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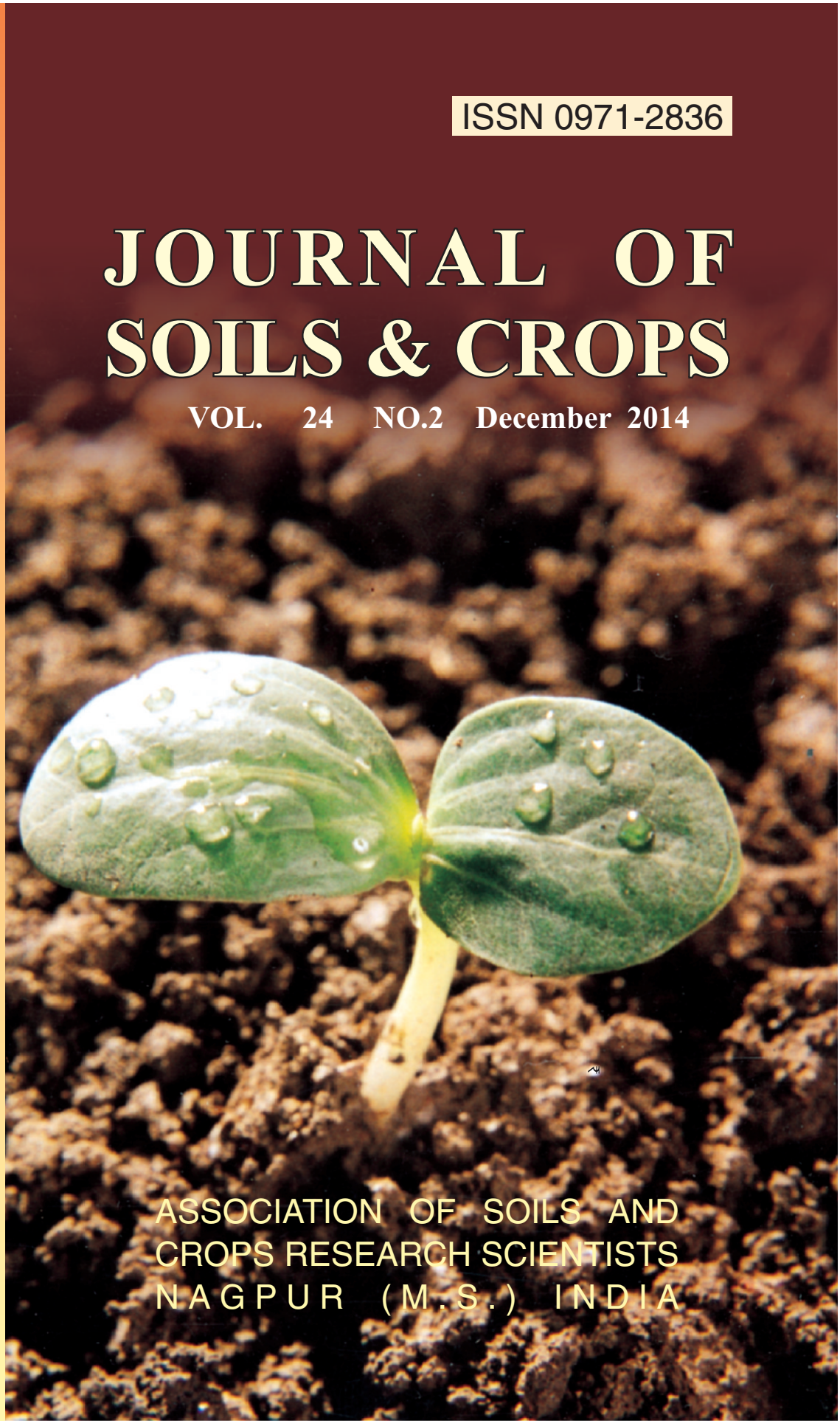

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MACRONUTRIENTS UPTAKE AND YIELD IN BASMATI RICE AS INFLUENCED BY ESTABLISHMENT METHODS AND NITROGEN LEVELS

Jagjot Singh Gill[1], Sohan Singh Walia[2] and Roopinder Singh Gill[3]

ABSTRACT

A field experiment was conducted at Student's Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during *kharif* season of 2010 and 2011 in strip plot design with 6 establishment methods in horizontal plots and 4 nitrogen levels in vertical plots on sandy loam soil with normal soil reaction (pH 8.10 and 8.00), low in organic carbon (0.28 and 0.26 %) and available nitrogen (255.02 and 238.20 kg ha^{-1}), medium in available phosphorus (19.10 and 17.20 kg ha^{-1}) and potassium (155.00 and 140.00 kg ha^{-1}). Results indicated that grain yield was significantly higher with machine transplanted basmati rice after puddling. Biological yield was significantly higher with machine transplanted basmati rice after puddling during 2010. N, P and K content (%) in basmati rice grains and straw did not vary significantly among different methods of establishment. However, N, P and K uptake in grain and N, P and K uptake in straw were significantly higher in direct seeded basmati rice with brown manuring. Among nitrogen levels grain, straw and biological yield were significantly higher with 125% of recommended dose of nitrogen (51.14 kg N ha^{-1}). N content (%), N, P and K uptake in grain and straw were maximum in 125% of recommended dose of nitrogen. The interaction effects between nitrogen levels and establishment methods were non-significant.

(Key words: Basmati rice, establishment methods, nitrogen levels, macronutrient content, uptake, yield)

INTRODUCTION

Rice (*Oryza sativa* L.) is the second largest cereal crop and is the staple food of nearly one-half of the world's population (Sharma *et al.,* 2012). Being the staple food, rice is the main source of carbohydrates and protein. It is critically important for ensuring food security, alleviating poverty and conserving the vital natural resources that the world's present and future generations will be entirely dependent upon for their survival and well-being (Rothschild, 1997). In India, rice occupied 39.16 million ha with a production of 85.59 Mt and average yield 2185 kg ha^{-1} (Anonymous, 2013). Basmati rice is known as queen of rice and area under scented rice varieties is also increasing day by day with the opening of world market as well as with increased domestic consumption (Singh *et al.*, 2008). Rice is mainly grown by transplanting of the seedling in the puddled fields. This technique, however, is very cumbersome, labour intensive, time consuming, costly and requires relatively high water input. Therefore, the need of hour is to develop alternative methods of establishment. Nitrogen fertilization plays a great role in increasing rice production. Rao and Raja (1987) reported that rice yields increased significantly when fertilized with 120 kg N ha^{-1}. Production of high quality aromatic rice by farmers for domestic as well as export purposes is major concern of future agriculture strategy (Ghosh *et al.*, 2004). The application of nitrogen and phosphorus fertilizer either in excess or less than optimum rate affects both yield and quality to a remarkable extent (Manzoor *et al.*, 2006). Keeping these views in mind, an experiment was conducted at Punjab Agricultural University, Ludhiana to assess the effect of different establishment methods and nitrogen levels on yield and macronutrient uptake in rice.

MATERIALS AND METHODS

The field experiment was conducted at Student's Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during *kharif* season of 2010 and 2011. The composite soil samples from 0-15 and 15-30 cm profile layers were collected before sowing from randomly selected sites and analyzed for chemical analysis. The soil was sandy loam with normal soil reaction (pH 8.10 and 8.00) and electrical conductivity (0.36 and 0.32 dSm^{-1}), low in organic carbon (0.28 and 0.26 %) and available N (255.02 and 238.20 kg ha^{-1}), medium in available P (19.10 and 17.20 kg ha^{-1}) and K (155.00 and 140.00 kg ha^{-1}) at both the depths

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(Table 1). Methods used for soil analysis are mentioned in table 1. The experiment was conducted in strip plot design with 6 establishment methods viz., direct seeded basmati rice, direct seeded basmati rice with brown manuring, machine transplanting in zero-tillage (ZT) with brown manuring, machine transplanting in zero-tillage (ZT) without brown manuring, machine transplanting after puddling and conventional practice in horizontal plots and 4 nitrogen levels viz., control, 75% (30.68 kg N ha^{-1}), 100% (40.91 kg N ha^{-1}) and 125% (51.14 kg N ha^{-1}) of recommended dose of nitrogen (RDN) in vertical plots. The recommended dose of nitrogen was 90 kg urea ha^{-1} (40.91 kg N ha^{-1}). Nitrogen fertilizer was applied in two equal splits to transplanted basmati rice at about 3 weeks and 6 weeks after transplanting and two equal splits of nitrogen fertilizer were applied to direct seeded rice as half dose after two weeks and rest half of nitrogen fertilizer was applied five weeks after sowing. The recommended dose of phosphorus (30 kg P_2O_5 ha^{-1}) and potassium (30 kg K_2O ha^{-1}) was applied at the time of field preparation through single super phosphate (SSP) and muriate of potash (MOP), respectively. Basmati rice variety Punjab Mehak 1 was used as test variety. For brown manuring, seeding of Sesbania aculeata was done 30 days before the sowing of direct seeded rice and machine transplanted rice in zero tilled plots. 2, 4-D @ 1 kg ha^{-1} was sprayed on Sesbania three days before direct sowing of rice and transplanting of rice with machine in zero tilled plots. The sowing of direct seeded rice (DSR) was done with rice drill in dry moist soil. Nursery for machine transplanting was raised in plastic trays. Seeds @ 30 kg ha^{-1} (for 500 trays) were used for raising nursery in trays. Twenty five days old nursery was used in mechanized transplantation. In case of conventional transplanting, nursery was raised by broadcasting seed @ 20 kg for transplanting a hectare. Transplanting was done using 25 days old seedlings. Machine transplanting was done by paddy transplanter. In zero tilled plots, it was done in standing water. In conventional transplanting, nursery was irrigated before uprooting, seedlings were uprooted and then transplanted @ two seedlings $hill^{-1}$ about 2-3 cm deep in puddled field in lines at 20x15 cm spacing manually. In direct seeded rice and transplanted rice weeds were controlled by applying Stomp 30 EC (pendimethalin) @ 2.5 litre ha^{-1} within two days of sowing and transplanting of basmati rice and Nominee Gold 10 SL (bispyribac) @ 250 ml ha^{-1} at 30 days after sowing and 25 days after transplanting of basmati rice, respectively. The left over weeds were removed by two hand weedings in direct seeded basmati rice at 51 and 66 days after sowing and one hand weeding in transplanted rice after 56 days of transplanting during *kharif* 2010. In *kharif* 2011 left over weeds were removed by two hand weedings in direct seeded basmati rice (DSBR) at 50 and 72 days after sowing and one hand weeding in transplanted rice after 49 days of transplanting. Irrigation was applied as per requirement to direct seeded basmati rice. In transplanted rice, water was kept standing continuously for first fifteen days after transplanting. After that irrigations were applied two days after the ponded water has infiltrated into soil. No irrigation was applied during rainy days. Irrigation application was withheld 15 days before harvesting of crop. The crop was harvested manually with the help of sickle when grains almost matured and straw had turned yellow and data on grain, straw and biological yield were recorded. For the determination of nitrogen, plant samples collected at harvest were first dried in hot air oven at 60°C for hours till constant weight and then these dried samples were grounded. Afterward, 0.5 g grounded plant samples digested for determination of nitrogen by using 10 ml of concentrated sulphuric acid (H_2SO_4), copper sulphate ($CuSO_4$), selenium powder and mercury oxide. All these chemicals put in digestion tube, which kept for over night, then start of heating on next day in Kjeldahl's digestion unit from low (75°C) to high temperature upto 400°C to get colourless content. Then digested material was used to make volume 50 ml in volumetric flask using distilled water.

Nitrogen content in sample was determined by using Kjeldahl's distillation method. The nitrogen content was expressed as percentage. For the determination of phosphorus, the grounded sample of 0.5g (grain and straw) was digested in triple acid mixture i.e. nitric acid (HNO_3), perchloric acid ($HClO_4$) and sulphuric acid (H_2SO_4) in the ratio of 9:3:1, respectively. The phosphorus in plant (grain and straw) determined by using Vanado-Molybdo-Phosphoric yellow colour method in nitric acid (Jackson, 1967). Intensity of developed colour was measured by using Spectronic-20 colorimeter at wavelength of 470 nm. The reading of colorimeter was compared with standard curve to get phosphorus content in percentage. The aliquot (digested material

of grain and straw) samples, that were used for phosphorus determination, were also used for the determination of potassium content in grain and straw by using flame photometer (Jackson, 1967). The reading of flame photometer was compared with standard curve to get potassium content in percentage. To calculate the uptake ha^{-1} by crop, the per cent nitrogen, phosphorus and potassium content in plant (grain, straw and total biomass) was multiplied with grain, straw and total plant biomass yield.

RESULTS AND DISCUSSION

Grain yield

The data on grain yield presented in table 2 showed that machine transplanting of rice after puddling yielded significantly more grain yield as compared to other methods of establishment but was statistically at par with direct seeded basmati rice with brown manuring during both the years of study. Machine transplanted basmati rice after puddling produced 0.96, 2.76, 4.62, 5.07 and 7.31 per cent more grain yield over direct seeded basmati rice with brown manuring, direct seeded basmati rice without brown manuring, conventional transplanted basmati rice, machine transplanted basmati rice in zero tilled plots with brown manuring and machine transplanted basmati rice in zero tilled plots without brown manuring, respectively during 2010 and the corresponding values for the year 2011 were 1.34, 2.69, 4.58, 5.35 and 7.49 per cent, respectively. Conventional transplanted basmati rice and machine transplanted basmati rice in zero tilled plots with brown manuring were statistically at par with each other during both 2010 and 2011 but both methods of direct seeding were at par with each other only during 2011. The more grain yield under machine transplanting of basmati rice after puddling was mainly due to better yield attributes through optimum utilization of resources (Land, water, energy and nutrients) which had direct bearing on production of higher yield of basmati rice. Dixit *et al.*(2010) also observed that grain yield was the highest in transplanting with Japanese manual transplanter (7.85 t ha^{-1}) followed by direct – seeded drill with adjustment of 30 kg ha^{-1} seed rate (7.80 t ha^{-1}) and direct seeded drill with adjustment of 15 kg ha^{-1} seed rate (7.20 t ha^{-1}). Gangwar *et al.* (2009) reported that direct seeding – dry bed (8.29 t ha^{-1}) and mechanical transplanting – puddled (8.20 t ha^{-1}) were at par with respect to grain yield. Nitrogen had significant effect on grain yield of basmati rice. Grain yield increased with each increment in nitrogen level upto 125% of RDN (51.14 kg N ha^{-1}). All levels of nitrogen differed significantly from each other (Table 2). The highest grain yield was obtained with 125% of RDN (51.14 kg N ha^{-1}) during both the years of study. Higher grain yield with higher nitrogen level might be due to higher values of growth parameters like dry matter accumulation etc. which might have resulted in higher capture of solar energy and hence led to enhanced values of yield attributing characters that ultimately resulted in higher grain yield. Mahajan *et al.* (2011) also opined that increasing nitrogen application to 150 kg ha^{-1} resulted in the highest grain yield over the application 120 kg N ha^{-1}. Singh and Walia (2010) reported that application of 120 and 150 kg N ha^{-1} gave similar grain yield in direct seeded and transplanted rice but significant superior to 90 kg N ha^{-1}.

Interaction effect

Data presented in table 2b revealed that 100% of RDN (40.91 kg N ha^{-1}) nitrogen level in direct seeded basmati rice without brown manuring was statistically at par with 125% of RDN (51.14 kg N ha^{-1}) nitrogen level in direct seeded basmati rice with brown manuring in respect of grain yield. Similarly, 100% of RDN (40.91 kg N ha^{-1}) nitrogen level in direct seeded basmati rice with brown manuring and machine transplanted basmati rice in zero tilled plots without brown manuring recorded statistically similar grain yield with 125% of RDN (51.14 kg N ha^{-1}) nitrogen level in machine transplanted basmati rice in zero tilled plots with brown manuring and machine transplanted basmati rice after puddling during the study year 2010.

Straw yield

The data on straw yield presented in table 2 clearly showed that different crop establishment methods had non-significant effect on straw yield. The increase in straw yield in machine transplanted basmati rice after puddling was 0.87, 2.66, 4.51, 4.84 and 7.10 per cent with respect to direct seeded basmati rice with brown manuring, direct seeded basmati rice without brown manuring, conventional transplanted basmati rice, machine transplanting basmati rice in zero tilled plots with brown manuring and machine

transplanting of basmati rice in zero tilled plots without brown manuring, respectively, during 2010, while in 2011 it was 1.34, 2.70, 4.58, 5.38 and 7.48 per cent, respectively. Amongst the various nitrogen levels, 125% of RDN (51.14 kg N ha^{-1}) gave significantly higher straw yield during both the years of study but was at par with 100% of RDN (40.91 kg N ha^{-1}) during 2010 (Table 2). 100% of RDN (40.91 kg N ha^{-1}) and 75% of RDN (30.68 kg N ha^{-1}) were statistically at par with each other during 2011.

Biological yield

The highest biological yield was obtained with machine transplanting of basmati rice after puddling, which was statistically at par with direct seeded basmati rice with brown manuring, direct seeded basmati rice without manuring and conventional transplanted basmati rice during 2010 (Table 2). Machine transplanting of basmati rice after puddling gave 0.90, 2.69, 4.55, 4.91 and 7.18 per cent more yield than direct seeded basmati rice with brown manuring, direct seeded basmati rice without brown manuring, conventional transplanted basmati rice, machine transplanted basmati rice in zero tilled plots with brown manuring and machine transplanted basmati rice in zero tilled plots without brown manuring, respectively during 2010. During 2011, effect of different crop establishment methods on biological yield was statistically non-significant. Significantly higher biological yield was obtained with 125% of RDN (51.14 kg N ha^{-1}) as compared to all other levels of nitrogen during both the years of study but was statistically at par with 100% of RDN (40.91 kg N ha^{-1}) during 2010. 125% of RDN (51.14 kg N ha^{-1}) produced 4.11, 31.30 and 67.06 per cent more biological yield than 100% of RDN (40.91 kg N ha^{-1}), 75% of RDN (30.68 kg N ha^{-1}) and control, during 2010, respectively, while in 2011 the increase was 14.66, 21.64 and 57.99 per cent, respectively (Table 2).

Plant analysis

Nitrogen (N), phosphorus (P) and potassium (K) content of basmati grain and straw

Different crop establishment methods were statistically at par with each other with respect to nitrogen, phosphorus and potassium content (%) of basmati rice grains and straw. Nitrogen levels significantly affected the nitrogen content of basmati rice grain. The highest nitrogen level i.e. 125% of RDN (51.14 kg N ha^{-1}) recorded significantly higher nitrogen content (%) as compared to control and was statistically at par with 100% of RDN (40.91 kg N ha^{-1}) and 75% of RDN (30.68 kg N ha^{-1}). 125% of RDN (51.14 kg N ha^{-1}) nitrogen level resulted in 6.72, 7.52 and 19.17 per cent increase in nitrogen content (%) over 100% of RDN (40.91 kg N ha^{-1}), 75% of RDN (30.68 kg N ha^{-1}) and control (Pooled data, Table 3). The increase in nitrogen content (%) of basmati rice grain resulted from increase in nitrogen level might be due to more availability of nitrogen with increased dose of nitrogen. Significantly higher nitrogen content (0.65%) in basmati rice straw was found in 125% of RDN (51.14 kg N ha^{-1}). This might be due to increased availability of nitrogen from increased amount of nitrogen application in 125% of RDN (51.14 kg N ha^{-1}) and resulted in higher uptake of nitrogen by plants and higher accumulation of nitrogen content in vegetative parts. Phosphorus and potassium content in basmati rice grains and straw was not influenced significantly by different nitrogen levels (Table 4 and 5).

Nitrogen uptake by basmati rice grains and straw

Data in table 6 revealed that nitrogen uptake (kg ha^{-1}) by basmati rice grains was influenced significantly by different methods of crop establishment. Direct seeded basmati rice with brown manuring resulted in significantly more nitrogen uptake [48.54 kg ha^{-1} (2010), 43.43 kg ha^{-1} (2011) and 45.99 kg ha^{-1} (Pooled)] as compared to all other methods of establishment. All methods of crop establishment differed significantly from each other except machine transplanted basmati rice without brown manuring and conventional transplanted basmati rice which were statistically at par with each other during the study year 2010. During 2011, direct seeded basmati rice without brown manuring was statistically at par with machine transplanted basmati rice after puddling and machine transplanted basmati rice in zero tilled plots with brown manuring but significantly higher than conventional transplanted rice.

Crop establishment methods also significantly influenced nitrogen uptake by basmati rice straw. Direct seeded basmati rice with brown manuring recorded significantly higher nitrogen uptake [48.41 kg ha^{-1} (2010), 52.92 kg ha^{-1} (2011) and 50.68 kg ha^{-1} (pooled)] by basmati rice straw but was

statistically at par with direct seeded basmati rice without brown manuring, machine transplanting of basmati rice in zero-tilled plots with brown manuring and machine transplanted basmati rice after puddling during 2010. The lowest nitrogen uptake in basmati rice straw was observed under conventional transplanted basmati rice and machine transplanted basmati rice in zero tilled plots without brown manuring which were statistically at par with each other during both the years of study.

Total nitrogen uptake (Grains + Straw) was significantly higher with direct seeded basmati rice with brown manuring [96.95 kg ha^{-1} (2010), 96.38 kg ha^{-1} (2011) and 96.67 kg ha^{-1} (pooled)] closely followed by direct seeded basmati rice without brown manuring, machine transplanting of basmati rice in zero-tilled plots with brown manuring and machine transplanted basmati rice after puddling which were statistically at par among themselves (Table 6).

Among different nitrogen levels, as in table 6, nitrogen level 125% of RDN (51.14 kg N ha^{-1}) resulted in significantly higher nitrogen uptake [55.41 kg ha^{-1} (Pooled), 61.95 kg ha^{-1} (Pooled) and 117.36 kg ha^{-1} (pooled)] in basmati rice grains, straw and total (Grain and Straw) as compared to 100% of RDN (40.91 kg N ha^{-1}), 75% of RDN (30.68 kg N ha^{-1}) and control. The higher nitrogen uptake by basmati rice grains in 125% of RDN (51.14 kg N ha^{-1}) might be attributed to higher grain, straw and total (Grains + Straw) yield and nitrogen content. Mahajan *et al.* (2011) also reported that N uptake in grains was the highest in rice when N was applied at 150 kg ha^{-1} in dry seeded rice. Choubey *et al.* (1999) also opined that application of 60 kg N ha^{-1} significantly increased N uptake in direct seeded rice over 30 kg N ha^{-1}.

Phosphorus uptake by basmati rice grains and straw

Data in table 7 showed that phosphorus uptake in basmati rice grains was significantly higher [12.23 kg ha^{-1} (2010), 10.86 kg ha^{-1} (2011) and 11.55 kg ha^{-1} (pooled)] with direct seeded basmati rice with brown manuring followed by machine transplanted basmati rice in zero tilled plots with brown manuring during both the years of study. All other methods of establishment differed significantly except the direct seeded basmati rice without brown manuring and machine transplanted basmati rice in zero tilled plots with brown manuring which were statistically at par with each other.

Direct seeded basmati rice with brown manuring significantly increased phosphorus uptake in straw as compared to other establishment methods (Table 7). Machine transplanting of basmati rice in zero-tilled plots without brown manuring and conventional transplanted basmati rice recorded the lowest phosphorus uptake in straw and were statistically at par with each other.

Total phosphorus uptake was also significantly higher [37.01 kg ha^{-1} (2010), 34.31 kg ha^{-1} (2011) and 35.66 kg ha^{-1} (pooled)] with direct seeded basmati rice with brown manuring. Machine transplanting of basmati rice in zero-tilled plots without brown manuring and conventional transplanted basmati rice, being statistically at par with each other had significantly decreased total phosphorus uptake.

Nitrogen levels significantly affected the phosphorus uptake by basmati rice grains, straw and total (Grains + Straw) as given in table 7. Significantly higher phosphorus uptake (14.23 and 12.70 kg ha^{-1} in grains, 28.14 and 22.12 kg ha^{-1} in straw and 42.37 and 34.82 kg ha^{-1} total) was noticed in 125% of RDN (51.14 kg N ha-1) during 2010 and 2011. All nitrogen levels differed significantly from each other and phosphorus uptake increased with the increase in nitrogen level.

The higher P uptake by basmati rice in 125% of RDN (51.14 kg N ha^{-1}) as compared to 100% of RDN (40.91 kg N ha^{-1}), 75% of RDN (30.68 kg N ha^{-1}) and control might have been due to higher grain and straw yield in this treatment. Choubey *et al.* (1999) also reported that application of 60 kg N ha^{-1} significantly increased P uptake in direct seeded rice over 30 kg N ha^{-1}. Singh and Sharma, (2000) also reported that P uptake by rice straw increased significantly with each successive increase of 60 kg N ha^{-1} from 0-180 kg N ha^{-1}.

