks, and the cross I-07-9-9 x CLQ-30 exhibited significantly superiority over the checks HM-5 and GM-2 for protein content (9.07%), lysine in protein (3.37%) over both the checks, tryptophan in protein (0.97%) over both the checks, starch content (64.43%) over check GM-2 and oil content (4.17%) over check HM-5. These three crosses were identified as potential crosses for exploiting heterosis on the basis of *per se* performance.

The cross I-07-7-4 x CLQ-30 exhibited significant and positive standard heterosis over both checks HM-5 (17.85%) and GM-2 (21.81%) for protein content, over check HM-5 (16.87%) for lysine content, over HM-5 (9.95%) and GM-2 (11.00%) for tryptophan in protein, over GM-2 (5.39%) for starch content, over HM-5 (29.20%) and GM-2 (10.19%) for oil content this cross also showed significant and negative standard heterosis over checks HM-5 (-14.38%) and GM-2 (-22.48%) for grain moisture content. The cross I-07-56-7 x CLQ-30 exhibited significant and positive standard heterosis over both the checks HM-5 (14.98%) and GM-2 (18.84%) for protein content, over HM-5 (24.17%) and GM-2 (25.36%) for tryptophan in protein, over GM-2 (4.94%) for starch content, this cross also showed significant and negative standard heterosis over check GM-2 (-11.68 %) for grain moisture content. The cross I-07-9-9 x CLQ-30 exhibited significant and positive standard heterosis over both the checks HM-5 (14.85%) and GM-2 (18.71%) for protein content, over check HM-5 (21.69%) and GM-2 (8.60%) for lysine content, over HM-5 (38.39%) and GM-2 (39.71%) for tryptophan in protein, over GM-2 (4.89%) for starch content and over HM-5 (10.62%) for oil content.

These three crosses besides having significant standard heterosis for protein content and biochemical characters also had significant *per se* performance for respective characters. The level of heterosis observed in these hybrids justified the development of commercial hybrids in quality protein maize. Such potential of quality protein maize crosses for commercial exploitation of heterosis have been reported by many maize breeders like Hemavathy and Balaji (2008), Dubey *et al.* (2009) and Premlatha *et al.* (2011).

Estimates of gca and sca effects (Table 3 and 4) among the parents and crosses showed variation in the level of significance for different characters. The estimates of gca effects showed that among lines I-07-7-4 was found to be the best general combiner as it recorded significant positive gca effects for protein content (0.81%), lysine in protein (0.41%), oil content (0.55%) and significant negative gca effects for grain moisture content (-0.30%). Line I-07-9-9 was also identified as a good general combiner as it exhibited significant positive gca effects for protein content (0.18%), tryptophan in protein (0.05%) and starch content (0.72%). However, line I-07-10-1 was identified as a good general combiner as it exhibited significant positive gca effects for protein content (0.28%), starch content (0.76%) and significant negative gca effects for grain moisture content (-0.95 %). While line I-07-56-4 was recorded significant positive gca effects for protein content (0.33%), lysine in protein (0.35%), tryptophan in protein (0.06%), starch content (1.19%) and oil content (0.53%). Among the testers CLQ-30 was identified as a good general combiner as it recorded significant positive gca effects for protein content (0.14%).

Out of fourty-five crosses studied the only one cross I-07-9-9 x CLQ-30 which was identified as superior cross on the basis *per se* performance and standard heterosis over both the checks were also observed to exhibit positive significant sca effects for protein content (0.62%) and other parameters lysine in protein (0.25%) and tryptophan in protein (0.13%). Besides this the cross I-07-56-8 x CLQ-47 recorded significant positive sca effects for protein content (0.92%) and tryptophan in protein (0.06%) and I-07-8-6 x HKI-163 for protein content (0.91%) and tryptophan in protein (0.05%) and I-07-57-5 x CLQ-47 for protein content (0.83%), tryptophan in protein (0.06%) and oil content (0.38%). The significant gca and sca effects were also reported by Hemavathy and Balaji (2008), Shanthi *et al.* (2010) and Premlatha *et al.* (2011) in maize.

The success in commercial production to hybrid maize depends on extensive assessment of inbred lines. For exploiting hybrid vigour, *per se* performance, sca effects and the extent of heterosis of hybrid are important. Among the fourty-five crosses studied the only one cross I-07-9-9 x CLQ-30 was identified as best cross since it possessed high *per se* performance, sca effects and standard heterosis over both checks for protein content and other biochemical parameters. It is therefore, suggested that this cross can be used directly for heterosis breeding in quality protein maize. Among the genotypes five genotypes namely I-07-7-4, I-07-9-9, I-07-10-1, I-07-56-4 and CLQ-30 were identified as a good general combiner for several characters. These genotypes could be utilised for the development of either the synthetic variety or an elite breeding population by allowing

Table 1. Analysis of variance for heterosis

Source of variation	d.f.	Grain moisture (%)	Protein content (%)	Lysine in protein (%)	Tryptophan in protein (%)	Starch content (%)	Oil content (%)
Replications	2	0.21	0.09	0.07	0.00	1.13	0.03
Genotypes	65	8.86**	1.23**	1.54**	0.06**	33.66**	1.05**
Parents	17	5.52**	1.85**	1.65**	0.07**	55.00**	1.20**
Crosses	44	9.36**	1.05**	0.36**	0.03**	26.12**	1.05**
Parents vs. Crosses	1	31.08**	0.60**	55.71**	1.09**	0.64	0.08
Between checks	2	3.10**	0.10	0.16	6.72**	101.69**	1.63**
Checks vs. Crosses	1	27.12**	1.13**	0.24**	5.60	1.14	2.44
Error	130	0.28	0.03	0.02	0.00	0.46	0.03

*, ** indicate level of significance at 5 % and 1 %, respectively

Table 2. Analysis of variance for combining ability

Source of variation	d.f.	Grain moisture (%)	Protein content (%)	Lysine in protein (%)	Tryptophan in protein (%)	Starch content (%)	Oil content (%)
Replications	2	0.14	0.10	0.05	0.00	0.71	0.05
Hybrids (H)	44	9.36**	1.05**	0.36**	0.03**	26.12**	1.055**
Lines (L)	14	14.13*	1.19	0.54	0.04	27.63	1.51
Testers (T)	2	10.97	0.72	0.01	0.05	2.16	0.31
Lines x Testers	28	6.85**	1.00**	0.29**	0.02**	27.08**	0.87**
Error	88	0.25	0.02	0.02	0.00	0.09	0.03

*, ** indicate level of significance at 5% and 1%, respectively

Table 3. Mean performance and GCA of lines and testers

Sr. No.	Genotypes	Grain moisture (%)		Protein content (%)		Lysine in protein (%)		Tryptophan in protein (%)		Starch content (%)		Oil content (%)	
	Lines	**Mean**	**GCA**	**Mean**	**GCA**	**Mean**	**GCA**	**Mean**	**GCA**	**Mean**	**GCA**	**Mean**	**GCA**
1	I-07-7-1 (L_1)	12.4	-0.41**	8.91	-0.03	2.10	-0.01	0.59	0.08**	61.83	-2.62**	4.86	0.27**
2	I-07-7-4 (L_2)	13.4	-0.30**	7.40	0.81**	1.37	0.41**	0.57	-0.01	73.13	-1.93**	4.00	0.55**
3	I-07-7-11 (L_3)	10.9	0.54**	8.93	-0.12**	1.63	0.23**	0.55	0.03**	62.37	-0.52**	4.60	0.57**
4	I-07-8-4 (L_4)	9.3	-1.61**	8.00	0.05	1.53	0.11*	0.87	0.00	60.50	-1.81**	4.93	0.12*
5	I-07-8-5 (L_5)	9.8	-1.64**	8.02	-0.28**	1.37	-0.31**	0.41	-0.16**	59.87	1.46**	4.87	-0.39**
6	I-07-8-6 (L_6)	11.9	0.22	8.83	-0.10*	1.70	-0.19**	0.62	-0.06**	60.43	3.14**	4.87	-0.67**
7	I-07-9-9 (L_7)	12.2	1.90**	7.24	0.18**	1.67	0.02	0.61	0.05**	72.07	0.72**	3.80	-0.15**
8	I-07-10-1 (L_8)	10.1	-0.95**	9.50	0.28**	1.57	-0.16**	0.58	-0.04**	62.80	0.76**	3.17	-0.46**
9	I-07-13-1 (L_9)	8.5	-0.52**	7.83	-0.58**	3.10	-0.07	0.46	0.02*	61.53	0.59**	5.00	-0.28**
10	I-07-54-1 (L_{10})	10.4	-2.04**	9.17	-0.31**	1.70	-0.37**	0.54	-0.11**	70.93	2.00**	2.90	-0.40**
11	I-07-56-4 (L_{11})	11.8	1.33**	8.80	0.33**	1.67	0.35**	0.71	0.06**	65.15	1.19**	4.54	0.53**
12	I-07-56-7 (L_{12})	9.3	-0.33*	8.52	0.51**	1.43	-0.19**	0.42	0.01	63.83	-2.43**	4.27	-0.34**
13	I-07-56-8 (L_{13})	10.0	1.69**	6.90	-0.21**	1.27	0.32**	0.56	0.13**	63.40	-0.24**	4.27	0.25**
14	I-07-57-5 (L_{14})	10.2	1.37**	7.03	-0.28**	1.20	-0.21**	0.55	-0.03*	66.00	1.26**	5.03	0.04
15	I-07-57-6 (L_{15})	11.1	0.76**	7.84	-0.25**	1.77	0.10*	0.47	0.03*	59.73	-1.57**	4.03	0.34**
	S E ±	0.31	0.14	0.10	0.04	0.10	0.05	0.01	0.01	0.39	0.09	0.11	0.05
	CD @5%	0.85	-	0.28	-	0.27	-	0.03	-	1.09	-	0.30	-
	Testers												
1	HKI-163 (T_1)	8.6	0.37**	8.03	-0.04*	3.63	-0.02	0.81	-0.03	60.80	0.24**	4.87	-0.05*
2	CLQ-30 (T_2)	10.6	0.19**	9.22	0.14**	3.53	0.01	0.90	0.00	65.40	-0.18**	4.83	-0.05*
3	CLQ-47 (T_3)	9.4	-0.56**	8.30	-0.11**	1.80	0.01	0.90	0.03	68.96	-0.05	4.87	0.10**
	S E ±	0.31	0.05	0.10	0.02	0.10	0.02	0.01	0.00	0.39	0.03	0.11	0.02
	CD @5%	0.85	-	0.28	-	0.27	-	0.03	-	1.09	-	0.30	-

*, ** indicate level of significance at 5% and 1%, respectively

Table 4. Performance of crosses for mean, standard heterosis (HM-5, GM-2) and specific combining ability (SCA)

Crosses	Grain moisture (%)				Protein content (%)			
	Mean	HM-5	GM-2	SCA	Mean	HM-5	GM-2	SCA
L_1 x T_1	12.6	1.59	-8.03*	1.20**	8.63	9.28**	12.95**	0.58**
L_1 x T_2	10.6	-14.92**	-22.97**	-0.67**	7.88	-0.21	3.14	-0.35**
L_1 x T_3	9.9	-19.83**	-27.42**	-0.53**	7.76	-1.77	1.53	-0.23**
L_2 x T_1	10.0	-19.75**	-27.35**	-1.55**	8.93	13.00**	16.79**	0.03
L_2 x T_2	10.6	-14.38**	-22.48**	-0.70**	9.31	17.85**	21.81**	0.23**
L_2 x T_3	12.8	3.47	-6.33*	2.26**	8.57	8.44**	12.08**	-0.26**
L_3 x T_1	13.6	9.67**	-0.71	1.25**	8.32	5.27**	8.81**	0.35**
L_3 x T_2	11.8	-5.19	-14.16**	-0.41*	7.37	-6.75**	-3.62	-0.78**
L_3 x T_3	10.6	-14.75**	-22.82**	-0.85**	8.32	5.36**	8.90**	0.43**
L_4 x T_1	12.7	2.12	-7.54*	2.46**	8.64	9.37**	13.04**	0.50**
L_4 x T_2	8.2	-33.81**	-40.07**	-1.81**	8.48	7.38**	10.99**	0.17**
L_4 x T_3	8.6	-30.50**	-37.08**	-0.65**	7.39	-6.46**	-3.31	-0.68**
L_5 x T_1	8.4	-32.20**	-38.61**	-1.76**	7.73	-2.19	1.09	-0.08
L_5 x T_2	11.7	-5.67	-14.60**	1.72**	7.67	-2.95	0.31	-0.32**
L_5 x T_3	9.3	-25.24**	-32.31**	0.04	8.13	2.95	6.41**	0.40**
L_6 x T_1	13.6	9.84**	-0.56	1.60**	8.90	12.66**	16.44**	0.91**
L_6 x T_2	9.3	-24.70**	-31.82**	-2.50**	7.73	-2.11	1.18	-0.43**
L_6 x T_3	12.0	-3.25	-12.41**	0.91**	7.44	-5.78**	-2.62	-0.48**
L_7 x T_1	14.5	16.50**	5.47	0.74**	8.22	4.05*	7.54**	-0.05
L_7 x T_2	13.7	10.45**	0.00	0.17	9.07	14.85**	18.71**	0.62**
L_7 x T_3	11.9	-4.33	-13.38**	-0.91**	7.63	-3.38	-0.13	-0.57**
L_8 x T_1	9.4	-24.43**	-31.58**	-1.49**	8.57	8.44**	12.08**	0.19**
L_8 x T_2	12.5	0.64	-8.88**	1.80**	8.42	6.54**	10.12**	-0.13*
L_8 x T_3	9.6	-22.47**	-29.81**	-0.31	8.24	4.30*	7.81**	-0.06
L_9 x T_1	10.9	-12.25**	-20.56**	-0.41*	7.67	-2.95	0.31	0.15*
L_9 x T_2	11.6	-6.75	-15.57**	0.46*	8.28	4.81**	8.33**	0.59**
L_9 x T_3	10.3	-16.80**	-24.67**	-0.04	6.70	-15.23**	-12.39**	-0.75**
L_{10} x T_1	9.1	-26.39**	-33.36**	-0.64**	7.62	-3.59*	-0.35	-0.16**
L_{10} x T_2	10.5	-15.05**	-23.09**	0.95**	8.30	5.06**	8.59**	0.35**
L_{10} x T_3	8.5	-31.28**	-37.79**	-0.31	7.52	-4.85**	-1.66	-0.19**
L_{11} x T_1	14.2	14.62**	3.77	1.07**	8.13	2.91	6.37**	-0.29**
L_{11} x T_2	13.5	8.90*	-1.41	0.55**	8.62	9.07**	12.73**	0.02
L_{11} x T_3	10.6	-14.59**	-22.68**	-1.62**	8.63	9.28**	12.95**	0.28**
L_{12} x T_1	11.7	-6.07	-14.96**	0.17	7.90	0.00	3.36	-0.70**
L_{12} x T_2	12.1	-2.45	-11.68**	0.80**	9.08	14.98**	18.84**	0.31**
L_{12} x T_3	9.6	-22.71**	-30.02**	-0.97**	8.92	12.95**	16.75**	0.39**
L_{13} x T_1	13.5	9.03**	-1.29	0.03	7.53	-4.64**	-1.44	-0.35**
L_{13} x T_2	13.1	5.21	-4.74	-0.26	7.48	-5.27**	-2.09	-0.57**
L_{13} x T_3	12.8	3.20	-6.57*	0.24	8.73	10.55**	14.26**	0.92**
L_{14} x T_1	12.1	-2.18	-11.44**	-1.04**	7.07	-10.55**	-7.54**	-0.74**
L_{14} x T_2	13.8	11.13**	0.61	0.79**	7.89	-0.08	3.27	-0.09
L_{14} x T_3	12.5	0.78	-8.76**	0.25	8.57	8.44**	12.08**	0.83**
L_{15} x T_1	11.0	-11.69**	-20.05**	-1.61**	7.51	-4.98**	-1.79	-0.34**
L_{15} x T_2	11.5	-7.28*	-16.06**	-0.88**	8.40	6.33**	9.90**	0.38**
L_{15} x T_3	14.1	13.95**	3.16	2.50**	7.73	-2.11	1.18	-0.04
S Ed (±)	**0.31**	**0.43**	**0.43**	**0.19**	**0.10**	**0.14**	**0.14**	**0.06**

*, ** indicate level of significance at 5 % and 1 %, respectively

Table 4 Contd…

Crosses	Lysine in protein (%)				Tryptophan in protein (%)			
	Mean	**HM-5**	**GM-2**	**SCA**	**Mean**	**HM-5**	**GM-2**	**SCA**
L_1 x T_1	3.13	13.25**	1.08	0.07	0.85	20.38**	21.53**	0.02*
L_1 x T_2	3.47	25.30**	11.83**	0.38**	0.82	16.11**	17.22**	-0.05**
L_1 x T_3	2.63	-4.82	-15.05**	-0.46**	0.93	32.23**	33.49**	0.03**
L_2 x T_1	3.30	19.28**	6.45	-0.18*	0.67	-4.74	-3.83	-0.07**
L_2 x T_2	3.23	16.87**	4.30	-0.27**	0.77	9.95**	11.00**	0.00
L_2 x T_3	3.97	43.37**	27.96**	0.45**	0.87	24.17**	25.36**	0.07**
L_3 x T_1	3.53	27.71**	13.98**	0.23**	0.86	21.80**	22.97**	0.08**
L_3 x T_2	3.33	20.48**	7.53	0.01	0.72	1.90	2.87	-0.10**
L_3 x T_3	3.10	12.05*	0.00	-0.23**	0.86	22.75**	23.92**	0.02*
L_4 x T_1	3.23	16.87**	4.30	0.05	0.66	-6.64*	-5.74*	-0.10**
L_4 x T_2	3.07	10.84*	-1.08	-0.14*	0.88	25.59**	26.79**	0.09**
L_4 x T_3	3.30	19.28**	6.45	0.09	0.83	18.01**	19.14**	0.01
L_5 x T_1	2.80	1.20	-9.68*	0.04	0.59	-16.11**	-15.31**	-0.01
L_5 x T_2	2.90	4.82	-6.45	0.12	0.63	-9.95**	-9.09**	0.00
L_5 x T_3	2.63	-4.82	-15.05**	-0.16*	0.67	-4.74	-3.83	0.01
L_6 x T_1	2.77	0.00	-10.75*	-0.12	0.74	5.21*	6.22*	0.05**
L_6 x T_2	2.60	-6.02	-16.13**	-0.31**	0.64	-9.48**	-8.61**	-0.09**
L_6 x T_3	3.33	20.48**	7.53	0.42**	0.81	15.17**	16.27**	0.05**
L_7 x T_1	3.17	14.46**	2.15	0.07	0.83	17.54**	18.66**	0.02*
L_7 x T_2	3.37	21.69**	8.60*	0.25**	0.97	38.39**	39.71**	0.13**
L_7 x T_3	2.80	1.20	-9.68*	-0.32**	0.72	2.84	3.83	-0.15**
L_8 x T_1	2.77	0.00	-10.75*	-0.15*	0.73	4.27	5.26	0.02*
L_8 x T_2	2.60	-6.02	-16.13**	-0.34**	0.69	-2.37	-1.44	-0.06**
L_8 x T_3	3.43	24.10**	10.75*	0.49**	0.81	15.17**	16.27**	0.03**
L_9 x T_1	2.67	-3.61	-13.98**	-0.34**	0.69	-1.42	-0.48	-0.08**
L_9 x T_2	3.10	12.05*	0.00	0.07	0.86	22.27**	23.44**	0.05**
L_9 x T_3	3.30	19.28**	6.45	0.27**	0.88	25.12**	26.32**	0.04**
L_{10} x T_1	2.67	-3.61	-13.98**	-0.04	0.58	-17.06**	-16.27**	-0.06**
L_{10} x T_2	2.80	1.20	-9.68*	0.07	0.76	8.06**	9.09**	0.08**
L_{10} x T_3	2.70	-2.41	-12.90**	-0.03	0.68	-2.84	-1.91	-0.03**
L_{11} x T_1	3.43	24.10**	10.75*	0.01	0.70	-0.95	0.00	-0.12**
L_{11} x T_2	3.33	20.48**	7.53	-0.12	0.92	30.81**	32.06**	0.07**
L_{11} x T_3	3.57	28.92**	15.05**	0.11	0.92	31.28**	32.54**	0.04**
L_{12} x T_1	3.40	22.89**	9.68*	0.52**	0.87	24.17**	25.36**	0.11**
L_{12} x T_2	2.63	-4.82	-15.05**	-0.27**	0.85	21.33**	22.49**	0.06**
L_{12} x T_3	2.67	-3.61	-13.98**	-0.25**	0.66	-5.69*	-4.78*	-0.17**
L_{13} x T_1	3.20	15.66**	3.23	-0.19**	0.87	24.17**	25.36**	-0.01
L_{13} x T_2	3.70	33.73**	19.35**	0.28**	0.86	22.75**	23.92**	-0.05**
L_{13} x T_3	3.33	20.48**	7.53	-0.09	1.01	43.13**	44.50**	0.06**
L_{14} x T_1	2.83	2.41	-8.60*	-0.03	0.83	17.54**	18.66**	0.11**
L_{14} x T_2	2.80	1.20	-9.68*	-0.08	0.59	-16.59**	-15.79**	-0.17**
L_{14} x T_3	3.00	8.43	-3.23	0.11	0.85	21.33**	22.49**	0.06**
L_{15} x T_1	3.23	16.87**	4.30	0.06	0.83	17.54**	18.66**	0.04**
L_{15} x T_2	3.53	27.71**	13.98**	0.34**	0.86	21.80**	22.97**	0.04**
L_{15} x T_3	2.80	1.20	-9.68*	-0.40**	0.78	10.43**	11.48**	-0.08**
S Ed (±)	**0.10**	**0.13**	**0.13**	**0.07**	**0.01**	**0.017**	**0.017**	**0.01**

*, ** indicate level of significance at 5 % and 1 %, respectively

Table 4 Contd…

Crosses	Starch content (%)				Oil content (%)			
	Mean	**HM-5**	**GM-2**	**SCA**	**Mean**	**HM-5**	**GM-2**	**SCA**
L_1 x T_1	60.77	-12.48**	-1.07	-1.36**	4.90	30.09**	10.94**	0.29**
L_1 x T_2	60.80	-12.43**	-1.02	-0.91**	5.03	33.63**	13.96**	0.43**
L_1 x T_3	64.10	-7.69**	4.35**	2.26**	4.03	7.08	-8.68**	-0.72**
L_2 x T_1	64.74	-6.76**	5.39**	1.92**	5.06	34.34**	14.57**	0.18*
L_2 x T_2	61.57	-11.33**	0.23	-0.83**	4.87	29.20**	10.19**	-0.01
L_2 x T_3	61.43	-11.52**	0.01	-1.09**	4.87	29.20**	10.19**	-0.16*
L_3 x T_1	62.83	-9.51**	2.29*	-1.39**	4.93	30.97**	11.70**	0.03
L_3 x T_2	65.09	-6.25**	5.97**	1.29**	5.05	34.07**	14.34**	0.15*
L_3 x T_3	64.03	-7.78**	4.24**	0.10	4.87	29.20**	10.19**	-0.18*
L_4 x T_1	62.10	-10.56**	1.10	-0.83**	4.04	7.26	-8.53**	-0.42**
L_4 x T_2	63.77	-8.16**	3.81**	1.25**	4.47	18.58**	1.13	0.01
L_4 x T_3	62.23	-10.37**	1.31	-0.41**	5.00	32.74**	13.21**	0.40**
L_5 x T_1	66.50	-4.22**	8.26**	0.30*	3.44	-8.76*	-22.19**	-0.51**
L_5 x T_2	65.23	-6.06**	6.19**	-0.56**	4.75	26.11**	7.55	0.80**
L_5 x T_3	66.17	-4.70**	7.72**	0.26*	3.80	0.88	-13.96**	-0.29**
L_6 x T_1	66.57	-4.13**	8.37**	-1.31**	3.04	-19.20**	-31.09**	-0.62**
L_6 x T_2	68.60	-1.20	11.68**	1.14*	3.63	-3.54	-17.74**	-0.03
L_6 x T_3	67.77	-2.40**	10.32**	0.18	4.47	18.58**	1.13	0.66**
L_7 x T_1	61.90	-10.84**	0.78	-3.56**	4.77	26.55**	7.92*	0.58**
L_7 x T_2	64.43	-7.20**	4.89**	-0.61**	4.17	10.62**	-5.66	-0.02
L_7 x T_3	69.33	-0.14	12.87**	4.16**	3.77	0.00	-14.72**	-0.56**
L_8 x T_1	68.48	-1.38	11.48**	2.97**	3.50	-6.99	-20.68**	-0.37**
L_8 x T_2	67.70	-2.50**	10.21**	2.61**	3.30	-12.39**	-25.28**	-0.57**
L_8 x T_3	59.63	-14.11**	-2.92**	-5.58**	4.97	31.86**	12.45**	0.95**
L_9 x T_1	68.27	-1.68*	11.14**	2.93**	3.47	-7.96*	-21.51**	-0.59**
L_9 x T_2	61.80	-10.99**	0.61	-3.12**	4.53	20.35**	2.64	0.48**
L_9 x T_3	65.23	-6.06**	6.19**	0.18	4.32	14.60**	-2.26	0.11
L_{10} x T_1	60.62	-12.70**	-1.32	-6.12**	4.44	17.79**	0.45	0.50**
L_{10} x T_2	69.43	0.00	13.03**	3.11**	3.80	0.88	-13.96**	-0.13
L_{10} x T_3	69.47	0.05	13.09**	3.02**	3.70	-1.77	-16.23**	-0.38**
L_{11} x T_1	68.09	-1.93*	10.85**	2.16**	4.83	28.32**	9.43**	-0.03
L_{11} x T_2	61.47	-11.47**	0.07	-4.05**	4.90	30.09**	10.94**	0.04
L_{11} x T_3	67.53	-2.74**	9.94**	1.89**	5.00	32.83**	13.28**	-0.01
L_{12} x T_1	61.17	-11.91**	-0.42	-1.15**	4.67	23.89**	5.66	0.67**
L_{12} x T_2	64.46	-7.16**	4.94**	2.57**	3.37	-10.62**	-23.77**	-0.63**
L_{12} x T_3	60.60	-12.72**	-1.35	-1.42**	4.09	8.67	-7.32**	-0.05
L_{13} x T_1	66.47	-4.27**	8.20**	1.96**	4.40	16.81**	-0.38	-0.19**
L_{13} x T_2	62.30	-10.27**	1.42	-1.79**	4.97	31.86**	12.45**	0.38**
L_{13} x T_3	64.03	-7.78**	4.24**	-0.18	4.53	20.35**	2.64	-0.20**
L_{14} x T_1	68.70	-1.06	11.84**	2.70**	4.80	27.43**	8.68*	0.42**
L_{14} x T_2	67.40	-2.92**	9.73**	1.82**	3.57	-5.22	-19.17**	-0.80**
L_{14} x T_3	61.20	-11.86**	-0.37	-4.51**	4.90	30.09**	10.94**	0.38**
L_{15} x T_1	63.94	-7.91**	4.10**	0.77**	4.73	25.66**	7.17*	0.06
L_{15} x T_2	60.83	-12.39**	-0.97	-1.92**	4.57	21.24**	3.40	-0.11
L_{15} x T_3	64.03	-7.78**	4.24**	1.15**	4.87	29.20**	10.19**	0.05
S Ed (±)	**0.39**	**0.56**	**0.56**	**0.12**	**0.11**	**0.15**	**0.15**	**0.07**

*, ** indicate level of significance at 5 % and 1 %, respectively

through mixing among them to achieve new genetic recombination and then subjecting the resultant population to recurrent selection (Iqbal *et al,.* 2007). This population could serve as the source for new desirable inbred lines.

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ROLE OF CLIMATE OF NAGPUR ON PERSISTENCY OF LACTATION OF CROSSBRED COWS

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ABSTRACT

The investigation on role of climate on persistency of lactation in crossbred cows was carried out at College Dairy Farm, Animal Husbandry and Dairying Section, College of Agriculture, Nagpur. The five years data (2006-10) on weekly milk yield of cows calved during each season for twelve weeks and climatic attributes like temp. (max. and min.), humidity (max. and min.), sunshine hours during corresponding period were collected. Weekly milk yield data were analyzed statistically to see the effect of climatic attributes and to know the association with persistency. Persistency of milk yield was found to be more (0.049±0.02) in summer months due to dry climatic farm condition and significantly less in rainy months (0.034 ± 0.03) due to high humidity. Availability of fodder in winter and also helped in better persistency of milk yield but was slightly lower than summer.

During summer season, average mean weekly persistency was more which indicated that freshly calved crossbred cows maintained their weekly production throughout the summer season. It is also seen that high temperature with less humidity and more sunshine hours contributed to more percentage of persistency of milk production in crossbred cows under dairy farm conditions. It can be opined that apart from availability of quality nutritious fodder during different seasons maximum milk yield persistency was recorded during summer (0.049±0.02) followed by winter (0.040± 0.02) and rainy seasons respectively, when freshly calved crossbred cows are considered for lactation performance under dairy farm conditions.

(Key words : Crossbred cows, lactation, climate)

INTRODUCTION

India ranks first in the world, among the milk producing countries. The total milk production of India was estimated at 121.8 MT during the year 2010 (Anonymous, 2011).The performance of cattle in the milk production is greatly affected by environmental factors, besides genetic factors. The environmental factors such as temperature, humidity, rainy days and sunshine hours may cause variation in milk production (Kale and Basu, 1993).

Persistency of lactation yield is an important element of total yield and advantageous because of better use of feed and reduction of stress during high peak yield. Persistency of lactation is the ability of a cow to continue producing milk at a high level after the peak of her lactation. The distribution of yield over the lactation can be measured through persistency (Dekkers *et al*., 1998). However, there are certain limitations, such as high persistency is associated with a slow rate of decline in yield following peak milk yield and low persistency is associated with a rapid rate of decline peak milk yield.

Persistency of lactation counted is a very important factors in the yearly milk yield and economical production of milk. As a matter of fact, knowledge on Persistency of lactation as a character of dairy cow is very limited as far as exact quantitative analysis is concerned. Therefore, studies on role of climate on persistency of crossbred cows maintained at College Dairy Farm, Animal Husbandry and Dairying Section, Agriculture College, Nagpur during the year 2011-2012.

MATERIALS AND METHODS

The investigation was carried out on role of climate on persistency of lactation in crossbred cows" at College Dairy farm, Animal Husbandry and Dairying Section, College of Agriculture, Nagpur during the year 2011-2012. Five years (2006 to 2010) data were collected in respect of crossbred cows having 50% exotic (Jersey) inheritance of their parental breeds. The yearly data were further divided into 3 climatic seasons as under.

1. Rainy (S_1) - June to September
2. Winter (S_2) - October to January
3. Summer (S_3) - February to May

The weekly metrological data for all the seasons in respect of temperature (max. and min.) and humidity (max. and min.) and sunshine hours were collected from the metrological observatory of the college campus situated under the section of Agronomy, College of Agriculture, Nagpur. The weekly milk yield of crossbred cows calved during

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each season were considered upto 12th weeks for calculating persistency of lactation by adopting the method suggested by Mahadevan (1951) by using following formula .

$$P = \frac{A-B}{B}$$

Where,

P = Persistency of lactation.
A = Weekly milk yield obtained in subsequent week.
B = Weekly milk yield obtained in previous week.

The data were analysed by calculating the correlation to study the extent of relationship among the selected variables by the following formula recommended by Sukhatme and Amble (1976).

$$r = \frac{Cov(x.y)}{S.D.(x).S.D.(y)}$$

The significance or correlation was tested by 't' as

$$t - Cal = \frac{r}{S.E.(r)}$$

The table value of 't' noted at (n-2) d.f. for deriving significance.

Where,

COV- Covariance,
SD(x) - standard deviation of 'x' variable
SE (r) - standard error for correlation
SD(y) - standard deviation of 'y' variable
Cal. - calculated

RESULTS AND DISCUSSION

Effect of seasonal climate on weekly milk yield and persistency :

It is seen from the table 1 that the during rainy, winter and summer season maximum temperature were recorded in the range of 31.15 to 35.89, 30.12 to 32.45 and 36.89 to 39.89 °C respectively , corresponding figures for minimum temperature were recorded in the range of 21.74 to 25.52, 14.10 to 16.84 and 19.09 to 25.80°c respectively. With regards to max. relative humidity levels ,81.45, 65.95 and 45.75 per cent R.H. was noticed in 28th, 41 th and 16th meteorological weeks during rainy, winter and summer season respectively. On the other hand, maximum sunshine hours 5.30, 8.43 & 8.63 were recorded in 32th , 47 and 9th meteorological weeks.

The climate of the season might have influenced the persistency index in animals. To examine this logic, weekly milk persistency in relation to seasonal climate was calculated. It appears from the weekly milk yield persistency that the crossbred was persistent in milk production as the weekly variation in the milk yield was not significant except for few weeks. During the winter season, the variation in weekly milk yield did not cross the limit of 20 per cent in crossbred cows, while it exceeded only in 50th and 51st meteorological week. The persistency was from 1 to 15 % in crossbred cow during winter while in rainy season, the variation in weekly milk yield ranged from 12 to 33%. However, the milk yield inclined by 13.4% in 31th meteorological week. In summer season, it was 10 to 27% and the increased level of milk yield with increased persistency was noticed in 15th meteorological week. Probably, variation in the availability of feed and fodder might have affected the milk production in animals.

The role of feed and fodder in maintaining the lactation in animals have been pointed out by many past workers (Kulkarni, 1996 and Atkare *et al.,* 1999). Besides this, seasonal climate might be the factor to influence the production level in animal. Therefore, to find out the interrelationship between climatic attributes and persistency the data was subjected to correlation coefficient. The results obtained in this respect are discussed in the following paragraphs as under.

Persistency of lactation during rainy season and its correlation:

The results with regards to the correlation between persistency and different climatic factors during rainy season are presented in table 2.

It is evident from table 2 that, the average weekly persistency index was 0.034 $\pm$ 0.03 in crossbred cow. During rainy season there was increase in milk production at the rate of approximately 0.1 to 0.5 per cent week^{-1}. This means that the crossbred cow maintained their production level in rainy season. Thus, climate of rainy season was not a limiting factor in milk production. Probably, availability of fresh green fodder as major share in diet of animals might have contributed to this trend. This contention is confirmed from correlation analysis where the different climatic factors except max. tem., max. hum., and min. hum. did not establish with weekly milk yield persistency. Max. tem.

(r=0.767),and max. hum. (0.749) exhibited positive significant association with weekly milk yield persistency, while min. hum. (-0.680) influenced the persistency significantly in negative direction. This trend appears to be advantageous as humidity levels are generally more throughout the rainy season. Therefore, the decline in milk secretion rate would be at slower rate by increasing humidity levels.

Kale and Basu (1993) and Atkare *et al.* (2006) noticed that the minimum temperature was more important in affecting milk yield than change in maximum temperature. This trend during rainy season supports the observation obtained in Jersey crossbreds in the present study. Thus, it can be opined that Jersey crossbreds are affected to lesser degree by environmental factor under dairy farm condition during rainy season.

Persistency of lactation during winter season and its correlation:

Data regarding correlation coefficients between climatic attributes and persistency during winter season are presented in table 3.

It was evident that average weekly milk persistency during winter season was 0.040 $\pm$ 0.02 in Jersey crossbred cows. It indicated the rate of decline in milk production of Jersey crossbred cows during this season. The factors like max. hum. and min. hum. were significantly related with persistency in Jersey crossbred cows. The max. hum. indicated positive influence on persistency and the correlation value of it was 0.947. Minimum humidity indicated negative influence on persistency with correlation value -0.747. The positive significant association of max. hum. during cold dry climate seems to favour the maintenance of milk production in freshly calved crossbreds.

The degree of 'r' values indicated more favourable effect of winter climate on the performance of crossbred cows as compared to rainy climate, for maintaining desired lactation. In maximum persistency, the maximum contribution was due to max. and min. hum. (89.6% and 55.8%) followed by max. tem. (27%) and min. tem. (11.9%) and sunshine hrs. (5%). The climate can be considered as major non genetic factor responsible for contributing the variation in persistency. In winter, the animals do not experience the shortage of green fodder. On the other hand, they are in a position to receive the quality feed and fodder during winter and hence, persistency of lactation is not adversely affected.

However, Kulkarni (1996) emphasized the availability of feeds and fodder as main reason for variation in persistency. This logic does not work for winter season's results of present investigation.

Persistency of lactation during summer season and its correlation :

The data regard to the correlation coefficients between persistency and climatic attributes during summer season are tabulated in table 4.

Table 4 indicated that the Jersey crossbred cow was persistent in summer and the climate did not influence their weekly performance. The mean weekly persistency was 0.049 $\pm$ 0.02 in Jersey crossbred cows. This indicates increase in weekly milk production at the rate of 4.9 per cent week^{-1}. This fact is confirmed from the correlation values of climatic factors with that of persistency. It was observed from table 4 that max. hum. and min. hum. were significantly correlated with the persistency. The max. hum. (0.947) had positive association with the persistency and min. hum. (-0.935) had negative association with the persistency in Jersey crossbred cows, whereas max. tem. (0.132), min. tem. (0.254) and sunshine hrs. (0.423) were non significantly correlated with the persistency in positive direction. The positive non significant relationship between sunshine hrs; max. tem. and min. tem. was maintained by dry climate during summer, which might have favoured the persistency in milk production of freshly calved crossbreds.

The results of summer season, further, support the earlier contention that the persistency was under the influence of nutrition status and management of animals (Saxena and Kumar, 1960). Therefore, it can be inferred that apart from availability of quality nutritious fodder during different seasons, maximum milk yield persistency was recorded during summer (0.049$\pm$0.02) followed by winter (0.040$\pm$ 0.02) and rainy (0.034 $\pm$ 0.03) seasons respectively. Thus, the results clearly once again establish the fact that, the dry climate favours the milk production in freshly calved crossbreds under dairy farm condition of Nagpur.

Table 1. Effect of different seasonal climate on weekly milk yield and persistency in Jersey crossbred cow

Met. week	Temp. (max.)	Temp. (min.)	Hum. (max)	Hum. (min.)	Sun. (Hrs.)	Milk yield (Lit.)	Per.
			Rainy season				
23	34.43	25.52	73.55	60.10	3.12	27.38	0.33
24	35.89	25.26	74.00	62.80	3.48	36.68	-0.044
25	35.53	24.93	74.65	59.55	3.26	35.05	0.036
26	33.26	24.73	76.42	59.00	3.64	36.33	0.122
27	32.29	24.03	81.45	64.50	3.28	37.98	-0.001
28	31.57	23.85	81.85	70.95	2.98	37.94	0.029
29	31.75	23.89	78.20	62.30	4.05	39.05	0.006
30	32.17	23.19	76.32	58.00	4.24	39.30	0.012
31	32.03	22.11	75.60	57.60	5.13	39.79	0.143
32	31.44	22.17	77.75	62.30	3.68	45.14	0.092
33	31.58	21.74	76.70	58.50	5.17	49.30	-0.010
34	31.85	21.45	74.25	56.35	5.3	48.77	-
	32.64 ± 0.39	**23.57 ± 0.41**	**76.72 ± 0.78**	**60.99 ± 0.14**	**3.94 ± 0.24**	**39.39 ± 1.24**	**0.034 ± 0.03**
			Winter season				
40	30.81	16.84	16.60	43.60	6.95	33.65	0.159
41	30.95	16.33	65.95	39.15	7.55	39.03	0.017
42	30.92	15.98	64.20	39.00	7.73	39.70	0.069
43	30.12	13.39	57.70	33.65	8.41	42.47	0.008
44	30.39	14.60	61.25	35.10	7.52	42.13	0.012
45	30.70	15.40	61.86	35.80	7.53	42.66	0.057
46	30.84	15.66	62.46	35.66	7.75	45.12	-0.025
47	30.86	14.10	53.93	30.66	8.43	43.95	0.053
48	31.50	14.77	55.93	29.86	7.96	46.31	0.050
49	32.45	16.54	54.40	31.60	8.12	48.65	0.135
50	32.08	16.34	59.00	32.80	7.34	55.22	-0.029
51	32.84	15.91	50.60	28.10	8.27	53.60	-
	31.20 ± 0.24	**15.48 ± 0.30**	**59.49 ±1.46**	**34.58 ± .28**	**7.76 ± 0.13**	**43.62 ± 1.62**	**0.040 ± 0.02**
			Summer season				
5	36.89	19.09	40.10	19.55	8.85	31	0.27
6	37.34	21.02	38.75	22.00	8.59	39.37	0.10
7	37.80	20.08	41.90	22.25	8.41	43.34	-0.066
8	38.23	20.76	41.25	22.10	8.91	40.45	0.125
9	39.83	20.04	37.10	20.10	8.97	45.51	0.042
10	39.68	24.29	37.95	21.40	8.06	47.46	0.024
11	39.89	22.95	41.20	24.25	7.65	48.62	0.014
12	39.83	25.10	43.95	26.95	7.77	49.31	-0.005
13	39.16	23.34	45.75	31.25	7.48	49.04	0.006
14	39.22	25.80	47.35	33.80	6.90	49.37	0.157
15	39.21	26.72	45.75	32.80	6.59	57.15	-0.074
16	39.07	26.30	51.55	35.35	6.59	52.87	-
	38. 84 ± 0.29	**22.95 ± 0.77**	**42.55 ± 1.26**	**25.93 ± 1.65**	**7.89 ± 0.25**	**44.37 ± 1.34**	**0.049 ± 0.02**

Table 2. Mean values and correlation coefficients of climatic attributes with weekly persistency in Jersey crossbreds during rainy season (S_1)

Va riables	Avg. Values with S.E.(±)	Correlation coefficient	% contribution
Max.Tem.(°c)x_1	32.64 ± 0.39	0.767**	0.588
Min.Tem. (°c)x_2	23.57 ± 0.41	-0.099 ^{NS}	0.009
Max.Hum.(%)x_3	76.72 ± 0.78	0.749**	0.561
Min. Hum.(%)x_4	60.99 ± 1.14	-0.680*	0.462
Suns hine hrs. x_5	3.94 ± 0.24	0.060 ^{NS}	0.003
Weekly milk yield persistency		0.034(±) 0.03	

Table 3. Mean values and correlation coefficients of climatic attributes with weekly persistency in Jersey crossbreds during winter season (S_2)

Variabl es	Avg. Values with S.E.(±)	Correlation coefficient	% contribution
Max.Tem.(°c)x_1	31.20 ± 0.24	0.520 ^{NS}	0.270
Min.Tem. (°c)x_2	15.48 ± 0.30	0.346 ^{NS}	0.119
Max.Hum.(%)x_3	59.49 ± 1.46	0.947**	0.896
Min. Hum.(%)x_4	34.58 ± 1.28	-0.747**	0.558
Sunshine hrs. x_5	7.76 ± 0.13	-0.225 ^{NS}	0.050
Weekly milk yield persistency		0.040 ± 0.02	

Table 4. Mean values and correlation coefficients of climatic attributes with weekly persistency in Jersey crossbreds during summer season (S_3)

Variables	Avg. Values with S.E.(±)	Correlation coefficient	% contribution
Max.Tem.(°c)x_1	38.84±0.29	0.132 ^{NS}	0.017
Min.Tem. (°c)x_2	22.95±0.77	0.254 ^{NS}	0.064
Max.Hum.(%)x_3	42.55±1.26	0.947**	0.8 96
Min. um.(%) x_4	25.93±1.65	-0.935**	0.874
Sunshine hrs. x_5	7.89±0.25	0.423 ^{Ns}	0.17
Weekly milk yield persistency		0.049±0.02	

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GENETIC ANALYSIS OF BUDFLY RESISTANCE AND YIELD COMPONENTS IN LINSEED (*Linum usitatissimum* L.)

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ABSTRACT

In the present study genetic analysis of budfly resistance and yield components in linseed (*Linum usitatissimum* L.) comprises of eleven male parents viz., Lakshmi, T-397, Jeevan, Kiran, Mukta, Parvathi, Sheela, RLC-92, Deepika, Nagarkot and Himani and three female parents viz., Padmini, Neelum and PKVNL-260 along with thirty three crosses obtained by crossing male and female were grown in randomized complete block design with two replications at College of Agriculture, Nagpur in *rabi* 2011-12. The row to row spacing was 30 cm with single row plot. The cultivar PKVNL-260 was grown on all sides of the block to avoid border effect. Data were recorded on five randomly selected plants of each family for the nine characters viz., days to maturity, plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1}, budfly infestation (%), Alternaria blight infestation (%), powdery mildew, 1000 seed weight (g) and seed yield plant^{-1} (g). These selected lines of linseed (*Linum usitatissimum* L.) were used to assess the budfly resistance and yield components and selection of potential parents and crosses for linseed breeding programme. Additive (D), dominance (H1), and epistasis components of genetic variation played an important role in the inheritance of days to 50% flowering, plant height, number of branches plant^{-1}, number of capsules plant^{-1}, 1000 seed weight, seed yield plant^{-1}, alternaria blight infestation(%) and budfly infestation(%). The parents viz., Deepika, T-397, Parvati, Kiran, Jeevan and Lakshmi with maximum additive genetic variation will be useful for improvement of economic traits and may be utilized in hybridization programme.