Potassium uptake by basmati rice grains and straw

Data in table 8 revealed that direct seeded basmati rice with brown manuring gave significantly higher postassium uptake [10.50 kg ha^{-1} (2010), 9.89 kg ha^{-1} (2011) and 10.20 kg ha^{-1} (pooled) by basmati

Table 1. Chemical properties of soil of the experimental field at PAU

Soil characters	Soil depth(cm)				Method used
	2010		2011		
	0-15	15-30	0-15	15-30	
pH	8.10	8.30	8.00	8.18	1:2 soil:water suspension (Jackson, 1967)
EC (dSm^{-1})	0.36	0.31	0.32	0.26	1:2 soil:water suspension with solubridge conductivity meter (Jackson, 1967)
Organic carbon (%)	0.28	0.27	0.26	0.25	Walkley and Black's rapid titration method (1934)
N ($kg\ ha^{-1}$)	255.02	240.69	238.20	224.21	Modified alkaline potassium permanganate method (Subbiah and Asija, 1956)
P ($kg\ ha^{-1}$)	19.10	19.60	17.20	17.68	0.5N sodium bicarbonate extractable P by Olsen's method (Olsen *et al.,* 1954)
K ($kg\ ha^{-1}$)	155.00	147.80	140.00	133.00	Ammonium acetate extractable K (Merwin and Peech, 1950)
DTPA-extractable Mn (ppm)	10.10	9.63	8.60	8.11	DTPA extraction and atomic absorption spectrophotometer (AAS)
DTPA-extractable Fe (ppm)	21.50	21.63	19.20	19.31	DTPA extraction and AAS
DTPA-extractable Zn (ppm)	3.50	2.01	3.10	1.62	DTPA extraction and AAS

Table 2. Effect of different crop establishment methods and nitrogen levels on grain yield, straw yield, biological yield (q ha^{-1}) of basmati rice

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Biological yield (q ha^{-1})		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Establishment methods									
DSBR	33.70	30.90	32.3	85.94	78.78	82.36	119.65	109.68	114.665
DSBR with brown manuring *Sesbania spp.*	34.30	31.31	32.805	87.47	79.84	83.655	121.77	111.15	116.46
Machine transplanting in ZT with brown manuring	32.96	30.12	31.54	84.16	76.78	80.47	117.12	106.90	112.01
Machine transplanting in ZT without brown manuring	32.27	29.52	30.895	82.38	75.28	78.83	114.65	104.81	109.73
Machine transplanting after puddling	34.63	31.73	33.18	88.23	80.91	84.57	122.87	112.64	117.755
Conventional practice	33.10	30.34	31.72	84.42	77.37	80.895	117.52	107.71	112.615
SE±	0.17	0.18	0.175	0.36	0.31	0.335	1.80	0.39	1.095
CD (P=0.05)	0.47	0.52	0.495	-	-	-	5.36	-	5.36
Nitrogen levels (kg ha^{-1})									
Control	22.25	19.88	21.065	63.50	60.83	62.165	85.75	80.71	83.23
75% of RDN	32.49	30.17	31.33	76.61	74.66	75.635	109.10	104.83	106.965
100% of RDN	38.60	35.49	37.045	99.00	75.72	87.36	137.60	111.21	124.405
125% of RDN	40.64	37.07	38.855	102.62	90.46	96.54	143.25	127.51	135.38
SE±	0.27	0.58	0.425	2.30	1.95	2.125	2.25	1.87	2.06
CD (P=0.05)	0.73	1.37	1.05	6.86	5.92	6.39	6.86	5.72	6.29

Table 2b. Interaction effect of different crop establishment methods and nitrogen levels on grain yield (q ha^{-1}) of basmati rice during *kharif* 2010

Treatments	Control	75% of RDN	100% of RDN	125% of RDN
DSBR	21.66	33.35	40.52	43.01
DSBR with brown manuring *Sesbania spp.*	22.93	34.16	39.22	40.87
Machine transplanting in ZT with brown manuring	22.23	33.96	38.24	40.38
Machine transplanting in ZT without brown manuring	22.13	31.0	38.20	40.50
Machine transplanting after puddling	21.88	31.0	37.03	39.15
Conventional practice	22.68	31.44	38.38	39.91
CD (P=0.05) = 1.41				

Table 3. Effect of different crop establishment methods and nitrogen levels on N content (%) of basmati rice grain and straw

Treatments	2010			2011			Pooled		
	Grain N (%)	Straw N (%)	Total N (%)	Grain N (%)	Straw N (%)	Total N (%)	Grain N (%)	Straw N (%)	Total N (%)
Establishment methods									
DSBR	1.34	0.54	1.88	1.32	0.57	1.89	1.33	0.56	1.89
DSBR with brown manuring *Sesbania*	1.41	0.55	1.96	1.38	0.66	2.04	1.40	0.61	2.01
Machine transplanting in ZT with brown manuring	1.35	0.55	1.9	1.33	0.60	1.93	1.34	0.58	1.92
Machine transplanting in ZT without brown manuring	1.33	0.52	1.85	1.30	0.56	1.86	1.32	0.54	1.86
Machine transplanting after puddling	1.34	0.52	1.86	1.30	0.57	1.87	1.32	0.55	1.87
Conventional practice	1.32	0.51	1.83	1.30	0.50	1.8	1.31	0.51	1.82
SE±	0.03	0.04	0.07	0.02	0.01	0.03	0.04	0.01	0.05
CD (P=0.05)	-	-	-	-	-	-	-	-	-
Nitrogen levels (kg ha^{-1})									
Control	1.21	0.42	1.63	1.19	0.45	1.64	1.20	0.44	1.64
75% of RDN	1.34	0.50	1.84	1.31	0.55	1.86	1.33	0.53	1.86
100% of RDN	1.36	0.59	1.95	1.31	0.58	1.89	1.34	0.59	1.93
125% of RDN	1.40	0.63	2.03	1.45	0.66	2.11	1.43	0.65	2.08
SE±	0.06	0.05	0.11	0.05	0.07	0.12	0.06	0.07	0.13
CD (P=0.05)	0.18	0.18	0.36	0.16	0.18	0.34	0.17	0.18	0.35

Table 4. Effect of different crop establishment methods and nitrogen levels on P content (%) of basmati rice grain and straw

Treatments	2010			2011			Pooled		
	Grain P (%)	Straw P (%)	Total P (%)	Grain P (%)	Straw P (%)	Total P (%)	Grain P (%)	Straw P (%)	Total P (%)
Establishment methods									
DSBR	0.34	0.23	0.57	0.32	0.24	0.56	0.33	0.24	0.57
DSBR with brown manuring *Sesbania*	0.35	0.28	0.63	0.34	0.29	0.63	0.35	0.29	0.64
Machine transplanting in ZT with brown manuring	0.35	0.26	0.61	0.33	0.26	0.59	0.34	0.26	0.60
Machine transplanting in ZT without brown manuring	0.33	0.21	0.54	0.30	0.22	0.52	0.32	0.22	0.54
Machine transplanting after puddling	0.34	0.22	0.56	0.30	0.24	0.54	0.32	0.23	0.55
Conventional practice	0.30	0.21	0.51	0.30	0.22	0.52	0.30	0.22	0.52
SE±	0.01	0.02	0.03	0.03	0.01	0.04	0.02	0.02	0.04
CD (P=0.05)	-	-	-	-	-	-	-	-	-
Nitrogen levels (kg ha^{-1})									
Control	0.32	0.19	0.51	0.29	0.19	0.48	0.31	0.19	0.50
75% of RDN	0.34	0.21	0.55	0.31	0.22	0.53	0.33	0.22	0.55
100% of RDN	0.34	0.26	0.60	0.32	0.25	0.57	0.33	0.26	0.59
125% of RDN	0.35	0.27	0.62	0.34	0.24	0.58	0.35	0.26	0.61
SE±	0.01	0.04	0.05	0.02	0.02	0.04	0.01	0.03	0.04
CD (P=0.05)	-	-	-	-	-	-	-	-	-

Table 5. Effect of different crop establishment methods and nitrogen levels on K content (%) of basmati rice grain and straw

Treatments	2010			2011			Pooled		
	Grain K (%)	Straw K (%)	Total K (%)	Grain K (%)	Straw K (%)	Total K (%)	Grain K (%)	Straw K (%)	Total K (%)
Establishment methods									
DSBR	0.26	1.54	1.80	0.28	1.56	1.84	0.27	1.55	1.82
DSBR with brown manuring *Sesbania spp.*	0.30	1.59	1.89	0.31	1.64	1.95	0.31	1.62	1.93
Machine transplanting in ZT with brown manuring	0.27	1.56	1.83	0.30	1.60	1.90	0.29	1.58	1.87
Machine transplanting in ZT without brown manuring	0.22	1.52	1.74	0.24	1.50	1.74	0.23	1.51	1.74
Machine transplanting after puddling	0.24	1.54	1.78	0.27	1.54	1.81	0.26	1.54	1.80
Conventional practice	0.21	1.48	1.69	0.23	1.50	1.73	0.22	1.49	1.71
SE±	0.04	0.03	0.07	0.03	0.05	0.08	0.04	0.04	0.08
CD (P=0.05)	-	-	-	-	-	-	-	-	-
Nitrogen levels (kg ha^{-1})									
Control	0.21	1.48	1.69	0.23	1.50	1.73	0.22	1.49	1.71
75% of RDN	0.25	1.50	1.75	0.25	1.52	1.77	0.25	1.51	1.76
100% of RDN	0.26	1.52	1.78	0.29	1.54	1.83	0.28	1.53	1.81
125% of RDN	0.27	1.54	1.81	0.31	1.56	1.87	0.29	1.55	1.84
SE±	0.01	0.03	0.04	0.02	0.01	0.03	0.02	0.02	0.04
CD (P=0.05)	-	-	-	-	-	-	-	-	-

Table 6. Effect of different crop establishment methods and nitrogen levels on N uptake (kg ha^{-1}) by basmati rice grain and straw

Treatments	N (kg ha^{-1})								
	2010			2011			Pooled		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
DSBR	45.36	46.70	92.06	41.00	45.18	86.18	43.18	45.94	89.12
DSBR with brown manuring *Sesbania*	48.54	48.41	96.95	43.43	52.95	96.38	45.99	50.68	96.67
Machine transplanting in ZT with brown manuring	44.66	46.58	91.24	40.27	46.31	86.58	42.47	46.45	88.92
Machine transplanting in ZT without brown manuring	43.13	43.12	86.25	38.58	42.45	81.03	40.86	42.79	83.65
Machine transplanting after puddling	46.62	46.14	92.76	41.43	46.42	87.85	44.03	46.28	90.31
Conventional practice	43.90	43.29	87.19	39.60	38.98	78.58	41.75	41.14	82.89
SE±	0.20	1.18	1.38	0.26	1.54	1.80	0.23	1.36	1.59
CD (P=0.05)	0.60	3.57	4.17	0.76	4.55	5.31	0.68	4.06	4.74
Nitrogen levels (kg ha^{-1})									
Control	27.22	26.34	53.56	23.70	27.38	51.08	25.46	26.86	52.32
75% of RDN	43.56	38.12	81.68	39.61	41.39	81.00	41.59	39.76	81.35
100% of RDN	52.63	57.64	110.27	46.61	43.70	90.31	49.62	50.67	100.29
125% of RDN	57.02	64.33	121.35	53.79	59.56	113.35	55.41	61.95	117.36
SE±	0.38	1.26	1.64	0.49	1.03	1.52	0.44	1.15	1.59
CD (P=0.05)	1.10	3.85	4.95	1.51	3.04	4.55	1.31	3.45	4.76

Table 7. Effect of different crop establishment methods and nitrogen levels on P uptake (kg ha^{-1}) by basmati rice grain and straw

Treatments	P (kg ha^{-1})								
	2010			2011			Pooled		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
DSBR	11.67	20.01	31.68	10.05	19.20	29.25	10.86	19.61	30.47
DSBR with brown manuring *Sesbania spp.*	12.23	24.78	37.01	10.86	23.45	34.31	11.55	24.12	35.66
Machine transplanting in ZT with brown manuring	11.75	22.18	33.93	10.16	20.25	30.41	10.96	21.22	32.17
Machine transplanting in ZT without brown manuring	10.85	17.58	28.43	9.06	16.84	25.90	9.96	17.21	27.17
Machine transplanting after puddling	11.95	19.67	31.62	9.70	19.68	29.38	10.83	19.68	30.50
Conventional practice	10.09	18.02	28.11	9.31	17.26	26.57	9.70	17.64	27.34
SE±	0.05	0.47	0.52	0.07	0.52	0.59	0.06	0.50	0.56
CD (P=0.05)	0.16	1.42	1.58	0.21	1.61	1.82	0.19	1.52	1.71
Nitrogen levels (kg ha^{-1})									
Control	7.11	12.20	19.31	5.74	11.60	17.34	6.43	11.90	18.33
75% of RDN	10.89	16.37	27.26	9.48	16.16	25.64	10.19	16.27	26.45
100% of RDN	13.26	25.64	38.90	11.44	18.80	30.24	12.35	22.22	34.57
125% of RDN	14.23	28.14	42.37	12.70	22.12	34.82	13.47	25.13	38.60
SE±	0.09	0.64	0.73	0.16	0.41	0.57	0.13	0.53	0.66
CD (P=0.05)	0.28	1.91	2.19	0.45	1.19	1.64	0.37	1.55	1.92

Table 8. Effect of different crop establishment methods and nitrogen levels on K uptake (kg ha^{-1}) by grains and straw of basmati rice

Treatments	K (kg ha^{-1})								
	2010			2011			Pooled		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
DSBR	8.92	132.63	141.55	8.85	123.14	131.99	8.89	127.89	136.77
DSBR with brown manuring *Sesbania spp.*	10.50	139.34	149.84	9.89	131.23	141.12	10.20	135.29	145.48
Machine transplanting in ZT with brown manuring	9.12	131.53	140.65	9.20	123.15	132.35	9.16	127.34	136.50
Machine transplanting in ZT without brown manuring	7.30	125.51	132.81	7.29	113.20	120.49	7.30	119.36	126.65
Machine transplanting after puddling	8.49	136.17	144.66	8.79	124.86	133.65	8.64	130.52	139.16
Conventional practice	7.16	125.23	132.39	7.19	116.35	123.54	7.18	120.79	127.97
SE±	0.04	2.96	3.00	0.05	3.27	3.32	0.05	3.12	3.17
CD (P=0.05)	0.12	8.87	8.99	0.14	9.76	9.90	0.13	9.32	9.45
Nitrogen levels (kg ha^{-1})									
Control	4.61	93.95	98.56	4.60	91.30	95.90	4.61	92.63	97.23
75% of RDN	8.12	114.91	123.03	7.67	113.51	121.18	7.90	114.21	122.11
100% of RDN	10.07	150.51	160.58	10.21	116.58	126.79	10.14	133.55	143.69
125% of RDN	10.94	157.97	168.91	11.47	141.03	152.50	11.21	149.50	160.71
SE±	0.07	3.31	3.38	0.13	3.10	3.23	0.10	3.21	3.31
CD (P=0.05)	0.21	9.97	10.18	0.39	9.29	9.68	0.30	9.63	9.93

rice grains followed by machine transplanted basmati rice in zero tilled plots with brown manuring and direct seeded basmati rice without brown manuring. Conventional transplanted basmati rice resulted in significantly lower potassium uptake.

Direct seeded basmati rice with brown manuring recorded significantly higher potassium uptake [139.34 kg ha^{-1} (2010), 131.23 kg ha^{-1} (2011) and 135.29 kg ha^{-1} (pooled)] by straw and was statistically at par with direct seeded basmati rice without brown manuring, machine transplanting of basmati rice in zero-tilled plots with brown manuring and machine transplanted basmati rice (Table 8). Machine transplanting of basmati rice in zero-tilled plots without brown manuring and conventional transplanting of basmati rice gave the lowest uptake of potassium in straw and were at par with each other. The reason for higher potassium uptake by straw in direct seeded basmati rice with brown manuring treatment might be higher potassium content in straw and higher straw yield as compared to other establishment methods.

Total potassium uptake was also significantly higher with direct seeded basmati rice with brown manuring [149.84 kg ha^{-1} (2010), 141.12 kg ha^{-1} (2011) and 145.48 kg ha^{-1} (pooled)] and was statistically at par with direct seeded basmati rice without brown manuring and machine transplanted basmati rice after puddling.

Further, it was observed from the table 8 that potassium uptake by basmati rice grains [11.21 kg ha^{-1} (Pooled)], straw [149.50 kg ha^{-1}(Pooled)] and total (Grain + Straw) [160.71 kg ha^{-1}(Pooled)] was significantly more with 125% of RDN (51.14 kg N ha^{-1}). All levels of nitrogen differed significantly among each other but potassium uptake by basmati rice straw with 125% of RDN (51.14 kg N ha^{-1}) was at par with 100% of RDN (40.91 kg N ha^{-1}) during 2010. This might be due to higher potassium content of grains and straw and higher grain and straw yield in 125% of RDN (51.14 kg N ha^{-1}) treatment. Pandey *et al.* (1991) also observed that the uptake of K by grain and straw significantly increased with an increase in N level. The highest uptake of K was at 90kg N ha^{-1} followed by 60 kg N ha^{-1} and 30 kg N ha^{-1}.

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EFFECT OF SPLIT APPLICATION OF SULPHUR ON BULB YIELD AND USE EFFICIENCY BY GARLIC IN LIGHT SOIL

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ABSTRACT

An investigation was carried out to find the effect of split application of S on bulb yield and use efficiency by garlic using S-35 radioisotope on low S status soil during *kharif* 2007-08 to 2009-10 at Radio Tracer laboratory, Agricultural Research Institute, Rajendranagar, Hyderabad. Irrespective of the S level, sulphur application in two equal splits as basal and at 30 DAS made a significant dent on bulb yield of garlic compared to its one time application either at sowing or at 30 DAS. The bulb yield of garlic increased progressively with increasing rate of sulphur application from 20 to 40 kg ha^{-1}. The highest bulb yield (3272 kg ha^{-1}) was achieved at 40 kg S ha^{-1} and the control treatment receiving no fertilizer had the lowest yield (2871 kg ha^{-1}). It was found that a minimum of 30 kg S ha^{-1} is needed to obtain good yields of garlic, although higher level of its application had beneficial effect on the crop, albeit, to an extent of 1-2% increase due to application of sulphur @ 40 kg ha^{-1}.When yield data were considered on split dose basis, the mean bulb yield of garlic was the highest (3326 kg ha^{-1}) when S was applied in two splits (1/2 as basal + ½ at 30 DAS) followed by full dose at 30 DAS (3202 kg ha^{-1}) and full dose as basal (3091 kg ha^{-1}). The mean bulb yield of garlic was in the range of 3059 to 3371 kg ha^{-1} due to application of different levels and methods of S application. The highest bulb yield (3371 kg ha^{-1}) was recorded when 30 kg S ha^{-1} was applied in two equal splits as basal and at 30 DAS. S-35 radioisotope @ 0.25 mCi g^{-1} of S was tagged with gypsum to determine the use efficiency of applied S in garlic crop as the radioisotopes only differentiate the uptake of nutrient from natural and applied source. Sulphur application in two equal splits as basal and at 30 DAS has recorded highest S use efficiency (34.35%) by garlic bulb when compared to single time application either as basal (10.87%) or at 30 DAS (10.02%).The utilization of applied S by garlic was found to be higher at 20 kg S ha^{-1} level compared to its application at 30 and 40 kg S ha^{-1}.

(Key words: Garlic, sulphur , per cent Sdff , fertilizer S uptake, S-utilization)

INTRODUCTION

Sulphur is the fourth major plant nutrient after nitrogen, phosphorus and potassium. It is essential for the synthesis of amino acids like cystine, cysteine and methionine, a component of vitamine A and activates certain enzyme systems in plants (Havlin *et al*.,2004). Now-a –days, increased use of S free fertilizers, adoption of high yielding varieties and multiple cropping systems are causing sulphur deficiency in soils (Tandon,1991). In addition to this, use of more N and P fertilizers in comparison to S may result in widening ratios of N:S and P:S. This imbalance affects the efficiency of fertilizers, impairs the quality of produce and accelerates the removal of S from the soil (Tandon,1991). Aulakh *et al*.(1990), and Khajanchilal *et al*. (1996) had observed that the seed yield of soybean was improved with increasing the S levels from 0 to 40 kg ha^{-1}. Venkata Reddy *et al*.(2004) while working with S deficient Alfisols reported that there was significant increase in bulb yield of onion from 22.3 to 24.3 t ha^{-1} by increasing the level of S from 0 to 30 kg ha^{-1}. Conventionally, the sulphur application to oilseeds, pulses and other crops is made once in a crop season to meet its requirement and for better use efficiency. However, recent study by Girish and Venkata Reddy (2005) through their field study conducted on S deficient Alfisol reported that the highest sulphur concentration and uptake by soybean leaves and stems at flowering stage was noticed when S @ 45 kg ha^{-1}.This study suggested that split application of slowly available S with proper timing may help in avoiding losses of S and non-accumulation of it in deeper layers of soil. This will also help in de-risking the loss of S input cost in the event crop fails during early stage due to failure in monsoon or for any other reason.

In general apparent use efficiency of applied fertilizer was computed by taking into consideration of control plot yield, whereas by using radioisotopes, it is possible to quantify the applied fertilizer use efficiency by differentiating the uptake of nutrient from applied source to natural source (Subbiah *et al*;1994). Garlic, which is the second most important spice crops next to onion (Bose and Som,1990),needs considerable amount of sulphur. A very little information is available regarding the sulphur requirement to garlic crop. Hence, the present investigation was carried out to study the effect of different levels and timings of sulphur on its requirement and use efficiency by garlic using S-35 radioisotope.

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MATERIALS AND METHODS

The experiment was conducted in specialized rings (1.13 m^2) at Radiotracer Laboratory, Agricultural Research Institute, Rajendranagar, Hyderabad during *kharif* 2007-08, 2008-09 & 2009-10 to investigate the effect of split application of sulphur on yield at different S levels and its use efficiency by garlic on light soils. The initial characteristics of the experimental soil as determined by standard procedures (Tandon, 1993) and are presented in table 1. The pH of the experimental field was slightly alkaline in nature. The soils were normal without any salt problem, low in available N, high in available P_2O_5 and K_2O and low in available sulphur content. The main treatments included four levels of sulphur (0,20, 30 and 40 kg ha^{-1}) applied at three different times(as sub treatments) ; i) full dose as basal, ii) half dose as basal + half at 30 DAS and iii) full dose at 30 DAS . The treatments were replicated thrice in factorial randomized block design. The sulphur in the gypsum was tagged with S-35 radio isotope to a final specific activity of 0.25 mCi g^{-1} of sulphur. Recommended dose of 60 kg N and 35 kg P_2O_5 ha^{-1} was supplied through urea and DAP, respectively and 60 kg K_2O ha^{-1} in the form of muriate of potash to all the rings . Other standard package of practices were followed during experimentation. The bulb samples were collected from the rings at harvest stage and were analyzed for sulphur content and ^{35}S radioassay (Anonymous, 1990) to derive the S-uptake, Per cent sulphur derived from fertilizer, Fertilizer S-uptake and %S use efficiency. For this purpose, bulb samples were charred, heated at 550^0 C for three hours in a muffle furnace and counting beta radiation was done with a Geiger – muller counter (model – RCS 4207A) as suggested by International Atomic Energy Agency, Vienna. The use efficiency of applied fertilizer by using S-35 was computed as follows:

a) S-uptake (kg ha^{-1}) = Bulb yield (kg ha^{-1}) X % S content / 100
b) S-ppm = % S content X 16
c) ml mg^{-1} S = 1000 / S-ppm
d) Counts $Second^{-1}$ = Reading from Geiger Muller counter Sec^{-1}
e) Counts $mg^{-1}sec^{-1}$ = Counts sec^{-1} X ml mg^{-1}S

f) % Sulphur derived from fertilizer (Sdff) = Counts $mg^{-1}sec^{-1}$ of plant / Counts $mg^{-1}sec^{-1}$ of fertilizer

g) Fertilizer S uptake (kg ha^{-1}) = % Sdff X S-uptake (kg ha^{-1}) / 100

h). % S use efficiency = Fertilizer S uptake X 100 / Dose of applied fertilizer

RESULTS AND DISCUSSION

Bulb yield

Three years pooled data on bulb yield of garlic as influenced by different levels and times of sulphur application are presented in table 2.The mean bulb yield of garlic increased significantly due to application of S at 20 kg ha^{-1}(3130 kg ha^{-1}), 30 kg ha^{-1} (3218 kg ha^{-1}) and 40 kg ha^{-1}(3272 kg ha^{-1}) over control (2871 kg ha^{-1}). The highest bulb yield recorded at 40 kg S ha^{-1} was at par with 30 kg S ha^{-1} treatment. The increase in bulb yield was to the extent of 9.02, 10.41 % and 13.96% due to application of 20, 30 and 40 kg S ha^{-1} when compared with control (2871 kg ha^{-1}) . Such a response of garlic crop to S application in terms of bulb yield is expected in soils low in available S status. The increase in bulb yield with increase in the level of sulphur from 0 to 45 kg ha^{-1} was also reported by Zaman *et al*. (2011). Irrespective of the level, sulphur application in two equal splits as basal and at 30 DAS made a significant dent on bulb yield of soybean compared to its one time application either at sowing or at 30 DAS. The mean bulb yield of garlic was the highest (3326 kg ha^{-1}) when S was applied in two splits (1/2 as basal + ½ at 30 DAS) followed by at 30 DAS (3202 kg ha^{-1}) and full dose as basal (3091 kg ha^{-1}) . The bulb yield increased with increase in the level of sulphur from 20 to 30 kg ha^{-1} and thereafter decreased when S was applied to the crop in two splits. The maximum bulb yield of 3371 kg ha^{-1} was obtained when 30 kg S ha^{-1} was applied to the crop in two splits (1/2 as basal + 1/2 at 30 DAS) than at 40 kg S ha^{-1}.No specific trend was observed with application of different levels of S to the crop when applied as basal, whereas there was significant increase in bulb yield of garlic when full dose was applied at 30 DAS. The increase in bulb yield in the treatments where S was applied in splits may be due to the continued supply of S nutrient throughout the crop growth period.

Sulphur uptake

The sulphur uptake (Table 3) by the crop increased from 11.48 kg ha^{-1} in control to 15.27, 16.27 and 16.72 kg ha^{-1} due to application of sulphur at 20, 30 and 40 kg ha^{-1}, respectively. The maximum uptake

of S (16.72 kg ha^{-1}) by the garlic bulb was noticed when crop was supplied with 40 kg S ha^{-1} when compared to 20 and 30 kg S ha^{-1}. The result is in conformity with the finding of Venkat Reddy *et al.* (2004) who reported that with increased levels of S application from 0 to 30 kg ha^{-1} there was increase in S uptake (7.22 to 10.98 kg ha^{-1}) by onion bulbs. The different times of sulphur application significantly influenced the S-uptake by the crop. The split application of sulphur and full dose at 30 DAS showed their superiority with respect to S uptake by garlic over one time application as basal. The mean S uptake by garlic cloves was non significant when S was applied as two equal splits (17.1 kg S ha^{-1}) or full dose at 30 DAS (17.2 kg ha^{-1}).The interaction of different levels and timings of S application showed significant effect on S uptake by garlic bulbs. The application of S @ 40 kg ha^{-1} in two equal splits (1/2 as basal + 1/2 at 30 DAS) recorded maximum uptake of S (17.9 kg ha^{-1}) by garlic bulbs over 20 and 30 kg S ha^{-1}.

Per cent sulphur derived from fertilizer (Sdff)

The mean per cent Sdff in garlic bulbs at harvest increased significantly from 20.3 to 24.9 per cent with increasing the level of S application from 20 to 40 kg ha^{-1} (Table 4). This increase in per cent Sdff in bulbs of the crop with the increased fertilizer application is expected because a large amount of S becomes accessible to the crop with its increased application. Venkata Reddy *et al*.(2004) reported that the per cent Sdff in onion bulbs at harvest increased from 26.6 to 30.8 due to increased application of sulphur from 20 to 40 kg ha^{-1}. The mean per cent Sdff in bulbs of the crop was found to be significantly higher (28.8%) when S was applied in two splits when compared to one time application either as basal (22.0 %) or at 30 DAS (16.8%). The interaction of different levels and timings of S application showed significant impact on per cent Sdff. The maximum per cent Sdff (34.5 %) was obtained at 40 kg S ha^{-1} when applied in two equal splits over 20 (24.8%) and 30 kg S ha^{-1} (27.2%).At all levels, sulphur application at 30 DAS made a significant decrease on per cent Sdff by garlic compared to its application either at sowing or as two equal splits.

Fertilizer S uptake

The fertilizer S uptake by the crop increased significantly with increase in applied S level from 20 to 40 kg ha^{-1}. The maximum fertilizer S uptake (4.23 kg ha^{-1}) by the crop was noticed when S was applied @ 40 kg ha^{-1}. The fertilizer S uptake increased by about 38.69 % due to increase in sulphur application from 20 to 40 kg ha^{-1}.The fertilizer S uptake by the crop increased significantly with increment of S application whether the entire dose of S is applied at one time at sowing or at 30 DAS or in two equal splits at sowing and at 30 DAS (Table 5).The maximum uptake of S by the crop from fertilizer (4.91kg ha^{-1}) was noticed when S was applied in two equal splits irrespective of level of S applied to the crop. It is obvious that the fertilizer S uptake by the bulb was significantly higher when S was applied in two splits compared to single time application either as basal or at 30 DAS due to its continued availability during crop growth period. The interaction of different levels and timings of S application showed significant impact on fertilizer S uptake by the crop. Application of 40 kg S ha^{-1} in two equal splits recorded significantly highest fertilizer S uptake (6.07 kg ha^{-1}) by the crop when compared to 20 (3.93 kg ha^{-1}) and 30 kg S ha^{-1}(4.72 kg ha^{-1}).Fertilizer S uptake by the crop at different levels of S was non significant when full dose was applied as basal or at 30 DAS.

S-utilization

The utilization of applied S by bulbs of garlic was more influenced due to different times of application than the sulphur levels (Table 6). The utilization of applied S by garlic was found to be higher at 20 kg ha^{-1} (22.47%) level compared to 30 (17.15%) and 40 kg ha^{-1}(15.63%).Venkat Reddy *et al.* (2004) reported that the increase in S application from 20 to 40 kg ha^{-1} significantly decreased its utilization from 11.8 to 7.4% by onion. Sulphur application in two equal splits as basal and at 30 DAS has recorded the highest S use efficiency in garlic bulbs by 34.35% when compared to single time application either as basal (10.87%) or at 30 DAS (10.02%) respectively. In the treatment where the entire dose of S was applied at one time as basal at the time of sowing, the supply of sulphur to the crop gets decreased with time. But when the full dose of S was applied at 30 DAS, the crop suffers due to lack of available S in sufficient quantities to meet the plant requirements in the initial stages (up to 30 DAS).

When the S was applied in two splits (1/2 as basal+1/2 at 30 DAS) the supply of sulphur nutrient

Table 1. Physico- chemical characteristics of experimental soil

Characteristic	2007-08	2008-09	2009-10
pH	8.0	8.1	8.0
EC (dSm^{-1})	0.07	0.19	0.21
Available nitrogen ($kg\ ha^{-1}$)	141	152	148
Available phosphorus ($kg\ ha^{-1}$)	70	66	68
Available potassium ($kg\ ha^{-1}$)	424	384	326
Available sulphur ($mg\ kg^{-1}$)	5.6	7.8	8.6

Table 2. Effect of different levels and times of S application on garlic bulb yield ($kg\ ha^{-1}$)

Details	S-20 kg ha^{-1}				S-30 kg ha^{-1}				S-40 kg ha^{-1}				Control (with out S)	Grand mean
	2007	2008	2009	Mean	2007	2008	2009	Mean	2007	2008	2009	Mean		
Full dose as Basal	3206	3156	3012	3125	3108	3058	3012	3059	3157	3107	3003	3089	-	3091
½ as Basal+ ½ at 30 DAS	3255	3210	3070	3178	3420	3375	3319	3371	3494	3448	3344	3326	-	3326
Full dose at 30 DAS	3168	3120	2972	3087	3268	3222	3180	3223	3365	3317	3210	3297	-	3202
Mean	3210	3162	3018	3130	3265	3218	3170	3218	3339	3291	3186	3272	2871	
S Em±	M= 6.32, D= 6.58 ,MxD = 10.82													
CD (P=0.05)	M=13.32, D =13.82, M x D =22.22													

Note: DAS=Days after sowing , M=Methods and D=Doses

Table 3 . Effect of different levels and times of S application on sulphur uptake (kg ha^{-1}) by garlic cloves

Details	S-20 kg ha^{-1}				S-30 kg ha^{-1}				S-40 kg ha^{-1}				Control (with out S)	Grand Mean
	2007	2008	2009	Mean	2007	2008	2009	Mean	2007	2008	2009	Mean		
Full dose as Basal	13.5	13.9	12.1	13.1	13.9	14.4	12.9	13.8	15.2	15.5	14.7	15.1	-	14.0
½ as Basal+ ½ at 30 DAS	16.3	16.7	15.0	16.0	17.5	17.9	16.6	17.3	17.0	18.6	18.1	17.9	-	17.1
Full dose at 30 DAS	17.1	17.5	15.5	16.9	17.9	18.4	16.9	17.7	17.5	17.9	16.1	17.2	-	17.2
Mean	15.6	16.1	14.2	15.3	16.5	16.9	15.5	16.3	16.5	17.4	16.3	16.7	11.48	16.1
S Em±	M= 0.15 ,D= 0.16 ,MxD= 0.28													
CD(P= 0.05)	M=0.32,D=0.33,MxD=0.58													

Table 4. Effect of different levels and times of S application on per cent Sdff by garlic bulbs

Details	S-20 kg ha^{-1}				S-30 kg ha^{-1}				S-40 kg ha^{-1}				Grand mean
	2007	2008	2009	Mean	2007	2008	2009	Mean	2007	2008	2009	Mean	
Full dose as Basal	20.3	19.6	24.6	21.5	21.2	20.1	24.7	22.0	22.0	21.1	24.5	22.5	22.0
½ as Basal+ ½ at 30 DAS	23.1	23.2	27.9	24.8	26.9	25.0	29.6	27.2	35.4	31.5	36.4	34.5	28.8
Full dose at 30 DAS	12.4	14.1	17.1	14.5	14.7	16.3	19.8	16.9	16.7	17.9	21.9	18.9	16.8
Mean	18.6	19.0	23.2	20.3	21.0	20.5	24.7	22.0	23.5	23.5	27.6	24.9	
S Em±	M=0.10,D= 0.10 , MxD =0.21												
CD(P= 0.05)	M=0.23,D=0.23,MxD=0.44												

Table 5. Effect of different levels and times of S application on Fertilizer S uptake (kg ha^{-1}) by garlic bulbs

Details	S-20 kg ha^{-1}				S-30 kg ha^{-1}				S-40 kg ha^{-1}				Grand mean
	2007	2008	2009	Mean	2007	2008	2009	Mean	2007	2008	2009	Mean	
Full dose as Basal	2.73	2.73	2.96	2.81	2.97	2.88	3.20	3.02	3.34	3.27	3.60	3.40	3.08
½ as Basal+ ½ at 30 DAS	3.72	3.88	4.20	3.93	4.67	4.48	5.0	4.72	5.86	5.87	6.47	6.07	4.91
Full dose at 30 DAS	2.11	2.47	2.65	2.41	2.65	2.99	3.33	2.99	2.93	3.22	3.51	3.22	2.87
Mean	2.85	3.03	3.27	3.05	3.43	3.45	3.84	3.57	4.04	4.12	4.53	4.23	
S Em±	M= 0.16 ,D= 0.16 ,MxD=0.34												
CD(P=0.05)	M=0.36,D=0.36,MxD=0.70												

Table 6. Effect of different levels and times of S application on S utilization (%) by garlic bulbs

Details	S-20 kg ha^{-1}				S-30 kg ha^{-1}				S-40 kg ha^{-1}				Grand mean
	2007	2008	2009	Mean	2007	2008	2009	Mean	2007	2008	2009	Mean	
Full dose as Basal	13.65	13.63	14.82	14.03	9.90	9.61	10.67	10.06	8.35	8.18	9.0	8.51	10.87
½ as Basal+ ½ at 30 DAS	37.19	44.79	42.01	41.33	31.09	29.87	33.30	31.42	29.27	29.36	32.31	30.31	34.35
Full dose at 30 DAS	10.56	12.36	13.23	12.05	8.83	9.98	11.09	9.97	7.31	8.05	8.78	8.05	10.02
Mean	20.47	23.59	23.35	22.47	16.60	16.49	18.35	17.15	14.98	15.20	16.70	15.63	
S Em±	M= 0.11, D= 0.11, MxD =0.22												
CD(P= 0.05)	M=0.25,D=0.25,MxD=0.46												

was sufficient throughout the crop growth period. Hence, there was significant increase in bulb yield, S-uptake, per cent S derived from fertilizer, fertilizer S uptake and utilization of applied sulphur. This clearly indicates that shortage of sulphur to garlic in the early stage or at bulb formation stage results on reduced bulb yields. The interaction of different levels and timings of S application showed significant impact on utilization of applied S by the crop. Application of 20 kg S ha^{-1} in two equal splits recorded maximum S utilization (41.33 %) when compared to other levels 31.42 and 30.31% with 30 & 40 kg S ha^{-1} respectively and timings of S application. Significant reduction in utilization of applied S by the crop was noticed at higher levels of S application *i.e.,* at 30 and 40 kg ha^{-1} either applied full dose as basal (10.06& 8.51%) or at 30 DAS (9.97& 8.05%).

Thus, the present study indicated that a minimum of 30 kg S ha^{-1} in two splits (1/2 as basal + 1/2 at 30 DAS) would be beneficial to garlic crop in low S status soil for gainful yields though the higher application (40 kg ha^{-1}) can be positively beneficial to the crop, albeit, to a small extent without significance.

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IDENTIFICATION OF SOURCES OF RESISTANCE TO BROWN PLANTHOPPER, *Nilaparvata lugens* (Stal.) FROM RAIPUR LOCATION

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ABSTRACT

An experiment was conducted on resistant rice genotypes against brown plant hopper *Nilaparvata lugens* (Stal.) in the glass house, Department of Entomology, IGKV, Raipur (C.G.) during 2012-2013. The resistance was analysed through nymphal survival and ovipositional response as antibiosis parameter on different genotypes. The lowest nymphal survival (46.0 %) was found in resistant genotype R78554-145-1-3-2, while it was the highest (90.0 %) in susceptible check TN 1. Developmental period on resistant genotype R 1723-1413-3-357-1 was 17.68 days. Among different genotypes tested for their ovipositional effect on BPH, the genotype R1723-1411-2-356-1 had the lowest number of nymphal emergence (40.0) along with the highest number of unhatched eggs (53.20). The genotypes R 1723-1413-3-357-1 and IR 78554-145-1-3-2 were found promising source of resistance for BPH.

(Key words: Rice, BPH, varietal resistance, *Nilaparvata lugns*)

INTRODUCTION

Rice (*Oryza sativa* L.) is the primary staple food source for half of the world's population. The brown planthopper (BPH) *Nilaparvata lugens* (Stal.) (Hemiptera: Delphacidae) is a typical sap sucking pest of rice, which feeds on phloem sap near the base of plant and thus affects the growth of rice and results in 'hopperburn' in rice fields (Watanabe and Kitagawa, 2000). In addition to the feeding damage, it also transmits grassy stunt (Rivera *et al*., 1966), ragged stunt (Ling *et al*., 1978) and wilted stunt viral disease of rice (Chen and Cheng, 1978).

Host plant resistance has played an important role in the management of pests successfully during past two decades. Several resistant varieties have been developed and grown in different areas of India (Mathur *et al*., 1999 and Krishnaiah *et al*., 1999). The important BPH resistant varieties released in India were Jyothi, CO 42, Sonasali, PY 3, Suraksha,. Chandan, Vijram, Pavizham, MTU 4870 and Bhadra (Soundararajan *et al.,* 2005).The land races existing in different areas of India provide enough opportunity to select good sources of resistance through proper screening against this pest. Sources of resistance to BPH were first identified in 1967 (Pathak *et al.,* 1969).Since then many donors for resistance to BPH have been identified and used in breeding BPH-resistant varieties. Some of the donors are Mudgo, ASD7, Rathu Heenati, Babawee, ARC 10550, Swarnalata, T 12, Chin Saba, Balamawee, *Oryza officinalis, O. australiensis*, and *O. minuta* from cultivated and wild species of rice (Brar *et al.,* 2009).

Keeping this fact in view, the experiment was conducted in the glass house, Department of Entomology, College of Agriculture, IGKV, Raipur during the year 2012-13 to identify the potential sources of resistance to BPH from Raipur germplasm collection.

MATERIALS AND METHODS

Screening of different rice genotypes was carried in glass house as suggested by Kalode *et al.* (1979). The test genotypes along with checks were pre-germinated in petridishes and then sown in rows 5 cm apart in 50 x 40 x 7 cm wooden trays, containing well puddle homogenous soil. Each tray accommodated twenty four rows of test entries with 20 seedlings in each row including two middle rows of resistant check (Ptb 33) and susceptible check (TN1) and four border rows of susceptible check (TN1).

These trays were placed in 7.5 cm deep water on cement platform to maintain moisture level. When the seedling become 7 to 10 days old age, first and second instar nymphs were uniformly released on these seedlings, so that each seedling must be get infested with at least 8 to 10 nymphs. The observations were recorded on the basis of 0-9 scale, when more than 90 per cent TN1 seedling were killed by the brown planthopper insect.

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Scoring of seedling was done on the basis 0-9 scale as follows:

Score*	Rating	Symptoms
0	Highly resistant	No visible damage
1	Resistant	Partial yellowing at first leaf
3	Moderately resistant	Partial yellowing first and second leaves
5	Moderately susceptible	Pronounced yellowing and some wilting
7	Susceptible	More than halves of the plants are wilted or dead and remaining plants severely stunted
9	Highly susceptible	All plants dead

*Mean score of plant damage (Anonymous, 1996)

Seventeen resistant genotypes including standard checks were selected to study the BPH nymphal survival. These seventeen varieties were resistant to BPH in screening test and hence investigated in detail for BPH resistance. Ptb 33 (Pattambi) is standard BPH resistant check (Anonymous, 1996). To get the regular supply of insect for various studies, the brown planthopper (BPH), was mass reared initially at $30^0 \pm 5^0$C on potted TN 1 (Taichung Native) variety and the population was maintained throughout the year in the air cooled glass house. High degree of resistance i.e. antibiosis to *Nilaparvata lugens* can be studied by nymphal survival, nymphal developmental period and growth index value (Alagar and Suresh, 2007 and Khinkhin *et al*., 2009). Both for nymphal survival test and oviposition behaviour test of BPH, the well germinated seeds of resistant rice genotypes were sown in 500 ml earthen pots filled with fertilizer enriched puddled soil. After 30 days, the plants were covered by the Mylar tube with ventilating windows. For nymphal survival, 10 nymphs (First and second instar) were released in individual tube. The per cent nymphal survival was calculated by using following formula (Heinrichs *et al*., 1985).

$$\text{Per cent nymphal survival} = \frac{\text{Number of adult emerged}}{\text{Number of nymphs released}} \times 100$$

Developmental period was studied by counting the days taken by the nymphs to reach the adult stage (Pongprasert and Weerapat, 1979). Growth index (GI) of BPH on each genotype was computed from the data obtained from the experiments on nymphal survival and developmental period as below (Panda and Heinrichs, 1983).

$$\text{Growth Index (GI)} = \frac{\text{Per cent of nymphs survived}}{\text{Mean developmental period}}$$

Ovipositional test was carried out as per method adopted by Reddy *et al*. (2005). Per cent unhatched eggs were calculated by following formula.

$$\text{Per cent of unhatched eggs} = \frac{\text{Number of unhatched eggs}}{\text{Number of nymphs+Number of unhatched emerged eggs}} \times 100$$

Number of nymphs emerged + Number of unhatched eggs = Fecundity

Sex of insect was observed at adult stage. The male and female population was expressed in percentage.

RESULTS AND DISCUSSION

Nymphal survival

All resistant genotypes exhibited average nymphal survival values varied from 46.00 to 74.00 per cent which was significantly lower than the susceptible check TN 1 (90.0%). The nymphal survival value was significantly lower in all the tested genotypes and Ptb 33 than susceptible check TN 1(Table 1). Resistant check Ptb 33 showed nymphal survival of 56.00 per cent, which was significantly higher than IR 78554-145-1-3-2, and R 1723-1413-3-357-1 genotypes but significantly lower than 5 genotypes *viz.,* R 1700-309-1-171-1, R 1682-1997-61754-1, R 1747-4941-1-515-1, R 1700-304-1-161-1, R 1656-1146-5-513-1 and susceptible check TN 1. The genotype IR 78554-145-1-3-2 had the lowest nymphal survival (46.00%) followed by R 1723-1413-3-357-1 (48.00) which was significantly lower than the susceptible check TN 1. In all the resistant genotypes tested, the genotype R 1700-309-1-171-1 had the highest nymphal survival value (74.00 %) followed by genotypes R 1682-1997-61754-1, R 1747-4941-1-515-1, and R 1700-304-1-161-1 (64.00%), but it was significantly lower than the susceptible check variety TN 1.

Develomental period

All resistant genotypes exhibited developmental period values in the range of 11.38 to 17.68 days. Nine genotypes (R 1675-1844-2-1257-1, R 1723-1411-1-355-1, R 1723-1413-3-357-1, R 1682-1997-6-1754-1, R 1605-315-131-1, R 1700-301-1-155-1, R 1700-304-1-161-1, IR 78554-145-1-3-2 and IR 81166-39-1-2-3) showed significantly higher developmental period than susceptible check TN 1. In TN 1 susceptible check variety developmental period was 11.33 days, whereas, it was 18.18 days on Ptb 33. The genotype 1723-1413-3-357-1 had the highest value of developmental period (17.68 days) followed by R 1675-1844-2-1257-1 (17.45 days) and IR 78554-145-1-3-2 (15.79 days), which was also significantly higher than susceptible check TN 1.

Among all the resistant genotypes tested, the genotype R 1700-309-1-171-1 had the lowest developmental period value (11.38 days) followed by PBS RC 68 (12.02 days) and R 1747-4941-1-515-1 (12.46 days), but it was not significantly different from susceptible check TN 1.

Growth index

Among all the resistant genotypes studied, the growth index (GI) values ranged from 2.71 to 6.50. The values showed that in resistant check Ptb 33, it was 3.08 and in susceptible check TN 1 it was maximum i.e. 7.94. The results revealed that the genotype R 1723-1413-3-357-1 had the lowest growth index (2.71) followed by IR 78554-145-1-3-2 (2.95) and R 1675-1844-2-1257-1 (3.32). In general all the resistant genotypes tested showed the lower growth index value as compared to susceptible check TN 1.

The susceptible check TN 1 showed the highest female population value (64.78%) and lowest male population (35.22%). The highest male population per cent was found in genotype R 1723-1413-3-357-1 (59.00%) followed by R 1675-1844-2-1257-1 (58.76) which were significantly higher than TN 1.

Ovipositional behavior

Low fecundity (Total eggs) of BPH was observed on all resistant genotypes as well as on resistant check Ptb 33 than TN 1. The number of eggs laid by BPH female on all the resistant genotypes ranged from 84.60 to 125.20 which was lower than susceptible check TN 1 (154.20). The lowest fecundity of BPH was observed on the genotype R 1723-1413-3-357-1 (84.60) followed by R 1700-301-1-155-1 (89.00) and IR 78554-145-1-3-2 (93.20), while it was 80.40 and 154.20 on resistant check Ptb 33 and susceptible check TN 1, respectively.

The mean number of nymph emerged was significantly higher in susceptible check TN 1 (136.60), than all the tested genotypes and Ptb 33. Among resistant genotypes, the nymphal emergence values ranged from 40.00 to 103.40 (Table 2). The resistant check Ptb 33 had the nymphal emergence value of 29.80. The lowest number of nymphal emergence was found in genotypes IR 78554-145-1-3-2 (40.00) followed by R 1723-1413-3-357-1 (41.40) and R 1700-301-1-155-1 (43.00), while it was the highest in IR 81166-39-1-2-3 (103.40).

The mean number of unhatched eggs varied from 21.80 to 53.20 among the resistant genotypes, whereas it was minimum (17.60) in susceptible check TN 1 and maximum (50.60) in resistant check Ptb 33. The highest number of unhatched eggs was found in the genotype IR 78554-145-1-3-2 (53.20) followed by genotype R 1700-304-1-161-1 (48.80) and R 1700-301-1-155-1(46.00). All the resistant genotypes showed significantly higher number of unhatched eggs than the susceptible check TN 1.

The per cent unhatched eggs values ranged from 17.41 to 57.08 per cent among all resistant test genotypes, whereas it was 62.94 per cent and 11.41 per cent in checks Ptb 33 and TN 1, respectively. The highest percentage of unhatched eggs was found in the test genotype IR 78554-145-1-3-2 (57.08 %) followed by genotype R1700-301-1-155-1 (51.69 %). The genotype IR78554-145-1-3-2 showed the highest (70.72 %) reduced hatching over the susceptible check TN 1 followed by genotype R 1723-1413-3-357-1 (69.69), while the genotype IR78554-145-1-3-2 (66.92) showed the highest per cent increase in unhatching value over the susceptible check TN 1 (66.92 %) followed by genotype R 1700-301-1-155-1 (61.74 %).

Low nymphal survival, lower growth index value and prolonged nymphal development in resistant genotypes/varieties were earlier reported by Soundararajan *et al*. (2004),), Reddy *et al*. (2005),

Table 1. Per cent nymphal survival and developmental period of BPH on selected resistant rice genotypes

Sr. No.	Designation	Nymphal survival (%)	Developmental period (days)	Growth index (GI)	Male %	Female %
1.	R 1675-1844-2-1257-1	58.00 (49.67)	17.45	3.32	58.76 (50.30)	41.24 (39.70)
2.	R 1723-1411-1-355-1	56.00 (48.51)	14.05	3.98	57.43 (49.51)	42.57 (40.49)
3.	R 1723-1413-3-357-1	48.00 (43.85)	17.68	2.71	59.00 (50.31)	41.00 (39.69)
4.	R 1682-1997-6-1754-1	64.00 (53.18)	13.72	4.66	52.38 (46.79)	47.62 (43.21)
5.	PBS RC 68	54.00 (47.31)	12.02	4.49	48.00 (43.85)	52.00 (46.15)
6.	R 1605-315-131-1	54.00 (47.31)	13.64	3.95	44.00 (41.31)	56.00 (48.69)
7.	R 1656-1146-5-513-1	62.00 (52.02)	11.38	5.44	44.00 (41.31)	56.00 (48.69)
8.	Indira Sugandhit Dhan 1	58.00 (50.67)	12.54	4.62	48.57 (44.18)	51.43 (45.82)
9.	R 1688-2150-5-2060-1	58.00 (50.82)	12.54	4.62	43.90 (41.44)	56.10 (48.56)
10.	R 1747-4941-1-515-1	64.00 (53.18)	12.46	5.13	43.81 (41.41)	56.19 (48.59)
11.	R 1700-301-1-155-1	60.00 (50.82)	13.11	4.57	46.57 (43.03)	53.43 (56.98)
12.	R 1700-304-1-161-1	64.00 (53.23)	14.47	4.42	44.86 (48.65)	55.14 (48.03)
13.	R 1700-309-1-171-1	74.00 (59.45)	11.38	6.50	48.22 (43.98)	51.78 (46.02)
14.	IR 78554-145-1-3-2	46.00 (42.69)	15.79	2.95	47.00 (43.38)	53.00 (46.62)
15.	IR 81166-39-1-2-3	60.00 (50.82)	13.62	4.40	51.62 (45.80)	48.38 (44.20)
16.	PTB 33	56.00 (48.46)	18.18	3.08	60.66 (51.20)	39.34 (38.80)
17.	TN 1	90.00 (73.63)	11.33	7.94	35.22 (36.31)	64.78 (53.68)
	SEm±	2.08	0.43		3.87	3.87
	CD at 5%	5.87	1.23		10.93	10.93

· Average of five replications *Figures in the parenthesis are arc sin transformed values

Table 2 Ovipositional response of BPH on selected rice resistant genotypes

Sr. no.	Designation	No. of nymph emerged	No. of unhatched eggs	fecundity (No.)	% unhatched eggs	% reduced hatching over TN-1	% increase unhatched over TN-1
1	R1675-1844-2-1257-1	61.20 (51.54)	38.20 (38.16)	99.4	38.43	55.2	53.93
2	R1723-1411-1-355-1	78.60 (62.74)	31.20 (33.86)	109.8	28.42	42.46	43.59
3	R1723-1413-3-357-1	41.40 (40.03)	43.20 (41.05)	84.6	51.06	69.69	59.26
4	R1682-1997-6-1754-1	87.00 (69.55)	34.60 (35.93)	121.6	28.45	36.31	49.13
5	PBS RC 68	85.60 (68.01)	24.40 (29.56)	110	22.18	37.34	27.87
6	R1605-315-131-1	56.40 (48.70)	43.40 (41.19)	99.8	43.49	58.71	59.45
7	R1656-1146-5-513-1	69.80 (56.81)	34.00 (35.62)	103.8	32.76	48.9	48.24
8	Indira Sugandhit Dhan 1	66.40 (54.65)	34.80 (36.12)	101.2	34.39	51.39	49.43
9	R1688-2150-5-2060-1	91.40 (73.68)	24.80 (29.82)	116.2	21.34	33.09	29.03
10	R1747-4941-1-515-1	61.40 (51.64)	40.20 (39.33)	101.6	39.57	55.05	56.22
11	R1700-301-1-155-1	43.00 (40.95)	46.00 (42.69)	89	51.69	68.52	61.74
12	R1700-304-1-161-1	49.20 (44.53)	48.80 (44.31)	106.8	27.53	43.34	40.14
13	R1700-309-1-171-1	68.60 (56.01)	40.20 (39.33)	108.8	36.95	49.78	56.22
14	IR78554-145-1-3-2	40.00 (39.18)	53.20 (46.85)	93.2	57.08	70.72	66.92
15	IR81166-39-1-2-3	103.40 (97.49)	21.80 (27.79)	125.2	17.41	24.3	19.27
16	PTB 33	29.80 (33.05)	50.60 (45.35)	80.4	62.94	78.18	65.22
17	TN 1	136.60 (126.98)	17.60 (24.70)	154.2	11.41	-	-
	SEm±	2.37	1.48				
	CD at 5%	6.67	4.18				

· Average of five replications *Figures in the parentheses are arc sine transformed values

Maheshwari *et al*. (2006), Alagar and Suresh (2007) and Alagar *et al*. (2007). The variety of chemicals is released by the host plant as a defense mechanism (Rana and Dubey, 2010). The results on the reduction in the survival rate of BPH on resistant genotypes might be due to presence of antibiosis factors or presence of feeding deterrents (Sable and Rana, 2011). The genotypes R 1723-1413-3-357-1 and IR 78554-145-1-3-2 were found promising source of resistance for BPH. The genotypes with high and moderate resistance can be further investigated with advanced molecular techniques.

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SCREENING OF RIL MAPPING PLANT POPULATION OF RICE FOR BROWN PLANTHOPPER (*Nilaparvata lugens* Stal.) RESISTANCE

Sonali Kar[1] and M.G. Sable[2]

ABSTRACT

The brown plant hopper (*Nilaparvata lugens* Stal.) is one of the major insect pests of rice (*Oryza sativa* L.). Exploitation of host plant resistance is a major component to manage this pest. Mass screening of two hundred seventy lines of recombinant inbred lines (RILs) of Danteshwari/Dagad Deshi in F_9 generation was done under glass house condition for brown planthopper resistance during 2009-10. The lines found resistant for BPH were further tested by feeding test. Feeding rate measured by probing mark and honeydew excretion test. In the probing mark test lines showing more than about 25 punctures were considered as resistant and in the feeding test, such lines were considered resistant in which the feeding rate by the insect on particular lines was comparatively less. The result of probing mark showed that two recombinant inbred lines *viz.,* line number 77 and 79 exhibited transgressive segregation for reaction to BPH for this test, whereas 7 resistant lines *viz.,* 10, 46, 77, 102,155,163 and176 were obtained as per the result of feeding test.

(Key words: Rice, F_9 generation of RILs of Danteshwari/Dagad Deshi Screening, BPH, *Nilaparvata lugens*)

INTRODUCTION

Rice is one of the domesticated cereals, a tropical C_3 grass that evolved in a semi-aquatic, low-radiation habitat. Over half of the world's population depends on rice as a staple food. Engineering and breeding resistant plant varieties are the most effective and environmental friendly ways to manage agricultural pests and improve crop performance. The brown planthopper (*Nilaparvata lugens* Stal.) is one of the major insect pests of rice (*Oryza sativa* L.). Exploitation of host plant resistance is a major component to manage this pest. The important BPH resistant varieties released in India *viz.,* Jyothi, CO 42, Sonasali, PY 3, Suraksha, Chandan, Vijram, Pavizham, MTU 4870 and Bhadra (Soundararajan *et al.,* 2005). The inheritance of polygenic traits is complex. The basic assumption is that many genes with small and roughly equal effects govern the trait and expression of the trait is strongly influenced by the environment (Kar *et al.,* 2011). Selection becomes inefficient in such condition. Danteshwari, highly susceptible to BPH is high yielding and well adopted variety of Chhattisgarh while Dagad Deshi, resistant to BPH is tolerant to drought. To evaluate the plant resistance, screening is the quick and reliable method (Anonymous, 1996). As in F_9 generation homogeneity is almost get fixed and no further segregation occurs, a study was conducted to screen rice genotypes developed from recombinant inbred lines of Danteshwari/Dagad Deshi for BPH resistance under controlled conditions of glass house.

MATERIALS AND METHODS

Plant Material

The experimental material consisted of two parents *viz*., Danteshwari and Dagad Deshi, and their 270 recombinant inbred lines (RILs) in F_9 generation. The crosses were made to incorporate desirable characters of both the parents. These lines were evaluated for their reaction against BPH infestation during 2009-10. Mass screening of two hundred seventy lines of recombinant inbred lines (RILs) of Danteshwari/Dagad Deshi in F_9 generation was done under glass house condition for brown planthopper resistance using standard seedbox screening test (SSST) technique (Kalode *et al*., 1979). The lines found resistant for BPH were further tested by probing mark test and feeding test.

Characteristic features of parents

Sr. No.	Parent	Pedigree	Plant damage Score	Reaction to BPH
1.	Danteshwari	Shamridhi x IR 8608 -298	9.0	Highly Susceptible
2.	Dagad deshi	Land race	2.5	Resistant

Rearing of insect

The brown planthopper (BPH), was mass reared initially at 30^0 5^0C on potted TN 1 (Taichung Native) variety and the population was maintained in the air cooled glass house condition. Potted TN 1

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plants were placed inside the mass rearing cages for egg laying along with at least 3-4 pairs (Male and Female) of brown planthopper hill^{-1}. After 2-3 days, the females started egg laying inside the leaf sheath of paddy plants. When newly emerged nymphs reached to second instar, they were collected and used to infest the test materials for screening of mapping population.