(Key words: Genetic analysis, budfly resisstance, yield components, linseed)

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is one of the oldest oilseed crop cultivated by man for its seed and fibre. The Egyptian records mention its cultivation from about 5000 years back to Bronze Age. Linseed is an annual, self pollinated species and grown to a height of 30 to 120 cm. The linseed is cultivated for the main products fibre (flax fibre) and seed oil (linseed) or both (dual purpose linseed), In India, it has been grown mainly for seed used in extracting oil. Linseed has 30 per cent protein and contains 35 to 45 per cent oil. As it is self pollinating crop development of high yielding varieties is necessary through hybridization programme. Linseed crop suffers from several diseases and insect pest in India (Srivastava *et al.,* 1997). The significant yield losses occurs in linseed due to budfly (*Dasyneura lini*) (20 to 97%), alternaria blight (*Alternaria lini*) and powdery mildew (*Odium lini*) (up to 60 %), and rust. Therefore, there is a need to develop varieties resistant to pests and diseases to stabilize the yield potentials of linseed varieties. Therefore, this research work helps in developing varieties resistant to pest and diseases to stabilize the yield potentials of linseed varieties. The manipulation of inherent potentials of plants in the form of resistant. Triple test cross analysis and its modifications are available since 1968 which detect epistasis and estimate additive and dominance components of genetic variation in self-pollinating crops. The present investigation was undertaken to study the genetics of budfly resistance and yield components and selection of potential parents for linseed breeding programme.

MATERIALS AND METHODS

The complete set of material under study comprised of 11 male parents viz., Lakshmi, T-397, Jeevan, Kiran, Mukta, Parvathi, Sheela, RLC-92, Deepika, Nagarkot and Himani and 3 female parents Padmini (resistance to budfly and alternaria blight), Neelum (susceptible to powdery mildew and budfly) and PKVNL-260 (resistant to budfly) and 33 crosses among them were grown in randomized complete block design with two replications in *rabi* 2011-12. The row to row spacing was 30 cm with single row plot. The cultivar PKVNL-260 was grown on all sides of the block to avoid border effect. Recommended package of practices were followed to raise a good crop. Data were recorded on five randomly selected plants of each family for the nine characters viz., days to maturity, plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1}, budfly infestation (%), Alternaria blight infestation (%), powdery mildew, 1000 seed weight (g) and seed yield plant^{-1} (g) except days to 50% flowering for which observations were recorded on plot basis.

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The data were subjected to the statistical and biometrical analysis as per the methodology suggested by Panse and Sukhatme (1954) for analysis of variance and Jinks *et al.* (1969) for estimation of additive, dominance and epistatic components of variation.

RESULTS AND DISCUSSION

Test of epistasis and epistatic contribution of individual lines :

The analysis of variance (Table 1) for the experimental design showed that mean squares due to between families were highly significant for all characters under study indicating substantial genetic variability for all the traits.

The test of epistasis for different characters (Table 2) indicating the presence of epistasis was significant for all characters except plant height and days to maturity. Epistasis ($L_{1i}+L_{2i}-P_i$) is an important component in the inheritance for all traits under study. The estimates of individual line contribution to the epistatic comparision (Table 2) indicated that, the parent Deepika had maximum epistatic variation for days to 50% flowering. T-397 showed maximum epistatic variation for number of capsules plant^{-1}. For number of branches plant^{-1} the parent Parvati exhibited maximum epistatic variation. Kiran contributed maximum epistatic variation for the budfly infestation (%) and seed yield plant^{-1}. Similarly, Jeevan recorded maximum epistatic variation for alternaria blight infestation (%) and for 1000 seed weight Lakshmi showed maximum epistatic variation. Same epistatic results for yield and its components has been reported in linseed by Anita (2005), Vivek Singh *et al.* (2006), Reddy (2008), Mane (2009), Jadhav *et.al.* (2011) and Reddy (2010). The analysis of variance for sums ($L_{1i}+L_{2i}$) and differences ($L_{1i} - L_{2i}$) and estimates of additive (D) and dominance (H_1) components are presented in table 3 and 4 respectively. The mean squares due to sums ($L_{1i}+L_{2i}$) were significant for all the characters except plant height and days to maturity. The mean squares due to differences ($L_{1i} - L_{2i}$) were significant for the characters viz., number of branches, number of capsules plant^{-1}, 1000 seed weight and seed yield plant^{-1}. Significant mean squares for sums and difference were also reported by Patel *et al.* (2000), Anita (2005), Vivek Singh *et al.* (2006), Reddy (2008), Mane (2009), Jadhav (2011), and Reddy (2010) in linseed.

The additive genetic variation is predominantly exploited in varietal improvement programme in linseed. Therefore, the parents with high additive genetic variation may be utilized in linseed breeding programme. The additive (D) and dominance (H_1) components were estimated for different characters under epistatic model and are presented in (Table 5). Maximum additive genetic variation was contributed by the parent Deepika for days to 50% flowering, the parent Parvathi for number of branches plant^{-1}, the parent T-397 for number of capsules plant^{-1}, the parent Kiran for budfly infestation (%) and seed yield plant^{-1}, the parent Jeevan for Alternaria blight infestation (%) and the parent Lakshmi for 1000 seed weight.

In the present study, genetics of budfly resistance and yield components in linseed both additive (D) and dominance (H_1) components of genetic variation play an important role in the inheritance of characters under study. The parent Jeevan showed high additive genetic variation for budfly infestation (%), Alternaria blight infestation (%) and 1000 seed weight. Kiran showed high additive genetic variation for budfly infestation (%) and seed yield plant^{-1}. The parent Parvathi showed high additive genetic variation for number of branches plant^{-1}, number of capsules plant^{-1} and seed yield plant^{-1}. Therefore, simple recurrent selection should be utilized to capitalize the additive genetic variation. Also, selective intermating in F_2 generation should be followed and further segregating material should be carried by single seed descent method to obtain superior recombinant lines. The parents with maximum additive genetic variation will be useful for improvement of economic traits and may be utilized in hybridization programme.

Table 1. Analysis of variance for the experimental design

Source of variation	Degrees of freedom	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	Budfly (%)	Alternaria blight (%)	1000 seed weight (g)	Seed yield plant^{-1} (g)
Replication	1	3.41	52.74	53.82	0.83	76.92	0.07	0.06	0.57	0.28
Crosses	32	17.17**	53.14**	114.62**	2.23**	557.14**	61.79**	8.76**	1.17**	1.79**
Error	32	3.25	37.93	21.54	0.34	30.30	9.83	1.48	0.15	0.13

*, ** = Significant at 5% and 1% level respectively

Table 2. Test of epistasis for different characters

		Mean squares								
Source of variation	**Degrees of freedom**	**Days to 50% flowering**	**Days to maturity**	**Plant height (cm)**	**Number of branches plant^{-1}**	**Number of capsules plant^{-1}**	**Budfly (%)**	**Alternaria blight (%)**	**1000 seed weight (g)**	**Seed yield plant^{-1} (g)**
Epistasis $L_{1i}+L_{2i}-P_i$	10	16.04**	45.74	26.96	0.45*	328.15**	22.75*	9.60**	1.66**	**0.79****
Error	10	2.50	26.33	16.81	0.15	22.61	8.96	2.34	0.13	**0.09**

*, ** = Significantat 5% and 1% level respectively

Table 3. Estimation of individual line (Pi) contribution to the epistasis comparison $L_{1i}+L_{2i}$ P_i for different characters

Sr. No.	Parents (Pi)	Days to 50% flowering	Number of branches plant^{-1}	Number of capsules plant^{-1}	Budfly (%)	Alternaria blight (%)	1000 seed weight (g)	Seed yield plant^{-1} (g)
1	Lakshmi	62.0	4.00	61.80	13.44	10.17	8.06*	2.88
2	T-397	60.0	4.40	110.20*	21.03	3.67	5.13	3.62
3	Jeevan	68.5	3.00	42.00	26.77	14.25*	7.40	2.59
4	Kiran	59.0	5.20	62.90	32.40*	11.22	7.22	5.59*
5	Mukta	60.0	3.00	34.50	31.92	9.79	7.25	2.75
6	Parvati	58.5	5.60*	88.70	22.39	10.49	4.06	4.54
7	Sheela	57.5	4.85	84.40	20.29	4.42	3.73	4.62
8	RLC-92	66.5	4.40	55.70	26.98	3.33	7.98	2.83
9	Deepika	73.5*	4.40	52.75	28.05	13.84	5.36	4.18
10	Nagarkot	64.5	5.00	52.70	29.06	10.28	5.96	1.91
11	Himani	63.5	4.20	55.10	30.78	10.28	4.63	3.43

***=Epistatic parent**

Table 4. Analysis of variance for the sums and differences for different characters

		Mean squares								
Source of variation	Degrees of freedo m	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	Budfly (%)	Alternaria blight (%)	1000 seed weight (g)	Seed yield plant^{-1} (g)
Sums $\overline{L_{1i}+L_{2i}}$	10	9.80**	62.25	32.38	1.38**	309.86**	64.08 **	6.47**	0.54**	0.98**
Error	10	2.77	29.30	21.06	0.12	7.02	6.89	2.00	0.07	0.07
Differences $\overline{L_{1i}}-\overline{L_{2i}}$	10	4.51	39.32	36.26	1.27**	640.54**	20.06	4.15	1.77**	0.88**
Error	10	2.29	61.52	29.35	0.20	6.57	7.33	1.58	0.28	0.16
		Components of genetic variation								
D		7.03	-	-	1.26	301.84	57.19	4.47	0.47	0.91
H_1		-	-	-	1.07	633.97	-	-	1.49	0.72
$\sqrt{\frac{H_1}{D}}$		-	-	-	0.92	1.44	-	-	1.78	0.88

*,** = Significant at 5% and 1% level respectively

Table 5. Estimation of individual line ($\overline{Pi}$) contribution to the (1) Additive comparison ($\overline{L}_{1i}+\overline{L}_{2i}$) and (2) Dominance comparison ($L_{1i}-L_{2i}$) for different characters

Sr. N.	Parents (Pi)	Days to 50% flowering		Number of branches plant^{-1}		Number of capsules plant^{-1}		Budfly (%)		Alternaria blight (%)		1000 seed weight (g)		Seed yield plant^{-1} (g)	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2
1	Lakshmi	120.0	-1.0	7.20	-0.60	20.79	-5.35	13.96	20.79	-5.35	13.96	13.96	1.99	5.27	-0.47
2	T-397	119.0	3.0	7.20	1.60	16.35	0.01	12.06	16.35	0.01	12.06	12.06	2.70	5.27	1.93
3	Jeevan	121.5	3.5	6.70	1.30	23.26	-1.24	14.03	23.26	-1.24	14.03	14.03	0.09	4.89	1.32
4	Kiran	122.0	2.0	8.70	0.90	20.66	-0.23	13.37	20.66	-0.23	13.37	13.37	1.23	7.07	-0.44
5	Mukta	125.0	5.0	8.70	-0.10	20.31	-0.05	12.86	20.31	-0.05	12.86	12.86	0.38	5.95	-1.15
6	Parvati	125.0	1.0	9.20	-0.40	18.99	0.35	12.24	18.99	0.35	12.24	12.24	-0.23	6.24	0.65
7	Sheela	125.5	1.5	10.05	-0.35	16.59	0.55	13.83	16.59	0.55	13.83	13.83	-1.51	5.85	0.12
8	RLC-92	126. 0	0.0	7.50	-0.30	15.13	-1.12	13.36	15.13	-1.12	13.36	13.36	-1.44	4.55	-0.36
9	Deepika	124.5	-2.5	10.10	-2.50	22.20	0.25	12.63	22.20	0.25	12.63	12.63	-0.32	7.20	-0.42
10	Nagarkot	130.0	0.0	8.70	-0.50	19.50	-4.71	12.24	19.50	-4.71	12.24	12.24	-0.76	3.98	-0.44
11	Himani	125.5	1.5	7.50	0.70	20.91	-2.09	12.41	20.91	-2.09	12.41	12.41	-0.25	5.86	0.98

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HETEROSIS AND COMBINING ABILITY ESTIMATES FOR OIL CONTENT, SEED COTTON YIELD AND OTHER ECONOMIC TRAITS IN UPLAND COTTON (*G. hirsutum* L.)

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ABSTRACT

Studies on heterosis and combining ability analysis in intra specific hybrids of cotton *(Gossypium hirsutum* L.) was carried out to assess extent of heterosis over standard check for oil content, seed cotton yield and other economic traits, to study the general and specific combining ability of parents and crosses respectively and to identify superior parents and crosses. Fourty four crosses obtained by crossing four lines and eleven testers were raised in Randomized Block design with three replications in the research farm of Regional Research Station, Anand Agricultural University, Anand during the year 2010-11. Parents and check (G. Cot Hy. 12) were also raised adjacent to the crosses. The data were recorded on seed cotton yield plant $^{-1}$, lint yield plant $^{-1}$, ginning percentage, seed index, lint index and oil content. Considerable variability existed among the genotypes for all the characters studied as observed from the significant mean squares due to genotypes. The crosses BC 68-2 x MCU 11, BC 68-2 x AC 738, BN 1 x Riba B-50 had high mean performance for yield plant $^{-1}$ and the cross 76 IH-20 x AC 738 had high mean performance for oil content. The mean squares due to the interaction effects of parents vs. crosses were found to be significant for all the characters indicating the choice of exploitation of heterosis. Four crosses namely BC 68-2 x MCU 11, BC 68-2 x AC 738, BN 1 x Riba B-50 and 76 IH-20 x AC 738 were identified as promising crosses as they exhibited significant useful heterosis for yield and oil content, respectively. These crosses also had significant *per se* performance for their respective characters. The mean squares for lines and testers were significant for all the six characters i.e. seed cotton yield plant $^{-1}$, lint yield plant $^{-1}$, ginning percentage, seed index, lint index and oil content. The higher magnitude of variance in line x tester interaction suggested the presence of greater variability among the crosses than among the parents. The gca estimates of lines and testers emphasized the importance of six parents BC 68-2, 76 IH-20, Riba-B-50, G COT-10, AC 738 and MCU-11 for their use as good general combiner for yield, yield contributing characters and oil content. Out of fourty four crosses studied cross BN 1 x Riba B-50 was identified as the most potential cross for hybrid production on the basis of high *per se* performance and high significant useful heterosis in addition to high significant sca effects and hence, it is suggested that this cross can be practically exploited in heterosis breeding programme.

(Key words: Upland Cotton, standard heterosis and combining ability)

INTRODUCTION

India is pioneer in commercialization of heterosis in cotton. Even though heterosis occurs in cotton, it has not been utilized widely as compared to maize and castor due to difficulties in producing cheap commercial F_1 hybrids seed production.

Cotton being a long duration crop grown over a wide range of environments, its productivity and production is not stable. For better exploitation of heterosis in cotton, development simple and economically variable of hybrid seed production technique is essential. Improvement in yield has been achieved through distant hybridization, particularly through intraspecific hybridization. The evolution of hybrid-4 (Patel, 1971) is a splendid example of successful utilization of hybrid vigour in cotton on commercial scale for the first time in the world. Evaluation of breeding materials for general combining ability and specific combining ability as well as to study the extent of heterosis for yield and yield contributing characters are prerequisites for any breeding programme aimed in development of hybrids. The breeding methods to be adopted for improvement of a crop depend on the nature of gene action involved in the inheritance of economically important traits. Besides its use in selection of potential parents and superior crosses, combining ability also provide information on the nature and magnitude of gene effects involved in the expression of quantitative traits. Such information is of practical value in formulating as well as executing efficient breeding programme for obtaining maximum gain with minimum resource and time. Therefore, the present investigation was undertaken to study the heterosis and combining ability using Line x Tester analysis.

MATERIALS AND METHODS

Four lines viz., L_1 (G. Cot-16), L_2 (BC-68-2), L_3 (BN 1), L_4 (76 IH-20) were crossed with eleven testers viz., T_1 (American nectariless), T_2 (MCU 11),

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T_3 (AC 738), T_4 (Surat Dwarf), T_5 (Riba-B-50), T_6 (Khandwa 2), T_7 (LRA 5166), T_8 (G. Cot 100), T_9 (G. Cot 10), T_{10} (Narsimha), T_{11} (Guj-247) by following Line x Tester mating design to produce 44 crosses in *kharif* 2009-10. These 44 crosses were grown in Randomized block design in three replications with the spacing of 120 cm x 45 cm. Fifteen parents and a standard check hybrid G. Cot Hy. 12 were also raised in three replications adjacent to the crosses for the estimation of heterosis. Recommended package of practices were followed to raise a good crop. The data were recorded on randomly selected plants from each genotype on six characters viz., seed cotton yield plant $^{-1}$, lint yield plant $^{-1}$, ginning percentage, seed index, lint index and oil content . The analysis of variance for the experimental design was analysed by the method given by Panse and Sukhatme (1978) and the combining ability analysis was carried out by following the methodology of Kempthorne (1957) with fixed effect model (Model I) of Eisenhart (1947).

RESULTS AND DISCUSSION

The results of analysis of variance are presented in table 1. Considerable variability existed among the genotypes for all the characters studied as observed from the significant mean squares due to genotypes. The mean squares due to parents were found to be highly significant for all the traits except ginning percentage. Significant mean squares for crosses were recorded for all the six characters. Mean squares due to parents v/s crosses was found to be significant for all the six traits studied thereby suggesting differences between parents and crosses and possibility of heterotic effects for some of the characters. Similar results were found by Ashokkumar and Ravikesavan (2008) who also reported the presence of heterosis due to the significant differences in the mean performance of crosses and parents .

The results on the analysis of variance for combining ability for different characters are presented in table 2. The variation between crosses was partitioned into different components representing the mean squares due to lines, testers and line x tester interaction. The mean squares due to lines, testers and line x tester interaction were significant for all the six characters. These significant mean squares due to lines, testers and line x tester interaction revealed the presence of significant variances among them. The higher magnitude of variance in line x tester interaction suggested the presence of great variability among the crosses than among the parents. Similar to the above results Patel *et al*. (2009) and Saaravanan *et al*. (2010) also reported significant mean squares due to lines, testers and line x tester in cotton.

The utility of heterosis breeding approach lies in the identification of most heterotic and useful cross combinations in order to develop well adapted commercial hybrid. In the present investigation, the heterosis has been estimated over standard check hybrid G.Cot Hy.-12 for the traits under study. Thus, the aim of heterosis analysis in the present study was to identify promising hybrids which may give high degree of useful (economic) heterosis and characterization of parents for their prospects for future use in breeding programme.

On the basis of *per se* performance (Table 3) studied for yield and yield contributing characters among 44 crosses along with check G.Cot Hy.-12, the cross BC 68-2 x MCU 11 was identified as superior cross as it performed significantly superior over check G.Cot Hy.-12 for seed cotton yield plant $^{-1}$ (480.33g) and for oil content (18.37%). This was followed by the cross BC 68-2 x AC 738 which performed significantly superior over check G.Cot Hy.-12 for seed cotton yield plant $^{-1}$ (477.67 g) and for oil content (17.92%) and the cross BN 1 x Riba B-50 exhibited significant superiority for grain yield plant $^{-1}$ (467.67 g) and oil content (19.22%). These three crosses were identified as potential crosses for exploiting heterosis on the basis *per se* performance. Cross 76 IH-20 x G. Cot 100 showed significant superiority for seed index (18.39 g). None of the crosses registered significant superiority over standard check for lint yield plant^{-1}, ginning percentage and lint index.

The expression of heterosis was worked out for all the characters over standard check and are presented in table 4. Seed cotton yield plant^{-1} is very important attribute which the breeder attempt to improve by evolving high yielding hybrids. Cross BC-68-2 x MCU 11 recorded significant and positive standard heterosis (14.55 %) over check G. Cot. Hy.12, respectively. Similar to the above results

Muthu *et al*. (2005), Verma *et al*. (2006) and Ashokkumar and Ravikesavan (2008) also reported positive significant and standard heterotic effect for seed cotton yield.

Among the 44 hybrids evaluated, cross 76 IH-20 x G. Cot 100 (23.64%) exhibited significant positive standard heterosis over standard check for seed index. For oil content, 76 IH-20 x AC 738 (23.74 %) showed significant positive standard heterosis over standard check. None of the crosses had significant positive standard heterosis for lint yield plant^{-1}, ginning percentage, lint index. The significant positive standard heterosis over standard check cotton hybrid were also reported by Patil *et al*. (2012) and Balu *et al*. (2012).

The overall study of heterosis and *per se* performance indicated that the cross combinations like BC-68-2 x MCU 11, BC-68-2 x AC 738 and BN 1 x Riba B-50 were found to be outstanding in respect of seed cotton yield plant^{-1} and important yield contributing traits like plant height, total number of bolls plant^{-1} and average boll weight. These may be exploited commercially after critical evaluation for its superiority in performance with stability across the location over years.

Estimates of gca and sca effects (Table 3 and 4) among the parents and crosses showed wide variation in the level of significance for different characters. None of the parents nor crosses had high and significant gca and sca effects in the desirable direction for all the characters studied. The significant gca and sca effects were also reported by Singh *et al*. (2010) and Kaliyaperumal *et al*. (2010). The estimates of gca effects showed that among the lines 76 IH-20 was found to be the best general combiner as it recorded significant positive gca effect for seed cotton yield plant $^{-1}$, lint yield plant $^{-1}$, seed index, lint index and oil content. Line BC-68-2 was also identified as a good general combiner as it exhibited significant positive gca effect for seed cotton yield plant $^{-1}$ and lint yield plant $^{-1}$. Among the testers, Riba-B-50, AC 738 and MCU 11 were identified as good general combiner as it recorded significant positive gca effect for seed cotton yield plant^{-1}, lint yield plant^{-1} and oil content. Besides this G.Cot 10 showed significant positive gca effect for seed cotton yield plant^{-1}, lint yield plant^{-1}, seed index, lint index and oil content. From this study, thus six parents 76 IH-20, BC-68-2, Riba-B-50, AC 738, MCU 11 and G.Cot 10 were identified as best general combiner for yield, yield contributing characters and oil content.

Out of the fourty four crosses studied cross BN 1 x Riba B-50 was identified as superior cross on the basis of *per se* performance and useful heterosis was also observed to exhibit positive significant sca effects (109.01)for seed cotton yield plant $^{-1}$ and lint yield plant $^{-1}$ (34.56). Besides these two crosses BN 1 x G.Cot 100 and 76 IH-20 x Narsimha recorded significant positive sca effect for seed cotton yield plant $^{-1}$ (134.79 and 107.74), lint yield plant $^{-1}$ (46.84 and 33.95) and for oil content (0.27 and 0.40). These two crosses did not show its superior performance for mean and heterosis. On the basis of sca effect these three crosses viz., BN 1 x Riba B-50, BN 1 x G.Cot 100 and 76 IH-20 x Narsimha were identified as superior crosses for hybrid production.

For exploiting hybrid vigour, *per se* performance, sca effect and the extent of heterosis of hybrid are important. Selection based on any one of the criteria may not be effective (Patel *et al*., 2009). The hybrids with high *per se* performance need not always reveal high sca effect and vice-versa. So the selection must be based on all the three parameters. Among the fourty four crosses analysed in this study the cross BN 1 x Riba- B-50 was identified as best cross since it possessed high *per se* performance, sca effect and useful heterosis for yield and important yield contributing characters. It is therefore suggested that cross BN 1 x Riba- B-50 can be used directly for heterosis breeding programme in cotton. Among the parents six parents namely BC 68-2, 76 IH-20, Riba-B-50, G. COT-10, AC 738 and MCU-11 were identified as best general combiner for several characters. Use of these parents would be more rewarding for boosting yield in cotton.

Table 1. Analysis of variance for experimental design

Source of variation	d.f.	Seed cotton yield plant $^{-1}$ (g)	Lint yield plant $^{-1}$ (g)	Ginning percentage	Seed Index (g)	Lint index	Oil content (%)
Replications	2	260.65	41.08	2.74	2.76	1.00	0.04
Genotypes	59	18815.66**	2016.20**	6.03**	5.08**	1.34**	7.70**
Parents	14	4448.85**	554.81**	2.89	3.88**	1.04**	7.04**
Crosses	43	20739.96**	2118.51**	6.64**	5.23**	1.27**	8.13**
Parents vs. Crosses	1	112228.00**	13502.81**	16.83**	20.57**	9.00**	1.34**
Checks vs. Crosses	1	33674.15**	5214.96**	10.75*	0.01	0.60	5.29**
Error	118	449.34	54.51	1.79	1.03	0.31	0.11

*, ** indicate level of significance at 5% and 1%, respectively

Table 2. Analysis of variance for combining ability

Source of variation	d.f.	Seed cotton yield plant $^{-1}$ (g)	Lint yield plant $^{-1}$ (g)	Ginning percentage	Seed Index (g)	Lint index	Oil content (%)
Replications	2	40.72	27.48	1.58	6.48	2.11	0.06
Lines	3	74495.77**	6763.73**	5.41*	29.96**	6.62**	3.46**
Testers	10	18908.10**	1810.54**	6.39**	3.90**	0.86**	17.99**
Lines X Testers	30	15975.00**	1756.64**	6.84**	3.19**	0.87**	5.31**
Error	86	382.89	54.35	1.83	1.06	0.33	0.10

*, ** indicate level of significance at 5% and 1%, respectively

Table 3. Mean performance and GCA of lines and testers

Sr. No.	Genotypes	Seed cotton yield plant^{-1} (g)		Lint yield plant^{-1} (g)		Ginning percentage		Seed Index (g)		Lint index		Oil content (%)	
	Lines												
1	G. Cot-16	275.54	-55.93**	88.29	-18.00**	32.00	0.08	8.53	-0.55**	4.01	-0.25**	17.38	0.35**
2	BC-68-2	212.82	59.26**	62.56	16.69**	29.30	-0.56**	9.93	-0.11	4.12	-0.17*	15.55	-0.42**
3	BN-1	329.53	-9.26**	106.06	-1.72	32.20	0.40*	10.33	-0.72**	4.90	-0.25**	18.25	-0.06
4	76 IH-20	285.00	6.32*	92.96	3.03**	32.70	0.09	11.00	1.38**	5.36	0.67**	18.41	0.13**
	S E ±	12.24	2.55	4.26	0.96	0.77	0.18	0.59	0.13	0.32	0.08	0.19	0.04
	CD @ 5%	34.44	--	12.00	--	2.18	--	1.65	--	0.91	--	0.54	--
	Testers												
1	American nectariless	232.10	--73.42**	74.66	-21.85**	32.22	0.75*	10.82	0.28	5.14	0.29*	16.43	-0.20*
2	MCU 11	285.51	30.97**	86.73	8.29**	30.40	-0.49	11.57	0.07	5.05	-0.07	17.61	0.47**
3	AC 738	233.26	26.96**	74.51	5.93**	32.00	-0.75*	7.90	0.25	3.71	-0.03	15.71	1.39**
4	Surat Dwarf	250.73	-44.33**	77.86	-14.58**	31.00	0.33	8.36	-1.19**	3.76	-0.53**	17.86	-2.69**
5	Riba B-50	250.11	56.12**	77.53	15.14**	31.00	-0.64*	9.93	0.36	4.48	0.01	19.52	1.16**
6	Khandwa 2	228.81	-36.36**	68.56	-9.93**	30.00	0.46	9.60	-0.17	4.11	0.01	18.65	0.86**
7	LRA 5166	188.92	0.75	59.19	3.68*	31.33	-1.09**	8.32	-0.13	3.79	0.19	17.55	-0.04
8	G. Cot 100	302.54	7.01	98.10	3.17	32.50	0.15	10.78	0.31	5.19	0.19	17.94	-1.24**
9	G. Cot 10	241.70	25.24**	75.65	8.83**	31.33	0.02	8.80	0.82**	4.01	0.41**	19.36	1.08**
10	Narsimha	285.40	-24.14**	91.30	-11.27**	32.00	-1.35**	10.55	0.25	4.96	-0.20	15.60	-0.87**
11	Guj - 247	213.44	31.20**	65.29	12.59**	30.67	0.44	9.27	-0.83**	4.08	-0.27	20.92	0.07
	S E ±	12.24	4.65	4.26	1.75	0.77	0.32	0.59	0.25	0.32	0.14	0.19	0.08
	Cd @ 5%	34.44	--	12.00	--	2.18	--	1.65	--	0.91	--	0.54	--

*,** indicate level of significance at 5% and 1% respectively

Table 4. Performance of crosses for mean, standard heterosis (SH) and specific combining ability (SCA)

Crosses	Seed cotton yield plant $^{-1}$ (g)			Lint yield plant $^{-1}$ (g)			Ginning percentage		
	Mean	SH	SCA	Mean	SH	SCA	Mean	SH	SCA
L_1 x T_1	150.62	-64.08**	-32.22**	48.62	-65.80**	-11.53**	32.33	-4.91	-0.58
L_1 x T_2	273.29	-34.83**	-13.94	83.22	-41.46**	-7.08*	30.50	-10.29**	-1.17*
L_1 x T_3	288.98	-31.09**	5.77	87.91	-38.17**	-0.02	30.43	-10.50**	-0.98
L_1 x T_4	189.46	-54.82**	-22.47**	66.34	-53.34**	-1.08	35.03	3.03	2.54**
L_1 x T_5	264.42	-36.94**	-47.96**	88.18	-37.98**	-8.96**	33.37	-1.85	1.85**
L_1 x T_6	209.87	-49.95**	-10.03	69.99	-50.77**	-2.08	33.33	-1.97	0.71
L_1 x T_7	331.36	-20.98**	74.35**	101.15	-28.85**	15.46**	30.55	-10.15**	-2.70**
L_1 x T_8	241.02	-42.52**	-22.25**	80.21	-43.58**	-4.97	33.33	-1.97	1.02
L_1 x T_9	308.48	-26.44**	26.97**	96.70	-31.98**	5.86	31.33	-7.85*	-0.85
L_1 x T_{10}	233.53	-44.31**	1.41	70.50	-50.41**	-0.23	30.20	-11.18**	-0.61
L_1 x T_{11}	327.83	-21.82**	40.37**	109.24	-23.16**	14.64**	33.37	-1.85	0.76
L_2 x T_1	314.11	-25.09**	16.09*	97.85	-31.17**	3.00	31.17	-8.32**	-1.10*
L_2 x T_2	480.33	14.55**	77.92**	146.71	3.19	21.72**	30.53	-10.21**	-0.49
L_2x T_3	477.67	13.91**	79.26**	147.33	3.63	24.69**	30.93	-9.03**	0.16
L_2x T_4	388.41	-7.37	61.29**	117.88	-17.09**	15.75**	30.37	-10.68**	-1.49**
L_2x T_5	410.00	-2.22	-17.56*	123.32	-13.26**	-8.52**	30.17	-11.26**	-0.71
L_2x T_6	334.72	-20.18**	-0.36	117.22	-17.55**	10.45**	35.00	2.94	3.01**
L_2x T_7	285.77	-31.85**	-86.43**	95.58	-32.77**	-24.80**	33.47	-1.56	0.86
L_2x T_8	370.86	-11.56*	-7.60	115.49	-18.77**	-4.39	31.15	-8.38**	-0.52
L_2x T_9	336.87	-19.66**	-59.82**	107.11	-24.66**	-18.43**	31.78	-6.53*	0.24
L_2x T_{10}	263.77	-37.10**	-83.53**	79.54	-44.05**	-25.89**	30.17	-11.26**	0.00
L_2 x T_{11}	423.37	0.96	20.73*	135.69	-4.56	6.40*	32.00	-5.88	0.04
L_3 x T_1	228.05	-45.62**	-1.07	77.86	-45.23**	1.43	34.17	0.50	0.93
L_3x T_2	366.83	-12.52**	33.32**	122.45	-13.87**	15.88**	33.33	-1.97	1.34*
L_3x T_3	294.27	-29.82**	-35.23**	94.42	-33.59**	-9.80**	32.10	-5.59	0.37
L_3x T_4	210.73	-49.75**	-47.48**	70.88	-50.14**	-12.83**	33.67	-0.97	0.85
L_3x T_5	467.67	11.53*	109.01**	147.98	4.09	34.56**	31.67	-6.85*	-0.17
L_3x T_6	312.18	-25.55**	46.01**	97.80	-31.21**	9.43**	31.33	-7.85*	-1.62**
L_3x T_7	260.86	-37.79**	-42.43**	89.75	-36.87**	-12.23**	34.33	0.97	0.76
L_3x T_8	444.33	5.96	134.79**	148.31	4.32	46.84**	33.33	-1.97	0.70
L_3x T_9	299.54	-28.57**	-28.24**	93.85	-33.99**	-13.27**	31.30	-7.94*	-1.20**
L_3x T_{10}	252.78	-39.72**	-25.62**	79.20	-44.29**	-7.82*	31.33	-7.85*	0.20
L_3 x T_{11}	190.70	-54.52**	-143.05**	58.69	-58.72**	-52.19**	30.77	-9.50**	-2.16**
L_4 x T_1	262.28	-37.45**	17.19*	88.29	-37.90**	7.10*	33.67	-0.97	0.75
L_4x T_2	252.19	-39.86**	-97.29**	80.80	-43.17**	-30.53**	32.00	-5.88	0.32
L_4x T_3	295.67	-29.49**	-49.80**	94.10	-33.81**	-14.87**	31.87	-6.26*	0.45
L_4x T_4	282.84	-32.55**	8.65	86.61	-39.08**	-1.85	30.60	-10.00**	-1.90**
L_4x T_5	331.14	-21.03**	-43.49**	101.10	-28.89**	-17.08**	30.57	-10.09**	-0.96
L_4x T_6	246.53	-41.21**	-35.62**	75.30	-47.04**	-17.80**	30.53	-10.21**	-2.11**
L_4x T_7	373.79	-10.86*	54.52**	128.29	-9.76*	21.57**	34.33	0.97	1.08
L_4x T_8	220.58	-47.40**	-104.94**	68.72	-51.66**	-37.49**	31.13	-8.44**	-1.19*
L_4x T_9	404.85	-3.45	61.09**	137.71	-3.14	25.84**	34.00	0.00	1.81**
L_4x T_{10}	402.11	-4.11	107.74**	125.72	-11.57**	33.95**	31.23	-8.15*	0.41
L_4 x T_{11}	431.67	2.94	81.95**	146.78	3.24	31.15**	33.97	-0.09	1.35*
S Ed (±)	**12.24**	**16.95**	**8.06**	**4.26**	**6.00**	**3.04**	**0.77**	**1.08**	**0.56**

Table 4 Contd….

Crosses	Seed Index (g)			Lint index			Oil Content (%)		
	Mean	SH	SCA	Mean	SH	SCA	Mean	SH	SCA
L_1 x T_1	10.85	3.83	0.63	5.17	-4.44	0.16	17.86	7.33**	-0.27*
L_1 x T_2	10.51	0.57	0.50	4.61	-14.79	-0.04	18.85	13.28**	0.04
L_1 x T_3	9.47	-9.38	-0.72	4.13	-23.66**	-0.55*	20.35	22.30**	0.63**
L_1 x T_4	9.43	-9.76	0.68	5.09	-5.91	0.90**	16.50	-0.84	0.86**
L_1 x T_5	9.80	-6.22	-0.50	4.92	-9.06	0.19	19.47	17.01**	-0.02
L_1 x T_6	9.60	-8.13	-0.17	4.80	-11.28	0.08	17.88	7.45**	-1.32**
L_1 x T_7	10.47	0.19	0.65	4.60	-14.97	-0.30	17.95	7.87**	-0.34**
L_1 x T_8	11.49	9.95	1.24**	5.76	6.47	0.85**	17.32	4.09*	0.23
L_1 x T_9	10.78	3.16	0.02	4.93	-8.87	-0.19	19.82	19.11**	0.41**
L_1 x T_{10}	9.46	-9.47	-0.73	4.09	-24.40**	-0.43	16.37	-1.62	-1.10**
L_1 x T_{11}	7.53	-27.94**	-1.58**	3.77	-30.31**	-0.67**	19.28	15.87**	0.87**
L_2 x T_1	11.00	5.26	0.33	4.96	-8.32	-0.13	17.58	5.65**	0.22
L_2 x T_2	8.75	-16.27*	-1.71**	3.84	-29.02**	-0.88**	18.37	10.40**	0.33*
L_2x T_3	9.28	-11.20	-1.35**	4.17	-22.92**	-0.59*	17.92	7.69**	-1.04**
L_2x T_4	9.72	-6.99	0.52	4.24	-21.63**	-0.02	12.91	-22.42**	-1.97**
L_2x T_5	11.45	9.57	0.70	4.94	-8.69	0.13	18.41	10.64**	-0.32*
L_2x T_6	9.78	-6.41	-0.43	5.26	-2.77	0.46	19.30	15.99**	0.87**
L_2x T_7	10.63	1.72	0.38	5.36	-0.92	0.38	17.57	5.59**	0.04
L_2x T_8	9.87	-5.55	-0.83	4.45	-17.74*	-0.53*	14.32	-13.94**	-2.01**
L_2x T_9	11.61	11.10	0.40	5.44	0.55	0.25	19.51	17.25**	0.87**
L_2x T_{10}	11.40	9.09	0.77	4.93	-8.87	0.34	17.86	7.33**	1.16**
L_2 x T_{11}	10.78	3.16	1.22**	5.10	-5.73	0.58*	19.49	17.13**	1.85**
L_3 x T_1	9.75	-6.70	-0.31	5.08	-6.10	0.07	18.82	13.10**	1.10**
L_3x T_2	10.40	-0.48	0.56	5.20	-3.88	0.56*	20.48	23.08**	2.08**
L_3x T_3	11.62	11.20	1.60**	5.51	1.85	0.83**	18.63	11.96**	-0.68**
L_3x T_4	6.63	-36.56**	-1.95**	3.36	-37.89**	-0.82**	14.44	-13.22**	-0.79**
L_3x T_5	10.27	-1.72	0.13	4.79	-11.46	0.06	19.22	15.50**	0.14
L_3x T_6	10.60	1.44	0.99*	4.86	-10.17	0.14	19.61	17.85**	0.83**
L_3x T_7	9.60	-8.13	-0.05	5.02	-7.21	0.12	17.51	5.23**	-0.37**
L_3x T_8	8.93	-14.55	-1.15**	4.53	-16.27*	-0.37	16.95	1.86	0.27*
L_3x T_9	11.55	10.53	0.95*	5.28	-2.40	0.16	19.43	16.77**	0.43**
L_3x T_{10}	9.60	-8.13	-0.42	4.37	-19.22*	-0.14	16.60	-0.24	-0.46**
L_3 x T_{11}	8.61	-17.61*	-0.34	3.83	-29.21**	-0.61*	15.46	-7.09**	-2.53**
L_4 x T_1	11.49	9.95	-0.66	5.81	7.39	-0.11	16.85	1.26	-1.06**
L_4x T_2	12.59	20.48**	0.65	5.93	9.61	0.36	16.13	-3.06	-2.45**
L_4x T_3	12.60	20.57**	0.48	5.91	9.24	0.31	20.59	23.74**	1.09**
L_4x T_4	11.44	9.47	0.76	5.04	-6.84	-0.06	17.31	4.03*	1.89**
L_4x T_5	11.90	13.88	-0.33	5.26	-2.77	-0.39	19.48	17.07**	0.21
L_4x T_6	11.32	8.33	-0.38	4.97	-8.13	-0.68**	18.59	11.72**	-0.38**
L_4x T_7	10.75	2.87	-0.99*	5.62	3.88	-0.20	18.74	12.62**	0.67**
L_4x T_8	12.92	23.64**	0.74	5.87	8.50	0.04	18.39	10.52**	1.52**
L_4x T_9	11.33	8.42	-1.36**	5.82	7.58	-0.21	17.49	5.11**	-1.71**
L_4x T_{10}	12.50	19.62*	0.39	5.67	4.81	0.23	17.64	6.01**	0.40**
L_4 x T_{11}	11.75	12.44	0.70	6.06	12.01	0.70**	17.99	8.11**	-0.19
S Ed (±)	**0.59**	**0.82**	**0.43**	**0.32**	**0.45**	**0.24**	**0.19**	**0.27**	**0.13**

***, ** indicate level of significance at 5 % and 1 %, respectively**

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EFFECT OF DIFFERENT LEVELS OF FYM AND HARVESTING TIME ON YIELD, QUALITY AND NUTRIENTS UPTAKE OF KALMEGH

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ABSTRACT

The experiment was conducted during *kharif* season of 2006-2007 at Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to find out the effect of different levels of FYM and harvesting time on yield, quality and nutrients content of Kalmegh (*Andrographis paniculata).* The experiment was carried out in factorial randomized block design(FRBD) with three replications comprising twelve treatment combinations (4-levels of FYM i.e. F_0 – Control, F_1 – 2.5 t ha^{-1}, F_2 –5 t ha^{-1}, F_3 – 7.5 t ha^{-1} and 3 levels of harvesting time i.e. D_1 – 105 DAS, D_2 – 120 DAS, D_3 – 135 DAS). The results showed that the dry foliage yield (15.59 q ha^{-1}), andrographolide content (2.50%), total andrographolide yield (38.92 kg ha^{-1}) and N (1.14), P (0.34) and K (0.60) content and uptake were recorded significantly highest with the application of FYM @ 7.5 t ha^{-1} as compared to other FYM levels. The application of FYM @ 5 t ha^{-1} was found at par with FYM @ 7.5 t ha^{-1} in respect of dry foliage yield, andrographolide content and yield and content and uptake of nutrients. The dry foliage yield of Kalmegh was also found to be increased successively with each harvesting time and significantly higher dry foliage yield (16.85 q ha^{-1}) was recorded at 135 DAS (D_3) followed by 120 DAS (D_2) (14.14 q ha^{-1}) yield. However, andrographolide content was maximum with the harvesting time of 120 DAS (D_2). Further, it was noticed that the nutrient status was improved with the each increased level of FYM application and the highest gain of 10.70 kg N, 4.38 kg P_2O_5 and 17.02 kg K_2O ha^{-1} were recorded with the application of FYM @7.5 t ha^{-1}. The interaction effect between FYM levels and harvesting time on dry foliage yield, andrographolide content, yield and nutrient content and uptake was non-significant.

(Key words : Andrographolide content, FYM, harvesting time, Kalmegh, foliage yield)

INTRODUCTION

The demand of medicinal and aromatic plants is on the rise in both developing and developed countries due to their growing recognition in pharmaceutical, cosmetic, agricultural and food industry. Commercially, the business of the plant derived medicines, essential oils and products is worth about 70 billion US $ worldwide including a global business of medicinal herbal material 60 billion US $ (Khanuja *et al*., 2007). The medicinal and aromatic plants are valued for their secondary metabolites. Contribution to higher productivity and desired quality of the produce is influenced by factors like genetic, soil, climatic, age and stage of plants at harvest (Maiti *et al*., 2004).

Genus *Andrographis* belongs to family *Acanthaceae* which consists of about 40 species, out of which 19 species are found in India (Singh *et al*., 1999). Out of these, two species *Andrographis paniculata* and *Andrographis alata* have medicinal properties (Patra *et al*., 2004). Kalmegh, (*Andrographis paniculata* Nees) is a genus of herbs and shrubs, distribution mostly in tropical and moist regions. It comprises of about 19 plant species found in India and Sri Lanka, certain parts of Thailand and Bangladesh (Patidar *et al.*,2011).

Its cultivation is confined to garden's only, especially by the traditional users of medicinal plants. Large scale systematic cultivation of Kalmegh in India is yet to be initiated. *Andrographis paniculata* (Burm. F.) is an annual herb and perennial, if maintained. The active ingredient present in Kalmegh is `Andrographolide' which is used for many disorders in human beings. According to Ayurvedic and Homeopathic system of medicine, Kalmegh is a potential herbal drug for fever and lever diseases. It is useful in dysentery, influenza, cough, sore throat, tonsillitis, ostodynia, bronchitis, hypertension and piles. A decoction of plant is blood purifier used for cure of turbid liver (Singh *et al*., 1999). With the movement of organic farming, medicinal plants are encouraged to cultivate under organic farming system. The time of harvesting of medicinal and

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aromatic plants is also most crucial and important factor for adequate synthesis of secondary metabolites. In view of above, an experiment was conducted at Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during *kharif* season of 2006-2007 to find out the effect of different levels of FYM and harvesting time on yield, quality and nutrient uptake of Kalmegh.