Screening of mapping plant population (By SSST)

Screening of rice mapping plant population was carried by standard seedbox screening test (Kalode *et al.,* 1979). Seed of the test lines and check varieties (Susceptible TN 1 and resistant PTB 33) were pre-germinated in petridishes (10 cm diameter) and these germinated seeds were sown in rows 5 cm apart in 50 x 40 x 7 cm wooden trays, containing well puddle homogenous soil. When the seedling became 7 to 10 days old, sufficient number of first and second instar nymphs were uniformly released on these seedlings, so that each seedling must be get infested with at least 8 to 10 nymphs. The observations were recorded when more than 90 per cent TN 1 seedling were killed by BPH insect on the basis of 0-9 scale as below:

Score*	Rating	Symptoms
0	Highly resistant	No visible damage
1	Resistant	Partial yellowing at first leaf
3	Moderately resistant	Partial yellowing first and second leaves
5	Moderately susceptible	Pronounced yellowing and some wilting
7	Susceptible	More than halves of the plants are wilted or dead and remaining plants severely stunted
9	Highly susceptible	All plants dead

Probing mark test

Probing mark test was carried out according to methodology suggested by Natio (1964). For this purpose, seeds of identified promising recombinant inbred lines and check varieties TN 1 and PTB 33, respectively, were germinated separately in petridishes. Germinated seeds were sown into wooden trays containing well puddled soil. After seven days, the seedling of each RIL were removed from trays and washed thoroughly with water and then transferred individually into 15 cm long test tubes containing a few drops of water. One, two days old gravid female was introduced individually into each test tube and allowed to make punctures on the seedling for 12 hrs. The female was confined in test tube by plugging the mouth of test tube with the help of cotton swab. Thereafter, the seedlings were taken for staining in another tube containing erythrosine dye aqueous solution (Fig 1). Insect probing marks were counted visually after 30 minutes of staining.

Feeding tests

Honeydew excretion test was done to ascertain level of feeding as suggested by Sogawa and Pathak (1970). It was assessed by quantifying the area of honeydew excreted by the two females on the filter paper after 24 hours of confinement on the test genotype. The females were confined on test plant with the help of inverted glass funnel (Fig 2). White Whatman No.1 filter paper (10 cm dia) used for soaking honeydews, were dipped in a solution of bromocresol green (2 g l^{-1} ethanol) and allowed to dry in sunlight, so that the filter paper turned yellowish orange (Pathak and Heinrichs, 1982) initially and thereafter upon contact with honeydew secreted by females, blue spots appeared on the treated filter papers. As the concentration of the honeydew increased, the spots turned white in the center with the blue edges. The spots were traced on transparency and later on measured by keeping on millimeter square graph. For getting more nitrogen from plant sap hoppers generally used to feed voraciously and excrete out the honeydew. The amount of feeding by the insect on the test genotypes as well as susceptible (TN 1) and resistant check (PTB 33) expressed in terms of honeydew excretion per 2 female in mm^2 unit.

RESULTS AND DISCUSSION

There were 26 lines having scores between 0 to 3 (highly resistant). From the values presented below, it is clear that the scoring values obtained are skewed.

BPH reaction of recombinant inbred lines (RILs)

Score	Genotype / Lines
0-3	26 lines
3-5	38 lines
5-7	40 lines
7 9	133 lines

The 26 lines which were found highly resistant in the mass screening were then used in probing mark test (Table1). The number of punctures made by the insect in different lines was compared with the

Table. 1 Average number of probes caused by BPH on 26 RILs

S. No.	Genotype / Line No.	No. of punctures	S. No.	Genotype / Line No.	No. of punctures
1.	Danteshwari	7.83	17.	106	13.50
2.	Dagad deshi	31.16	18.	155	26.33
3.	10	20.83	19.	157	17.83
4.	14	24.00	20.	163	22.83
5.	46	20.50	21.	166	24.83
6.	47	19.83	22.	176	17.00
7.	63	20.00	23.	180	20.50
8.	66	14.16	24.	181	25.50
9.	75	21.83	25.	183	26.16
10.	77	37.16	26.	186	21.66
11.	78	21.50	27.	192	29.50
12.	79	31.66	28.	225	16.00
13.	102	19.83	29.	TN 1	10.33
14.	103	18.50	30.	PTB 33	39.33
15.	104	22.16		SE±	2.41
	105	21.00		CD@5%	6.75

Table. 2 Feeding response of brown planthopper on RILs

S. No.	Genotype / Line No.	Mean (mm^2 per 2 females)
1.	Danteshwari	80.5
2.	Dagad deshi	16.5
3.	10	14.75
4.	46	20.75
5.	77	22.25
6.	102	8.75
7.	104	27.75
8.	105	25.33
9.	155	14.00
10.	163	15.50
11.	176	9.66
12.	181	32.25
13.	TN 1	89.75
14.	PTB 33	21.5
	SE±	2.70
	CD@5%	7.71

Fig. 1. Probing mark test -Staining with 1.0 % erythrosine solution

Fig. 2. Honeydew excretion test of BPH on resistant rice genotypes

of punctures made in the checks (resistant check PTB 33 and susceptible check TN 1). The average number of probes made by the insect were 7.83 and 31.16 for the parents Danteshwari and Dagad deshi respectively. The results of probing behaviour indicated that the resistant lines received more number of probing punctures than the susceptible ones (Table 1). Lines showing more than 25 punctures were considered resistant. Line number 77, 79, 155, 181, 183 and 192 were having values more than 25, whereas the number of probe was 10.33 and 39.33 in TN 1 and PTB 33 respectively. Therefore, it can be inferred that these 6 lines out of 26 lines used in the probing mark test were found to be highly resistant. The result of probing mark showed that two recombinant inbred lines viz., line number 77 and 79 exhibited transgressive segregation for reaction to BPH for this test. The lines which showed good results in probing mark test only those were forwarded for feeding test by honeydew excretion method.

Honeydew excreted by brown plant hopper, Nilaparvata lugens (Stal) had been used as a criterion for determining the amount of sap ingested by the insect on resistant and susceptible rice genotypes. It was observed that the feeding activity on resistant lines was significantly less as compared to susceptible lines. The feeding rate of brown plant hopper in case of susceptible parent i.e. Danteshwari was found to be 80.5 mm^2 (relatively more) and 16.5 mm^2 (relatively less) in case of resistant parent Dagad deshi. Feeding rate was 21.5 mm^2 on resistant check PTB 33 and 89.75 mm^2 on susceptible check TN 1. The observations of feeding test for the selected 10 lines are presented in the table 2.

The values of feeding test obtained from ten resistant lines were compared with the values of the standard checks (resistant check PTB 33 and susceptible check TN 1). Those lines having honeydew excretion values less than 25 mm^2 were categorized as resistant. The result revealed that there were 7 lines out of the selected 10 lines having values less than 25 mm^2. Such lines were considered resistant as the feeding rate by the insect on these particular lines was comparatively less.

Therefore, it can be inferred that the line number 10, 46, 77, 102, 155, 163 and 176 showed values < 25 mm^2 in the feeding test and hence are considered as resistant. However line number 104, 105 and 181 showed values > 25 mm^2 and hence these 3 lines were considered as moderately resistant as per the result of feeding test.

Such influence of insect population behavior has also been reported by Reddy and Pasalu (2004) who studied the inheritance of resistance to the brown plant hopper (N. lugens) and found a single dominant gene present in Rathu Heenati to be effective, whereas Santhanalakshmi *et al*. (2010) reported the inheritance to be quantitative in nature in response to segregating population (F_3) from cross between the susceptible popular indica variety Swarna and the resistant variety PTB 33 for its reaction against Indian biotype of BPH. The identified resistant lines against Indian biotype should be tested against other prevalent biotypes of the region to identify the genotypes possessing resistance for local biotype.

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GENETIC DIVERGENCE STUDIES IN TOMATO (*Lycopersicon esculentum* MILL.)

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ABSTRACT

Twenty-one genotypes of tomato were assessed to know the nature and magnitude of genetic divergence during *rabi* season, 2011. Data were subjected through Mahalanobis D^2 multivariate and canonical analysis and subsequently genotypes were grouped into eight clusters. Maximum genotypes were in cluster I and II (6 in each). The clustering pattern indicated that there was no association between geographical distribution of genotypes and genetic diversity. The genetic drift and selection in different environments can produce greater diversity than geographical distance. High yielding genotypes of clusters VII and IV were highly diverse to genotypes of clusters VIII, V and VI, which contain genotypes with maximum number of fruits plant^{-1} and plant height. The characters namely, plant height, number of fruits plant^{-1}, fruit width, fruit yield, fruit length and average fruit weight were contributing maximum diversity and played dominant role in the improvement of tomato yield. Accession No. EC-41587 and EC-104044 in clusters VI and VIII showed more genetic distance from genotype SKAU-T-2 placed in cluster VII. Hybridization among these genotypes is expected to yield transgressive segregants for fruit number and size. Selection for divergent parents based on these characters is recommended for getting good hybrids or segregates in tomato.

(Key words: Tomato, D^2 statistics, divergence, canonical analysis)

INTRODUCTION

Present study is the maiden attempt to identify the diverse genotypes for attempting hybridization to develop varieties with better adaptation and higher yield. While formulating the tomato crop improvement programmes, understanding about the nature and the degree of genetic divergence available in the germplasm plays pivotal role. For development of hybrid, information on genetic divergence among parental lines is essential, because it is well established that the use of diverse parents resulted in the superior hybrids and desirable recombinations. Hence, the present investigation was carried out using Mahalanobis D^2 multivariate and canonical analysis techniques to examine the nature and magnitude of genetic divergence of twenty-one genotypes of tomato.

MATERIALS AND METHODS

Twenty-one tomato genotypes collected from NBPGR, New Delhi and other research institutes were grown during *rabi* season of 2011 at two locations in a randomized block design with three replication at Department of Horticulture, Institute of Agricultural Sciences, BHU, Varanasi. Thirty-five days old seedlings were transplanted at a spacing of 45 cm x 45 cm in a plot size of 3 m x 2 m consisting of 30 plants plot^{-1} in each replication. All the recommended agronomic practices were followed to raise a good crop. Observations were recorded on ten randomly selected plants of each genotype in each replication for eight characters viz., plant height (cm), number of branches plant^{-1}, number of fruits plant^{-1}, fruit length (cm), fruit width (cm), fruit diameter (cm), average fruit weight (g) and fruit yield q ha^{-1}. Genetic diversity between groups were estimated as per D^2 statistics of Mahalanobis's (Mahalanobis, 1936) following the procedure given by Rao (1952). All the eight correlated variables were transformed into uncorrelated linear combinations through Pivotal condensation method using the error variance – covariance dispersion matrix. The mean values of the uncorrelated linear combinations where computed to calculate D^2 values between all possible pairs of genotypes. The grouping of genotypes was done using Tocher's method as described by Rao. Canonical analysis (Rao, 1952) was carried out by calculating the first two vectors of canonical roots.

RESULTS AND DISCUSSION

Analysis of variance showed highly significant differences among genotypes for all the traits. The divergence for traits within the genotypes tested by Wilk's criterion was significant (χ^2 = 1449.66 for 160 d.f.), thus the analysis of genetic divergence among the genotypes used in the study was considered relevant.

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After computing D^2 values for all the possible pairs, twenty-one genotypes were grouped into eight clusters, which indicated a large genetic diversity (Table 1). The cluster I and II had the largest with six genotypes in each followed by cluster III with three and cluster IV with two genotypes. Cluster V, VI, VII and VIII included only one genotype in each. From the clustering behavior it is quite evident that clustering pattern is not based on geographical origin. In the present investigation, genotypes of same state were not spread in same cluster, but, were spread in different clusters. This suggested that geographical origin is not a single factor for genetic diversity in tomato. It may be either genetic drift or selection in different environments. Present results are also supported by the findings of Shashikanth *et al.* (2010) who also found that cluster grouping is not based on geographical origin in tomato.

Canonical analysis was employed to obtain the spatial positions of all the 21 genotypes on a graph (Fig. 1). Arbitrarily these were grouped into 8 clusters, thus confirming the clustering pattern obtained by D^2 statistics. The proportion of variation accounted for by the first two canonical roots were 62.92 and 22.95 per cent. The results suggests that classification of a number of genetic stocks using D^2 statistics provides a set of groups from which parents can be chosen for further breeding programmes and points to the potency of the method of grouping.

The intra and inter cluster distance represent the index of genetic diversity among clusters as given in table 2. The cluster IV recorded a maximum intra cluster distance 21.82, where as cluster III had the minimum distance of 8.31. With respect to inter cluster distance, cluster VII showed the highest distance from cluster VIII (134.18) while it was minimum (23.36) between cluster II and V. The larger cluster distance was also observed between cluster VI and VIII, cluster IV and VIII, cluster V and VII and cluster III and VIII. Based on distribution of genotypes into different clusters, hybridization of high yielding genotypes (SKAU-T-2, Punjab Chuhara and Sel.7) of cluster VII and IV with more number of fruits plant^{-1} and maximum plant height containing genotypes (EC-104044, EC- 41587 and EC- 385648) of cluster VIII, V and VI is suggested. These genotypes may be under taken in a hybridization programme for evolving good hybrids or segregants. For crop improvement, intercrossing among genotypes with outstanding mean performance was suggested by Rana and Singh (2010) and Shashikanth *et al. (*2010) in tomato.

The comparison of cluster means for different characters indicated considerable difference between clusters for all the characters (Table 3). The maximum cluster mean was observed for fruit yield (q ha^{-1}), average fruit weight and fruit length in cluster VII, however, cluster VIII recorded maximum number of fruits plant^{-1} followed by cluster V and VI. Cluster III had maximum fruit width and fruit diameter, while cluster VI had maximum plant height. Cluster I recorded maximum number of branches plant^{-1}. Inter crossing the genotypes from these clusters may result in wide array of variability for exercising effective selection for these traits. Narolia and Reddy (2012); and Muhammad and Ghafoor (2013) reported that clusters with wider distances can be useful in production of divergent hybrids and varieties in tomato crop. Ravindra *et al.* (2012) suggested the possible prediction of heterosis based on D^2 values and useful in rejection of inferior combinations in tomato.

Per cent character contribution towards total divergence among the tomato genotypes was maximum from plant height followed by number of fruits plant^{-1}, fruit width, fruit length and average fruit weight (Table 4). The principal components corresponding to the two largest eigen values supplied by the two best orthogonal vectors indicated that fruit yield (0.909) and average fruit weight (0.1331) were the most important primary cause of divergence, recorded high linear functions in the first component (Table 4). Number of fruits plant^{-1} (0.712) fruit yield (0.356) and average fruit weight (0.1764) were the secondary cause of divergence as they had highest linear function in the second component, thus it is clear that these are the basic common attributes of plant architecture.

De *et al.* (1988) proposed that traits contributing maximum towards the D^2 values need to be given great emphasis for deciding on the cluster to be chosen for the purpose of further selection and choice of parents for hybridization. Hence, selection for divergent parents based on characters like plant height, number of fruits plant^{-1}, fruit width, fruit

Table 1. Grouping of 21 tomato genotypes in clusters

Cluster	Number of genotypes	Genotypes
I	6	SKAU-KT-1, SKAU-KT-3, EC-126453, Pusa Early Dwarf, Arka Vikas, Pusa Ruby
II	6	EC-212358, EC-368956, EC-368978, EC-385607,EC-41579, EC-6148
III	3	Shalimar-I, Shalimar-II, Summer Market
IV	2	Punjab Chuhara, Sel.-7
V	1	EC-385648
VI	1	EC-41587
VII	1	SKAU-T-2
VIII	1	EC-104044

Table 2. Intra and inter cluster distance (D) values in 21 tomato genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII
I	**19.00**	44.65	27.13	44.08	46.26	61.89	71.95	95.94
II		**18.91**	48.32	67.42	23.36	37.46	97.04	89.85
III			**8.32**	23.56	60.09	76.05	53.75	103.89
IV				**21.82**	76.87	91.06	35.48	113.42
V					**00.00**	27.32	105.19	76.29
VI						**00.00**	116.17	93.72
VII							**00.00**	134.18
VIII								**00.00**

Table 3. Cluster means and percent contribution of yield contributing characters towards divergence in twenty-one genotypes of tomato

Character	Cluster							
	I	II	III	IV	V	VI	VII	VIII
Plant height (cm)	84.76	44.40	44.42	40.24	73.53	97.00	53.53	87.40
Number of branches plant $^{-1}$	12.46	9.09	8.40	10.24	9.33	7.47	10.00	11.73
Number of fruits plant $^{-1}$	33.98	38.49	30.54	38.25	62.64	55.50	47.06	153..87
Fruit length (cm)	3.28	4.30	3.96	5.41	3.74	3.73	6.70	1.75
Fruit width (cm)	5.30	4.30	5.46	5.43	3.03	3.45	4.94	2.10
Fruit circumference (cm)	15.87	13.98	17.04	16.79	10.08	11.98	14.99	7.25
Av. fruit weight (g)	28.67	33.04	39.49	43.32	20.55	30.37	52.22	4.44
Fruit yield (q ha $^{-1}$)	349.55	197.45	400.57	533.17	211.05	229.33	763.94	219.44

Table 4. Per cent contribution of different yield and its traits in 21 tomato genotypes

Character	Number of time appearing as first in the rank	Per cent contribution towards total divergence	Canonical vectors	
		D^2 Statistics	Vector I	Vector II
Plant height (cm)	43	23.24	-0.071	0.097
Number of branches plant $^{-1}$	11	5.95	0.000	0.027
Number of fruits plant $^{-1}$	29	15.67	-0.218	0.712
Fruit length (cm)	25	13.51	0.072	-0.084
Fruit width (cm)	28	15.13	0.057	-0.129
Fruit diameter (cm)	15	8.11	0.066	-0.102
Average fruit weight (g)	24	12.97	0.133	0.164
Fruit yield (q ha $^{-1}$)	10	5.40	0.909	0.356
Total	185	100	62.94 %	22.95 %

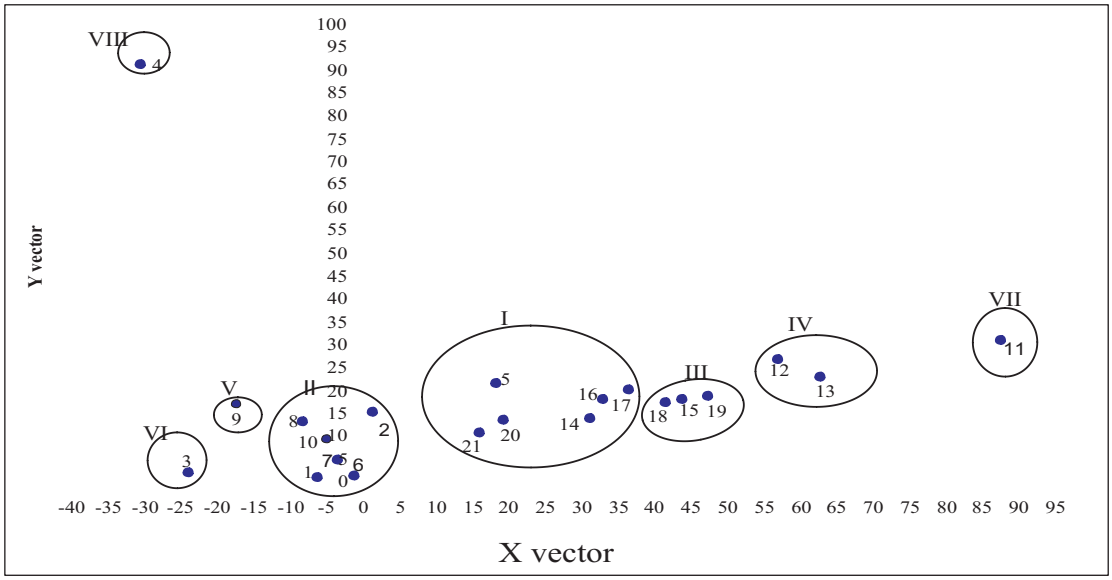

Fig. 1. Canonical diagram of first two vectors showing relative position of 21 tomato genotypes

length and average fruit weight will be useful for breeding hybrid as well as open pollinated varieties in tomato. Accordingly crossing among the distantly placed genotypes namely EC-41587, EC-104044 and SKAU-T-2 are proposed to obtain higher yielding segregants under Varanasi region.

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT (INM) ON YIELD AND NUTRIENT UPTAKE OF HYBRID RICE (*Oryza sativa* L.) IN PARTIALLY RECLAIMED SODIC SOIL

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ABSTRACT

A field experiment was carried out at Instructional Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) during *kharif* 2010-11 to study the effect of integrated nutrient management on yield and nutrient uptake of hybrid rice (*Oryza sativa* L.) in partially reclaimed sodic soil. The experiment was laid out by adopting Randomized Block Design with three replications. The treatments consisted of seven integrated nutrient management combinations i.e. T_1 - 100% RDF (150:60:60 kg ha^{-1}), T_2-75% RDF, T_3-50% RDF,T_4-75% RDF + 25% FYM-N, T_5 -50% RDF + 50% FYM-N, T_6 -25% RDF + 75% FYM-N and T_7 -100% FYM-N. Results revealed that, the treatment 75% RDF + 25% FYM-N recorded significantly higher grain yield (69.16 q ha^{-1}), total uptake of N (155.12 kg ha^{-1}), P (44.16 kg ha^{-1}) and K (158.24 kg ha^{-1}) and available soil N (174.20 kg ha^{-1}), P (16.82 kg ha^{-1}) and K (251.27 kg ha^{-1}) after harvest as compared to other treatments. The next best treatment was 100% RDF. Maximum gross income (Rs. 70489.4 ha^{-1}) was recorded under the treatment 75% RDF + 25% FYM-N followed by the treatment 100 % RDF (Rs.68066.2 ha^{-1}). The maximum net returns of Rs.43242.61ha^{-1} and B: C ratio of were recorded 1.64 under the treatment 100% RDF. Under the treatment 50% RDF + 50% FYM-N higher gross return of Rs.60557.0 ha^{-1} was obtained but net return (Rs.27871.12 ha^{-1}) was lower and B: C ratio (0.87) was also lower compared to 75% RDF. The highest cost of cultivation (Rs.37528.18 ha^{-1}) and minimum gross return (Rs.42235.8 ha^{-1}), net return (Rs.4707.62 ha^{-1}) and B: C ratio (0.12) were obtained under 100% FYM-N.

(Key words: Hybrid rice, Integrated Nutrient Management, sodic soil, growth, yield, uptake and economics)

INTRODUCTION

Rice (*Oryza sativa* L.), being one of the richest starch food, is consumed by about half of the world population. Production of rice ranks second among the food grain, and half of the world population subsist on rice by receiving the highest calories (26.2%) intake from it (Anonymous, 2005).Utter Pradesh is the largest rice growing state after West Bengal in the country, where rice is grown over an area of 5.63 m ha with production and productivity of 11.94 m t and 21.20 q ha^{-1} respectively (Anonymous, 2012). Area under hybrid rice in India is about 2.5 m ha, which is very low as compared to other rice growing countries *viz.,* China and Japan. Hybrid rice gives about 15-20% more yield than promising high yielding commercial rice varieties.

Salt affected (sodic) soils are those soils, which have an excess of soluble salt or an excess of exchangeable sodium (Na^+) or both in root zone to such an extent that it adversely affect crop growth besides toxicity, create physiological imbalance in growing plant. In India about 72 lakh ha of land was affected by salinity and alkanity. Its maximum area was in North India. Only in U.P. 13 lakh ha soil is affected by salts comprising districts *viz*; Aligarh, Eta, Meerut, Bulandshar, Manipuri, Hardoi, Kanpur, Unnao, Lucknow, Raibarely, Sultanpur, Gazipur, Pratapghar etc. (Singh, 2008).

Integrated nutrient supply involving combined use of organic and chemical fertilizer as nutrient sources has been developed. The use of adequate dose of organic source coupled with chemical fertilizers is expected to ensure optimum growth condition under intensive agriculture using rice hybrid. Singh *et al.* (2004) from Hissar reported that 100 per cent recommended NPK through chemical fertilizer, 50 per cent NPK through chemical fertilizer + 50 per cent N through FYM and 75 per cent NPK through chemical fertilizer + 25 per cent N through FYM in rice-wheat cropping system gave 39.21, 17.5 and 23.1 per cent higher returns over farmers' practice.

FYM, a by-product of dairy farm, is a potential source of plant nutrients. Organic resources are largely biological in origin and they have several nutrients in their composition, which on decomposition are released into soil. Future

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agriculture is poised again to make efficient and exploitive use of these organic manures for crop production, as it is established that they cut down the expenditure on chemical fertilizer at least by 50 per cent. It has been well established that the applied organic sources not only increase soil fertility but also improve soil physical conditions, which help in proper growth of plant and increased water holding capacity, aeration, permeability, soil aggregation and nutrient holding capacity and decreased bulk density and soil crusting due to the continuous use of organic manure (Das, 2011). Majumdar *et al.* (2007) reported that N, P and K uptake by paddy and various forms of N in soil increased significantly by application of fertilizer N along with Farm yard manure and nitrogen fixation bacteria. Keeping these in view, the present investigation was aimed at studying the effect of integrated nutrient management on hybrid rice in partially reclaimed sodic soil.

MATERIALS AND METHODS

A field experiment was conducted on silt loam (sodic soil) at Instructional Farm of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad which is situated at 26.47^0 North latitude and 81.12^o East longitude with an elevation of about 113 m from mean sea level in the Gangatic eastern Uttar Pradesh during the year 2010-2011 to study the effect of integrated nutrient management (INM) on hybrid rice (*Oryza sativa* L.) in partially reclaimed sodic soil.The area falls under subtropical zone which is characterized by hot and dry summer with cold winters. Rains are more often confined to the period from July to September with occasional winter and summer rains. The experimental field was well leveled having good irrigation and drainage facilities. The mean annual rainfall is 1200 mm. The soil of experimental field (0-15 cm) had pH (1:2.5) 8.9, EC 0.40 dSm^{-1} at 25^{o}C, organic carbon 0.25 per cent, available N 192.0 kg ha^{-1}, available P 14.21 kg ha^{-1} and available K 245.90 kg ha^{-1}. The integrated nutrient management treatments consisted of: 100% RDF i.e. 150 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} (T_1), 75% RDF (T_2), 50% RDF (T_3), 75% RDF + 25% FYM-N (T_4), 50% RDF + 50% FYM-N (T_5) 25% RDF + 75% FYM-N (T_6) and 100% N through FYM i.e. 30 t ha^{-1} (T_7), where FYM-N considered N, P and K source of RDF. The treatments were imposed as per the treatments details. Organic matter has solubilizing effect on some mineral compounds present in soil. During decomposition of organic matter various organic acids and CO_2 liberate in the soil which help to reduce alkalinity of soil (Das, 2011). The experiment was laid out in a Randomized Block Design with three replications having net plot size of 4 m × 4.95 m. Seed of hybrid rice was sown @ 17 kg ha^{-1}. Hybrid rice variety ARIZE-6444 was selected for cultivation in *kharif* season. Farm yard manure was incorporated according to the treatments at the time of field preparation and mixed thoroughly. One-third of nitrogen and full dose of phosphorus and potassium were applied as per treatments at the time of transplanting and remaining dose of nitrogen was applied in two equal splits at tillering and panicle initiation stages through urea. Recommended dose of fertilizers was applied @ 150 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} for hybrid rice. All recommended agronomic and cultural practices were followed for good rice crop in a sequence.

Grain and straw yields were recorded at maturity of crops; grain and straw samples were dried in oven at 65 ^{0}C. Total nitrogen in grain and straw samples were estimated after digestion in H_2SO_4 and H_2O_2 mixture by modified Kjeldahl method (Anonymous, 1975). For total P content, samples were digested with try acid mixture having nitrate, perchloric and sulphuric acid in 10:4:1 ratio and was determined by vanadomolybdo phosphoric yellow colour method and K determination by using flame photometer (Jackson, 1973). Uptake of N, P and K was computed by total nutrient content in grain and straw multiplying with corresponding yields of the crop. Composite surface (0-15 cm) soil samples from each plots were collected at the harvest. Soil samples were air-dried and pulverized to pass through 2 mm sieve. Soil samples were analyzed by using standard procedures as described for pH (Jackson, 1973), organic carbon (Walkley and Black's, 1956), available nitrogen (Subbiah and Asija, 1956), available phosphorus (Olsen *et al.,*1954) and available potassium (Jackson,1973).