MATERIALS AND METHODS

A field experiment was carried out during *kharif* season of 2006-2007 at Nagarjun Medicinal Plants Garden, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola situated at a latitude of $22^0$42' N and longitude of $77^0$22' E, altitude of 307.41 metres above the mean sea level (Arabian Sea) to find out the effect of different levels of FYM and harvesting time on yield, quality and nutrient uptake of Kalmegh (*Andrographis paniculata* Burn. F.). The soil of experimental field was clayey in texture and having 176.2 kg ha^{-1} alkaline permanganate oxidizable N (Subbiah and Asija, 1956), 14.2 kg ha^{-1} Olson's extractable available P (Jackson, 1967), 280.23 kg ha^{-1} 1 *N* ammonium acetate extractable K (Jackson, 1967) and 4.9 g kg^{-1} organic carbon (Jackson, 1967). The pH of soil was 7.9 (1:2.5 soil and water ratio). The treatment combinations comprised of four levels of farm yard manure (FYM) *viz.,* Control (F_0) , 2.5 t ha^{-1} (F_1), 5.0 t ha^{-1} (F_2) and 7.5 t ha^{-1} (F_3) and three levels of harvesting time *viz.,* 105 DAS (D_1), 120 DAS (D_2) and 135 DAS (D_3) and were replicated thrice in factorial randomized block design. The seeds of Kalmegh were sown in the first week of June at a spacing of 30 cm x 30 cm. The seedling establishment and early growth was satisfactory. Total rainfall received during the period of the crop growth (from 16th August to 15th January) was 334.8 mm (44.64%) which was received in 15 rainy days. The average mean maximum temperature varied from 28.3 to 34.3^0C, while minimum temperature ranged from 10 to 23.4^0C. Andrographolide content was estimated by the solvent extraction method described by Handa and Sharma (1990). The dried and powdered sample (5 gm) was extracted successively with petroleum ether, chloroform and methanol and concentrated to about 500 ml.The solution was treated with charcoal for 24 hours, filtered and filtrate was concentrated to about 300 ml and kept overnight for crystallization. The crystals were collected by filtration. The recovered charcoal was refluxed with methanol for 2 hours, filtered and combined the filtrate with the mother liquor obtained earlier, it was concentrated to about 500 ml and left overnight for crystallization. The crystals were purified by recrystallization from methanol to get Androgarpholide. The amount of the harvested Andrographolide crystals was weighed and the percentage was calculated. The nitrogen content in plant sample was estimated by Kjeldhal's method which includes digestion, distillation and titration (Piper, 1966). The phosphorus and potassium content in plant sample was estimated by Vanadomolybdate yellow colour and flame photometrically diacid extract (Piper, 1966). For dry foliage yield, biomass harvested $plot^{-1}$ was air dried at room temperature and then oven dried at 60^0C temperature till the constant weight was obtained and dry weight was computed ha^{-1}.

Total potassium content :

The potassium content in plant sample was estimated by flame photometrically from diacid extract (Piper, 1966).

RESULTS AND DISCUSSION

Foliage yield:
Effect of FYM

It is evident from the data that the dry foliage yield (15.59 q ha^{-1}) was significantly highest with the application FYM @ 7.5 t ha^{-1} followed by FYM @ 5 t ha^{-1} (14.59 q ha^{-1}). These results are in line with Ramamoorthy *et al*. (2003), who concluded that the application of FYM in combination with a fertilizer level of 60:25:40 kg NPK ha^{-1} in Senna enhanced herbage, pod and seed yield and germination percentage. Joy *et al*. (2005) reported that FYM @ 30 t ha^{-1} was the optimum level and substitution of FYM to the tune of 25% with inorganic fertilizers was ideal for realizing highest black musali rhizome yield of good quality.

Effect of harvesting time :

The dry foliage yield of Kalmegh was also found to be increased with each harvesting time and significantly maximum dry foliage yield of 16.85 q ha^{-1} was recorded at 135 DAS (D_3) followed by 120 DAS (D_2) with 14.14 q ha^{-1} yield and minimum dry foliage yield of 10.5 q ha^{-1} was recorded at 105 DAS

(D_1 i.e.) (Table 1). These results are in agreement with the findings of Wankhade *et al*. (2003). They reported the significantly highest fresh foliage yield due to harvesting at late stages.

Interaction effect :

The interaction effect of FYM levels and harvesting time on dry foliage yield was found to be non- significant.

Andrographolide content and yield:
Effect of FYM :

The application of FYM at different levels had favourable effect on the andrographolide content. Significantly highest andrographolide content (2.50%) was recorded with the application of 7.5 t FYM ha^{-1}. The andrographolide yield was also significantly influenced with the FYM application at various levels. The Highest total andrographolide yield was recorded with the application of 7.5 t FYM ha^{-1}(38.92 kg ha^{-1}) followed by application of 5.0 FYM ha^{-1} (35.77 kg ha^{-1}) (Table1). The application of FYM provides the nutrient to the crop. In addition, it contains plant hormones, growth regulators, enzymes which might have regulated the metabolic functions in the plant more effectively which resulted in increase in secondary metabolites i.e. and rographolide content (Chauhan and Tiwari 2003).

Effect of harvesting time :

Andrographolide content was maximum with the harvesting time of 120 DAS (2.48 %). It is noticed that the andrographolide content was significantly lowest with the further delay in harvesting time i.e. 135 DAS (2.21 %). On the contrary, the total andrographolide yield increased with each harvesting time and significantly highest andrographolide yield was recorded with the harvesting time of 135 DAP (37.54 kg ha^{-1}). Mamta and Kaul (1997) reported andrographolide content of three different populations and *Andrographis paniculata* was found to contain it between 1.87 to 2.21 per cent at the harvest between 180-200 days.

Interaction effect :

The interaction effect of FYM levels and harvesting time on Andrographolide content and yield was found non significant.

Nutrient content and uptake:
Effect of FYM :

The data on uptake of nitrogen (Table 1) indicated that the uptake increased significantly with increased FYM levels and significantly highest nitrogen uptake (16.03 kg ha^{-1}) was noticed with FYM @ 7.5 t ha^{-1} followed by 5.0 t FYM ha^{-1} (14.54 kg ha^{-1}). The increase in the content and uptake of nitrogen with the application of FYM at various levels might be due to the increased availability of nutrient in soil solution which resulted in increased content and uptake by the crop plants.

The highest content of P (0.34 %) was noticed with the application of 7.5 t FYM ha^{-1} followed by 5.0 t FYM ha^{-1} (0.32 %). The phosphorus uptake also significantly increased with increased FYM levels. Significantly highest phosphorus uptake (5.31 kg ha^{-1}) was noticed with the application of FYM @ 7.5 t ha^{-1} followed by FYM @ 5.0 t ha^{-1} (4.69 kg ha^{-1}). The increase in the content and uptake of phosphorus might be due to the FYM addition which makes the phosphorus more soluble due to organic acids released during decomposition of FYM, which resulted in increased availability of the nutrient in soil solution and thereby in increased content and uptake of phosphorus.

The K uptake was also significantly influenced with the various levels of FYM application. Significantly highest K uptake (9.42 kg ha^{-1}) was recorded with the FYM application @ 7.5 t FYM ha^{-1} (F_3) followed by FYM @ 5 t ha^{-1}.

Effect of harvesting time :

The data on the effect of harvesting time indicated that the N content was successively decreased with the increase in harvesting time. Significantly highest N content was recorded with harvesting time of 105 DAS, which was subsequently decreased with the delayed harvesting. On the contrary, the nitrogen uptake was found to be increased with the advancement in harvesting time due to increased foliage yield and significantly highest uptake of nitrogen was recorded with the harvesting at 135 DAS. The lowest nitrogen uptake was observed with harvesting at 105 DAS. Phosphorus content was maximum (0.33 % P) with the harvesting at 105 DAS which decreased with the

Table 1. Effect of different levels of FYM and harvesting time on dry foliage yield, andrographolide content, nutrient content and uptake by Kalmegh

Treatments	Dry foliage yield (q ha^{-1})	Andrographolide content (%)	Andrographolide yield (kg ha^{-1})	Nutrient content and uptake					
				N		P		K	
				Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})	Content (%)	Uptake (kg ha^{-1})
FYM levels									
F_0 – Control	11.59	2.09	23.87	0.88	10.23	0.238	2.76	0.457	5.30
F_1 – 2.5 t ha^{-1}	13.55	2.34	31.47	0.99	13.54	0.296	4.02	0.561	7.59
F_2 – 5.0 t ha^{-1}	14.59	2.46	35.77	1.11	14.54	0.321	4.69	0.591	8.63
F_3 – 7.5 t ha^{-1}	15.59	2.50	38.92	1.14	16.03	0.340	5.31	0.604	9.42
SE(m)±	0.36	0.059	0.80	0.006	0.22	0.003	0.16	0.017	0.36
CD at 5%	1.05	0.174	2.37	0.018	0.66	0.010	0.46	0.051	1.02
Harvesting time									
D_1 – 105 DAP	10.50	2.35	24.75	1.18	11.57	0.331	3.48	0.620	6.60
D_2 – 120 DAP	14.14	2.48	35.25	0.96	13.84	0.302	4.27	0.560	7.93
D_3 – 135 DAP	16.85	2.21	37.54	0.91	15.34	0.287	4.84	0.513	8.67
SE(m)±	0.31	0.051	0.70	0.005	0.38	0.003	0.14	0.015	0.31
CD at 5%	0.91	0.151	2.05	0.016	1.09	0.009	0.42	0.044	0.89
Interaction									
SE(m)±	0.62	0.103	1.40	0.011	0.76	0.006	0.28	0.030	0.62
CD at 5%	--	--	--	--	--	--	--	--	--

Table 2. Effect of different levels of FYM and harvesting time on nutrient gain/loss after harvest of kalmegh crop

Treatments	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	Initial	Final	Gain/loss	Initial	Final	Gain/loss	Initial	Final	Gain/loss
FYM levels									
F_0 – Control	176.2	164.25	-11.95	14.2	10.24	-3.96	280.23	274.58	-5.65
F_1 – 2.5 t ha^{-1}	176.2	171.66	-4.54	14.2	11.88	-2.32	280.23	282.78	+2.55
F_2 –5 t ha^{-1}	176.2	179.60	+3.40	14.2	14.96	+0.76	280.23	291.82	+11.59
F_3 – 7.5 t ha^{-1}	176.2	186.9+7	+10.70	14.2	18.58	+4.38	280.23	297.25	+17.02
Harvesting time									
D_1 – 105 DAS	176.2	179.40	+3.20	14.2	14.48	+0.28	280.23	287.78	+7.55
D_2 – 120 DAS	176.2	175.50	-0.70	14.2	14.00	-0.20	280.23	286.31	+6.08
D_3 – 135 DAS	176.2	171.96	-4.24	14.2	13.27	-0.93	280.23	285.72	+5.49

successive harvesting time and significantly lowest P content (0.287%) was recorded with the harvesting at 135 DAS. On the contrary, the P uptake was found significantly highest (4.84 kg ha^{-1}) with the harvesting at 135 DAS followed by the uptake of 4.27 kg ha^{-1} at 120 DAS. The minimum uptake of P (3.48 kg ha^{-1}) was recorded with the harvesting at 105 DAS.

Content of K was significantly influenced by the harvesting time and significantly highest K content (0.620%) was observed with the harvesting at 105 DAS which successively decreased with the increase in harvesting time. The decreased content of nutrients with the increase in harvesting period might be due to the dilution effect. Further, the data on K uptake showed that the uptake of K was found to increase with each harvesting time and significantly highest K uptake (8.67 kg ha^{-1}) was recorded with the harvesting at 135 DAS (D_3) followed by K uptake of 7.93 kg ha^{-1} with harvesting at 120 DAS, but both were on par .

Nutrient Status :

There was remarkable depletion of soil fertility status in respect of N, P and K content after harvest of Kalmegh crop applied with no manure (control). Further, it was noticed that the nutrient status was successively improved with the each level of FYM application and the highest gain of 10.70 kg N, 4.38 kg P_2O_5 and 17.02 kg K_2O ha^{-1} were recorded with the application of FYM @ 7.5 t ha^{-1}.

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MEASUREMENT OF AGRICULTURAL GROWTH OF BHANDARA DISTRICT OF MAHARASHTRA STATE BY COMPOSITE INDEX APPROACH

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ABSTRACT

Present study on "Measurement of Agricultural Growth of Bhandara District of Maharashtra state by composite index approach" was undertaken with an objective to find out agricultural growth on the basis of (1) Composite Index based on crop indicators, (2) Value of crop production and (3) Integrated composite index of crop indicators plus other indicators. For the present study 39 years time series data (1970-71 to 2008-09) on 51 agricultural growth indicators (A/P/Y of 17 crops) and 15 other (non-crop) indicators were collected from secondary source. These 66 indicators were divided into two groups - namely (a) Crop Indicators (Area, Production and Productivity of crops) and (b) Other (non-crop) Indicators. It was observed from the study that C. V. (%) of productivity was less as compared to C. V. (%) of area and production. It indicates that variation in productivity was less as compared to the area and production. Compound Growth rate (CGR%) values indicated that area under *rabi* Jowar, *kharif* Jowar, *kharif* groundnut and other cereals is probably shifting to other crops such as soybean, summer groundnut, sugarcane and safflower. In study period, CGR % values of other (non-crop) indicators had recorded significant growth. The correlation coefficient between values of gross output (Y1) and all other (non-crop) fifteen other indicators was significant. In other words, it can be opined that these indicators had significant impact on values of agricultural produce. It is observed that Coefficient of Determination value (R^2) with Y1 (Y1 = Gross output value of crops production at minimum support price) was 0.91598029. It indicated that all 15 indicators are able to explain more than 90% variation present in Y1. In other words, these 15 indicators had strong relationship with Y1. The value of R^2 was significant at 1% level of significance.**

Study revealed that agriculture growth of Bhandara district based on composite index approach was - 0.4821 for area, 0.0385 for production, 1.1019 for yield, 0.2388 for A+P+Y. For all 66 indicators, it was 0.6044. All values were significant. Agriculture growth of Bhandara district based on composite index of Gross Output Values at MSP price was 8.4331.

(Key words : Agricultural growth, composite index, compound growth rate)

INTRODUCTION

Economic survey of India, 2011-12 stated that, the Ninth and Tenth Five Year Plans witnessed agricultural sectoral growth rate of 2.44 per cent and 2.30 per cent respectively compared to 4.72 per cent during Eighth Five Year Plan.

During the current Five Year plan, agriculture growth is estimated at 3.28 per cent against a target of 4 per cent. Twelth Five Year Plan emphasises the need to "redouble our efforts to ensure that 4.0 per cent average growth" is achieved during the Plan, if not more.

There is no any exact definition of agriculture growth. There is lot of confusion and disagreement between scientists about agricultural growth. Measurement of agricultural growth is complex phenomena, which is dependent on various factors. These factors are co- related with each other. Hence, all factors may be influenced due to change in any one factor. Composite index represents entire data in one figure like arithmetic mean. In this paper, composite index had been constructed by methods suggested by Narian *et al*. (1991).

Present study is important as modified methodology of measurement of agriculture growth is used. In general, Agricultural growth is measured by the methodology developed by Central Statistical organization (CSO). In the present study composite index methodology was used which is superior methodology as compared to CSO methodology. Drawbacks of CSO methodology are (a) Agricultural growth measured only by taking into the account the values of crop production and (b) contributions of other (non-crop) indicators are not being taken into account.

Results obtained from above consideration (a and b) reveal false and misleading estimates of agricultural development, as the other (non-crop) indicators are not included in the estimation. In fact other (non-crop) indicators do hold the significant contribution in the estimates of agricultural

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development. It is, therefore, essential to consider inclusion of non-crop indicators in the analysis. Hence, the present research work was inclusive of non-crop indicators (NCI) to Area (A) +Production (P) + Productivity (Y) and aimed at real and true estimates of agricultural growth.

Further, it is noticed that the methodology adopted by CSO considers only "production" aspect for the estimation of agricultural development. Whereas, aspects like areas, productivity and integrated growth (A+P+Y) which also weigh equally, are neglected. This is a sort of drawback in the methodology of CSO. This drawback had been waved off in this present study by adopting composite index approach so as to get crystal clear results.

Secondly, measurement of agriculture growth is important for agriculture department for year to year planning. Traditionally, Bhandara district is rice dominant district. Now, slowly, this belief is changing. Cropping pattern is drastically changing in last 39 years. Crops like - soybean, summer groundnut and sugarcane are rapidly replacing traditional crop like rice. On this background, present study is important for future planning.

The present study was undertaken with the objective to measure the agricultural growth of Bhandara district based on composite index. The objectives are

1. To measure the agriculture growth by constructing composite index based on crop indicators, non-crop indicators and based on value of agricultural produce.

2. To study nature of relationship of other (non crop) indicators with composite index based on crops and other (non-crop) indicators.

MATERIALS AND METHODS

The present study was undertaken at the Department of Agricultural Economics and Statistics, College of Agriculture, Nagpur during the year 2011-12. Present study includes 66 indicators of agricultural growth which were divided into two groups – the first group included 51 crop indicators i.e. area, production and productivity of 17 crops and the second group includesd 15 other (non-crop) indicators. Compound Growth Rate (CGR) and Composite Index (CI) were calculated for these 66 indicators. Agricultural growth of Bhandara district was measured on the basis of these composite indices and gross output value of crop production based on Minimum Support Price of (MSP) crops.

The Data:

Time series data of 39 years from 1970-1971 to 2008-2009 on area, production, productivity of 17 crops of Bhandara district were downloaded / collected from web-site of Department of Agriculture, Maharashtra Government and other related web sites. Time series data of other group's indicators were collected from Department of Agriculture, Nagpur and Bhandara.

Selection of Indicators:

Sixty Six important indicators related to agriculture growth had been selected for this study. These indicators are classified into two groups.

In first group, 51 crops indicators; related to Area, Production and Productivity of 17 crops were included. The study crops were (1) Rice, (2) Wheat, (3) *Kharif* Jowar (Sorghum), (4) *rabi* Jowar, (5) Other Cereals, (6) Total Cereals, (7) Tur, (8) Gram, (9) Other Pulses, (10) Total Pulses, (11) Total Food Grain, (12) *kharif* Groundnut, (13) Summer Groundnut, (14) Soybean, (15) Safflower, (16) Total Oilseeds and (17) Sugarcane.

The second group included 15 other (non-crop) indicators. These indicators were (1) Oil Engines in use, (2) Electric Pumps in use, (3) Tube Wells in use, (4) Fertilizer consumption(MT), (5) Gross Irrigation (in 00 ha), (6) Net irrigated area (in ,00 ha), (7) Well Irrigation (in ,00 ha), (8) Average Annual Rain Fall (MM) (JUN.-AUG.), (9) Area under high yielding varieties (HYV) (,00 ha.) (10) No. of tractors in use, (11) No. of Sprayers and Dusters in use, (12) Population Density (Population km^{-2}), (13) Literacy in rural area (in %), (14) Average area served per $regulated^{-1}$ market and (15) Credit available (Lakh Rs.).

Method of Analysis :

C -I) **Statistics of data:** For the purpose of analysis, the basic statistics of data i. e. Arithmetic Mean, Co-efficient of Variation (C.V.), Range and Compound Growth Rate were calculated.

C-II) **Compound growth rate:** Compound growth rates were calculated to study the growth of all 66 indicators, composite index and gross output value of crop production based on Minimum Support Price of (MSP) crops by fitting the exponential model to data.
$Y = a*b^t$

Where, Y= Observed value of Indicators, a= Intercept, b= Regression coefficient, t= Year.

The above equation reduced to the following linear equation, on taking logarithms of both sides of equation.

$\log Y = \log a + (\log b) \times t$
Compound growth rate (CGR %) was estimated as,
$CGR\% = [\text{Antilog}(\log(b))-1] \times 100 = (b-1) \times 100$
The growth rates were tested for significance,

$t = \frac{|b|}{S.E.(b)}$ with (n-2) degrees of freedom at 5% and 1% level of significance.

C-III) **Value of Agricultural Produce:** The value of production of selected 17 crops was calculated on the basic of Minimum Support Price (MSP) for study period (1970-71 to 2008-09). This methodology was the base of measuring agriculture growth of Bhandara district by calculating values of agricultural production of 17 crops for 39 years period (1970-71 to 2008-09).

C-IV) **Correlation study:** Karl Pearson correlation coefficients were calculated as per standard methods between other indicators and values of agriculture production. Significance of correlation coefficient was tested.

C-V) **Composite index of growth:** Composite index of 51 crop indicators was calculated by the procedure suggested by Narain *et. al.* (1991). Agricultural growth was measured on the basis of this composite index. The detailed procedure is as follows:

Composite index of development was estimated by the following procedure.

Let, there be a set of n points, '***n***' represents the years and "***k***" indicates number of indicators.

Then, the level of each indicator is represented by the n x k matrix. $X_{i,j}$

Where, i = 1,2,3,……..,n and j = 1,2,3,…….,k

The scale of the indicators being different, they are brought on relative scales by standardization or normalization.

$$Z_{ij} \quad \frac{X_{ij} - \ddot{X}_j}{S_j}$$

Where, $Z_{i,j.}$ = Normalize value of j^{th} indicator at i^{th} year
$Z_{i,j}$ = Observation of j^{th} indicator at i^{th} year.
$\ddot{X}_j$ = Arithmetic Mean of j^{th} Indicator and S_j = Standard Deviation of j^{th} indicator
Where,

$S_j \quad \sqrt{\sum_{i\ 1}^{n} \frac{(X_{i,j} \quad \overline{X}_j)^2}{n}}$ and $\overline{X}_j \quad \sum_{i\ 1}^{n} \frac{X_{i,j}}{n}$

With i = 1,2,3,……,n and j = 1,2,3,…….k

$\{Z_{i,j}\}$ denotes the matrix of standardized indicators.

For each indicator, the ideal level of growth was identified from the level of different **years** and its normalized value, was taken as "standardized level $Z_{0,j}$

The pattern of development for the i^{th} year is given as:

$$C_i \quad \sum_{j\ 1}^{k} (Z_{ij} \quad Z_{oj})^2 \quad ^{1/2}$$

The composite index of development was worked out as: $D_i \quad \frac{C_i}{C}$ Where, $C \quad \overline{C} \quad 2S$ With $\overline{C} \quad \sum_{i\ 1}^{n} \frac{C_i}{n}$ and $S \quad \sum_{j\ 1}^{k} \frac{(C_i \quad \overline{C})^2}{n} \quad ^{1/2}$

The value of composite index was non-negative, and it was between 0 to 1. The value of composite Index closer to zero indicates the higher level of growth, while the value of index closer to 1 indicate the lower level of development of the respective year.

Aggregate value of agricultural output

In the present study, production of all crops was converted into monetary term and then added together to form the series of aggregate value of output. Aggregate value of output for each year was estimated by multiplying the physical quantity of each crop by its respective prices and then adding together the products.

Aggregate value of output = $\Sigma_{n=i}^{i}$ **Qi Pi**

Where, Q_i = Quantity of production of i^{th} crop and P_i = Constant price of i^{th} crop

Since, farm harvest prices changes over time, aggregate value at same constant prices is a satisfactory measure of total physical output over long period. In the present study aggregation of selected crops was done at Minimum Support Price (MSP) during the study period.

RESULTS AND DISCUSSION

Average, Coefficient of Variance (C. V. %), Range and CGR % based on area of 17 crops were calculated and are presented in the table 1.

It is observed from the table 1 that area of Safflower, Summer Groundnut, Soybean and *Kharif* Jowar were most unstable, as their values of C. V. (%) are 1132.57%, 107.44%, 102.73% and 99.07%, respectively. Compound Growth rate (CGR%) values (table 1) indicated that area under *rabi* Jowar (CGR % -13.59**), *kharif* Jowar (CGR % -11.20**), *kharif* Groundnut (CGR % -8.26**), and Other Cereals (CGR% -8.11**) were significantly decreasing over last 39 years. In other words, area of these crops is shifting to other crops. The area under crop Soybean (CGR% 18.88**), Summer Groundnut (CGR% 5.26**), Sugarcane (CGR% 3.50**) and Safflower (CGR% 2.46**) were significantly increasing. In other word, part of area under other crops is shifting towards these crops.

Average, Coefficient of Variance (C. V. %), Range and CGR % based on production of 17 crops were calculated and are presented in the table 2.

It is observed from the table 2 that Production of Summer Groundnut (133.36%), Safflower (131.52%), *kharif* Jowar (108.53%) and Soybean (106.76%) were not stabilized as their C. V. (%) values were at higher side. Production of the crops Soybean (CGR% 18.10**), Summer Groundnut (CGR% 7.25**), Tur (CGR% 3.33**), and Sugarcane (CGR% 2.68**) had indicated significantly increasing trend. However, production of crops *rabi* Jowar (CGR% -12.53**), *kharif* Jowar (CGR% - 7.79**), *kharif* Groundnut (CGR% - 6.94**) and Other Cereals (CGR% -5.03**) were decreasing significantly.

Average, Coefficient of Variance (C. V. %), Range and CGR % based on productivity (yield) of 17 crops were calculated and are presented in the table 3.

It is observed from the table 3. that productivity of Safflower(127.83%), Soybean (93.83%), *kharif* Jowar (74.98) and Summer Groundnut (74.82%) were scattered maximum as compared to other crops. The CGR values of productivity (yield) of crops viz., Safflower 59.26**, Summer Groundnut 45.09**, Soybean 38.40** and Other Cereals 3.35** had expressed significant increasing trend. However, Sugarcane -0.79* by expressed significant by decreasing trend. Productivity of other crops had expressed significantly increasing trend except Rice and *kharif* Jowar. Total Cereals and *kharif* Groundnut had indicated non-significant CGR values. However, productivity of crops was comparatively stable as compared to area and production of crops, as Coefficient of Variance (C.V. %) of productivity was comparatively less as compared to C. V. of the area and production.

Narain *et al.* (2007) studied the "Statistical Evaluation of Socio-economic Development of Different States in India" by adopting methodology suggested by Narain *et al.* (1991). The present paper was based on same methodology. Findings of their study were (a) The state of Punjab ranked first and Bihar ranked last in overall socio-economic development, (b) Wide disparities were observed in the level of development among different states., (c) The overall socio-economic development was positively associated with the development in agricultural sector and (d) The infrastructural facilities and literacy status were influencing the socio-economic development.

Thote *et al.* (2008) studied agricultural growth of Nagpur District. Their study concluded that compound growth rate (CGR%-values) production of four crops showed significantly increasing trend. These four crops were total oilseeds (CGR% 34.85**), sunflower (CGR% 20.51**), safflower (CGR% 19.77**), and summer groundnut (CGR% 15.98**). However, decreasing trends were observed in case of bajri (CGR% -11.15**), *rabi* jowar (CGR% -7.99**), wheat (CGR% -7.36**) and *kharif* groundnut (-5.86**) production.

Thote *et al.* (2012) studied agricultural growth of Amravati district based on Composite Index Approach. The study included 60 crop indicators and 12 non-crop indicators. Study was

based on 36 years (1971-72 to 2005-06) time series data of crop and non-crop indicators. Study revealed that agricultural growth of Amravati district was -0.6438*% (Based on crop and non-crop indicators, together).

Abdollahzadeh *et al.* (2012) studied Spatial Patterns of Agricultural Development, by using application of the Composite Index Approach (A Case Study of Fars Province). The study was concluded that three macro agricultural areas were identified on the basis of CADI, in which two countries were identified as being highly developed (Category 1), while five other countries were considered as belonging to the medium level of development (Category 2) and the remaining 15 counties were classified as underdeveloped (Category 3). The highly developed agricultural area which was characterized by modern agriculture and proportion of advantages of physical and economical factors represents the specific situation to quick and cheap access to urbanized market and, where the more labour force engaged in non-farm activities. The other two macro areas were mainly mountainous, arid and semi-arid regions or peripheral areas, characterized by poor endowment of natural and agricultural resources. However, less developed areas were subjected to desert and harsh climate conditions which greatly limit the scope for AD.

Bhatia and Rai (2012) studied the Statistical Evaluation of Agricultural Development in Asian Countries. Study was based on methodology suggested by Narian *et al.* (1991). The study concluded that there are fifty countries in Asia, out of which eleven countries namely Bahrain, Brunei Darsm, East Timor, Gaza Strip, Hong Kong, Macau, Maldives, Mangolia, Oman, Qatar and Singapore were not having sufficient data for evaluating the level of agricultural development. Hence, these countries were not included in the present study. Out of 39 countries included in the study, China was found to be the highest developed country in agriculture. China and Japan comes in the first five developed countries in agricultural sector in Asia. Bhutan was on the last place in the continent with respect to development in agriculture. Wide disparities among different countries were found in agricultural development. The level of development was categorized in four stages as high level, high middle level, low middle level and low level. It was found that about 40 per cent population of the continent live in high developed countries whereas only two per cent population comes from the under developed countries. About 46 per cent population belongs to low middle level developed countries. General suggestions have been given for enhancing the level of agricultural development of low developed countries. It would be useful to examine and evaluate the level of development at micro level for giving location-wise specific recommendations for improving the level of development.

Statistical parameters and compound growth rate (cgr) of other indicators (non-crop) of Bhandara district :

The other fifteen (non-crop) indicators were identified who were having indirect impact in agriculture growth. The statistical parameters and CGR values of theses indicators were calculated and are presented in table 4.

It can be revealed from table 4 that Population Density (Population per Km^{-2}) having lowest CV% (8.38%), followed by Literacy in rural areas (in %) (15.17%). It indicated that these two indicators were more stable as compared to other indicators. However, Well irrigation and fertilizer consumption were most unstable which were indicated by their highest C. V. values i.e. (117.47% and 101.24%).

All 15 other non-crop indicators were indication of significant growth over 39 years. However, Population Density (Population per Km^{-2}) and Literacy in rural areas (in %) had recorded lowest growth, (0.57** and 1.04**), respectively. Tube Wells in numbers and Electric Pumps in use have recorded the highest growth i. e. 22.37** and 10.46**.

Correlation coefficient of other indicators with total values of produce

The year wise value of gross output of agriculture produce (i. e. production of all agriculture crops) was calculated at year wise Minimum Support Price (MSP). Correlation coefficient between non-crop indicators and gross output values were calculated to study the relationship between them. The results are presented in table 5.

It is observed from table 5 that all fifteen indicators have very strong correlation with value of gross output. In other words, we can say that these indicators have significant impact on values of agricultural produce.

Multiple linear regression analysis :

Multiple linear regression analysis of these 15 indicators was performed with Gross output values at MSP price (Y1) to study the pattern of relationship of these 15 indicators with Y1. The contribution of individual indicators was calculated to understand relative importance of these indicators. The results are presented in table 6.

It is observed from table 6 that Coefficient of Determination value (R^2) with Y1 was 0.91598029**. It indicated that all 15 indicators were able to explain more than 90% variation present in Y1. In other words these 15 indicators had strong relationship with Y1. The value of R^2 was significant at 1% level.

It is clear from the above discussion that these 15 indicators having notable impact in agricultural growth. Hence, it is not proper to ignore these non-crop indicators, role in agricultural growth.

Values of composite indices, value of gross output and their cgr% of Bhandara districts :

Composite index was constructed as per the methodology developed by Narian *et. al.* (1991) on the basis of 66 indicators (51 indicators of A/P/Y of 17 crops + 15 other (non-crop) indicators).

The composite indice's values are pure number and they are not depending on measuring units. The value of composite index was non-negative, and between 0 to 1. The value of composite Index closer to zero indicated the higher level of growth, while the value of index closer to 1 indicated the lower level of development of the respective year.

The main problem in measuring agricultural growth is that production or productivity or area of one crop is not possible to club with other crop directly. Composite index is providing the methodology to overcome this problem.

For example composite index value 0.77135 was representing all 66 indicators (crop and non-crop) for the year 1970-71. Year wise composite indices were calculated by five different methods. The value of gross output of agriculture produce (i. e. production of all agriculture crops) was calculated at MSP price. The complete data are presented in table 7.

The agricultural growth of Bhandara district was measured by calculating CGR value of these 39 years composite indices values and total value of crop produced. It can be concluded from table 7 that agricultural growth of Bhandara district based on composite indices approach was **-0.4821**** for area, **0.0385*** for production, **1.1019**** for yield, **0.2388*** for A+P+Y. For all 66 indicators it was **0.6044****. All values were significant. Agricultural growth of Bhandara district based on composite index of Gross Output Values at MSP price was **8.4331**.**

It can be inferred from the results that agricultural area of Bhandara district is significantly decreasing @ 0.4821% per year. This decreasing rate is negligible but it is alarming thing on the background of increasing rate of population. This might have happened due to high rate of urbanization and diversion of cultivable land towards industrial projects. On this background, happy thing is that rate of production and productivity (yield) were significantly increasing @ 1.1019**% and 0.2388*% per year, respectively.

There is difference between growth and development. Development is next step of growth. Growth can be measured in particular sector (like area, production, productivity, etc.) and development is the integrated growth of all related sectors (like growth based on all 66 indicators (crop and non-crop)). Hence, agricultural development of Bhandra district based on all 66 indicators (crop and non-crop) is significantly increasing @ 0.6044**% per year. In other words, non-crop indicators were positively contributing in agricultural production.

The positive and highly significant growth of Bhandra district based on gross out value (8.4331**% per year) is mainly due to year wise increase in MSP for almost all crops. Hence, growth on the basis of MSP was combined impact of year wise increase in MSP and crop production. Hence, this method is not useful for measuring agricultural growth. It does not reveal true picture of growth. It gives misleading depiction.

Table 1. Statistical Parameters and Compound Growth Rate (CGR) of Crops Area (A) of Bhandara District

Sr. No.	Crop	Indicators	Number of Years	Mean	C. V. in (%)	CGR in (%)	Significance
			Area in "00" hectares				
1	Rice	CI – 1	39	3175.00	8.77	0.66	**
2	Wheat	CI – 2	39	251.92	33.61	-2.89	**
3	Kharif Jowar	CI – 3	30	7.92	99.07	-11.20	**
4	Rabi Jowar	CI – 4	37	160.92	84.49	-13.59	**
5	Other Cereals	CI – 5	37	30.94	65.32	-8.11	**
6	Total Cereals	CI – 6	39	3577.77	5.96	-4.85	NS
7	Tur	CI – 7	39	90.05	21.94	1.81	**
8	Gram	CI – 8	39	104.97	24.19	-0.89	*
9	Other Pulses	CI – 9	39	478.82	40.66	-3.45	**
10	Total Pulses	CI – 10	39	674.64	28.01	-2.23	**
11	Total Food grains	CI – 11	39	4277.44	7.25	-0.31	**
12	Groundnut *kharif*	CI – 12	36	6.12	96.52	-8.26	**
13	Summer Groundnut	CI – 13	28	1.77	107.44	5.26	**
14	Soybean	CI – 14	22	51.05	102.73	18.88	**
15	Safflower	CI – 15	18	0.85	132.57	2.46	NS
16	Total Oilseeds	CI – 16	39	362.05	24.79	-1.58	**
17	Sugar Cane	CI – 17	39	11.92	57.68	3.50	**

** indicate 5% and * 1% level of significance, respectively.

Table 2. Statistical Parameters and Compound Growth Rate (CGR) of Crops Production (P) of Bhandara District

Sr. No.	Crop	Indicators	Number of Years	Mean	C. V. in (%)	CGR in (%)	Significance
			Production in "00" metric tones				
1	Rice	CI - 18	39	3799.31	26.29	1.15	*
2	Wheat	CI - 19	39	158.26	35.06	-0.89	NS
3	*Kharif* Jowar	CI - 20	30	4.05	108.53	-7.79	**
4	*Rabi* Jowar	CI - 21	37	60.23	90.25	-12.53	**
5	Other Cereals	CI - 22	37	13.29	60.09	-5.03	**
6	Total Cereals	CI - 23	39	4003.10	26.36	0.68	NS
7	Tur	CI - 24	39	57.51	44.22	3.33	**
8	Gram	CI - 25	39	44.44	30.62	0.27	NS
9	Other Pulses	CI - 26	39	153.82	26.35	-0.77	NS
10	Total Pulses	CI - 27	39	249.39	23.88	0.02	NS
11	Total Food grains	CI - 28	39	4279.95	19.10	0.50	NS
12	*Kharif* Groundnut	CI - 29	36	3.97	98.11	-6.94	**
13	Summer Groundnut	CI - 30	28	2.44	133.36	7.25	**
14	Soybean	CI - 31	22	51.59	106.76	18.10	**
15	Safflower	CI - 32	18	0.51	131.52	-0.93	NS
16	Total Oilseeds	CI - 33	39	128.70	47.02	1.34	NS
17	Sugarcane	CI - 34	39	787.74	60.67	2.68	**

** indicate 5% and * 1% level of significance, respectively.

Table 3. Statistical Parameters and Compound Growth Rate (CGR) of Crops Productivity (Y) of Bhandara District

Sr. No.	Crop	Indicators	Number of Years	Mean	C. V. in (%)	CGR in (%)	Significance
			Average yield in kg hectare^{-1}				
1	Rice	CI - 35	39	1192.79	24.02	0.49	NS
2	Wheat	CI - 36	39	667.26	34.72	2.06	**
3	*Kharif* Jowar	CI - 37	30	498.36	74.98	-4.72	NS
4	*Rabi* Jowar	CI - 38	37	384.26	45.10	1.22	*
5	Other Cereals	CI - 39	37	548.10	52.08	3.35	**
6	Total Cereals	CI - 40	39	1113.44	24.86	0.72	NS
7	Tur	CI - 41	39	619.03	29.24	1.49	**
8	Gram	CI - 42	39	434.64	28.35	1.17	**
9	Other Pulses	CI - 43	39	363.69	36.72	2.77	**
10	Total Pulses	CI - 44	39	392.26	30.77	2.31	**
11	Total Food grains	CI - 45	39	1003.87	19.02	0.82	**
12	Groundnut *Kharif*	CI - 46	36	666.92	42.02	-1.67	NS
13	Summer Groundnut	CI - 47	28	880.46	74.82	45.09	**
14	Soybean	CI - 48	22	573.95	93.83	38.40	**
15	Safflower	CI - 49	18	301.08	127.83	59.26	**
16	Total Oilseeds	CI - 50	39	375.18	49.00	2.97	**
17	Sugar Cane	CI - 51	39	67899.44	23.44	-0.79	*

** indicate 5% and * 1% level of significance, respectively.

Table 4. Statistical Parameters and Compound Growth Rate (CGR) of Other (Non-Crop) Indicators of Bhandara District

Sr. No.	Indicators	Mean	C. V.	CGR %	Signific-ance
1	Oil Engines in use	3531.79	64.31	6.21	**
2	Electric Pumps in use	14336.85	87.95	10.46	**
3	Tube Wells in numbers	1354.13	91.48	22.37	**
4	Fertilizer Consumption in MT ha^{-1}	73.98	101.24	8.99	**
5	Gross Irrigation (00 ha)	2038.10	32.58	2.35	**
6	Net Irrigation (00 ha)	1742.43	26.33	1.84	**
7	Well Irrigation (00 ha)	377.45	117.47	9.89	**
8	Average Annual Rain Fall (MM) (Jun.-Aug.))	1286.74	48.92	1.99	**
9	Area under HYV (00 ha)	2589.19	21.11	1.73	**
10	No. of Tractors in use	1217.95	52.12	3.92	**
11	No. of Sprayers and Dusters in use	14361.03	37.39	3.12	**
12	Population Density(Population Km^{-2})	223.23	8.38	0.57	**
13	Literacy in rural areas (in %)	52.69	15.17	1.04	**
14	Average area served per regulated market/(Km)	3544.62	108.64	7.56	**
15	Credit available (Lac Rs.)	4936.15	69.01	5.48	**

** indicate 5% and * 1% level of significance, respectively.

Table 5. Correlation coefficient of other indicators with total values of produce(Y)

Sr. No.	Other Indicators	Variables	Correlation Coefficient	Significance
1	Oil Engines	X1	0.943703055	**
2	Electric Pumps	X2	0.942935622	**
3	Tube Wells	X3	0.943413025	**
4	Fertilizer Consumption in MT ha^{-1}	X4	0.885433679	**
5	Gross Irrigation	X5	0.867585076	**
6	Net Irrigation	X6	0.84997896	**
7	Well Irrigation	X7	0.842506027	**
8	Average Annual Rain Fall (MM) (Jun.–Aug.))	X8	0.633509916	**
9	Area under HYV (00 ha)	X9	0.861592294	**
10	No. of Tractors in use	X10	0.814804673	**
11	No. of Sprayers and Dusters in use	X11	0.62885941	**
12	Population Density(Population Km^{-2})	X12	0.763193527	**
13	Literacy in rural areas (in %)	X13	0.804159276	**
14	Average area served per regulated market(Km)	X14	0.834906838	**
15	Credit available (Lakh Rs.)	X15	0.844455274	**

** indicate 5% and * 1% level of significance, respectively.

Table 6: Multiple Linear Regression analysis

Sr. No.	Indicators	Parameters	Gross Output Values at MSP (Y1)
	Intercept ->	A	-1560049.7934936
1	Oil Engines	b1	171.9701606
2	Electric Pumps	b2	32.8557318
3	Tube Wells	b3	163.9358025
4	Fertilizer Consumption in MT ha^{-1}	b4	-2026.6101181
5	Gross Irrigation	b5	70.8480793
6	Net Irrigation	b6	46.9302180
7	Well Irrigation	b7	505.7652652
8	Average Annual Rain Fall (MM) (Jun.-Aug.))	b8	166.3529941
9	Area under HYV (00 ha)	b9	128.9631411
10	No. of Tractors in use	b10	-192.9585443
11	No. of Sprayers and Dusters in use	b11	11.2190344
12	Population Density(Population Km^{-2})	b12	13920.4662992
13	Literacy in rural areas (in %)	b13	-42311.9269544
14	Average area served per regulated market(Km)	b14	-34.9946456
15	Credit available (Lakh Rs.)	b15	19.9040233
	Coefficient of determination =	R^2	0.91598029**

** indicate 5% and * 1% level of significance, respectively.

Table: 7: Year wise values of Composite Index and their CGR% of Bhandara Districts

Year	Area (A)	Production (P)	Yield (Y)	All= (A+P+Y)	All Indicators	Total Value (Rs. in '000)
1970-71	0.794898	0.7965955	0.7031747	0.771216	0.77135	289817
71-72	0.7658126	0.8138346	0.7328584	0.7842323	0.78122	242731
72-73	0.7744351	0.9003142	0.8010314	0.8482869	0.82849	130354
73-74	0.7381645	0.8490989	0.7721381	0.8091595	0.78915	235621
74-75	0.7138379	0.7474585	0.7163306	0.7421686	0.73129	212626
75-76	0.7332736	0.6679106	0.6146476	0.6729598	0.68178	393268
76-77	0.759029	0.8051222	0.7118108	0.7702566	0.75058	285453
77-78	0.7610441	0.8135323	0.7036139	0.7701516	0.74776	364526
78-79	0.7517883	0.8207636	0.7127695	0.7748703	0.75371	356552
79-80	0.7321781	0.7939471	0.7027586	0.7564776	0.73303	314039
80-81	0.8502854	0.834096	0.655364	0.777606	0.74844	477142
81-82	0.7806818	0.8800832	0.6847961	0.7914423	0.75832	497303
82-83	0.7980502	0.8897251	0.7106057	0.8096459	0.76738	379144
83-84	0.7618178	0.7720566	0.5825876	0.7041982	0.69112	717262
84-85	0.7867521	0.8891848	0.6864682	0.7969593	0.78345	346261
85-86	0.7439416	0.8162846	0.6381566	0.7396016	0.73407	673909
86-87	0.7391459	0.8262633	0.6617498	0.752244	0.73804	627962
87-88	0.8889129	0.8078933	0.6649733	0.7812528	0.76918	771668
88-89	0.6402674	0.6221617	0.5231552	0.5956011	0.61231	969430
89-90	0.7101442	0.7106927	0.532822	0.6489549	0.65614	822945
90-91	0.6937966	0.7057385	0.5323316	0.6430194	0.63456	1007755
91-92	0.7528969	0.823866	0.6167679	0.7357829	0.70343	953606
92-93	0.7315518	0.7237376	0.5242586	0.6557476	0.6391	1289422
93-94	0.6361542	0.6062321	0.4402577	0.5554385	0.5434	1699537
94-95	0.6507718	0.6677847	0.4929807	0.602872	0.59055	1619255
95-96	0.793656	0.7338708	0.4849989	0.6608256	0.62972	1986349
96-97	0.8855623	0.6677405	0.4111729	0.6373407	0.60779	1869621
97-98	0.8069676	0.8410073	0.6272971	0.7588626	0.69866	1906950
98-99	0.8362556	0.7769548	0.4881391	0.6898221	0.63165	2061905
99-2000	0.8136638	0.7309548	0.4495331	0.6529093	0.58371	2752174
2000-01	0.9567158	0.8774344	0.5809763	0.7925232	0.70175	1899831
2001-02	0.9647054	0.8156276	0.4780582	0.7367335	0.65983	2722592
2002-03	0.9489444	0.8709929	0.4868261	0.756817	0.66511	2398570
2003-04	0.9125349	0.77536	0.4071645	0.6849597	0.60677	3440224
2004-05	1.05001	0.9718243	0.5701494	0.8505495	0.74051	1601603
2005-06	0.8588597	0.8443834	0.5810788	0.7548686	0.65485	3650093
2006-07	0.8141359	0.7644574	0.4969775	0.68221	0.5891	3347085
2007-08	0.766468	0.7068982	0.5831187	0.6813317	0.59396	3901971
2008-09	0.9276182	0.9175972	0.695067	0.8432476	0.72848	2808066
Particulars=>	**Area (A)**	**Production (P)**	**Yield (Y)**	**All= (A+P+Y)**	**All Indicators**	**Total Value**
CGR%	**-0.4821****	**0.0385***	**1.1019****	**0.2388***	**0.6044****	**8.4331****

** indicate 5% and * 1% level of significance, respectively.

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EFFECT OF STEEL SLAG AND PAPER MILL SLUDGE ON AGRICULTURAL TOP SOIL

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ABSTRACT

Agriculture occupies a prominent position in Indian policy-making not only because of its contribution to GDP but also because of the large proportion of the population that depends on this sector for its livelihood. This study was carried out during the academic year 2008 with the aim of studying the combined effect of Steel slag and Paper Mill sludge on agricultural top soil. The agricultural field was amended with steel slag and paper mill sludge at different doses and the crop chosen was wheat.