RESULTS AND DISCUSSION

Crop yield

An examination of data from table 1 manifested that maximum grain yield (69.16 q ha^{-1}) was recorded under the treatment receiving 75% RDF

+ 25% FYM-N while the minimum grain yield (41.40 q ha^{-1}) was recorded under 100% N, P and K applied though FYM. Under treatments 100% RDF, 75% RDF, and 50% RDF where inorganic fertilizer was applied, the grain yield recorded was 66.68, 53.20 and 42.36 q ha^{-1} respectively while in the treatments where inorganic + FYM were applied together such as 50% RDF + 50% FYM-N and 25% RDF + 75% FYM-N recorded 58.47 q ha^{-1} and 47.91 q ha^{-1} grain yield respectively. Under the treatment 75% RDF + 25% FYM-N maximum grain yield was recorded which was at par with the treatment 100% RDF and significantly superior over other treatments. Singh *et al.* (2004) at Hissar reported that 100% RDF through chemical fertilizers, 50% through chemical fertilizer + 50% N through FYM in rice-wheat cropping gave higher rice yield over farmers' practice and thus, present findings are in agreement with their findings.

The maximum straw yield (83.12 q ha^{-1}) was recorded in the treatment having 75% RDF + 25% FYM-N. Under the treatments 100% RDF, 75% RDF, and 50% RDF where inorganic fertilizer was applied, the straw yield recorded was 81.01, 65.62 and 53.65 q ha^{-1} respectively. While in the treatments where inorganic + FYM were applied such as 50% RDF + 50% FYM-N and 25% RDF + 75% FYM-N, they recorded 78.30 q ha^{-1} and 56.20 q ha^{-1} straw yield respectively. Under the treatment 75% RDF + 25% FYM-N, maximum straw yield was recorded which was at par with the treatment 100% RDF and 50% RDF + 50% FYM-N and significantly superior over rest of the treatments. The increase in grain and straw yield of hybrid rice may be due to the conjunctive application of FYM and inorganic fertilizers.These findings corroborate with those obtained by Sowmya *et al.* (2011) where integrated use of nutrients 10 t FYM ha^{-1} along with 50% RDF gave significantly higher grain (5595 kg ha^{-1}) and straw yield (6700 kg ha^{-1}) followed by the treatments 5 t FYM ha^{-1} + 50% RDF and 100% RDF alone.

Nutrient uptake

Application of chemical fertilizers (N, P and K) in combination with FYM significantly increased the total uptake of N, P and K by hybrid rice (Table 1). The highest total N, P and K uptake in grain (112.73, 24.20 and 56.01 kg ha^{-1} respectively) of hybrid rice was obtained with the application of 75% RDF + 25% FYM-N and was almost at par with 100% RDF which recorded 102.68, 22.67 and 52.01 kg N, P and K ha^{-1} respectively and they had significantly higher uptake than other treatments. Minimum uptake values of the N, P and K were recorded in the treatment 100% N through FYM. Sowmya *et al.* (2011) reported that integrated use of 10 t FYM ha^{-1} along with 50% RDF showed higher nutrient uptake (121.41, 31.76 and 110.56 kg N, P and K ha^{-1} respectively) followed by 5 t FYM ha^{-1} + 50% RDF and 100% RDF. The findings are almost supported by the present findings. Majumdar *et al*. (2007) reported that N, P and K uptake by paddy and various forms of N in soil increased significantly by application of fertilizer N alone with Farm yard manure.

Soil properties and fertility status

The data on soil pH (Table 2) after harvest of hybrid rice revealed a significant variation ranging from 8.89 (50% RDF) to 8.59 (100% N through FYM), as against the initial value of 8.90. Maximum reduction of pH (8.59) was measured in the plot treated with 100% N through FYM, which was at par with rest of the treatments. An increase in pH from 8.8 to 8.9 in control plot was noticed by Nalatwadmath *et al.* (2003) in a long term fertilizer experiment for 15 years where application of ammonical fertilizer or FYM was reduced. The pH significantly decreased from 8.9 to 8.7, which was mainly attributed to the production of acids on decomposition of organic manure and use of ammonical fertilizer due to their acidic residual effect.

Perusal of data (Table 2) indicated that maximum value of EC (0.38 dSm^{-1}) was recorded in treatments having 75% RDF and 50% RDF through chemical fertilizers respectively. While the lowest EC (0.23 dSm^{-1}) was observed in the treatment where 100% N through FYM was supplied. The treatment 25% RDF + 75% FYM-N was found at par with the treatment 50% RDF + 50% FYM-N. The data showed that increase in FYM dose decreased soil electrical conductivity**.** The maximum organic carbon in soil (0.39%) was recorded in the treatment receiving 100% N through FYM, while the minimum (0.25%) in the treatments receiving 75% RDF and 50% RDF respectively. The organic carbon content in soil increased with the increase in dose of FYM. The treatment 100 % FYM-N was at par with the treatments 25% RDF + 75% FYM-N and 50% RDF+ 50% FYM-N having organic carbon content 0.37% and 0.35 % respectively. Srinivasarao *et al.* (2012)

Table 1. Integrated Nutrient Management on grain, straw yield and nutrient uptake under various treatments

Treatments	Yield (q ha^{-1})		Nutrient uptake (kg ha^{-1})								
			Nitrogen			Phosphorus			Potassium		
	Grain yield	Straw yield	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1- 100% RDF (150:60:60)	66.68	81.01	102.68	42.15	144.83	22.67	13.77	36.44	52.01	102.07	154.08
T_2 – 75% RDF	53.20	65.62	75.01	28.87	103.88	17.02	9.84	26.86	37.24	76.77	114.01
T_3 – 50% RDF	42.36	53.65	53.79	21.99	75.78	13.13	7.51	20.64	24.99	60.08	85.07
T_4- 75% RDF + 25% FYM-N	69.16	83.12	112.73	42.39	155.12	24.20	19.96	44.16	56.01	102.23	158.24
T_5-50% RDF + 50% FYM-N	58.47	78.30	92.96	37.58	130.54	19.29	11.74	31.03	41.15	94.74	135.89
T_6-25% RDF + 75% FYM-N	47.91	56.20	67.07	25.85	92.92	15.33	8.99	24.32	30.18	67.44	97.62
T_7- 100% FYM-N	41.40	50.09	53.40	21.03	74.43	12.42	8.01	20.43	26.08	59.10	85.18
SEm±	3.11	2.47	1.95	0.76		0.35	0.29		1.02	1.46	
CD (P= 0.05)	6.78	5.39	5.53	2.20		1.06	0.85		2.96	4.24	

Table 2. Effect of INM of fertility status of soil after harvest of hybrid rice

Treatments	Soil pH (1:2.5)	Soil EC (dSm^{-1})	Organic carbon (%)	Available N (kg ha^{-1})	Available P O (kg ha^{-1})	Available K_2O (kg ha^{-1})
T_1- 100% RDF (150:60:60)	8.84	0.37	0.26	172.30	15.00	248.00
T_2 - 75% RDF	8.88	0.38	0.25	152.40	14.50	222.40
T_3 -50% RDF	8.89	0.38	0.25	135.10	13.00	205.10
T_4-75% RDF + 25% FYM-N	8.78	0.34	0.32	174.20	16.82	251.27
T_5-50% RDF + 50% FYM-N	8.71	0.27	0.35	155.90	16.00	238.90
T_6-25% RDF + 75% FYM-N	8.64	0.26	0.37	140.00	15.12	233.10
T_7-100% FYM-N	8.59	0.23	0.39	138.03	13.95	230.90
SEm±	0.22	0.01	0.04	5.32	0.65	7.07
CD (P= 0.05)	0.67	0.04	0.02	16.39	2.01	21.78

Table 3. Effect of INM on economics of various treatments of hybrid rice

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Cost of cultivation (Rs.ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B: C ratio
T_1- 100% RDF (150:60:60)	66.68	81.01	25723.59	68066.2	43242.61	1.64
T_2 - 75% RDF	53.20	65.62	24694.37	54424.4	29730.03	1.20
T_3 -50% RDF	42.36	53.56	23665.80	43503.0	19837.20	0.83
T_4-75% RDF + 25% FYM-N	69.16	83.12	28464.73	70489.4	42024.67	1.47
T_5-50% RDF + 50% FYM-N	58.47	78.30	31685.88	60557.0	27871.12	0.87
T_6-25% RDF + 75% FYM-N	47.91	56.20	34507.03	48665.2	14158.22	0.41
T_7-100% FYM-N	41.40	50.09	37528.18	42235.8	4707.62	0.12

also reported that application of farm yard manure (FYM) without and with mineral fertilizers increased C input and SOC concentration and stock. In comparison with the control, the 100% organic (FYM) treatment had significantly higher profile SOC (27.5 Mg ha^{-1}), and more C build up (55.0%) and C sequestration (6.6 Mg C ha^{-1}) to 1m depth vis-à-vis the antecedent values.

Available N, P and K status of soil after harvest of crop increased considerably with addition of FYM (Table 3). The maximum build up of available N, P and K (174.20, 16.82 and 251.27 kg ha^{-1} respectively) was obtained with conjunctive use of 75% RDF + 25% FYM-N. Dixit and Gupta (2000) reported earlier that increase in N, P and K contents of soil under conjoint application of FYM and inorganic fertilizers increased as compared to inorganic fertilizer alone. An organic material like FYM form a protective cover on sesquioxides and this facilitates reduction in the phosphate fixation capacity of soil. Similarly by the beneficial effect of FYM on available potassium may be ascribed to the reduction in potassium fixation, solubilization and release of potassium due to interaction of organic matter with clay (Tandan, 1987).

Economics

The cost of cultivation was marginally increased when the nutrients were applied through the combination of organic sources, but due to higher grain and straw yields, gross returns (Rs.70489.4 ha^{-1}) was also higher under the integrated use of organic and inorganic sources (75% RDF + 25% FYM) of nutrients but second in net return Rs.42024.67 ha^{-1} and B: C ratio 1.47 (Table 3). The higher net returns (Rs. 43242.61 ha^{-1} and the highest benefit: cost ratio 1.64) were obtained under the treatment 100% RDF. The minimum net return of Rs. 4707.62 ha^{-1} and maximum cost of cultivation of Rs.37528.18 ha^{-1} were computed in the treatment 100% N through FYM. Alone use of inorganic fertilizer under 75% RDF and 50% RDF obtained grass returns of Rs.54424.4 ha^{-1}, and Rs.43503.0 ha^{-1}, net returns of Rs.29730.03 ha^{-1} and Rs.19837.20 ha^{-1} and B: C ratio of 1.20 and 0.83 respectively. Conjugative use of FYM and inorganic fertilizes under the treatment 50% RDF + 50% FYM and 25% RDF + 75% FYM obtained gross returns of Rs.60557.0 ha^{-1} and Rs.48665.2 ha^{-1}, net returns of Rs.27871.12 ha^{-1} and Rs.14158.22 ha^{-1} and B: C ratio of 0.87 and 0.41 respectively. The cost of cultivation increased with increased dose of organic fertilizers e.g. FYM.

From the above results, it is found that the hybrid rice variety ARIZE-6444 produced higher grain (69.1 q ha^{-1}) and straw yield (83.1 q ha^{-1}) with application of 75% RDF + 25% FYM-N showing increase in available status of N, P_2O_5, K_2O and organic carbon and also gross returns followed by 100% RDF.

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VARIABILITY STUDIES FOR QUALITATIVE AND QUANTITATIVE TRAITS IN ADVANCED LINES OF OAT (*Avena sativa* L.)

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ABSTRACT

Genetic variability was estimated among thirty four genotypes of oat during *rabi* 2010 at the All India Co-ordinated Research Project on Forage crops, Seed Breeding Farm, JNKVV, Jabalpur(MP). Observations were recorded on days to harvest, plant height (cm), internode length (cm), peduncle length (cm), panicle length (cm), panicle weight (g), spikelets panicle^{-1}, chlorophyll content (µg cm^{-2}), total dry matter yield (kg), total green fodder yield (kg), awn nature and awn colour. Analysis of variance indicated highly significant differences among the genotypes for all the characters studied. The materials for the present study comprises of genotypes which were selected on the basis of performance for fodder yield and yield contributing characters in the previous generation and were derived from genotypes Kent and JO-1 subjected to doses of gamma rays which were grown in M_6 generation. In JO-1 population, the genotype JMO-187 had recorded maximum total green fodder yield while in Kent population the genotype JMO-429 recorded maximum total green fodder yield. The genotype JMO-448 had recorded highest panicle length and maximum number of spikelets panicle^{-1} in JO-1 population while in Kent population the genotype JMO-425 had recorded highest panicle length and maximum spikelets panicle^{-1}. High values of phenotypic and genotypic coefficient of variation was recorded for chlorophyll content followed by spikelets panicle^{-1}, total dry matter yield and total green fodder yield 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., chlorophyll content and spikelets panicle^{-1} suggesting the presence of additive gene action, thus there is scope for selection.Significant diversity for some qualitative traits was recorded during this investigation for awn nature and awn colour. The superior genotypes identified from these variability studies are JMO-187, JMO-448, JMO-425 and JMO-429.

(Key words: Oat, variability, PCV, GCV, heritability)

INTRODUCTION

Oat (*Avena sativa* L.) is an important forage annual crop of *rabi* season belongs to family Poaceae. The genus *Avena* incorporates diploid, tetraploid and hexaploid species based on a basic chromosome number of x = 7. *Avena sativa* L. and *Avena byzantina* K. Koch are the main species grown for fodder and grain. The cultivated oat *Avena sativa (*L.*)* (2n = 6x = 42), a natural allohexaploid, together with wild weedy hexaploid species like *A.sterilis* and *A.fatua*, have evolved through repeated cycles of introgression, hybridization and polyploidization, combining three distinct diploid genomes (AACCDD). The crop ranks sixth in world cereal production and is widely cultivated for fodder (as hay and silage) and feed for several years and accounts for at least 60 per cent of the total world production. The total world area under oat is approximately 26.8 m ha. Most of the oat grain worldwide is consumed as animal feed and is principally fed to dairy cattle, horses, mules and turkeys.The nutritive value of oat forage is high and dry matter digestibility is in excess of 75 per cent when fed to dairy cattle (Burgess *et al.,* 1972). The cereal straws have almost similar chemical composition but oat straws has more digestible organic matter and metabolizable energy (Cuddeford, 1995).In India, the oat is widely grown in Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, Himachal Pradesh, Rajasthan, Bihar, Gujarat, Andhra Pradesh and hilly tracts of southern plateau.

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 present investigation was conducted at All India Co-ordinated Research Project on Forage Crops, Seed Breeding Farm, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during the *rabi*

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2010-2011.Thirty four varieties of oat were treated with different doses(150,200,300 and 400 Gy) of gamma rays at Gamma chamber JNKVV, Jabalpur(MP) and response to the different doses of gamma rays in M_1 and onward generations were recorded. Seeds harvested in M_5 generation from the gamma rays treated populations and seeds of different mutants selected from the same generation were used as experimental materials for study in M_6 generation along with untreated population of same variety. The total treatments are mentioned below:

Treatments (M_6 population)

Sr.no.	Treatments	Variety	Mutagenic treatment	Sr. No.	Treatments	Variety	Mutagenic treatment
1	T_1	JO-1	Control	18	T_{18}	JMO-448	200
2	T_2	JMO-220	300	19	T_{19}	JMO-189	300
3	T_3	JMO-222	300	20	T_{20}	JMO-193	300
4	T_4	JMO-14	300	21	T_{21}	JMO-194	300
5	T_5	JMO-41	300	22	T_{22}	JMO-197	300
6	T_6	JMO-42	300	23	T_{23}	JMO-199	300
7	T_7	JMO-54	200	24	T_{24}	Kent	Control
8	T_8	JMO-56	200	25	T_{25}	JMO-425	300
9	T_9	JMO-71	200	26	T_{26}	JMO-424	300
10	T_{10}	JMO-75	200	27	T_{27}	JMO-421	300
11	T_{11}	JMO-79	200	28	T_{28}	JMO-419	300
12	T_{12}	JMO-131	200	29	T_{29}	JMO-415	300
13	T_{13}	JMO-139	200	30	T_{30}	JMO-413	300
14	T_{14}	JMO-149	400	31	T_{31}	JMO-407	300
15	T_{15}	JMO-159	300	32	T_{32}	JMO-404	300
16	T_{16}	JMO-158	300	33	T_{33}	JMO-401	300
17	T_{17}	JMO-187	300	34	T_{34}	JMO-429	300

Thirty four treatments as mentioned earlier including treated and untreated populations were sown in Randomized Complete Block Design with three replications. The sowing of experimental materials was done on 13.11.10. Each plot was maintained of size 3x10 m^2 and having three rows for each treatment in each replication. The distance between rows 30 cm and plants 5 cm was maintained. The following observations were recorded on five tagged plants in M_6 generation. Days to harvest, plant height (cm), internode length(cm), peduncle length (cm), panicle length (cm), panicle weight (g), spikelets $panicle^{-1}$, chlorophyll content (µg cm^{-2}), total dry matter yield (kg), total green fodder yield (kg), awn nature and awn colour. The relative chlorophyll content was assessed with a hand held chlorophyll meter. The analysis of variance for the experimental design was analyzed by the method given by Panse and Sukhatme (1954), heritability in broad sense was calculated by using the formula suggested by Hanson *et al.* (1956) and genetic advance as per Johnson *et al.* (1955).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences for all characters suggesting the presence of high genetic variability among the genotype assessed (Table 1). These results are in conformity with the findings of Bibi *et al.* (2012) who reported that all genotypes differ significantly with respect to days to harvest, plant height, internode length, total dry matter yield and total green fodder yield.

The genotypes were selected on the basis of mean performance of genotypes for different quantitative characters i.e. days to harvest, the range for days to harvest for JO-1 population was from 98.14 to 109.00 days, the genotype JMO-42 (98.14) was early maturing and late maturing variety was JMO-448 (109.00) while in Kent population for days to harvest ranged from 103.54 to 107.61 days, the genotype JMO-404 (103.54) was early maturing and late maturing variety was JMO-415 (107.61), for plant height the genotypes JMO-448 (119.24 cm) andJMO-220 (98.80 cm) were recorded maximum and minimum plant height in JO-1 population while in Kent population the genotypes JMO-415 (117.98 cm) and JMO-424 (103.25 cm) recorded maximum and minimum plant height, for internode length in

JO-1 population, highest value of internode length was recorded in genotype JMO-131(15.40 cm) while lowest internode length was observed in the genotype JMO-193(11.40 cm) while in Kent population maximum internode length was observed in the genotype JMO-429 (14.00 cm) and minimum internode length in the genotype JMO-424(12.60 cm), for peduncle length in JO-1 population maximum length was recorded in the genotype JMO-448(42.00 cm) while minimum in the genotype JMO-41 (34.03 cm), while in Kent population genotypes JMO-429(39.22 cm) and JMO-404 (36.76 cm) were recorded maximum and minimum peduncle length respectively (Table 2).

For panicle length in JO-1 population genotype JMO-448(24.67 cm), had maximum panicle length while minimum was observed in the genotype JMO-424(18.40 cm), while in Kent population genotypes JMO-425(23.75 cm) and JMO-424 (18.40 cm) were recorded maximum and minimum panicle length. The genotypes JMO-448 (12.60g) and JMO-149(6.70g) were recorded maximum and minimum panicle weight in JO-1 population, while in Kent population genotype JMO-425 (12.50g) recorded maximum whereas genotype JMO-429(7.90g) recorded minimum panicle weight, for spikelets panicle^{-1} in JO-1 population maximum number of spikelets panicle^{-1} was counted in JMO-448 (197.21) and minimum was recorded in JMO-159 (82.05), while in Kent population genotypes JMO-425 (198.53) and JMO-424 (82.05) showed maximum and minimum number of spikelets panicle^{-1}, for chlorophyll content in JO-1 population, maximum amount of chlorophyll content was recorded in genotype JMO-448(34.31 µg cm^{-2}) and minimum was recorded in genotype JMO-54(12.81 µg cm^{-2}), while in Kent population genotypes JMO-425(39.35 µg cm^{-2}) and JMO-424 (10.47 µg cm^{-2}) showed maximum and minimum amount of chlorophyll content. The genotypes JMO-448 (8.25 kg) and JMO-54 (3.55 kg) were recorded maximum and minimum total dry matter yield in JO-1 population, while genotypes JMO-413(8.23 kg) and JMO-424 (3.25 kg) were recorded maximum and minimum total dry matter yield in Kent population, for total green fodder yield in JO-1 population highest quantity fodder yield produced was recorded in the genotype JMO-187(39.55 kg) while least was observed in JMO-54(22.65kg), while in Kent population JMO-429(43.66kg) recorded maximum and JMO-425(21.45kg) recorded minimum total green fodder yield (Table 2).

Phenotypic coefficient of variation (PCV) was higher in magnitude than that of genotypic coefficient of variation (GCV) for chlorophyll content (35.48 and 30.86) followed by spikelets panicle^{-1} (31.44 and 26.11), total dry matter yield (23.44 and 19.41) and total green fodder yield (21.24 and 15.38) indicating the substantial modifying effect of environment in the expression of these traits (Table 3). Similar to these results Krishna *et al.* (2013) also observed that estimates of GCV was smaller than that of PCV suggesting influence of environment on them and Bibi *et al.* (2012) recorded that PCV was slightly greater than GCV for days to harvest, plant height and internode length indicating influence of environment on them. Sangwan and Arora (2011) also reported similar results for plant height and dry matter yield in fodder oat.

Heritability is the index of transmissibility of characters from parents; need to be studied in order to determine the extent to which the observed variation is inherited. High heritability estimates were observed for chlorophyll content(86.90), panicle length(84.40), panicle weight(83.10) and spikelets panicle^{-1}(83.00), such characters are governed by additive gene effects thus, there is scope for improvement through individual plant selection. Similar results were reported by Bahadur *et al.* (2008) who observed high heritability for panicle length and panicle weight in oat.

Chlorophyll content and spikelets panicle^{-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 Krishna *et al.* (2013) who observed that high heritability with high genetic advance for spikelets panicle^{-1}, plant height and green fodder yield which indicated the role of additive gene effects in the inheritance of these traits. Singh and Singh (2010) also recorded that, the heritability and genetic advance were high for characters like plant height, green fodder yield and dry matter yield indicating the involvement of additive type of gene action in controlling these characters (Table 3).

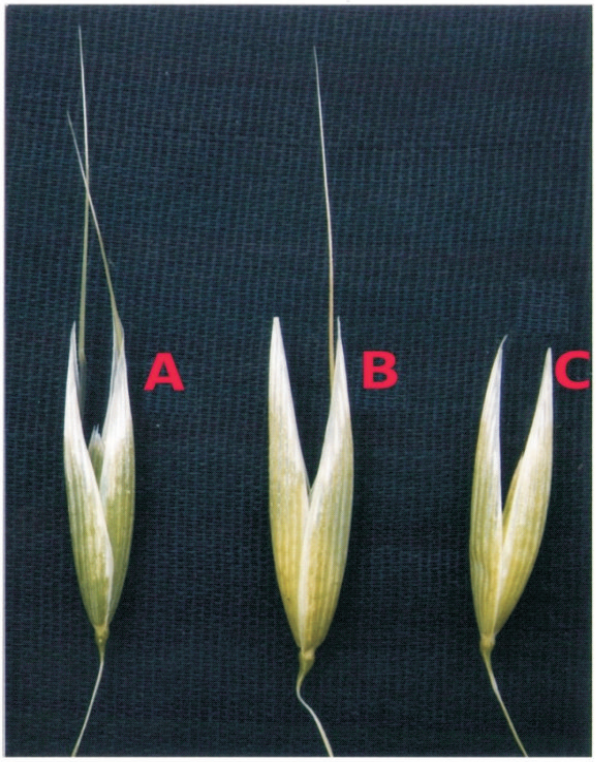

Fig.1. Presence of awn

A- Double awned, B-Single awened, c- Awnless

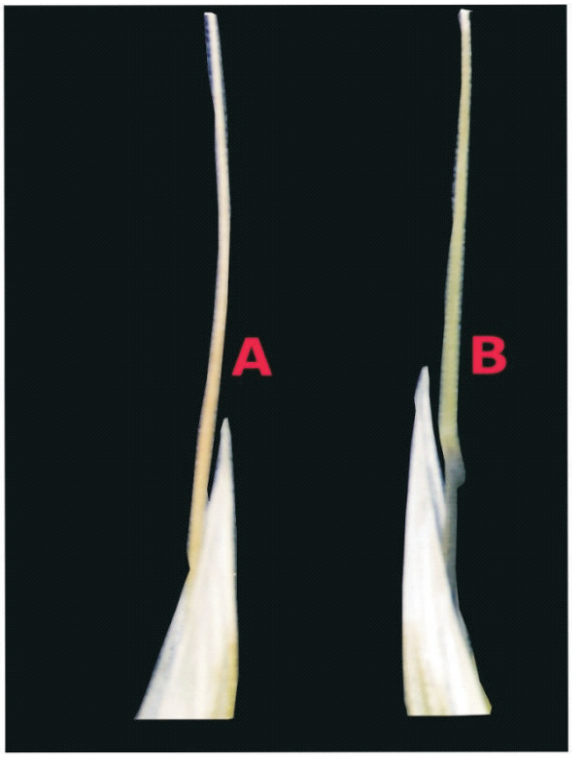

Fig.2. Awn colour

A-White colour awn, B-Black colour awn

Table 1. Analysis of variance for fodder yield and its components in oat

Source of Variation	d.f.	Days to harvest	Plant height (cm)	(cm)	Peduncle length (cm)	Panicle length (cm)
Replication	2	4.941	5.926	00.575	00.421	900.33
Genotype	33	17.996**	840.584**	200.383**	100.075**	80.556**
Error	66	10.296	00.555	0.682	0.742	00.495

Source of Variation	d.f.	Panicle weight (g)	Spikelets panicle $^{-1}$	Chlorophyll content (µg cm^{-2})	Total dry matter yield (k g)	Total green fodder yield (k g)
Replication	2	00.000098	20.1615	000.369	1100.382	170.582
Genotype	33	70.247**	316100.337**	1280.043**	50.161**	680.516**
Error	66	10.566	0.692	00.095	0.685	00.489

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

Table 2. Mean values of thirty four genotypes for different characters in oat

Sr. No.	Genotypes	Days to harvest	Plant height	Internode length	Peduncle length (cm)	Panicle Length (cm)	Panicle weight (g)	Spikelets panicle^{-1}	Chlorophyll content (µg cm^{-2})	Total dry matter yield (k g)	Total green fodder yield (kg)
1	JO-1	102.00	99.20	12.4	34.67	21.5	9.2	101.44	17.15	6.25	30.45
2	JMO-220	102.00	98.80	13.2	39.43	23.62	9.5	106.24	26.92	6.45	34.95
3	JMO-222	104.24	110.00	13.6	36.55	18.95	7.8	105.45	28.23	5.35	32.25
4	JMO-14	103.33	108.45	12.5	39.00	21.35	7.6	93.17	16.65	4.75	25.66
5	JMO-41	99.24	112.24	12.1	34.33	19.45	7.1	98.95	18.99	5.25	29.44
6	JMO-42	98.14	111.87	12.0	37.84	20.56	7.4	95.05	17.04	3.56	26.26
7	JMO-54	104.56	110.26	11.7	35.44	21.44	8.1	93.46	12.82	3.55	22.65
8	JMO-56	106.26	111.43	14.0	36.00	21.65	9.8	123.56	21.56	7.76	32.96
9	JMO-71	105.44	109.45	13.6	36.17	22.45	9.2	103.64	19.39	8.05	31.75
10	JMO-75	101.20	110.46	13.0	37.12	21.67	8.9	105.44	15.75	6.05	27.50
11	JMO-79	100.26	108.90	13.7	38.23	22.14	9.0	106.25	21.71	5.95	32.15
12	JMO-131	106.76	113.46	15.4	37.33	18.89	7.3	104.44	21.01	5.55	31.85
13	JMO-139	102.64	105.66	13.5	36.83	19.69	7.6	105.65	28.89	6.75	34.35
14	JMO-149	103.24	103.45	11.8	34.78	18.79	6.7	83.25	13.70	4.25	24.65
15	JMO-159	104.00	105.45	12.3	35.74	18.89	6.9	85.45	14.50	4.84	25.26
16	JMO-158	104.28	114.24	11.9	37.98	23.75	8.2	135.35	17.85	5.65	27.25
17	JMO-187	108.69	118.20	12.6	40.14	24.56	12.4	194.45	32.25	7.84	38.55
18	JMO-448	109.00	119.24	13.2	42.00	24.67	12.6	197.55	34.45	8.25	39.26
19	JMO-189	106.53	104.25	12.3	39.78	22.35	8.5	145	17.53	5.75	26.95
20	JMO-193	101.26	102.35	11.4	36.00	22.46	9.2	136.54	18.95	6.55	31.65
21	JMO-194	103.00	109.46	12.34	37.45	21.23	8.4	143.44	26.03	6.35	35.21
22	JMO-197	102.45	103.06	12.6	34.98	21.56	8.8	139.65	20.28	6.49	29.45
23	JMO-199	102.66	102.88	12.7	36.46	21.78	7.8	109.55	15.64	6.25	28.35
24	Kent	105.00	110.86	14.0	39.22	19.66	7.9	116.04	23.43	6.75	34.44
25	JMO-425	104.48	113.00	13.3	38.77	23.75	12.5	198.20	39.76	8.23	43.66
26	JMO-424	103.66	103.25	12.6	38.48	18.40	7.1	82.05	10.77	3.25	21.45
27	JMO-421	104.46	110.48	13.2	37.64	21.46	9.4	141.53	19.38	7.15	30.98
28	JMO-419	106.45	114.44	13.0	36.89	21.00	8.0	123.26	21.95	6.95	32.96
29	JMO-415	107.61	117.98	13.5	39.77	22.47	8.7	131.43	23.13	6.85	33.25
30	JMO-413	104.39	114.21	12.7	37.44	22.43	11.4	178.77	31.95	8.27	38.75
31	JMO-407	106.00	115.00	15.0	38.82	23.2	10	155.56	22.58	7.75	33.27
32	JMO-404	103.56	106.56	13.7	36.76	21.73	10.4	162.33	19.19	7.20	30.85
33	JMO-401	104.39	115.28	13.2	39.42	23.21	8.9	110.05	16.03	6.15	27.46
34	JMO-429	103.97	107.48	13.9	39.58	21.89	8.3	113.75	15.70	6.23	29.95

Table 3. Genetic parameters of variation for fodder yield and its components in oat

Characters	Range		Mean	Variances			Co-var.		Heritability broad sense (%)	Genetic advance as % of mean
	Min.	Max.		Phenotypic	Genotypic	Environment	GCV	PCV		
Days to harvest	98.14	109.00	141.51	2.982	2307	10.296	2.22	2.87	77.30	40.21
Plant height (cm)	98.80	119.24	600.112	28.565	28.009	00.555	6.23	8.54	72.90	9.86
Internode length (cm)	11.40	15.40	15.23	10.249	00.566	0.682	5.78	8.58	45.30	80.02
Peduncle length (cm)	34.03	42.00	37.55	3.853	30.111	0.742	4.69	5.22	80.70	19.55
Panicle length (cm)	18.40	24.67	21.55	30.182	2.687	00.497	7.60	8.27	84.40	29.05
Panicle weight (g)	6.70	12.60	8.84	20.4316	20.4019	00.023	15.25	18.35	83.10	35.97
Spikelets panicle^{-1}	82.05	198.53	124.27	1054.241	1053.241	0.6927	2611	31.44	83.00	41.06
Chlorophyll content (µgcm^{-2})	10.67	39.35	21.15	42.744	42.649	00.095	30.86	35.48	86.90	44.15
Total dry matter yield (k g)	3.0.25	80.27	60.29	20.177	10.492	0.685	19.41	23.44	68.50	33.10
Total Green fodder yield (k g)	21.45	43.66	30.95	23.165	22.675	00.489	15.38	21.24	72.40	31.35

Significant diversity for some qualitative traits was recorded during this investigation for awn nature and awn colour (Fig. 1 and 2). The genotypes JMO-159 and JMO-158 were double awned, JMO-56, JMO-71, JMO-75 and JMO-139 were single awned genotypes, while control JO-1 and JMO-187 were awnless genotype.Variation in awn colour was observed among the genotypes, straight type of awn was observed in JMO-75 and JO-1 (control) with white colour awn, while JMO-424 was with twisted and black coloured awns. These results are in conformity with the findings of Yu *et al*. (2007) who observed variation in awn colour and awn nature.