Individual tests for effect of steel slag on rice and effect of paper mill sludge on orange was also done. The results obtained through individual addition of steel slag indicated that the soil samples had an alkaline pH (7.8) with high calcium and manganese content (2.44 and 2.07% respectively) with relatively lesser amount of sodium (0.36%). The individual results obtained by the addition of paper mill sludge to orange crop indicated that the soil samples had an alkaline pH (7.9) with high aluminum and potassium content (24.15 and 2% respectively) with relatively lesser amount of phosphorus (0.11%). Bulk density was found to be as low as 1.5 g cm^{-3} by the addition of paper mill sludge.

Addition of steel slag and paper mill sludge in combination to wheat crop showed a considerable increase in pH from 7.6 to 11.1. P and Zn concentration also increased (from 0.08% to 0.9% and 0.016% to 0.021% respectively). Bulk density decreased from 1.56 g cm^{-3} to 1.49 g cm^{-3}. The concentration of K and Fe showed a considerable decrease from 1.6% to 1.55% and 3.5% to 3% respectively. The optimum dose was found to be a combination of 10% steel slag with 8% paper mill sludge.

(Key words: Steel slag, paper mill sludge, liming, rice, orange, wheat, optimum dosage)

INTRODUCTION

Solid wastes and chemicals have mainly caused land pollution. The main sources of land pollution have been the industries like, iron and steel plants, pulp and paper mills, oil refineries, power and heating plants, chemicals and fertilizer manufactures, plastic and rubber producing complexes and so on.

Steel is an alloy of iron usually containing less than 1% carbon. Iron and steel making slag is a by-product of the iron and steel making process. Slag has traditionally been used as a component of cement and construction aggregate. This has led the industry in promoting the effective use of slag.

Experiments had shown that moderate rates of slag, as soil amendment have substantially increased iron content in soil. Steel slag appears to be a promising and inexpensive source of Fe to alleviate Fe chlorosis in Fe-deficient calcareous soils (Wang and Cai, 2006). Simultaneously it also increases the plant uptake of Iron (Fe) and Copper (Cu) micronutrients (Melali and Shariatmadari, 2008).

Paper making generally produces a large amount of solid waste. Paper fibers can be recycled only a limited number of times before they become too short or weak to make high quality paper. Mixed paper mill sludges are an important source of N for crop production (Dayegamiye *et al.,* 2003).

Application of fresh paper mill sludge and their compost, creates a sustainable effect on soil aggregation (Bipfubusa *et al.,* 2005). Keeping in mind the above mentioned facts, the present study was undertaken to study the effect of steel sleg and paper mill sludge in agricultural top soil.

MATERIALS AND METHODS

Steel slag and paper mill sludge for analysis purpose was collected from Nippon Denro Ispat Industry, MIDC, Kalmeshwar and Apex Paper Mill, Bazargaon respectively. Crops chosen for individual analysis of steel slag, paper mill sludge and combination of these two were rice, orange and wheat. Soil samples were collected at a depth of about 10-15 cm from five different points on the fields which were later mixed to form composite samples, respectively.

The soil samples, collected in thick plastic bags were brought to the laboratory for further

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analysis. The sample was spread out on a tray for air drying. After drying, it was sieved over a 2 mm sieve and stored in air tight polythene bags.

Field experiments were conducted to study the effect of steel slag on crop productivity. The crop chosen was rice. Soil was mixed with farmyard manure (10% w/w) and amended with steel slag at 5%, 10%, 20% and 40% w/w, in the laboratory and added to selected site. In order to study the dose effect of paper sludge on crop productivity, the crop chosen was orange. Soil was mixed with farmyard manure (10% w/w) and amended with paper mill sludge at 0.5%, 1%, 2% and 4% w/w, in the laboratory and added to selected site.

A mixture of steel slag and paper mill sludge were also tested. Field experiments were done on wheat crop. Soil was amended with a mixed concentration of 10% steel slag with 8% paper mill sludge.

Physical soil parameters analyzed were pH, bulk density, moisture, water holding capacity and electrical conductivity. Chemical analysis included analysis of % organic carbon as suggested by Walkey and Black Method (1934), silica by Kolthoff and Sandell method (1952), calcium, magnesium and aluminum by Titration method, Iron by 1,10 phenanthroline method, potassium and sodium by Flame Photometry method, titanium, phosphate and zinc by Acid Digestion method, nitrate by Kjeldahl method, copper by Cheng and Bray method (1953), manganese by Willard and Greathouse method (1917) and exchangeable sodium percentage using the standard formula. All the above mentioned analysis methods have been prescribed by Black *et al.* (1965).

RESULTS AND DISCUSSION

Amelioration of acid soils with liming materials is a common practice. Some industrial by-products are also being used as liming agent. The most important by-product in amending acid soils is steelmaking basic slag. Slag compound contains 52.8% CaO and 2.2% MgO plus large amounts of other elements such as Fe, P, Si and Mn (Ali and Shahram, 2007).

Silicate liming materials contain elements with useful properties for plant nutrition and soil quality. pH and silicon content in soil showed an increase by the addition of steel slag. Similar observations were made by Hua (2005), Ali and Shahram, (2007) and Gu *et al.* (2011). They reported that the soil pH value and the content of available silicon in soil were increased evidently after it was receiving blast furnace slag, and their increasing trends were more and more obvious with increasing dosage of the blast furnace slag. Addition of calcium and magnesium compounds in the slag improved soil pH. Both elements also served as plant nutrients and stabilisers for soil aggregates. Results of similar nature were also observed by Carvalho *et al.* (2003). They observed that slag improved chemical attributes of the soil, increased root growth and root surface and reduced diameter.

Traces of arsenic, copper, zinc and manganese were also found at the agricultural setups. Experimentally the dose effect of 20% w/w was found to be the best suitable option during this study.

Paper sludge is the biggest source of lignin. Lignin application to arable soils can not only improve plant growth, but also reduce the accumulation of the heavy metals Cu, Zn, Cd, Pb, Cr and Ni in plants (Zhang *et al.,* 2004). Application of paper mill sludge also induces an increase in the concentration of available Fe. Combined primary and secondary paper mill sludge (PS) is a good potential source of C and other nutrients to restore low organic matter in sandy soils (Gagnon *et al.,* 2003). Application of fresh paper mill sludge and their compost, creates a sustainable effect on soil aggregation (Bipfubusa *et al.,* 2005). Keeping in mind the above mentioned facts, a study was undertaken to study the effect of paper mill sludge in agricultural top soil.

Paper mill sludge could ameliorate acidic soils and increased the yield of different crops by 34-68%. An increase in P, K, Fe and Mn in the crops was observed. Total organic carbon significantly increased in soils treated with the paper mill sludge. Similar results were observed by Madejón *et al.* (2003). Their results indicated that the repeated application to the soil of moderate amounts of organic amendment like paper mill sludge had positive effects on the chemical and biochemical properties of the soil. The optimum dose was found to be 2% for paper mill sludge.

Table 1. Changes in properties of soil on addition of steel slag and paper mill sludge Individually

Physical properties	Initial value	Changed value (Steel Slag)	Changed value (Paper Mill Sludge)
pH	7.60	7.80	7.90
Electrical conductivity (ds m^{-1})	0.28	0.30	0.31
Natural moisture content (%)	45.00	44.00	43.5
Bulk density (g cm^{-1})	1.56	1.52	1.50
Water holding capacity (%)	63.50	64.00	64.55
Chemical Properties			
% Organic carbon	0.62	0.60	0.65
SiO_2(%)	63.10	65.50	63.50
Al_2O_3(%)	24.07	24.10	24.15
Fe_2O_3(%)	3.50	4.50	3.50
CaO (%)	2.39	2.44	2.42
MgO (%)	1.55	1.60	1.57
MnO_4(%)	2.05	2.07	2.05
TiO_2(%)	0.04	0.09	0.04
P_2O_5 (%)	0.08	0.09	0.11
K_2O (%)	1.60	1.75	2.00
NO_3N (%)	0.05	0.035	0.045
Na_2O (%)	0.38	0.36	0.38
As_2O_3(%)	0.002	0.003	0.002
ESP	5.00	4.45	0.015

Table 2. Changes in properties of soil on combined addition of steel slag and paper mill sludge

Physical properties	Initial value	Changed value
pH	7.60	11.01
Electrical conductivity (dS m^{-1})	0.28	0.31
Natural moisture content (%)	45.00	42.00
Bulk density (g cm^{-3})	1.56	1.49
Water holding capacity (%)	63.50	64.90
Chemical Properties		
% Organic carbon	0.62	0.59
SiO_2 (%)	63.10	64.9
Al_2O_3 (%)	24.07	24.10
Fe_2O_3 (%)	3.50	3.00
CaO (%)	2.39	2.40
MgO (%)	1.55	1.51
MnO_4 (%)	2.05	2.06
TiO_2 (%)	0.04	0.08
P_2O_5 (%)	0.08	0.90
K_2O (%)	1.60	1.55
NO_3N (%)	0.05	0.04
Na_2O (%)	0.38	0.35
As_2O_3 (%)	0.002	0.003
ZnO (%)	0.016	0.021
ESP	5.00	4.48

The observed values indicate that agricultural soil amended with paper mill sludge helped in reducing its bulk density, optimized pH value, improved soil aeration, percolation and water retention, reduced crust formation, provided micro and macro-nutrients. However, its high pH reduces the bio availability of some nutrients. to be 2% for paper mill sludge.

Data on various soil parameters by the addition of steel slag and paper mill sludge are given in table 1.

The results (Table 2) showed an effective increase in the nutrient uptake by plants, as compared to control soil. Soil pH showed a considerable increase from 7.6 to 11.1. A decrease in bulk density was observed. The value decreased from 1.56 gcm^{-3} to 1.49 g cm^{-3}. The decrease in bulk density value of soil, indicated that the soil doesn't offer any kind of resistance to root penetration and increased porosity and high permeability during post-monsoon season.

An increase in Zn and available P and decrease in K and Fe content in soil were also observed. Concentration of Zn increased from 0.016% to 0.021% while that of P increased from 0.08% to 9%. K and Fe values decreased from 1.6% to 1.55% and 3.5% to 3% respectively. A result of similar nature was observed by Torkashvand (2010). His results indicated that the addition of steel slag and paper mill sludge increased P content in soil and decreased the Fe content.

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EFFECT OF MANURIAL LIQUIDS ON SOIL MICROBIOTA, PRODUCTIVITY AND ECONOMICS OF WHEAT

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ABSTRACT

A field experiment was conducted for three years from 2007 - 2008 to 2009 – 2010 at the farm of College of Agriculture, Nagpur to study the effect of manurial liquids on microbial count, yield and economics of wheat in Vertisol of Central Vidarbha Zone of Maharashtra. Treatments were inorganic fertilizers viz., 0, 50, 75 and 100 % RDF and methodologically prepared manurial liquids viz., no manurial liquid, Amritpani (200 lha^{-1}), Panchagvya (200 lha^{-1}) and vermiwash(50 lha^{-1}). Amongst the RDF, the highest grain yield (21.57 q ha^{-1}) was recorded in 100% RDF (100:50:50 kg NPK ha^{-1}). In the application of manurial liquids, the highest grain yield was obtained in Vermiwash @ 50 lha^{-1}. Significantly higher grain yield (23.69 t ha^{-1}) of wheat was recorded under application of 100% RDF (100:50:50 kg NPK ha^{-1} with three sprays of Amritpani at the rate of 200 litres ha^{-1}. There was 13.83 % increase in grain yield as compared to 100 % RDF alone. Higher bacterial and actinomycetes count was registered with low level of RDF whereas the fungi count (3.42 X 10^5 cfu g^{-1} of soil) recorded was higher with increasing level of RDF. The highest gross monetary returns of wheat were noticed with the application of 100% RDF + vermiwash. With the application of 75% RDF, the maximum B:C ratio(1.27) was found under the use of Amritpani.

(Key words: Manurial liquids, microbial count, wheat, vertisol)

INTRODUCTION

In recent years, despite of achieving increased productivity by adopting Green revolution technology, the problem of soil health deterioration is increased simultaneously (Ramanathan,2006).This may be due to unbalanced use of soil nutrients and decrease in soil organic carbon status.

Organic manure requires adding in bulk quantities and if it is not available on the farm its use become costly due to transportation. The quality of traditional organic manures like FYM and compost may be questioned for its limited use. The manurial liquids have advantage that it requires in less quantity. The time and labour required for its preparation and application is also short and better quality can be maintained. The total fresh excreta available from domestic animal is estimated around 10200 kg year^{-1} animal^{-1} (Selvaraj *et al*., 2005).It is equivalent to the 60, 20 and 50 kg NPK year^{-1}animal^{-1}.

Due to the use of Panchagavya 3% spray at 0, 30 and 50 days after rice crop, there was increase in yield to the tune of 8 to 9 % over its no use and similarly there was also increase in yield of bhendi (Laurduraj *et al*., 2005). The application of three sprays of Amritpant @ 200 litres ha^{-1}, panchagavya and vermiwash applied @ 50 litres ha^{-1}, is one of the key source for aiding the nutrient availability, balance in the micro flora, enzymes activities which stimulate the growth and crop yield.

In view of the above, the present investigation was undertaken to study response of different manurial formulation along with inorganic fertilizers on soil microbial count, productivity and economic of wheat.

MATERIALS AND METHODS

A field experiment was conducted for three years 2007 - 08 to 2009-10 on a vertisol at the farm of College of Agriculture, Nagpur. It was conducted in a Factorial Randomized Block design with sixteen treatment combinations consisting four levels of inorganic fertilizers viz., F_0:No fertilizer, F_1:50 % RDF, F_2:75 % RDF and F_3:100% RDF(100:50:50 kg NPK ha^{-1}) and four types of manurial liquids viz.,ML_O:No manurial liquid, ML_1: Amritpani, ML_2:Panchagavya and ML_3: Vermiwash. The experimental site was clayey in texture having pH 7.6, EC 0.32 dSm^{-1}, organic carbon 5.8 g kg^{-1}and soil available N, P_2O_5 and K_2O was 192.6, 14.20 and 502.1 kg ha^{-1}, respectively. Wheat cultivar (AKW-381) was sown with the row spacing of 22 cm by drilling method. Irrigation was given at all critical growth stages at an interval of 21 days. Half dose of nitrogen and full dose of P and K was given at the time of sowing and remaining half dose of nitrogen was applied at the time of CRI (Crown Root Initiation) stage. Similarly manurial liquid were given to the

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wheat crop at initial, crown root initiation and tillering stages. Soil samples were collected at 0 – 15 cm and available N, P and K was estimated as per methods described by Jackson (1973). Soil sample at 0-15 cm was collected at three stages (crown root initiation, tillering and jointing) after application of manurial liquids. Microbial count was determined by serial dilution plate techniques (Dhingra and Sinclair, 1993). Treatment wise inorganic fertilizers in the form of Urea, SSP and MOP were applied according to the plot size.

Preparation of manurial liquids :

ML_1= Amritpani : It was prepared in proportion of 10 kg cowdung+10 litres urine+ 1 kg Jaggery (Bindumol and Thomas, 2004)

ML_2=Panchgavya : It was prepared in proportion of 5 kg cowdung + 3 litres urine + 2 liters milk + 2 litres curd + 1 litre ghee (Mathivanan *et al*., 2006).

ML_3= Vermiwash : Collected as a leachate from decomposed and saturated vermicompost bed (Zambare *et al*.,2008).

The above mixtures were prepared in the earthen pots. For increasing the aeration, it was stirred daily with wooden stick for 10 minutes upto 7 days. Then these mixtures were diluted 10 times with water and applied hectare^{-1} basis. Vermiwash was applied @ 50 litres hectare^{-1}. Total three applications of these manurial liquid were given to the wheat crop at initial, crown root initiation and tillering stages. The microbial count of the manurial liquids was determined by serial dilution plate techniques (Dhingra and Sinclair,1993). The pH, electrical conductivity and organic carbon content were determined using standard methods. Nitrogen was analyzed by Kjeldahl's method (Piper,1966), Phosphorus by phosphomolybdovanadate yellow colour method and potassium by flame photometrically (Jackson,1967).

RESULTS AND DISCUSSION

Three kinds of manurial liquids were prepared and studied for its nutrient content and microbial count before application to the wheat crop. The values of nutrient and microbial content regarding the manurial liquids are presented in table 1.

Microbial count :

Among the values of three manure liquids, panchagavya showed more bacterial count whereas Amritpani recorded more fungal count. The other nutrients content were not much varied in the manure liquids. The microbial count of soil was analyzed at CRI stage. Pooled mean data from the table 2 showed that the bacterial and actinomycetes count were higher with low level of RDF whereas the fungi count recorded higher with increasing level of RDF. Shwetha (2007) observed significantly lower bacterial population in RDF treatment than the manuarial liquids like panchagvya, beejamruit, jeevamruit in soybean-wheat cropping system.

Fungi recorded double the microbial count (3.42×10^5 cfu g^{-1} of soil) with the application of 100 % RDF. Higher dose of fertilizers (100% RDF) were found beneficial for the development of fungi count g^{-1} of soil. The value of microbial count at CRI stage varied from 2.30×10^7 to 3.31×10^7 cfu g^{-1} of soil for bacteria, 1.32 to 3.42×10^5 cfu g^{-1} of soil for fungi and 1.56 to 1.96×10^8 cfu g^{-1} of soil for actinomycetes. Bacteria and fungi count significantly increased due to the application of Amritpani, Panchgavya and Vermiwash over control (No Manurial liquid).The interaction effect was also found significant. This suggest that the manurial liquids helps in maintaining higher population of bacteria and fungi in soil.

Grain yield:

Grain yield was significantly increased due to increasing levels of fertilizer. Pooled data indicated that the highest grain yield (21.57 q ha^{-1}) was observed with the application of 100 % RDF which was found significantly superior over 75 and 50 % RDF. The effect of manurial liquids on grain yield of wheat was found non significant. Interaction effect was found to be significant for grain yield of wheat. Significantly higher yield (23.69 t ha^{-1}) was recorded in 100% RDF with the three sprays of Amritpani. The increase in yield under treatment combination of vermivash + Amritpani was 13.86 % as compared to Vermiwash + no manurial liquid. 100% RDF alone and 75% RDF with Vermiwash or Panchgavya were found at par, which might be due to

Table 1. Chemical and biological properties of manurial liquids (Average of three years)

Sr.No.	Parameters	Amritpani	Panchagavya	Vermiwash
1.	pH	7.34	7.41	7.92
2.	EC, dSm^{-1}	3.56	3.47	2.35
3.	Total nitrogen ,%	0.18	0.14	0.17
4.	Total phosphorus , %	0.024	0.032	0.041
5.	Total potassium, %	0.092	0.104	0.143
6.	Organic carbon, g kg^{-1}	8.24	7.46	4.62
7.	Bacterial count, ml^{-1}	5.0 X 10^7	9.0 X 10^7	4.0 X 10^7
8.	Fungus count , ml^{-1}	9.0 X 10^4	9.0 X 10^4	3 X 10^4
9	Actinomycetes, ml^{-1}	7.0 X 10^6	8.0 X 10^6	5 X 10^6

Table 2. Effect of different levels of fertilizer and manurial liquids on microbial count of soil at CRI (Crown Root Initiation) stage of wheat

Treatments Levels of NPK kg ha^{-1}	Pooled mean (2007-08 to 2009-10) Bacterial count B X 10 ^{7}cfu g^{-1} of soil	Fungi count F X 10^5cfu g^{-1} of soil	Actinomycetes count A X 10^8cfu g^{-1} of soil
F_0 (0 kg NPK)	2.79	1.32	1.92
F_1 (50:25:25 kg NPK)	3.03	1.37	1.74
F_2 (75:37.5:37.5 kg NPK)	2.98	1.65	1.88
F_3 (100:50:50 kg NPK)	2.50	3.42	1.56
SE (m)	0.034	0.023	0.020
CD at 5%	0.099	0.070	0.058
Manurial liquids			
ML0 (no Manurial liquid)	2.30	1.67	1.96
ML_1 (Amritpani @ 200 l ha^{-1})	2.94	1.85	1.70
ML_2 (panchgavya @ 200l ha^{-1})	2.76	2.04	1.70
ML_3 (Vermiwash @ 50l ha^{-1})	3.31	2.19	1.74
SE (m)	0.034	0.023	0.020
CD at 5%	0.099	0.070	0.058
Interaction	RDF X ML		
SE(m)	0.067	0.047	0.039
CD at 5 %	0.20	0.141	0.117

Table 3. Effect of different levels of fertilizer and manurial liquids on grain yield of wheat

Treatments Levels of NPK kg ha^{-1}	Grain Yield, q ha^{-1}			
	2007-08	2008-09	2009-10	Pooled mean
F_0 (0 kg NPK)	12.78	9.17	16.98	12.98
F_1 (50:25:25 kg NPK)	14.09	17.64	18.64	16.79
F_2 (75:37.5:37.5 kg NPK)	15.64	20.68	20.51	18.94
F_3 (100:50:50 kg NPK)	19.04	24.10	21.56	21.57
SE (m)	0.44	0.30	0.63	0.41
CD at 5%	1.27	0.89	1.86	1.21
Manurial Liquids				
ML_0 (no Manurial liquid)	15.71	16.77	18.84	17.04
ML_1 (Amritpani @ 200 l ha^{-1}	15.65	18.51	19.48	17.88
ML_2 (panchgavya @ 200 l ha^{-1}	14.72	17.80	19.54	17.35
ML_3 (Vermiwash @ 50 l ha^{-1}	15.49	18.51	20.03	18.01
SE (m)	0.44	0.30	0.63	0.41
CD at 5%	1.27	0.89	--	--

Table 4. Interaction effect of different levels of fertilizer and manul liquids on grain yield (q ha^{-1}) of wheat Interaction (RDF x ML) (Yield)

	No RDF	50% RDF	75% RDF	100%RDF
ML_0 (no Manurial liquid)	11.58	17.45	18.31	20.81
ML_1 (Amritpani @ 200l ha^{-1}	12.88	17.67	17.38	23.69
ML_2 (panchgavya @200 l ha^{-1}	12.65	16.83	19.54	20.40
ML_3 (Vermiwash @ 50 l ha^{-1}	14.09	15.22	20.56	21.47
SE(m) = 0.82 CD at 5 % = 2.43				

Table 5. Effect of manurial liquids on GMR, NMR and B:C ratio of wheat Interaction (RDF x ML) for gross monetory returns

	No RDF	50% RDF	75% RDF	100%RDF	Mean
ML_0(no Manurial liquid)	14745	24030	27361	32099	24549
ML_1(Amritpani @ 200l ha^{-1}	16588	25989	30905	33671	26788
ML_2(panchgavya @ 200l ha^{-1}	16689	26476	28764	34146	26519
ML_3(Vermiwash @ 50l ha^{-1}	17491	27212	29694	34367	27191
Mean	16378	25927	29181	33571	

Interaction SE(m) = 1997 C D at 5 % =5892
Factor AxB SE(m)=999 C D at 5 % =2946

Interaction (RDF x ML) for net monetory returns

	No RDF	50% RDF	75% RDF	100%RDF	Mean
ML_0(no Manurial liquid)	-3410	4563	7521	11320	4999
ML_1 (Amritpani @ 200l ha^{-1}	-1668	5422	7819	11459	5508
ML_2 (panchgavya @ 200l ha^{-1}	-3245	5231	6864	11590	5110
ML_3 (Vermiwash @ 50l ha^{-1}	-4205	4222	6032	10049	4025
Mean	-3382	4859	7059	11105	---

Interaction SE(m) = 1997 C D at 5 % =5832

Factor A SE(m)=988 C D at 5 % =2946 Factor B = N.S.

Interaction (RDF x ML) for B :C ratio

	No RDF	50% RDF	75% RDF	100%RDF	Mean
ML_0 (no Manurial liquid)	0.81	1.24	1.36	1.54	1.24
ML_1 (Amritpani @ 200l ha^{-1}	0.86	1.26	1.40	1.54	1.27
ML_2 (panchgavya @ 200l ha^{-1}	0.84	1.25	1.31	1.51	1.23
ML_3 (Vermiwash @ 50l ha^{-1}	0.80	1.18	1.26	1.48	1.18
Mean	0.83	1.23	1.33	1.51	---

beneficial microbial activity of effective microorganism such as bacteria and fungi with the addition of these organic liquids.

The increase in grain yield due to manurial liquid without RDF combination was recorded in the range of 9.24 to 21.67 % over control. This indicates the role of manurial liquids in plant nutrient supply system. Xu and Xu (2000) reported that the presence of naturally occurring beneficial effective microorganisms in Panchagvya, Amritpani and vermiwash have the beneficial effect specially in improving soil fertility, growth and yield of sweet corn. Ghabelrahmat and Dhumal (2012) found significantly higher yield, soil microflora and nutrients due to the use of Jeevamrutha.

Economics:

The highest gross monetary return of wheat was noticed with the application of 100 % RDF + Vermiwash. Wheras net monetary return was highest in 100 % RDF + Panchgavya . In case of the application of 75 % RDF, the maximum B:C (1.27) ratio was found under the use of Amritpani.

On the basis of three years data, it is revealed that fertilization to wheat crop with recommended dose of fertilizer is quite comparable with 75% RDF +manurial liquids application in respect of microbial count and yield of wheat. Amongst the manurial liquids better contribution was given by Vermiwash than others.

Therefore, for increasing microbial count and maintaining yield level, the 75% RDF +Vermiwash could be applied to wheat crop.

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EFFECT OF CLIMATE OF NAGPUR ON MILK YIELD IN CROSSBRED COWS

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ABSTRACT

The investigation on effect of climate on milk yield in crossbred cows was carried out at College Dairy Farm, Animal Husbandry and Dairying Section, College of Agriculture, Nagpur during 2011-2012 The five years data (2006-10) on weekly milk yield of cows calved during Rainy(*kharif*) Winter(*rabi*) and Summer season each for twelve weeks and climatic attributes like temp. (max. and min.), humidity. (max. and min.), sunshine hours, dry bulb tempreture and wet bulb tempreture during corresponding period were collected. Weekly milk yield data were analyzed statistically to see the effect of climatic attributes and to know their association with milk yield.

The weekly milk yield of crossbred cows was 27.38 *l* in the 23rd week and reached to its peak in 33 rd week i.e. 49.30 *l* .Also the average weekly milk yield (39.39 *l*) was recorded in crossbred calvings in rainy season.

During summer season, average mean weekly milk yield was more which indicated that freshly calved crossbred cows maintained their weekly production throughout the summer season. It is also seen that high temperature with less humidity and more sunshine hours contributed to more milk production in crossbred cows calved during summer under dairy farm conditions.

It can be inferred that apart from availability of quality nutritious fodder during different seasons, maximum milk yield was recorded during summer (46.02 *l*) followed by winter (44.34 *l*) and rainy seasons (39.35 *l*) respectively, when freshly calved crossbred cows during respective season were considered for lactation performance under dairy farm conditions.

(Key words: Jersey crossbred cow, climate, weekly milking)

INTRODUCTION

India is endowed with significant share of world livestock population as well as milk production. As per the livestock census 2008, India has 184.2 million cattle which is about 15 per cent of the world cattle population. Out of the 185 million cattle, 24.8 million are crossbred cows which are 12.07 per cent of total cattle population (Anonymous, 2008). Between 1997 to 2003 crossbred cows population increased by 12.6 per cent and there was increase in milk production by 6 per cent. (Singh and Nair, 2008).

India ranks first in the world, among the milk producing countries. The total milk production of India was estimated at 121.8 MT during the year 2010 (Anonymous, 2011).The performance of cattle in the milk production is greatly affected by environmental factors, besides genetic factors. The environmental factors such as temperature, humidity, rainy days and sunshine hours may cause variation in milk production (Kale and Basu, 1993).

Animal life has constant struggle against the forces of nature and one important force is climate. Climate affects animals both directly with expansion on their systematic function and indirectly by governing the availability of nutrient. (Thokal *et al.*, 2004). Therefore, studies on effect of climate on milk yield in crossbred cows maintained were undertaken at College Dairy Farm, Animal Husbandry and Dairying Section, Agriculture College, Nagpur during the year 2011-2012.

MATERIALS AND METHODS

Selection of animals and records of laction :

The investigation was carried out on effect of climate on milk yield in crossbred cows at College Dairy farm, Animal Husbandry and Dairying Section, College of Agriculture, Nagpur, during the year 2011-2012. Five years (2006 to 2010) data were collected in respect of crossbred cows having 50% exotic (Jersey) inheritance of their parental breeds. Systematic records in respect to daily milk yield, incidence of calving, number of milch animals and daily herd strength were traced out from the record available on dairy farm. The above data in respect of only half breds were undertaken in the present study for the period 2006 to 2010 at Dairy farm of Animal Husbandry and Dairy Section, College of

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Agriculture, Nagpur. Finally seasonwise average weekly milk yield was determined.The periodical data were further divided into 3 climatic seasons as under.

1. Rainy (S_1)-June to September (23rd to 34th Met.week)
2. Winter (S_2) - October to January (40th to 51th Met.week)
3. Summer (S_3) - February to May (5thto 16th Met.week)

The weekly metrological data for all the seasons in respect of temperature (max. and min.) and humidity (max. and min.) , sunshine hours, dry bulb tempreture and wet bulb tempreture were collected from the metrological observatory of the College campus situated under the section of Agronomy, College of Agriculture, Nagpur. The index which combines these two climatic factors is Temperature-Humidity-Index(THI) which was calculated by following formula (Thomas and Acharya, 1981.) at weekly interval.

THI=0.75(dbt °C+wbt °C+40.6)

Where,

wbt= wet bulb temperature(°C)
dbt= dry bulb temperature(°C)

However, this index does not take into account the variation in temperature, humidity and sunshine hour. The best index indicating the stress due to solar radiation as well as the variation is Temperature-Humidity-Sunshine-Index (THSI). This index was calculated by following formula. (Thomas and Acharya, 1981.) for each week for 12 weeks.

$$THSI = \frac{0.75 \times S\,(THI \text{ at } 3 \text{ pm}) + (24 - 0.75\,S \times THI \text{ at } 9am)}{24}$$

Where,

THSI = Temperature-Humidity-Sunshine-Index.
THI = Temperature-Humidity-Index

The data were analysed by calculating the correlation to study the extent of relationship between milk yield and the selected variables viz., temp. (max. and min.), humidity. (max. and min.), sunshine hours,THI and THSI by using the following formula recommended by Sukhatme and Amble (1976).

$$r = \frac{Cov\,(x.\,y)}{S.D.\,(x).\,S.D.\,(y)}$$

The significance or correlation was tested by 't' as

$$t - Cal = \frac{r}{S.E.\,(r)}$$

The table value of 't' noted at (n-2) d.f. for deriving significance.

Where,

COV- Covariance, SD(x) - standard deviation of 'x' variable
SE (r) - standard error for correlation SD(x) - standard deviation of 'x' variable
Cal. - calculated

RESULTS AND DISCUSSION

Average weekly milk yield and seasonal climate :

During rainy, winter and summer season maximum temperatures were recorded in the range of 31.15 to 35.89, 30.12 to 32.45 and 36.89 to 39.89 °C respectively , corresponding figures for minimum temperature were in the range of 21.74 to 25.52, 14.10 to 16.84 and 19.09 to 25.80°c respectively. With regards to max. relative humidity levels, 81.45, 65.95 and 45.75 per cent R.H. were noticed in 28th(8thJuly to 14thJuly), 41th (14thOct. to 20th Oct.) and 16th (15thApril to 21stApril) meteorological weeks during rainy, winter and summer season respectively. On the other hand, maximum sunshine hours. of 5.30, 8.43 and 8.63 were recorded in 32th (5thAug.to 11thAug.),47th (25thOct.to 1stDec.) and 9th (26thFeb.to 3rdMarch)meteorological weeks.(Table 1).

The climate of the season might have influenced the milk yield of crossbred cows. To examine this logic weekly milk yields in relation to seasonal climate were calculated. The weekly milk yield was the highest (55.22 *l*) during 50th (16thDec.to 22ndDec.) meteorological week . In general, weekly milk yield increased upto 46th (18thOct. to 24th Oct.) meteorological week during the winter season but thereafter no definite trends could be observed. The difference between the weekly milk yield could be attributed changes in weather conditions.

In rainy season maximum milk yield and minimum milk yield were 49.30 *l* and 27.38 *l* during 33rd (12thAug.to 18thAug.) and 23rd (3rdJun to 9thJun) meteorological week respectively. In summer season maximum milk yield was 57.15 *l* during 5th (29thJan.to4thFeb.) meteorological week and minimum milk yield was 31.00 *l* during the 5th meteorological week. It is inferred from table 1 that the variation in milk yield was more or less similar in winter and summer season as compared to rainy season. The higher milk production during summer season,was consideration of cows calved during that season whose milk production for favoured by summer climate. Seasonal climate be the factor to influence the production level in animal. The average milk production (44.37 *l*) was more during summer season followed by winter (43.62 *l*) and rainy (39.39 *l*) season respectively. Therefore, to find out the interrelationship between climatic attributes and milk yield, the data was subjected to correlation coefficient. The results obtained in this respect are discussed in the following paragraphs.

Weekly milk yield during rainy season and its correlation :

The results with regards to the correlation between **milk yield** and different climatic factors during rainy season are presented in table 2.

It is observed from the table 2 that an average maximum temperature, minimum temperature, maximum humidity, minimum humidity ,sunshine hours, THI and THSI values were 32.64 + 0.39, 23.57 ± 0.41, 76.72 ± 0.78, 60.99 ± 1.14, 3.94 ± 0.54, 68.27 ± 0.24, and 68.64 ± 0.40 respectively during rainy season. The crossbreds were exposed to this climate from June to Sept. The average weekly milk yield production in crossbreds noticed as 39.35 ± 1.75 *l* under this climate.

It is evident from table 2 that, the during rainy season increasing trends in milk production was noticed from 31.44 *l* to 35.89 *l*.The highest weekly milk production was recorded during 33rd **(**12thAug.to 18thAug.**) me**teorological week and increased rate of milk secretion was noticed over first 34th **(**19thAug.to 25thAug.**)** week of lactation during rainy season without the influence of climate This contention is confirmed from correlation analysis where the different climatic factors except max. tem., max. hum., min. hum. and THI did not establish with weekly milk yield production. Max. tem. (0.767), max. hum. (0.749) exhibited positive significant association with weekly milk yield, while min. hum. (-0.680) and THI (-0.791) influenced on the milk yield significantly in negative direction (Table 2). This trend appears to be advantageous as humidity levels are generally more throughout the rainy season. Therefore, the decline in milk secretion rate would be at slower rate by increasing humidity levels.

Shinde *et al.* (1990) observed that high temperature coupled with high humidity was the cause to record minimum peak milk yield during rainy season. The results of Mandal *et al.* (2009) showed significant effect of maximum tempreture and relative humidity on herd dynamic and total daily milk production. Thus, the results of present investigation agree with these findings.

Weekly milk yield during winter season and its correlation :

Correlation coefficients between climatic attributes and milk yield are presented in table 3.

It is observed from the table 3 that an average max. temperature and minimum ambient temperature prevailing in the winter season were 31.20 ± 0.24 and 15.48 ± 0.30 respectively. Maximum humidity and minimum humidity during winter season were 59.49 ± 1.46 and 34.58 ± 1.28 respectively. Moreover, the Sunshine hours, THI and THSI were 7.76 ± 0.13, 69.10 ± 0.31 and 62.10 ± 1.19 respectively which were below the thermal stress 75.

The max. hum. indicated positive influence on milk yield and the correlation value of it was 0.947 and min. hum. indicated negative influence on milk yield with correlation value -0.747 and THI -0.508. The positive significant association of max. hum. and THSI favour the maintenance of milk production in crossbreds during winter season.

The degree of 'r' values indicate more favourable effect of winter climate on the performance of crossbred cows . The climate can be considered as major non genetic factor responsible for contributing the variation in milk production. Shinde *et al.* (1990) reported that THI above 72 was the point of thermal stress. These findings are in line with the findings of present investigation.

Table 1. Effect of different seasonal climate on weekly milk yield in Jersey crossbred cow

Met. week		Temp. (max.)	Temp. (min.)	Hum. (max)	Hum. (min.)	Sun. (Hrs.)	Milk yield (*l*)	THI	THSI
				Rainy season					
23	(3-7 Jun)	34.4	25.5	73.6	**60.1**	3.1	27.4	69.8	70.1
24	(10-16Jun)	35.9	25.3	74	62.8	3.5	36.7	70.1	70.4
25	(17-23 Jun)	35.5	24.9	74.7	59.6	3.3	35.1	70.5	70.7
26	(24-30 Jun)	33.3	24.7	76.4	59	3.6	36.3	68.9	69.3
27	(1-7 Jul)	32.3	24.0	81.5	64.5	3.3	38.0	68.7	69.0
28	(8-14 Jul)	31.6	23.9	81.9	71.0	3.0	37.9	68.8	69.1
29	(15-21 Jul)	31.8	23.9	78.2	62.3	4.1	39.1	68.4	68.1
30	(22-28 Jul)	32.2	23.2	76.3	58	4.2	39.3	68.1	68.5
31	(29Jul- 4 Aug)	32.0	22.1	75.6	57.6	5.1	39.8	67.4	68.0
32	(5-11 Aug)	31.4	22.2	77.8	62.3	3.7	45.1	66.7	67.0
33	(12-18Aug)	31.6	21.7	76.7	58.5	5.2	49.3	66.6	67.3
34	(19-25Aug)	31.9	21.5	74.3	56.4	5.3	48.8	65.3	66.1
		32.64 ±0.39	**23.57 ±0.41**	**76.72 ± 0.78**	**60.99± 0.14**	**3.94± 0.24**	**39.39 1.24**	**68.2**	**68.6**
				Winter season					
40	(7-13 Oct)	30.8	16.8	16.6	43.6	7.0	33.7	60.7	74.7
41	(14-20Oct)	31.0	16.3	66.0	39.2	7.6	39.0	60.3	61.8
42	(21-27Oct)	30.9	16.0	64.2	39	7.7	39.7	58.6	60.3
43	(28Oct-3 Nov)	30.1	13.4	57.7	33.7	8.4	42.5	57.7	60.0
44	(4-10 Nov)	30.4	14.6	61.3	35.1	7.5	42.1	58.8	62.5
45	(11-17Nov)	30.7	15.4	61.9	35.8	7.5	42. 7	59.2	60.6
46	(18-24Nov)	30.8	15.7	62.5	35.7	7.8	45.1	57.8	59.3
47	(25Nov- 1Dec)	30.9	14.1	53.9	30.7	8.4	44.0	57.5	59.4
48	(2-8 Dec)	31.5	14.8	55.9	29.9	8.0	46.3	58.9	60.4
49	(9-15 Dec)	32.5	16.5	54.4	31.6	8.1	48.7	60.0	62.2
50	(16-22Dec)	32.1	16.3	59.0	32.8	7.3	55.2	59.4	61.4
51	(22-29Dec)	32.8	15.9	50.6	28.1	8.3	53.6	60.3	60.5
		31.20 ±0.24	**15.48 ±0.30**	**59.49 ±1.46**	**34.58 ± .28**	**7.76± 0.13**	**1.62**	**69.1**	**62.1**
				Summer season					
5	(29Jan-4Feb)	36.9	19.1	40.1	19.6	8.9	31	65.4	67.2
6	(5-11 Feb)	37.3	21.0	38.8	22.0	8.6	39.4	65.7	67.4
7	(12-18Feb)	37.8	20.1	41.9	22.3	8.4	43.3	66.9	68.5
8	(19-25Feb)	38.2	20.8	41.3	22.1	8.9	40.5	67.8	69.5
9	(26Feb- 3Mar)	39.8	20.0	37.1	20.1	9.0	45.5	69.2	69.6
10	(4-10 Mar)	39.7	24.3	38.0	21.4	8.1	47.5	70.2	71.6
11	(11-17Mar)	39.9	23.0	41.2	24.3	7.7	48.6	70.2	71.7
12	(18-24Mar)	39.8	25.1	44.0	27.0	7.8	49.3	71.7	72.9
13	(25-31Mar)	39.2	23.3	45.8	31.3	7.5	49.0	70.9	72.2
14	(1-7 Apr)	39.2	25.8	47.4	33.8	6.9	49.4	71.5	72.7
15	(8-14 Apr)	39.2	26.7	45.8	32.8	6.6	57.2	71.1	72.2
16	(15-21 Apr)	39.1	26.3	51.6	35.4	6.6	52.9	71.3	72.4
		38.84 ±0.29	**22.95 ±0.77**	**42.55± 1.26**	**25.93 ± 1.65**	**7.89 ± 0.25**	**44.37 ± 1.34**	**69.3**	**70.6**

Table 2. Mean values and correlation coefficients of climatic attributes with weekly milk yield in Jersey crossbreds during rainy season (S_1)

Variables	Avg. Values with S.E. (±)	Correlation coefficient	% contribution
Max.Tem.(°c)x_1	32.64 + 0.39	0.767**	0.588
Min.Tem. (°c)x_2	23.57 + 0.41	-0.099^{NS}	0.009
Max.Hum.(%)x_3	76.72 + 0.78	0.749**	0.561
Min. Hum.(%)x_4	60.99 + 1.14	-0.680*	0.462
Sunshine hrs. x_5	3.94 + 0.24	0.060^{NS}	0.003
THI.x_6	68.27±0.44	-0.791**	0.625
THIS.x_7	68.64±0.40	0.325 ^{NS}	0.105
Weekly milk yield (*l*)	39.35 ±1.75		

Table 3. Mean values and correlation coefficients of climatic attributes with weekly milk yield in Jersey crossbreds during winter season (S2)

Variables	Avg. Values with S.E. (±)	Correlation coefficient	% contribution
Max.Tem.(°c)x_1	31.20 ± 0.24	0.520 ^{NS}	0.270
Min.Tem. (°c)x_2	15.48 ± 0.30	0.346 ^{NS}	0.119
Max.Hum.(%)x_3	59.49 ± 1.46	0.947**	0.896
Min.Hum.(%)x_4	34.58 ± 1.28	-0.747**	0.558
Sunshine hrs. x_5	7.76 ± 0.13	-0.225 ^{NS}	0.050
THI x_6	69.10±0.31	-0.508 ^{NS}	0.258
THSIx_7	62.10±1.19	0.650*	0.422
Weekly milk yield (*l*)	44.34±1.74		

Table 4. Mean values and correlation coefficients of climatic attributes with weekly milk yield in Jersey crossbreds during summer season (S3)

Variables	Avg. Values with S.E.(±)	Correla tion coefficient	% contribution
Max.Tem.(°c)x_1	38.84±0.29	0.132 ^{NS}	0.017
Min.Tem. (°c)x_2	22.95±0.77	0.254 ^{NS}	0.064
Max.Hum.(%)x_3	42.55±1.26	0.947**	0.896
Min. Hum.(%)x_4	25.93±1.65	-0.935**	0.874
Sunshine hrs. x_5	7.89±0.25	0.423 ^{NS}	0.17
THI x_6	65.29±0.16	-0.370 ^{NS}	0.171
THIS x_7	66.35±0.20	0.362*	0.136
Weekly milk yield (*l*)	43.50±1.90		

Weekly milk yield during summer season and its correlation :

The data with regard to the correlation coefficients between weekly milk yield and climatic attributes are tabulated in table 4.

It is seen from the table 4 that the average climatic condition during summer was maximum temperature, minimum temperature, maximum humidity, minimum humidity, Sunshine hours , THI and THSI were 38.84 ± 0.29, 22.95 ± 0.77, 42.55 ± 1.26, 25.93 ± 1.65, 7.89 ± 0.25, 65.29 ± 0.16 and 66.35 ± 0.20 respectively.

It is inferred from table 4 that the mean weekly milk yield was 43.50 ± 1.90 in Jersey crossbred cows, which was higher as compaired to rainy (39.35 *l*) season. This fact is confirmed from the correlation values of climatic factors with that of milk yield production. The max. hum. (0.947) had positive association with the milk yield and min. hum. (-0.935) influenced negative association with the milk yield in Jersey crossbred cows whereas max. tem. (0.132), min. tem. (0.254), sunshine hrs. (0.423) and THI (0.136) were non significantly correlated with the milk yield .

The positive non significant relationship between sunshine hrs, max. tem. and min. tem. and THI have maintained dry climate during summer, which might have favored the milk production of freshly calved cows during summer season. Thus, the results clearly once again establish the fact that, the dry climate favours the milk production apart from availability of nutrious fodder in crossbred cows under dairy farm condition. The results of Kulkarni *et al.* (1998) noticed that the average daily milk yield was influenced negatively by average negative minimum humidity. On contrary, Krishnender *et al*.(2011) noticed significant effect of season on milk yield traits with winter calving cows yielded significantly higher milk yield and the summer calving cows yielded lower milk yield. Apart from climatic attributes dimensions of udder and teat might be resulted in increased milk production in crossbred cows (Singh *et al*., 2010). These results are comparable with the findings of present investigation.

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