Above results indicated that a large amount of variation within accessions existed and such variation is helpful for plant breeder to exploit for the improvement of oat crop plants. Genetic variability was observed among the mutants for quantitative and qualitative traits which may increase the existing gene pool and the expression of heritability and genetic advance was found greatly influenced by gamma rays treatments. Such changes can be exploited in the improvement of desirable traits such as total green fodder yield, total dry matter yield, spikelets panicle^{-1} and plant height. Heritability estimates are of great importance to plant breeder primarily as a measure of the value of selection for particular characters in various types of progenies and a special tool for more accurate separation of variability due to inheritance. On the basis of mean performance of these characters superior genotypes JMO-187, JMO-448, JMO-425 and JMO-429 were identified.

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EVALUATION OF WHITE FLESH GUAVA (*Psidium guajava* L.) GENOTYPES FOR GROWTH, YIELD AND QUALITY ATTRIBUTES

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ABSTRACT

The present investigation was undertaken during the year 2011-12 at Fruit Research station Aurangabad, Marathwada Krishi Vidyapeeth Parbhani (M.S.). Eight white flesh guava genotypes viz., FRSG-W_1, FRSG-W_2, FRSG-W_3, FRSG-W_4, FRSG-W_5, FRSG-W_6, FRSG-W_7 and FRSG-W_8 were showed wide range of variation with respect to plant growth, yield and quality traits of fruit. However, the genotype FRSG-W_4 was found to be significantly superior in height of tree and stem girth while, the genotype FRSG-W_5 was significantly superior in plant spread. The highest length of fruit and breadth of fruit were recorded in genotype FRSG-W_8 and in genotype FRSG-W_7, respectively. The genotype FRSG-W_7 recorded maximum weight of fruit and yield and had significantly higher weight of pulp, pulp : seed ratio and volume of fruit. The genotype FRSG-W_8 had significantly lowest weight of seeds fruit^{-1} (2.50 g). The genotype FRSG-W_5 had significantly the higher TSS, ascorbic acid, total sugar and non-reducing sugar with maximum number of fruits tree^{-1}. While, the genotypes FRSG-W_5 and FRSG-W_7 had the lowest acidity and the highest reducing sugar. On the basis of different characteristics, genotypes FRSG-W_7 and FRSG-W_6 were found to be suitable for further improvement.

((Keywords: Guava genotypes, variability, yield and quality attributes)

INTRODUCTION

Guava (*Pisidium guajava* L.) belongs to the family Myrtaceae is one of the important fruit crop of India. Besides India, it is grown widely throughout the tropics of the world. Because of its better adoptability, guava is eulogized as 'the apple of tropics'. Guava fruit is rich in 'vitamin-C', minerals like calcium, iron and phosphorus with pleasant aroma. It is popular fruit of India due to its delightful taste, flavor and easy availability. Guava can resist water logged condition to a greater extent than other fruit crops and also withstand maximum temperature up to 45°C. Due in part to its ability to grow on a variety of soils and across a range of climates, guava has become invasive. Plant growth, yield and physico-chemical attributes are important parameters to study the variability among the different fruit crops.

MATERIALS AND METHODS

Eight genetically diverse white fleshed guava genotypes viz., FRSG-W_1, FRSG-W_2, FRSG-W_3, FRSG-W_4, FRSG-W_5, FRSG-W_6, FRSG-W_7 and FRSG-W_8 were evaluated with respect to growth, yield and quality traits of fruit at Fruit Research Station Aurangabad, Marathwada Krishi Vidyapeeth Parbhani (M.S.) on well established fourteen years old orchard of guava planted at 6.0 m X 6.0 m in winter season of year 2011-12. Observations were made on height of tree (m), spread of tree (m), girth of stem (cm), size of fruit (cm), weight of pulp (g), volume of fruit (ml) (Mazumdar and Mazumdar, 2003), weight of seeds fruit^{-1} (g), pulp:seed ratio, T.S.S. (°Brix), acidity (%), ascorbic acid (mg 100^{-1} g pulp) (Anonymous, 1984), total sugar (%), reducing sugar (%), non-reducing sugar (%) (Ranganna, 1979), number of fruits tree^{-1}, weight of fruit (g) and yield (kg tree^{-1}). The average values for each trait were worked out from the data of these fruits, which were then subjected to statistical analysis by method of analysis of variance using Random Block Design (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

Data showed (Table 1, 2 and 3) that genotypes differed significantly with respect to their growth, yield and physico-chemical attributes. It is evident from the results that genotype FRSG-W_4 had the maximum height of tree (4.96 m), followed by genotypes FRSG-W_3 (4.70 m) and FRSG-W_5 (4.45 m) with minimum in genotype FRSG-W_2 (3.50 m). The maximum height of tree might be due to the capacity of the plant root zone to absorb more nutrients causes vigorous growth. Similar findings were reported by Smita (2005) and Lakade *et al.* (2011). They reported a range of 2.90 m to 4.71 m and 3.71 m to 4.25 m, respectively. The plant spread recorded highest in genotype FRSG-W_5 (5.03 and 4.76 m) while,

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genotype FRSG-R_7 recorded the lowest value (3.03 and 3.0 m). This difference might be also due to individual growth behavior of different genotypes. Stem girth varied from 78.67 cm in genotype FRSG-W_4 to 36.30 m in genotype FRSG-W_8. Among all eight genotypes, maximum number of fruits tree^{-1} was recorded by genotype FRSG-W_5 (131.67), followed by genotype FRSG-W_7 (130.66) and minimum number of fruits tree^{-1} was recorded in genotype FRSG-W_1 (98.33). Smita (2005) found significant variation ranged from 109.5 to 241.2 in number of fruits tree^{-1} which support present results. The maximum weight of fruit was recorded in FRSG-W_7 (120.67 g), followed by genotype FRSG-W_1 (105.65).This might be due to maximum translocation of sink to the source. The minimum weight of fruit was found in genotype FRSG-W_5 (88.66 g). This might be due to less leaf area and low tree volume. The highest yield was recorded in genotype FRSG-W_7 (15.84 kg tree^{-1}) while, lowest fruit yield was found in genotype FRSG-W_4 (9.85 kg tree^{-1}). The higher yield was due to maximum spread of the plant produced more number of fruits tree^{-1} with greater size of fruit. Similar findings were reported by Smita (2005). She reported a range of 14.70 to 27.64 kg tree^{-1} fruit yield in different guava cultivars.

The highest length of fruit was recorded in genotype FRSG-W_8 (6.50cm) and lowest in genotype FRSG-W_4 (4.80 cm). The highest breadth of fruit was found in genotype FRSG-W_7,(6.16 cm) and least value in genotype FRSG-W_4(4.80cm)**.** The highest weight of pulp was recorded in genotype FRSG-W_7 (102.66 g), followed by FRSG-W_1 (93.33 g), while the lowest in genotype FRSG-W_5 (77.35 g). It might be due to the less number of seeds and minimum size of seed. The highest pulp per cent recorded in genotype FRSG-W_4 (88.13%) and the lowest value (80.07%) was recorded for genotype FRSG-W_5. The higher pulp per cent was due to the more pulp area or bigger size of fruit.

The highest volume of fruit was recorded in genotype FRSG-W_7 (119.60 ml) while the lowest in genotype FRSG-W_5 (89.66 ml). Similar findings were reported by Patidar *et al.* (2012). They reported a range of 55.00 ml to 186.25 ml volume of fruit in guava. The perusal of the data on weight of seeds fruit^{-1} had shown a wide range of variation from 2.50 g (FRSG-W_8) to 3.26 g (FRSG-W_2) among the genotypes. The lowest weight of seeds fruit^{-1} might be due to the lower weight of fruit. The results showed the significant variation in pulp: seed ratio. The highest pulp: seed ratio was (34.77) in FRSG-W_7, followed by FRSG-W_8 (33.14) and FRSG-W_1 (29.30). Similar findings were reported by Chaudhary *et al.* (2012). They reported highest pulp: seed ratio in L-49 (32.02) and lowest in R-72 (22.64).

The data regarding chemical analysis of fruit (Table 3) in terms of T.S.S. (°Brix), acidity (%), ascorbic acid (mg 100^{-1} g pulp), total sugar (%), reducing sugar (%), non reducing sugar (%) revealed that the highest TSS was recorded in genotype FRSG-W_5 (12.48 ^{0}Brix) followed by genotype FRSG-W_7 (12.16 ^{0}Brix) and lowest TSS was observed in genotype FRSG-W_8 (9.26 ^{0}Brix). It might be due to genetic makeup of genotypes. Singh (2003) found the highest TSS in genotype seedless (12.27 ^{0}Brix) which support present findings. The maximum (0.48%) acidity was recorded in genotype FRSG-W_1, followed by FRSG-W_8 (0.47%), whereas the minimum acidity was showed in both genotypes FRSG-W_5 and FRSG-W_7 (0.40%). Similarly, Patidar *et al.* (2012) reported 0.29% acidity in cultivar Chittidar and 0.48% acidity in cultivar Surkha. The highest ascorbic acid (287.55 mg 100^{-1} g) for guava was recorded in genotype FRSG-W_5, followed by genotype FRSG-W_4 (267.62 mg 100^{-1} g). The lowest ascorbic acid (217.32 mg 100^{-1} g) was found in FRSG-R_8 genotype. Similar findings were reported by Singh and Singh (2000). They reported the highest ascorbic acid in L-49 (294.5 mg 100^{-1} g) and the lowest in Allahabad Surkha (184.2 mg 100^{-1} g). The maximum total sugar (8.50%) was recorded in genotype FRSG-W_5, followed by genotype FRSG-W_7 (7.73%) and genotype FRSG-W_6 (6.48%) recorded lowest value. Similar findings were reported by Lakade *et al.* (2011a). They studied ten guava genotypes and found a range of 6.32% (GWS_5) to 8.47% (GWS_6) of total sugar. The highest reducing sugar (6.17%) was observed in genotype FRSG-W_2, followed by genotype FRSG-W_5 (6.12%) and the lowest reducing sugar was observed in genotype FRSG-W_8 (5.63%). Similarly, Chaudhary *et al.* (2012) reported 6.62 % reducing sugar in cultivar L. 49 and 4.74 % reducing sugar in cultivar Apple

Table 1. Performance of various white flesh guava genotypes for growth and yield characters

Genotypes	Height of plant (m)	Spread of plant (m)		Stem girth (cm)	Number of fruits tree^{-1}	Weight of fruit (g)	Yield (kg tree^{-1})
		N-S	E-W				
FRSG-W_1	3.88	4.16	3.9	70.0	98.33	105.65	10.50
FRSG-W_2	3.50	3.50	3.76	52.33	121.67	93.33	11.46
FRSG-W_3	4.70	3.40	3.60	42.66	105.0	100.30	10.62
FRSG-W_4	4.96	4.21	4.46	78.67	109.65	90.25	9.85
FRSG-W_5	4.45	5.03	4.76	50.33	131.67	88.66	11.89
FRSG-W_6	4.28	4.26	3.68	55.33	126.00	98.00	12.52
FRSG-W_7	4.07	3.03	3.00	54.35	130.66	120.67	15.84
FRSG-W_8	3.75	4.43	4.46	36.30	128.33	94.56	12.20
Mean	4.20	3.99	3.95	55.0	118.92	98.95	11.86
SE±	0.19	0.26	0.32	5.52	4.08	3.22	0.57
CD at 5%	0.58	0.80	0.97	16.73	12.37	9.76	1.73

Table 2. Performance of various white flesh guava genotypes for physical characters of fruits

Genotypes	Length of fruit (cm)	Breadth of fruit (cm)	Weight of pulp (g)	Pulp content (%)	Volume of fruit (ml)	Weight of seeds fruit^{-1} (g)	Pulp to Seed ratio
FRSG-W_1	5.50	5.66	93.33	81.10	105.00	3.20	29.30
FRSG-W_2	5.86	5.86	80.67	84.92	90.66	3.26	24.84
FRSG-W_3	6.40	5.63	83.42	82.96	102.33	3.18	26.63
FRSG-W_4	4.80	4.80	79.66	88.13	93.30	3.06	26.08
FRSG-W_5	5.43	5.60	77.35	80.07	89.67	3.05	25.37
FRSG-W_6	6.03	5.96	82.29	84.47	100.28	3.22	25.61
FRSG-W_7	6.23	6.16	102.66	85.35	119.60	2.96	34.77
FRSG-W_8	6.50	5.70	81.54	82.12	97.34	2.50	33.14
Mean	5.84	5.67	85.08	83.76	99.78	3.05	28.22
SE±	0.24	0.20	3.11	1.29	3.83	0.14	-
CD at 5%	0.75	0.61	9.43	3.87	11.61	0.44	-

Table 3. Performance of various white flesh guava genotypes for chemical characters of fruits

Genotypes	TSS (^{0}Brix)	Acidity (%)	Ascorbic acid (mg 100^{-1})	Total sugar (%)	Reducing sugar (%)	Non - reducing sugar (%)
FRSG-W_1	10.63	0.48	233.23	6.73	5.88	0.85
FRSG-W_2	10.73	0.46	246.85	6.83	6.17	0.66
FRSG-W_3	11.06	0.44	236.25	6.78	5.98	0.80
FRSG-W_4	11.50	0.42	267.62	7.47	5.97	1.50
FRSG-W_5	12.48	0.40	287.55	8.50	6.12	2.38
FRSG-W_6	11.36	0.44	262.31	6.48	5.87	0.61
FRSG-W_7	12.16	0.40	260.73	7.73	6.02	1.71
FRSG-W_8	9.26	0.47	217.32	6.74	5.63	1.11
Mean	11.15	0.44	251.48	7.15	5.95	1.17
SE±	0.42	0.01	11.08	0.24	0.14	0.13
CD at 5%	1.27	0.03	33.58	0.75	0.42	0.42

Colour. The highest non-reducing sugar content in genotype was observed in FRSG-W_5 (2.38%) and the lowest non-reducing sugar was observed in genotype FRSG-W_6 (0.61%).

Lakade *et al.* (2011) reported highest non-reducing sugar in genotype GWS_6 (3.31%) and lowest in GRS_1 (1.53%) which support the present results.

In the present investigation, it was observed that growth, yield and physico-chemical characteristics of fruits differed due to differences in genetic makeup of the genotypes and on the basis of different characteristics, genotypes FRSG-W_7 and FRSG-W_6 were found to be suitable for further improvement.

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ECONOMIC TRAITS DETERMINING SEED YIELD IN INDIGENOUS COLLECTION OF SOYBEAN (*Glycine max* (L.) Merrill)

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ABSTRACT

Fifty genotypes of soybean were grown under two environments in randomized block design with three replications during *kharif* 2011-12. Correlation coefficient and path coefficient analysis for all the quantitative characters for each environment and pooled were computed. The results revealed the existence of substantial amount of genetic variability for most of the yield and yield contributing characters like plant height, primary branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, seeds plant^{-1}, biological yield plant^{-1}, harvest index, nodules plant^{-1}. The genotypes namely S287, PI30781, IC15759 and JS79-214 showed high magnitude for the seed yield and yield components. Therefore, these genotypes could be recommended for commercial cultivation as well as for inclusion in further breeding programme as donor parents.

(Key words: Mean, correlation, path coefficient, soybean)

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is a self pollinated crop with low percentage of natural out-crossing. Taxonomically, the genus *Glycine* wild is a member of the legume family (*Leguminosae syn Fabaceae*), subfamily *Papilionoideae*, tribe Phaseoleae, and sub tribe Glycinininae. As currently delimited, the genus *Glycine* wild is divided into two subgenera, *Glycine* and *Soja* (Moench) F.J. Herm. The subgenus *Glycine* is now comprised of 16 wild perennial inbreeding species indigenous to Australia (Hermann,1962; Lackey,1977, Newell and Hymowitz and Singh,1987, Tindale and Craven,1993). The subgenus Soja includes the cultivated soybean, *Glycine max* and the wild annual soybean, *G.soja*. Both species are annual and diploid with 2n=40 chromosomes and hybridize readily. A weedy intermediate form between *G. max* and *G.soja* only occurs in Northeast China. Hermann (1962) removed *G. gracilis* from the species rank and incorporated it into *G.max*. It is an efficient producer of the two scarcest items in the world food economy that is high quality protein and oil. The whole bean contains about 40% protein, 20% carbohydrate, 20% oil, 4% ash and 8% moisture. The versatile plant serves as a natural soil fertilizer by fixing 50 kg nitrogen hectare^{-1}. For centuries soybean has served as an indispensable component in East Asian nutrition and cuisine. The soybean is the most important legume in the World in the terms of total production and international trade. World production was about 268.00 million tones and area about 108.75 million hectares (2012-13). India ranks fourth in the world as 10.8 million hectares area and production 12.55 million tons (2012-13) after USA, Brazil, Argentina and China with significant production in Bolivia, Canada, Indonesia, Paraguay and Thailand.

In India, area under soybean cultivation is around 100.80 lakh heacters with the production of 125.5 lakh tons in 2012 in comparison to 32000 hectares in 1970-71. From 10.80 million hectares area India produced 12.55 million tones soybean with 1162 kg ha^{-1} productivity in *kharif* 2012 while in Madhya Pradesh soybean covered 5.81 million hectares area to produce 6.68 million tones soybean with productivity of 1150 kg ha^{-1} (Anonymous, 2012). Soybean experienced phenomenal growth rate of 15-20% annum^{-1} which is one of the highest for any crop in the recent past. The significant contribution of M.P. (60-65%) in area and production which recognised as soya state of country. Considering the above facts present investigation was under taken to study the economic traits determining seed yield in indigenous collection of soybean (*Glycine max* (L.) Merrill).

MATERIALS AND METHODS

The experimental material consisted of 50 germplasms of soybean collected from the gene stocks of All India Coordinated Research Project on Soybean (AICRPS) at R.A.K. College of Agriculture, Sehore. The collected one hundred lines of soybean were sown on 2nd July, 2011. The major objectives to investigate major yield contributing traits in present genotypes and these to be used in future breeding

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work, The experiment was carried out in randomized complete block design with three replications. Each genotype was sown in two rows pattern with 3 meter row length, 40 cm row to row spacing with 2-5 cm plant to plant distance. The fertilizer dose of 20:60:20:20 NPKS kg ha^{-1} was applied uniformly over the soil and recommended package of practices and time to time plant protection measures were applied to raise the normal crop. A random selection of five plants in each genotype and replication was made and the observations were recorded on each selected plant. The mean values of each character under study were computed on the basis of five plants for each genotype in each replication. The genetic parameters like co-relation coefficients and direct and indirect effects were estimated through methods given by Singh and Choudhary (1985) and Deway and Lu (1959) respectively and were adopted.

RESULTS AND DISCUSSION

Phenotypic correlation coefficients

Plant height showed highly positive and strong association with biological yield $plant^{-1}$ (0.419), pods $plant^{-1}$ (0.383), seeds yield $plant^{-1}$ (0.382), seeds $plant^{-1}$ (0.375) and nodules $plant^{-1}$ (0.249). While 100 seed weight showed negative significant association (-0.327) (Table 2). These findings matched the earlier findings of Bangaer *et al*. (2003) for 100 seed weight (Table 2). Primary branches $plant^{-1}$ revealed significant positive relationship with seed yield $plant^{-1}$ (0.196). These results are in close harmony with the findings of Karnwal and Singh (2009). Pods $plant^{-1}$ expressed significant and positive association with seeds $plant^{-1}$ (0.928), seed yield $plant^{-1}$ (0.859), dry weight of nodules $plant^{-1}$ (0.523), biological yield $plant^{-1}$ (0.443), and seeds pod^{-1} (0.301). However, association was significant and negative with 100 seed weight (-0.500). These findings corroborated the earlier findings of Masoudi *et al*. (2008), Bhat and Basavaraja (2011) and Aditya *et al*. (2011) for seed yield $plant^{-1}$ and Bangaer *et al.* (2003) for seed weight. Seeds pod^{-1} expressed significant and positive association with seeds $plant^{-1}$ (0.614), days to maturity (0.540), seed yield $plant^{-1}$ (0.417), nodules $plant^{-1}$ (0.330), harvest index (0.271) and dry weight of nodules $plant^{-1}$ (0.251). However, association was found negative with growing degree days (-0.340). Seeds $plant^{-1}$ expressed significant and positive association with seed yield $plant^{-1}$ (0.858), nodules $plant^{-1}$ (0.650), dry weight of nodules $plant^{-1}$ (0.536) and biological yield $plant^{-1}$ (0.413). While it was negatively associated with 100 seed weight (-0.453). Biological yield $plant^{-1}$ showed strong significant and positive relationship with nodules $plant^{-1}$ (0.581), seed yield $plant^{-1}$ (0.555) and dry weight of nodules $plant^{-1}$ (0.447). While it was negative and significant with harvest index (-0.617). Correlation coefficient for harvest index was exhibited positive and significant with seed yield $plant^{-1}$ (0.251). While 100 seed weight showed negative significant (-0.240). These results corroborated the findings of Bhagat *et al.* (2007), Karnwal and Singh (2009), Bhat and Basavaraja (2011) and Aditya *et al*. (2011) for seed yield $plant^{-1}$. Nodules $plant^{-1}$ showed strong positive and significant association with dry weight of nodules $plant^{-1}$ (0.895) and seed yield $plant^{-1}$ (0.638). The estimated path coefficient are furnished in the table 2 and 3. In general the genotypic direct as well as indirect effect were slightly higher in magnitude as compared to corresponding phenotypic direct and indirect effects resulted true inheriant behavior of characters relationship. The results obtained from genotypic direct and indirect effect are presented as under.

Direct effects

Path coefficient analysis of different characters contributing towards seed yield $plant^{-1}$ showed that pods $plant^{-1}$ (0.955) had the highest positive direct effect followed by biological yield $plant^{-1}$ (0.587), harvest index (0.493), seeds pod^{-1} (0.388), 100 seed weight (0.320) and dry weight of nodules $plant^{-1}$ (0.115). Whereas seeds $plant^{-1}$ (-0.467), nodules $plant^{-1}$ (-0.266), days to maturity (-0.097) and plant height (-0.041) were found to be in negative direction. The present findings were in agreement of Karnwal and Singh (2009) for number of pods $plant^{-1}$, plant height, biological yield $plant^{-1}$ and harvest index.

Indirect effect

Plant height expressed the highest positive indirect effect on seed yield $plant^{-1}$ via pods $plant^{-1}$ (0.404), followed by biological yield $plant^{-1}$ (0.246),

fresh weight of nodules plant^{-1} (0.058), seeds pod^{-1} (0.048), dry weight of nodules plant^{-1} (0.025) and primary branches plant^{-1} (0.025). However, it had negative indirect effect of seeds plant^{-1} (-0.176), 100 seed weight (-0.105), nodules plant^{-1} (-0.066), harvest index (-0.011) and days to maturity (-0.008) on seed yield plant^{-1}. Primary branches plant^{-1} expressed the highest positive indirect effect through pods plant^{-1} (0.152), followed by harvest index (0.065), biological yield plant^{-1}(0.042),nodules plant^{-1}(0.011), dry weight of nodules plant^{-1}(0.008) and days to maturity (0.001).

Its negative indirect effect was through fresh weight of nodules plant^{-1} (-0.053), seeds plant^{-1} (-0.047) , 100 seed weight (-0.040) seeds pod^{-1} (-0.006), growing degree days (-0.003) and plant height (-0.003). Pods plant $^{-1}$manifested positive indirect effect through biological yield plant^{-1} (0.262), followed by seeds pod^{-1} (0.220), harvest index (0.096), dry weight of nodules plant^{-1} (0.062), fresh weight of nodules plant^{-1} (0.035), primary branches plant^{-1} (0.011) and growing degree days (0.002). It exhibited negative indirect effect viz., seeds plant^{-1} (-0.435), nodules plant^{-1} (-0.165), 100 seed weight (-0.161), plant height (-0.016) and days to maturity (-0.002). Seeds pod^{-1} expressed the highest indirect effect through pods plant^{-1} (0.327), followed by harvest index (0.139), biological yield plant^{-1} (0.014), days to maturity (0.005) and growing degree days (0.001). It exhibited negative indirect effect viz., seeds plant^{-1} (-0.090), 100 seed weight (-0.068), fresh weight of nodules plant^{-1} (-0.009), plant height (-0.005) and primary branches plant^{-1} (-0.001). Seeds plant^{-1} expressed the highest positive indirect effect through pods plant^{-1} (0.982) followed by biological yield plant^{-1} (0.245), seeds pod^{-1} (0.239), harvest index (0.110), dry weight of nodules plant^{-1} (0.064), fresh weight of nodules plant^{-1} (0.024), primary branches plant^{-1} (0.008) and growing degree days (0.001). It showed negative indirect effect through nodules plant^{-1} (-0.174), 100 seed weight (-0.146), plant height (-0.015) and days to maturity (-0.004). Biological yield plant^{-1} revealed high values of positive indirect effect on seed yield plant^{-1} through pods plant^{-1} (0.471), followed by dry weight of nodules plant^{-1} (0.053), fresh weight of nodules plant^{-1} (0.037), 100 seed weight (0.023), seeds pod $^{-1}$ (0.009), primary branches plant^{-1} (0.006) and growing degree days (0.004). It expressed a high negative indirect effect through harvest index (-0.305), seeds plant^{-1} (-0.195), nodules plant^{-1} (-0.156), plant height (-0.017) and days to maturity (-0.005). Harvest index expressed positive indirect effect on seed yield plant^{-1} through pods plant^{-1} (0.205), followed by seeds pod^{-1} (0.110), nodules plant^{-1} (0.031), primary branches plant^{-1} (0.010), days to maturity (0.002), plant height (0.001). It expressed a high negative indirect effect through seeds plant^{-1} (-0.104), 100 seed weight (-0.079), fresh weight of nodules plant^{-1} (-0.48), dry weight of nodules plant^{-1} (-0.013) and growing degree days (0.001). Growing degree days expressed positive indirect effect on seed yield plant^{-1} through fresh weight of nodules plant^{-1} (0.064), followed by biological yield plant^{-1} (0.056), pods plant^{-1} (0.042), dry weight of nodules plant^{-1} (0.020) and negative indirect effect on seed yield through days to maturity (-0.081), nodules plant^{-1} (-0.049), seeds pod^{-1} (-0.014), harvest index (-0.008), seeds plant^{-1}and plant height (-0.006), primary branches plant^{-1} (-0.005), and 100 seed weight (-0.002). Days to maturity was reported to have positive direct effect on seed yield plant^{-1} through fresh weight of nodules plant^{-1} (0.058), followed by growing degree days (0.032), biological yield plant^{-1} (0.027), pod plant^{-1} (0.024), dry weight of nodules plant^{-1} (0.017), seeds pod^{-1} (0.021), 100 seed weight (0.007). Its negative indirect effect was recorded through nodules plant^{-1}(-0.038), seeds plant^{-1} (-0.020), harvest index (-0.013), plant height (-0.004) and primary branches plant^{-1} (-0.001).100 seed weight expressed high positive indirect effect on seed yield plant^{-1} through seeds plant^{-1} (0.213), followed by seeds pod^{-1} (0.082), biological yield plant^{-1} (0.041), plant height (0.013), dry weight of nodules plant^{-1} (0.009), growing degree days(0.001). It expressed high negative indirect effect through pods plant^{-1} (-0.531), harvest index (-0.121), nodules plant^{-1} (-0.034), primary branches plant^{-1} (-0.010), fresh weight of nodules plant^{-1} (-0.009) and days to maturity (-0.002). Nodules plant^{-1} expressed high positive indirect effect on seed yield plant^{-1} through pods plant^{-1} (0.654), followed by biological yield plant^{-1} (0.343), seeds pod^{-1} (0.132), dry weight of nodules plant^{-1} (0.105), 100 seed weight (0.041), fresh weight of nodules plant $^{-1}$ (0.029) and growing degree days (0.007). It expressed high negative indirect effect

Table 1. Mean performance of different genotypes of soybean

Sr. No.	Name of Genotypes	Characters													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Plant height (cm)	Primary branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	Seeds plant^{-1}	Biological yield plant^{-1} (g)	Harvest index (%)	Growing degree days (^{O}C)	Days to maturity	100 Seed weight (g)	Nodules plant^{-1}	Fresh weight of nodules plant^{-1} (g)	Dry weight of nodules plant^{-1} (g)	Seed yield plant^{-1} (g)
1	EC287464	61.29	6.68	25.70	2.13	54.63	31.26	25.23	775.64	87.83	15.92	32.33	0.34	0.16	7.91
2	EC251762B	69.27	9.12	37.08	2.28	84.77	25.04	35.58	802.16	90.33	10.69	32.33	0.36	0.18	8.92
3	EC251531A	47.77	7.58	37.79	1.66	63.07	22.63	35.36	661.17	77.50	12.08	31.83	0.38	0.19	7.99
4	EC251496	51.18	9.55	32.66	2.04	66.81	23.36	35.31	854.46	93.83	13.02	44.67	0.55	0.27	8.24
5	EC389152	48.95	11.14	31.97	2.49	79.90	24.73	34.61	779.03	89.17	12.08	38.67	0.51	0.25	8.57
6	AGS128	44.77	7.61	30.05	2.17	65.18	22.80	31.96	768.91	90.17	10.99	39.17	0.43	0.21	7.29
7	AGS64	49.21	9.48	36.54	2.15	78.53	17.02	48.74	673.63	83.83	12.38	33.67	0.34	0.17	8.32
8	EC242104	74.76	6.74	23.14	2.66	61.61	19.00	35.07	651.22	86.67	10.38	35.33	0.43	0.22	6.63
9	EC241685	55.94	8.52	39.82	1.91	76.07	28.00	23.91	847.92	87.83	9.26	42.00	0.43	0.21	7.70
10	EC333939	55.90	7.62	39.78	2.65	105.43	23.56	29.72	787.64	88.17	6.28	43.83	0.50	0.24	6.70
11	EC333924	50.27	9.78	34.92	2.21	77.27	22.79	33.44	774.28	86.3	9.24	50.33	0.52	0.26	7.64
12	EC333899	49.30	9.37	39.74	2.59	103.59	15.09	57.01	806.74	87.67	7.48	28.00	0.39	0.19	8.56
13	**EC103334**	62.18	10.21	54.80	2.16	118.74	16.05	67.31	909.45	88.67	7.41	41.50	0.44	0.22	10.83
14	**BRG12**	74.34	6.63	59.09	2.17	128.08	18.58	59.92	768.18	88.50	6.22	41.67	0.45	0.22	11.18
15	EC333890	55.26	9.69	25.26	2.15	54.41	14.25	45.63	798.67	89.83	12.61	39.33	0.43	0.22	6.50
16	EC17266313	64.99	9.69	46.13	2.04	95.36	17.31	47.65	519.13	76.00	6.34	41.00	0.54	0.27	8.24
17	ICAL138	76.00	7.62	38.11	1.85	70.48	17.77	36.88	875.70	88.50	8.22	55.17	0.56	0.28	6.56
18	**EC309538**	58.34	11.73	57.75	2.71	156.64	23.19	58.85	778.31	87.00	7.93	38.00	0.35	0.17	13.65
19	EC309452	53.65	11.76	51.06	2.08	106.50	26.72	39.02	903.08	94.67	9.36	61.83	0.67	0.33	10.43
20	BB24-94	48.39	10.31	36.47	2.21	81.08	16.17	45.84	795.20	94.33	10.24	43.50	0.52	0.26	7.40
21	PX5(A)	46.84	4.62	21.98	1.98	43.61	11.06	58.73	894.27	93.17	12.32	28.00	0.31	0.15	6.49
22	BR10	57.40	9.70	35.68	2.03	72.29	17.32	37.31	763.14	92.00	7.57	27.67	0.36	0.18	6.47
23	IC1553	55.66	8.58	31.87	2.63	84.23	19.65	38.04	678.39	84.83	11.27	34.50	0.39	0.19	7.47
24	SPC174	67.39	9.60	46.09	2.81	129.52	21.65	40.10	705.27	84.17	7.52	35.83	0.39	0.20	8.69
25	GP30	66.24	9.63	46.57	2.04	95.42	17.61	46.75	693.50	84.00	6.04	31.33	0.43	0.21	8.23

Table 1. Cont...

Sr. No.	Name of Genotypes	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Plant height (cm)	Primary branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	Seeds plant^{-1}	Biological yield plant^{-1} (g)	Harvest index (%)	Growing degree days (^{O}C)	Days to maturity	100 Seed weight (g)	Nodules plant^{-1}	Fresh weight of nodules plant^{-1} (g)	Dry weight of nodules plant^{-1} (g)	Seed yield plant^{-1} (g)
26	**PI30781**	75.95	7.81	62.61	2.58	162.94	29.96	44.66	787.29	91.83	6.08	49.83	0.59	0.29	13.40
27	PLS01	66.64	7.62	33.79	1.99	67.44	23.11	27.90	868.33	96.00	10.13	41.50	0.53	0.26	6.45
28	**S287**	84.62	8.26	101.30	3.00	304.14	55.29	31.83	745.45	88.00	7.03	175.00	1.09	0.52	17.61
29	**JS79-214**	52.74	7.55	42.73	2.63	113.04	50.08	22.14	904.96	93.50	15.11	140.17	0.85	0.42	11.07
30	**IC15759**	67.26	8.35	61.63	2.02	124.45	30.26	43.69	911.97	93.33	12.19	117.33	0.77	0.38	13.22
31	**TGX1025-2F**	51.07	8.28	55.30	2.64	146.62	30.78	34.15	945.64	94.33	6.36	35.00	0.46	0.23	10.51
32	TGX825-3FF	46.09	8.43	56.98	1.80	103.02	24.84	31.46	833.36	88.17	6.09	40.50	0.45	0.23	7.95
33	TGX328-019D	67.17	7.68	34.07	2.10	71.75	19.20	37.45	906.08	94.17	9.46	35.33	0.48	0.24	7.19
34	**TGX814-44G**	57.89	10.08	41.67	2.07	86.23	28.42	39.25	821.97	90.50	8.06	39.67	0.51	0.25	11.16
35	TGX9964F6(B)	51.71	9.58	36.87	2.41	88.99	21.28	38.63	690.54	85.50	13.94	79.50	0.83	0.41	8.22
36	TGX1075-8E	47.30	7.42	30.02	2.57	77.61	19.97	36.19	640.92	85.83	8.92	34.17	0.43	0.22	7.22
37	TGX859-9A	49.37	8.24	43.97	2.38	104.89	30.22	32.81	754.59	88.00	8.11	34.67	0.35	0.17	9.95
38	TGX74401E	69.32	7.02	41.20	1.96	81.85	28.25	25.99	904.39	93.67	9.31	34.83	1.11	0.21	7.35
39	TGX813-15E	46.16	7.64	37.64	1.79	67.57	26.39	30.04	770.69	89.50	11.54	32.17	0.40	0.19	7.92
40	TGX814-148E	53.69	8.79	35.33	1.70	60.19	26.38	24.11	800.73	94.17	9.92	32.33	0.38	0.19	6.34
41	TGX814-73DI	47.37	9.74	31.45	2.06	64.88	22.61	31.26	815.57	92.83	11.10	39.50	0.47	0.23	7.10
42	TGX854-4E	61.12	9.57	30.11	1.85	55.82	21.23	35.90	944.83	96.17	11.85	41.33	0.50	0.28	7.61
43	TGX416-06C	50.68	8.52	39.53	1.61	63.63	29.60	30.43	615.70	84.50	13.06	26.83	0.34	0.17	9.08
44	TGX813-25D	45.56	7.78	36.02	1.75	63.02	27.97	26.05	581.99	73.17	11.99	36.00	0.48	0.24	7.28
45	**TGX573-209D**	52.55	9.14	34.44	2.16	74.65	26.45	40.31	724.42	78.50	15.04	50.33	0.56	0.28	10.66
46	TGX814-4EE	45.08	8.69	39.83	2.51	100.21	25.49	31.18	717.79	82.00	8.26	34.83	0.43	0.21	7.96
47	TGX1O73-30G	45.60	8.75	43.33	1.70	73.97	26.66	30.45	811.28	88.00	11.19	55.50	0.63	0.31	8.04
48	TGX854-57D	93.13	11.22	37.31	1.47	56.38	57.42	14.17	813.26	88.17	9.10	33.33	0.40	0.20	8.13
49	TGX803-99E	69.98	9.79	35.98	1.68	61.00	29.18	29.78	.741.25	78.50	7.30	40.50	0.48	0.23	8.69
50	TGX995-26	65.57	8.18	46.06	2.51	86.06	22.76	37.41	766.42	87.17	9.35	48.50	0.56	0.28	8.53
	C.D. 5 %	0.75	0.74	2.09	0.14	8.00	1.51	3.46	33.92	0.95	0.28	3.39	3.86	0.028	0.46
	C.V. %	0.73	4.91	2.87	3.73	4.97	3.41	5.24	2.42	0.62	1.61	4.15	353.95	6.680	2.98

Table 2. Estimates of phenotypic co-relation coefficients among nodulation, yield and its contributing characters in soybean

Sr. No	Characters	Primary branches Plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	Seeds plant^{-1}	Biological yield plant^{-1} (g)	Harvest index (%)	Growing degree days (^{O}C)	Days to maturity	100 Seed weight (g)	Nodules plant^{-1}	Fresh weight of nodules plant^{-1} (g)	Dry weight of nodules plant^{-1} (g)	Seed yield plant^{-1} (g)
1	Plant height (cm)	0.080	0.383**	0.120	0.375**	0.419**	-0.250	0.138	0.085	-0.327**	0.249*	0.080	0.213	0.382**
2	Primary branches plant^{-1}		0.135	-0.011	0.095	0.650**	0.122	-0.061	-0.011	-0.121	-0.038	-0.058	0.063	0.196*
3	Pods plant^{-1}			0.301*	0.928**	0.443**	0.192	0.038	0.022	-0.500**	0.016	0.052	0.523**	0.859**
4	Seeds pod^{-1}				0.614**	0.023	0.271**	-0.340**	0.540**	-0.205	0.330**	0.022	0.251**	0.417**
5	Seeds plant^{-1}					0.413**	0.220	0.012	0.042	-0.453**	0.650**	0.046	0.536**	0.858**
6	Biological yield plant^{-1} (g)						-0.617**	0.093	0.045	0.070	0.581**	0.046	0.447**	0.555**
7	Harvest index (%)							-0.019	-0.024	-0.240*	-0.113	-0.071	-0.107	0.251*
8	Growing degree days (^{O}C)								0.832**	-0.005	0.179	0.093	0.169	0.045
9	Days to maturity									0.023	0.142	0.084	0.139	0.015
10	100 Seed weight (g)										0.126	0.011	0.077	-0.032
11	Nodules plant^{-1}										.	0.037	0.895**	0.638**
12	Fresh weight of nodules plant^{-1} (g)												0.046	-0.004
13	Dry weight of nodules plant^{-1} (g)													0.531**

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

Table 3. Estimates of genotypic path coefficients among nodulation, yield and its contributing characters in soybean

Sr. No	Characters	Plant height (cm)	Primary branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	Seeds plant^{-1}	Biological yield plant^{-1} (g)	Harvest index (%)	Growing degree days (^{O}C)	Days to maturity	100 Seed weight (g)	Nodules plant^{-1}	Fresh weight of nodules plant^{-1} (g)	Dry weight of nodules plant^{-1} (g)	Co-relation with seed yield
1	Plant height (cm)	**-0.041**	0.007	0.404	0.048	-0.176	0.246	-0.011	0.005	-0.008	-0.105	-0.066	0.058	0.025	0.386**
2	Primary branches plant^{-1}	-0.003	**0.080**	0.152	-0.006	-0.047	0.042	0.065	-0.003	0.001	-0.040	0.011	-0.053	0.008	0.207
3	Pods plant^{-1}	-0.016	0.011	**0.955**	0.220	-0.435	0.262	0.096	0.002	-0.002	-0.161	-0.165	0.035	0.062	0.864**
4	Seeds pod^{-1}	-0.005	-0.001	0.327	**0.388**	-0.288	0.014	0.139	0.001	0.005	-0.068	-0.090	-0.009	0.031	0.444**
5	Seeds plant^{-1}	-0.015	0.008	0.982	0.239	**-0.467**	0.245	0.110	0.001	-0.004	-0.146	-0.174	0.024	0.064	0.867**
6	Biological yield plant^{-1} (g)	-0.017	0.006	0.471	0.009	-0.195	**0.587**	-0.305	0.004	-0.005	0.023	-0.156	0.037	0.053	0.512**
7	Harvest index (%)	0.001	0.010	0.205	0.110	-0.104	-0.363	**0.493**	-0.001	0.002	-0.079	0.031	-0.048	-0.013	0.244*
8	Growing degree days (^{O}C)	-0.006	-0.005	0.042	-0.014	-0.006	0.056	-0.008	**0.038**	-0.081	-0.002	-0.049	0.064	0.020	0.050
9	Days to maturit	-0.004	-0.001	0.024	0.021	-0.020	0.027	-0.013	0.032	**-0.097**	0.007	-0.038	0.058	0.017	0.015
10	100 Seed weight (g)	0.013	-0.010	-0.531	0.082	0.213	0.041	-0.121	0.001	-0.002	**0.320**	-0.034	-0.009	0.009	-0.029
11	Nodules plant^{-1}	-0.010	-0.003	0.654	0.132	-0.306	0.343	-0.058	0.007	-0.014	0.041	**-0.266**	0.029	0.105	0.654**
12	Fresh weight of nodules plant^{-1} (g)	-0.075	-0.135	0.983	-0.106	-0.356	0.801	-0.763	0.077	-0.179	-0.095	-0.246	**0.031**	0.221	0.159
13	Dry weight of nodules plant^{-1} (g)	-0.009	0.005	0.569	0.103	-0.259	0.272	-0.058	0.007	-0.014	0.226	-0.243	0.033	**0.115**	0.548**

Table 4. Estimates of phenotypic path coefficients among nodulation, yield and its contributing characters in soybean

Sr. No	Characters	Plant height (cm)	Primary branches plant^{-1}	Pods plant^{-1}	Seeds pod^{-1}	Seeds plant^{-1}	Biological yield plant^{-1} (g)	Harvest index (%)	Growing degree days (^{O}C)	Days to maturity	100 Seed weight (g)	Nodules plant^{-1}	Fresh weight of nodules plant^{-1}	Dry weight of nodules plant^{-1} (g)	Co-relation with seed yield
1	Plant height (cm)	**0.042**	0.002	0.530	0.057	-0.264	0.203	-0.009	0.01	-0.006	-0.127	-0.085	-0.003	0.032	0.382
2	Primary branches plant^{-1}	0.003	**0.024**	0.187	-0.005	-0.067	0.032	0.046	-0.004	0.001	-0.047	0.013	0.003	0.010	0.196
3	Pods plant^{-1}	0.016	0.003	**1.389**	0.143	-0.654	0.215	0.072	0.003	-0.001	-0.194	-0.210	-0.002	0.079	0.859
4	Seeds pod^{-1}	0.005	0.000	0.418	**0.476**	-0.433	0.011	0.102	-0.002	-0.003	-0.079	-0.112	-0.001	0.038	0.417
5	Seeds plant^{-1}	0.016	0.002	1.289	0.292	**-0.705**	0.2	0.083	0.001	-0.003	-0.175	-0.221	-0.002	0.081	0.858
6	Biological yield plant^{-1} (g)	0.018	0.002	0.615	0.011	-0.291	**0.485**	-0.232	0.006	-0.003	0.027	-0.198	-0.002	0.068	0.555
7	Harvest index (%)	-0.001	0.003	0.267	0.129	-0.155	-0.299	**0.376**	-0.001	0.002	-0.093	0.039	0.003	0.016	0.251
8	Growing degree days (^{O}C)	0.006	-0.001	0.052	-0.016	-0.009	0.045	-0.007	**0.070**	-0.054	-0.002	-0.061	-0.004	0.026	0.045
9	Days to maturity	0.004	0.000	0.031	0.025	-0.029	0.022	-0.009	0.058	**-0.065**	0.009	-0.048	-0.004	0.021	0.015
10	100 Seed weight (g)	-0.014	-0.003	-0.694	-0.057	0.319	0.034	-0.09	0.000	-0.001	**0.388**	-0.043	0.000	0.012	-0.032
11	Nodules plant^{-1}	0.011	-0.010	0.855	0.157	-0.458	0.282	-0.043	0.012	-0.009	0.049	**-0.341**	-0.002	0.135	0.638
12	Fresh weight of nodules plant^{-1} (g)	0.003	-0.001	0.073	0.011	-0.032	0.022	-0.027	0.006	-0.005	-0.004	-0.013	**-0.044**	0.007	-0.004
13	Dry weight of nodules^{-1} plant (g)	0.009	0.001	0.726	0.119	-0.378	0.217	-0.04	0.012	-0.009	0.03	-0.305	-0.002	**0.151**	0.531

through seeds plant^{-1} (-0.306), harvest index (-0.058), days to maturity (-0.014), plant height (-0.010) and primary branches plant^{-1} (-0.003). Fresh weight of nodules plant^{-1} expressed high positive indirect effect on seed yield plant^{-1} through pods plant^{-1} (0.983), followed by biological yield plant^{-1} (0.801), dry weight of nodules plant^{-1} (0.221) and growing degree days (0.007). It expressed high negative indirect effect through harvest index (-0.763), seeds plant^{-1} (-0.356), nodules plant^{-1} (-0.246), days to maturity (-0.179), primary branches plant^{-1} (-0.135), seeds pod^{-1} (-0.106), 100 seed weight (-0.095) and plant height (-0.075) on seed yield plant^{-1}. Dry weight of nodules plant^{-1} expressed high positive indirect effect on seed yield plant^{-1} through pods plant^{-1} (0.569), followed by biological yield plant^{-1} (0.272), 100 seed weight (0.226), seeds pod^{-1} (0.103), fresh weight of nodules plant^{-1} (0.033), growing degree days (0.007), and primary branches plant^{-1} (0.005). Whereas it expressed high negative indirect effect through seeds plant^{-1} (-0.259), nodules plant^{-1} (-0.243), harvest index (-0.058), days to maturity (-0.014) and plant height (-0.009).

Positive indirect effect

In present investigation the maximum positive indirect effects were noticed via pods plant^{-1} followed by biological yield^{-1}, seeds pod^{-1} and dry weight of nodules which was support by findings of Shukla *et al.* (1998) and Sultana *et al.* (2005). Therefore, simultaneous indirect selection pressure may also be practiced on these above traits for genetic amelioration.

Negative indirect effect

The findings of Vishnoi et *al.* (2007) for number of nodules plant^{-1}, seeds plant^{-1} and plant height, showed significant high magnitude of negative indirect effects, which are close harmony to the present finding.

Therefore, it could be concluded based on inter- relationship of traits and direct and indirect effects on seed yield that characters namely nodules plant^{-1} , plant height, biological yield plant^{-1}, pods plant^{-1}, seeds pod^{-1} and 100 seed weight appeared to be major yield contributing characters which need to be given emphasis while breeding high yielding varieties of soybean. Based on the mean performance of characters together, correlation and path analysis study, the better genotypes identified from the present study viz., S287, EC309538, PI30781, IC15759, BRG12, TGX814-44G,JS79-214,EC103334, GX573-209D and TGX1025-2F may be used for breeding high yielding variety of soybean.

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STABILITY ANALYSIS FOR YIELD AND ITS TRAITS IN SOYBEAN (*Glycine max* (L.) MERRILL)

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ABSTRACT

Thirty newly developed genotypes of soybean were grown at three sowing dates in randomized block design with three replications during *kharif* 2010-11. Analysis of variance for all the ten characters for each environment and on pooled basis indicated substantial amount of variability for most of the yield and yield contributing traits except for days to maturity in environment II and pooled environments. Genotype X environment extractions was found significant for number of primary branches plant^{-1}, plant height, number of pods plant^{-1}, biological yield plant^{-1}, number of seeds plant $^{-1}$, seed yield plant^{-1} and 100 seed weight. The genotypes x environments (Linear) mean sum of squares were significant for all the characters except for number of pods plant^{-1}. Genotypes namely RVS 2006-14, RVS 2006-25, RVS 2006-27 and RVS 9560 showed stable performance for all the yield and yield components. Therefore, these genotypes could be recommended for commercial cultivation as well as for inclusion in further breeding programme as donor parents.

(Key words: Mean regression, seed yield, soybean, stability)

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is a self pollinated crop with low 0.8 percentage of natural out crossing and ranked first among oil seed crops of quantity. Soybean was introduced in India probably as soon as it was domesticated in China. India is considered as secondary centre of domestication for soybean. The concentrated research and development efforts were initiated by Agricultural Universities like Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttaranchal) and Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur (M.P.) let this crop as a commercial oil seed crop of (Madhya Pradesh) lateron M.P. state called as soybean bowl of India.

Soybean improvement programme was started from 1967 which resulted in the development of 95 improved varieties suitable for various agro-climatic conditions of the country. However, the further genetic improvement and development of high yielding, disease resistant having wider adaptability soybean varieties are needed for sustainable yield advantage.

The stability analysis has two major objectives in plant breeding programme. First to identify the varieties with greater stability and wider adaptability for yield and its components, secondly to identify the potential varieties with high mean performance under wider range of environments for further breeding programme.

MATERIALS AND METHODS

A field experiment was conducted under All India Coordinated Research Project on Soybean at RAK College of Agriculture, Sehore (M.P.) during *Kharif* 2010-11.The experiment was laid out in complete randomized block design with three replications. Thirty genotypes were evaluated under three different environments created by three sowing dates *viz*., 07 July, 2010, 14 July 2010 and 21 July 2010. Each genotype was sown in two rows plot of 3 meter length with 45 cm row to row and 3-4 cm plant to plant distances. The fertilizer dose of 20:60:20 NPK kg ha^{-1} was applied uniformly and recommended package of practices were adopted for optimum crop growth and plant protection under rainfed condition. The detailed observations on yield and yield attributes were recorded on five competitive plants at the time of harvest from each plot. The analysis of variance was computed as per the method given by Panse and Sukhatme(1967). The stability analysis was carried out as per procedure outlined by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

The pooled analysis of variance for yield and yield contributing traits (Table 1) indicated that the genotype significantly different for all the characters taken under study. The interaction of genotype x environment (G x E) means sum of square were also

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found significant for all the characters *viz.,* days to 50% flowering, days to maturity, plant height, number of pods plant^{-1}, biological yield plant^{-1}, number of seeds plant^{-1}, seed yield plant^{-1} and 100 seed weight. The response of genotype to changing environment was measured by the environmental linear effect, which was found to be significant for all the characters except number of pods plant^{-1}.

The stability parameters viz., mean, regression coefficient (b) and deviation from regression S^2d for all characters of each genotype were computed and are presented in table 2. The substantial magnitudes of deviation from linearity for all characters were observed suggesting large fluctuation in the expression of all characters our environments. Mean sum of square, due to pooled deviation were found significant for most of the characters except days to maturity, biological yield plant^{-1} and number of seeds plant^{-1}. Stability parameters worked out for all the 30 genotypes for yield and its component traits showed that the genotypes namely RVS 2006-14, RVS 2006-25, RVS 2006-27 and RVS 9560 were stable for all the 10 characters studied. Genotypes RVS 2006-14 exhibited stable performance for six characters including seed yield plant^{-1}. Genotypes RVS 2006-2, RVS 2006-28 and RVS 9560 exhibited stability for 4 characters including seed yield plant^{-1}. RVS 2006-3 was found to be least stable showing stability only for three characters excluding seed yield plant^{-1}.

In respect of stability of different traits it was found that days to maturity and plant height, remained stable in most of the genotypes (28) followed by number of primary branches plant^{-1} (26), number of pods plant^{-1} (26) and harvest index (14) as observed from table 3. Number of seeds plant^{-1} was found stable in 19 genotypes, while seed yield plant^{-1} and 100 seed weight in 18 genotypes. Biological yield plant^{-1} was found least stable character, which was stable only in 17 genotypes.

For the development of improved varieties, Genotype x Environment interaction had been of great importance to the plant breeder. When genotypes are compared over a series of environments, relative ranking usually differ which causes difficulty in demonstrating the significant superiority of one genotype over the other. For reducing the impact of genotype x environment interaction breeder select stable genotypes , which will interact less with the environment in which they are likely to be grown.

Under present investigation adoptive potential and relative stability of 30 genotypes of soybean for yield and its contributing traits were determined. The pooled analysis of variance carried out to know the response of different characters to various environmental factor, revealed that genotype environment interactions were significant for number of primary branches plant^{-1}, plant height, number of pods plant^{-1}, biological yield plant^{-1}, number of seeds plant^{-1}, seed yield plant^{-1} and 100 seed weight. Similar results were also reported by Verma *et al* (2011). This suggested that these characters were highly sensitive to the changes in the environmental conditions. Whereas interactions for days to 50% flowering, days to maturity and harvest index were non-significant which indicated that these traits were well adopted and show least effect to the changes in the environmental conditions. Rawat *et al.* (2001), Joshi *et al.* (2005), Mahajan *et al.* (2006), Pan *et al.* (2007) and Rajkumar and Husain (2008) also reported significant G×E interaction for most of the yield and yield attributing characters in soybean.

Variances due to genotype × environment (linear) was significantly different for days to 50% flowering, number of primary branches plant^{-1}, plant height, biological yield plant^{-1}, number of seeds plant^{-1}, seed yield plant^{-1}, 100 seed weight and harvest index. Tyagi *et al.* (2012) also noticed similar results for all characters. They studied forty diverse soybean genotypes were evaluated for stability for yield, protein and days to maturity over eight environments. Both linear as well as non-linear components were significant for all the characters studied. The number of average stabee genotypes for both yield and days to maturity were five in medium (Pusa-40, MACS-450, and JS-22) and one in early (Pusa-16) maturing group. The genotype MACS-58 possessed above average stability and Indra-Soya-9 and Alankar possessed below average stability for seed yield. It indicated the differential response of genotypes to various agro-climatic conditions.

According to Eberhart and Russell (1966) an ideal genotype is one having high mean ($\bar{X}$)

Table 1. Analysis of variance for each environment

Environments	E-1		E-2		E-3	
Source of variation	***Genotype***	**Error**	***Genotype***	**Error**	**Genotype**	**Error**
	29	**58**	**29**	**58**	**29**	**58**
Days to 50% flowering	36.956**	0.963	19.808**	1.114	27.091**	1.077
Days to maturity	38.155**	1.078	29.590**	1.423	41.079**	1.155
Number of primary branches plant^{-1}	1.832	0.184	1.211	0.153	2.342**	0.183
Plant height (cm)	97.763**	6.337	144.389**	5.374	137.620**	8.873
Number of pods plant^{-1}	147.548**	3.626	122.608**	3.363	90.594**	3.353
Biological yield plant^{-1} (g)	65.301**	3.081	85.971**	3.133	104.127**	4.398
Number of seeds plant^{-1}	917.709**	19.167	607.143**	21.566	444.965**	18.253
Seed yield plant^{-1} (g)	16.034**	0.3003	8.521**	0.371	7.492**	0.232
100 seed weight (g)	6.633**	0.157	5.964**	0.183	6.038**	0.155
Harvest index (%)	263.890**	13.5009	184.475**	14.694	540.455**	21.390

**5% level of significant

Table 2. Analysis of variance for stability with regards to yield and its components in soybean

Source of variation	d.f.	Days to 50% flowering	Days to maturity	No. of primary branches plant^{-1}	Plant height (cm)	No. of pods plant^{-1}
Genotype	29	21.6388**	30.315	0.975	73.614**	106.072**
Environment	2	71.567**	204.502	3.359	1056.672**	327.832**
Geno.×Environ.	58	3.156	2.981	0.410**	26.487**	7.088**
Pooled error	174	1.051	1.219	0.173	6.861	3.447
Environ.+Geno.×Environ.	60	5.437	9.698	0.508	60.827	17.7802
Environment (linear)	1	143.119**	409.276**	6.718**	2113.292**	655.662**
Geno.×Environ. (linear)	29	2.911**	2.714	0.248**	27.2909	9.075
Pooled deviation	30	3.289**	3.131	0.552**	24.829**	4.932
Pooled error MSS for testing pooled deviation MSS		0.3506	0.4065	0.0579	2.287	1.149

Source of variation	d.f.	Biological yield plant^{-1} (g)	No. of seeds plant^{-1}	Seed yield plant^{-1} (g)	100 seed weight (g)	Harvest index (%)
Genotype	29	76.578**	579.186**	9.498**	5.104**	253.735**
Environment	2	140.611**	1459.059**	17.750	3.889**	11.294
Geno.×Environ.	58	4.277**	38.709**	0.592**	0.5538*	37.931
Pooled error	174	3.537	19.662	0.301	0.1655	16.527
Environ.+Geno.×Environ.	60	8.822	86.054	1.164	0.6650	37.043
Environment (linear)	1	281.216**	2918.2109**	35.503**	7.779**	22.593
Geno.×Environ. (linear)	29	5.709**	46.998**	0.575**	0.41201**	44.014**
Pooled deviation	30	2.751*	29.403	0.588**	0.6725**	30.787**
Pooled error MSS for testing pooled deviation MSS		1.179	6.554	0.1004	5.519	5.509

****- Significant at p=0.01 *- Significant at p=0.05**

Table 3. Stability of different genotypes for different traits

Genotype	Days to 50% flowering	Days to maturity	No. of primary branches plant^{-1}	Plant height (cm)	No. of pods plant^{-1}	Biological yield plant^{-1} (g)	No. of seeds plant^{-1}	Seed yield plant^{-1} (g)	100 seed weight (g)	Harvest index (%)	Total stable characters
RVS-2006-1	*	*	*		*	*		*	*		8
RVS-2006-2	*	*	*		*	*	*	*	*	*	9
RVS-2006-3	*	*	*	*	*	*	*			*	8
RVS-2006-4	*	*	*	*	*	*		*		*	8
RVS-2006-5	*	*	*	*	*	*	*	*	*	*	10
RVS-2006-6			*	*	*			*			4
RVS-2006-7	*	*	*	*		*	*	*			7
RVS-2006-8	*	*	*	*	*	*	*			*	8
RVS-2006-9	*	*		*	*	*	*	*		*	8
RVS-2006-10	*	*	*	*			*	*		*	7
RVS-2006-11	*	*	*	*	*	*	*	*	*		9
RVS-2006-12	*	*	*		*		*	*			6
RVS-2006-13	*	*	*	*	*	*	*	*	*		9
RVS-2006-14	*	*	*	*	*	*	*	*	*		9
RVS-2006-15	*	*		*	*		*			*	6
RVS-2006-16	*	*	*	*		*		*	*	*	8
RVS-2006-17				*	*	*	*	*		*	6
RVS-2006-18	*	*	*	*	*	*	*	*	*	*	10
RVS-2006-19	*	*	*	*	*	*			*		7
RVS-2006-20	*	*	*	*	*	*	*		*		8
RVS-2006-21	*	*	*	*	*		*	*	*		8
RVS-2006-22	*	*		*	*	*		*		*	7
RVS-2006-23	*	*	*	*	*	*	*	*	*		9
RVS-2006-24	*	*	*	*	*		*	*	*		8
RVS-2006-25	*	*	*	*	*	*	*	*			8
RVS-2006-26	*	*	*	*	*	*	*	*	*		9
RVS-2006-27	*	*	*	*		*		*	*	*	8
RVS-2006-28		*	*	*	*	*	*	*		*	8
RVS-9505	*	*	*	*	*	*	*	*	*	*	10
RVS-9560	*	*	*	*	*	*	*	*			8
Total stable genotype	27	28	26	28	26	24	24	25	16	14	

Table 4. Grouping of soybean genotypes based on of regression coefficient and deviation from regression showing suitability for different environmental conditions

Characters	Genotypes stable over Environment (gi>mean, bi=1,s2di=0)	Genotypes stable for poor Environment (gi >mean, bi<1,s2di=0)	Genotypes stable for favorable Environment (gi>mean, bi>1,s2di=0)
Days to 50% flowering	RVS2006-28, RVS 2006-17 RVS 2006 6	----	RVS 2006-14, RVS 2006-22, RVS 2006 28
Days to maturity	RVS 2006-14	----	RVS 2006-23
Number of primary branches plant^{-1}	RVS 2006-17, RVS 2006-15	RVS 2006-4	RVS 2006-14, RVS 2006-19, RVS 2006-27, RVS 2006-4
Plant height (cm)	RVS 2006-12, RVS 2006-2 RVS 2006-11	RVS 2006-17 , RVS 2006-20	RVS 2006-10, RVS 2006-25, RVS 2006 8
Number of pods plant^{-1}	RVS 2006-27, RVS 2006-7 RVS 2006-4, RVS 2006-10	RVS 2006-16	RVS 9560,RVS 2006-14, RVS 2006-25, RVS 2006-8
Number of seeds plant^{-1}	RVS 2006-16, RVS 2006-19, RVS 2006-6	RVS 2006-4	RVS 2006-14, RVS 2006-8, RVS 2006-20
Biological yield (g plant^{-1})	RVS 2006-10, RVS 2006-12, RVS 2006-15	RVS 2006-6, RVS 2006-24	RVS 2006-14, RVS 2006-25, RVS 9560 RVS 2006-8
100 seed weight (g)	RVS 2006-4, RVS 2006-7, RVS 2006-8	RVS 2006-3, RVS 2006-6, RVS 2006-9	RVS 2006-11, RVS 2006-5, RVS 2006-2
Harvest index	RVS 2006-12, RVS 2006-14, RVS 2006-20	RVS 2006-6, RVS 2006-7, RVS 2006-11	RVS 2006-4, RVS 2006-2, RVS 2006-18
Seed yield (g plant^{-1})	RVS 2006-8, RVS 2006-3, RVS 2006-15,RVS 2006-19	RVS2006-20	RVS 2006-14, RVS 2006-25, RVS 2006-27 RVS 9560

unit regression coefficient (b =1) and least deviation (S^2_d) around the regression slope i.e. mean deviation square from regression not significantly different from zero. Therefore, it implies that while selecting varieties, predicting rate of seed yield in a given environment, mean values, regression slope of the genotypes and deviation from regression should be considered. Overall stable genotypes identified were RVS 2006-14, RVS 2006-25, RVS 2006-27 and RVS 9560 which will be suitable for commercial at growing all different agro climatic zones of Madhya Pradesh.

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MORPHOLOGICAL CHARACTER OF *Colletotrichum gloeosporioides* FROM VARIOUS HOSTS

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ABSTRACT

The present investigation was carried out during the year 2010-2011 at Plant Pathology Section, College of Agriculture,Nagpur. Six different *Colletotrichum gloeosporioides* isolates were obtained from *Catharanthus roseus* (Cg_1),*Capsicum annuum*(Cg_2),*Citrus reticulata* (Cg_3),*Psydium guavajava* (Cg_4), *Phaseolus aureus* (Cg_5) and *Mangifera indica*(Cg_6), respectively. Pathogenicity of these isolates was proved on their native hosts. The morphological and compatibility studies of all isolates were undertaken on PDA. It was revealed that there was variation in growth. Maximum radial mycelial growth was attained by Cg_1 (81.00 mm) followed by Cg_3 (78.60 mm).Maximum length of conidia was noticed in Cg_6 isolate (12.57 mm) and maximum conidial breadth (5.13 mm) in Cg_3 isolate. It was clearly observed in all the isolates that there was no visible setae. Variation in colony colour was observed and acervuli were brownish to blackish in colour with raised conidial mass. The Compatibility studies showed variation among six isolates of *Colletotrichum gloeosporioides.* Isolates Cg_1 was compatible with Cg_2, Cg_5 and Cg_6 whereas Cg_2 with Cg_5 and Cg_6 but produced sterile perithecia. Isolate Cg_3 was not compatible with any other hosts.

(**Key words** : ***Colletotrichum gloeosporioides*, morpholigical study, compatibility study**)

INTRODUCTION

Colletotrichum is an economically important genus of fungus belonging to family-Melanconiaceae, order-Melanconiales, class-Coelomycetes and sub-division-Deuteromycotina. Recently it is classified under phylum – Ascomycota, class - Filamentous, Ascomycetes (Pyrenomycetes) order-Phyllachorales,genus-*Glomerella* (*Colletotrichum*) (Agrios,2005).

The teleomorph stage of some *Colletotrichum* species is *Glomerella* and both stages are widely prevalent in hot and humid climate. *C. gloeosporioides* produced straight conidia which are ovoid to oblong in shape but setae are not clearly visible. According to Phoulivong *et al*. (2010) *Colletotrichum* species is caused above-ground plant parts of crops as well as fruit trees can be affected by *Colletotrichum* anthracnose and in the case of fruit infection, there is a reduction in yield quantity or quality.The symptoms include anthracnose of mango, leaf blight and stem canker of citrus, dieback of chilli, pod blight, twig blight and fruit rot of guava and seedling blight in mungbean. It affects the mango severally and causes leaf spot, blossom blight and wither tip. It also affects infloranscence. According to Patel and Joshi (2005) 57% losses were caused by *C.gloeosporioides* on mango. Also in citrus (*Citrus reticulata*) *C. gloeosporioides* causes severel losses in nursery stage. Anthracnose of mungbean casuses severe damage to leaves and pods and reduce market value of mungbean. Dieback of chilli caused by fungus *C. gloeosporioides* lead to drying of the plants from apical buds and reduced the market value of fruits. Guava fruit rot caused by *C. gloeosporioides* but reduces the market value of fruits. Sanders and Korsten (2003) observed that *C.gloeosporioides* could cause infection on mango chilli , pepper and guava .Sadafuli (*Catharanthus roseus*) is a horticultural and medicinal plant and when it is attacked by *C. gloeosporioides* severally growth of the plants is adversely affected. Cannon *et al.* (2012) described that *C. gloeosporioides* caused disease of a very wide range of hosts. Considering the importance of this disease to infect wide range of host plants, it was thought worthwhile to undertake study of identification of the disease on some natural hosts by studying morphological characters after occurance of disease symptoms on their native hosts.

MATERIALS AND METHODS

The present investigation was carried out during year 2010-2011 at Plant Pathology Section, College of Agriculture, Nagpur.

Materials required

Collection of samples

The diseased samples of leaves of sadafuli (*Catharanthus roseus*), guava (*Psydium guavajava*) , citrus (*Citrus reticulata*), mungbean (*Phaseolus aureus*), mango (*Mangifera indica*) and chilli fruit (*Capsium annuum*) showing symptoms of *Colletotrichum* infection were collected from the premises of farms of College of Agriculture,Nagpur.

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Glasswares

Through out the work various glasswares like petriplate,test tube, micropippet etc. were used.The glasswares were sterilized in a hot air oven at 180 ^{0}C for one hour. The media and distilled water were sterilized in autoclave at 1.05 kg cm $^{-2}$ for 15 minutes.

Methods adopted

Preparation of potato dextrose ager medium (PDA) culture medium

The composition of (PDA)		
Peeled potatoes	-	200 g
Dextrose	-	20 g
Agar agar	-	20 g
Distilled water	-	1000 ml

200 g healthy peeled potatoes were cut into pieces and boiled in 1000 ml distilled water in sauce pan for 30 minutes. The extract was filtered through muslin cloth and adequate quantity of distilled water was added to make1000 ml volume. Agar agar and dextrose were dissolved at the time of heating.This filtered extract of PDA was poured into conical flasks and test tubes.They were plugged with non absorbant cotton and autoclaved at 1.05 kg cm^{-2} for 15 minutes.(Abang, 2003).

Isolation and maintenance of culture

The sample showing symptoms of anthracnose/ dieback/ fruit rots were collected from different localities by cutting along with healthy tissues. The infected bits were washed with sterilized water and surface sterilized by 0.1% mercuric chloride solution for one minute in the petriplates and subsequently three changes of distilled water were given to remove the traces of mercuric chloride. The bits were dried and then transferred to solidified sterile PDA in petriplates and were incubated at room temperature (27±2^{0}C) for seven days. All the operations were carried out aseptically.The fungus growth of *C. gloeospsorioides* was then transferred on PDA slant. The culture thus obtained was further purified by hyphal tip method and maintained on PDA slant for further use (Sanei and Razavi, 2011).

Indentification of pathogen

The isolated fungus was indentified on the basis of colony character, type of conidia ,spore and acervuli.The pathogen was identified as *C.gloeosporioides.*

Preparation of host plants for pathogenicity

For proving pathogenicity, seedlings of guava, mango, citrus, sadafuli and mungbean host were grown in earthen pots which were filled with sterilized soil. The host plants were regularly irrigated till they were well established in pots. Whereas healthy chilli fruits were used for disease inoculation.

Inoculation for pathogenicity

The epidermal layer of leaves was damaged by smearing carborandom powder before inoculation. The suspension of each isolate of *C. gloeosporioides* was used for inoculating the plant in pots by spraying the seedling with the help of automizer. Also the fruits of chilli were inoculated by smearing the inoculum on the upper surface and incubated in humid chamber. After inoculating the plants with *C.gloeosporioides*, they were examined regularly for disease establishment. After the disease symptoms were noticed,the fungus isolates were compared with the original one and details development of symptoms for each isolate were verified. (Than *et al*., 2008 and Lin *et al*., 2002).

Morphological variation

Autoclaved PDA was poured in the petriplate and allowed it to solidify.Thus, separate petriplates containing PDA were prepared. Fungal disc (5mm) of seven days old culture was transferred on solidified PDA in petriplate for each isolate. Inoculated plates were incubated at room temperature (±27^{0}C) under 12 hour lightness and 12 hour darkness. On solidified PDA, the culture was examined for radial mycelial growth on2nd, 4th, 6th and 8th days after inoculation. The colony dimeter was measured in two directions at right angle to each other passing through the centre of the colony. The dimension of conidia was taken by using ocular micrometer. The observations were based on one hundred acervuli (conidia) and mean size was worked out for the morphological variation. Similar procedure was followed by (Sanei and Razavi, 2011).

Compatibility

Compatibility among six isolates were studied on PDA plates for seven days. Fungal disc were cut with flame sterilized cork borer and one bit of each of two isolates of *C. gloeosporioides* were placed on PDA poured in sterilized petriplates opposite to each other 10 mm away from rim of the plates. For each combination of two different isolates,

three plates were maintained. The plates were incubated at room temperature as mentioned earlier. The plates were examined every day upto one month after inoculation to know whether the isolates make fruiting body structure at the margin of union. For compatibility among six isolates, the same procedure was followed eg. 1.(Cg_1&Cg_2), 2.(Cg_1&Cg_3), 3.(Cg_1&Cg_4), 4.(Cg_1&Cg_5) 5.(Cg_1&Cg_6) for other host samples (Sanei and Razavi,2011).

RESULTS AND DISCUSSION

Isolation

Collection of disease samples and isolation of pathogen *C. gloeosporioides* isolates from various hosts like sadafuli, chilli, citrus, guava, mung, mango were identified on the basis of morphological characters. The usual tissue isolation technique was followed to isolate the pathogen from infected plant parts showing fruit rot and anthracnose symptoms. The pathogen was identified as *C. gloeosporioides* having pink, white, grayish colony colour, conidia were hyline oblong cylindrical and which carry oil globule in the centre. Agostini *et al*. (1992) was described that in slow growing isolates of citrus produced deep orange pigment and colony had smaller conidia and produced rarely setae.

Pathogenicity on native hosts

For proving the pathogenicity of hosts plants were selected from field of College of agriculture Nagpur. Six isolates were grown in sterilize earthen pots, healthy chilli fruits were used for disease inoculation. All of the isolates were identified using morphological characters, colony growth rate and conidial characters were confirmed by Phoulivong *et al*.(2010).They described that *C. gloeosporioides* was highly pathogenic on citrus ,mango, chilli fruit and guava .

Morphological characters

Morphological characters of different *C. gloeosporioides* isolates with respect to mycelial growth, conidial character, setae, and acervuli were studied on PDA. *C. gloeosporioides* showed high variability in morphological characters and pathogenicity on PDA. Sanei and Razavi (2011) observed the sizes of conidia produced in culture by all isolates were within the range. Conidia from citrus however, formed a quite homogeneous group which could be morphologically distinguished from those from other hosts on the basis of a higher length/breadth.The results are presented in table 2 and plate 1 and 2. All six isolates of *C. gloeosporioides* were designated as Cg_1, Cg_2, Cg_3, Cg_4, Cg_5 and Cg_6 which produced white, pink and greyish colour of colony. Conidia of all isolates were oblong and cylindrical having one fat globule in centre but setae were not clearly observed. Acervuli had brownish to blackish coloured raised conidial mass.Johnston and Jones (1997) were noticed the isolates of *C. gloeosporioides* varied greatly in colony colour and appearance. The colour of *C. gloeosporioides* varied from white to grey, to dark orange or pink-grey, while the reverse side of the colonies was of white, dark grey, orange or a mixture and with regular colony margins. The growth pattern was either circular with the mycelia showing a uniform growth pattern and radial ring like pattern.Isolates of Cg_2 produced white, pink, greyish colour of colony, conidia were cylindrical and oil globule in centre. Setae were not clearly observed. Isolates of Cg_3 produced white greyish and slightly orange colour of colony, conidia cylindrical and oil globule in centre. Setae was not clearly observed. Acervuli has brownish to blackish coloured conidial mass .Variation of morphological characters was studied. Radial mycelial growth in diameter was measured in the form of diameter on 2^{nd},4^{th}, 6^{th} and 8^{th} day after inoculation on PDA and the data are presented in the table 3.Among all six Isolates of *C. gloeosporioides* , isolates from sadafulli had maximum growth of 30.66 mm on second day and 81mm on eighth day. The isolates from guava had maximum growth of 71.66 mm on eighth day. The Isolate from citrus had a minimum growth of 27 mm on second day and 78.6 mm on eighth day. Also the diameter of isolates of mungbean ranged from 26 mm on second day to74.66 mm on eighth day and the diameter of isolates of mango ranged from 27 mm on second day to 77.3 mm on eighth day. Out of all isolates of pathogen, isolates from chilli had minimum diameter of 23.33 mm on second day. The *C. gloeosporioides* complex is well known to exhibit high variability in conidial size and shape and in colony morphology (Peres *et al.,*2002).

Micrometric observations

The micrometric observation of *C. gloeosporioides* isolates, conidial shape and size were observed on PDA medium and are given in table 3. The conidial length of Cg_1 isolates noted was 10.53

Table 1. Pathogenicity of *Colletotrichum gloeosporioides* isolates on their native hosts

Host	Parts used	Isolates	Initiation of symptoms (DAI)	Spot size (mm)	Symptoms
C.roseus	Leaves	Cg_1	5	1-2	On leaves ash colour irregular necrotic spot were developed and leaves were fall down.
C.annum	Fruit	Cg_2	5	1-1.5	Browinsh, black colour spot and strip were devel oped on fruit after that fruit were rottened.
C.reticulata	Leaves	Cg_3	8	2-3	Brownish necrotic spot with ring were formed on leaves.
P.guavajava	Leaves	Cg_4	9	1-3	On leaves brown yellowish necrotic spot were developed.
V.radiata	Leaves	Cg_5	3	3-4	On leaves brown radish black spots were found such leaves were fall down after some days.
M.indica	Leaves	Cg_6	5	2-3	Browinsh radish black necrotic spot were found such leaves were fall down .On fruit black round or irregular, sunken spots were formed and fruits were rottoned.

Table 2. Radial mycelial growth (mm) and dimension of different *Colletotrichum gloeosporioides* isolated on PDA at various interval

Sr. No	Isolates	Radial mycelial growth(mm)				Dimension of conidia	
		2^{nd}	4^{th}	6^{th}	8^{th}	Length	Breadth
1	Cg1	30.66	60	69.33	81.00	10.53±1.455	2.65±0.458
2	Cg2	23.33	59	68.33	78.33	12.54±0.172	3.74±0.25
3	Cg3	27	59	68.33	78.6	9.96±2.088	5.13±0.655
4	Cg4	27.66	51.66	61.66	71.66	11.31±2.002	4.29±0.715
5	Cg5	26	54.66	64.66	74.66	10.52±1.352	2.73±0.228
6	Cg6	27	57	67.33	77.3	12.57±0.197	2.75±0.317

Table 3. Morphological characters of different *C. gloeosporioides* isolates on PDA

Isolate	Colony	Conidia	Acervuli
Cg_1	Circular white greyish colour of colony having regular growth	Oblong and hyline, one fat globule in centre	Brownish to blakish colour in which conidial mass raised
Cg_2	White slightly pinkish colour of colony circular having regular mycelium arial growth	Cylindrical and hyline, one fat globule in centre	Brownish to blakish colour in which conidial mass raised
Cg_3	Circular white greyish and slightly orange colour having saffron colour raised conidial mass in centre mycelial growth.	Oblong hyline one fat globule in centre	Brownish to blakish colour in which conidial mass raised
Cg_4	Colony circular whitegreyish in colour with cottony growth and aerial mycelial growth	Cylindrical hyline ,one fat globule in centre	Brownish to blakish colour in which conidial mass raised
Cg_5	Circular dull white greyish colour of colony having growth submerged	Cylindrical hyline, one fat globule in centre	Brownish to blakish colour in which conidial mass raised
Cg_6	Circular dull white greyish colour of colony having areial mycelium	Cylindrical hyline, one fat globule in centre	Brownish to blakish colour in which conidial mass raised

Table 4. Compatibility of *C. gloeosporioides* isolates on PDA

Sr.No.	Isolates	Cg1	Cg2	Cg3	Cg4	Cg5	Cg6
1	Cg1	-	C	X	X	C	C
2	Cg2	-	-	x	X	C	C
3	Cg3	-	-	-	X	X	X
4	Cg4	-	-	-	-	X	C
5	Cg5	-	-	-	-	-	C
6	Cg6	-	-	-	-	-	-

C = compatible X = non compatible

Table 5. Perithecial formation of *C. gloeosporioides* isolates on PDA

Sr.No.	Isolates	Cg1	Cg2	Cg3	Cg4	Cg5	Cg6
1	Cg1	-	P	NP	NP	P	P
2	Cg2	-	-	NP	NP	P	P
3	Cg3	-	-	-	NP	NP	NP
4	Cg4	-	-	-	-	NP	P
5	Cg5	-	-	-	-	-	P
6	Cg6	-	-	-	-	-	-

P = perithecia formation NP = No perithecia formation

mm and breadth was 2.65 mm and conidial length of Cg_2 isolates noted was 12.54 mm and breadth was 3.74 mm. Sanei and Razavi (2011) observed similar results on same isolates. The conidial length of Cg_3 isolates noted was 9.96 mm and breadth was 5.13 mm and conidial length of Cg_4 isolates noted was 11.31 mm and breadth was 4.29 mm. The conidial length of Cg_5 isolates noted was 10.52 mm and breadth was 2.73 mm and conidial length of Cg_6 isolates noted was 12.7 mm and breadth was 2.75 mm.The highest length of 12.57 mm was noted in Cg_6 isolates. However , maximum breadth was observed in Cg_3 5.13 mm isolates .

Compatibility of different isolates

Compatibility among the six isolates were carried out on PDA medium and results are presented in table 1.It is observed from the table that the isolate sadafuli was compatible with chilli , mungbean and mango but was not compatible with citrus and guava. Isolate of chilli was compatible with mungbean and mango and was not compatible with citrus and guava. Guava was compatible with mango but was not compatible with mungbean and isolate mungbean was compatible with mango Isolate only.Similar results were observed by Mathur *et al.*(2000). They found that *C. gloeosporioides* produced only vegetative compatibility with other isolates. However, isolates citrus was not compatible with any one of the isolates under study.

Production of perithecia

For the formation of perithecia compatibility study of six isolates of *C. gloeosporioides* on PDA was undertaken and results are presented in table 2 and plate 2. The results based on formation of perithecia showed that Cg_1 was compatible with Cg_2, Cg_5, Cg_6 and was not compatible with Cg_3, Cg_4.The colonies of two isolates were fused within 14 days,the perithecia were formed between the juncture of two isolates but there was no formation of ascus during the course of study. Isolate Cg_2 was compatible with Cg_5 and Cg_6 but not compatible with Cg_3 and Cg_4. The colony fused with each other within 14 days. At the juncture of line sterile perithecia were formed without containing ascus.The isolate of Cg_4 was compatible with Cg_6 and formed perithecia, without forming ascospore in ascus at the juncture of line where two colonies were fused. But it was not compatible with Cg_5 isolate. Isolate Cg_5 was compatible with Cg_6 and formed sterile perithecia at the juncture of line, without forming ascospore in ascus. The isolate Cg_3 was not compatible with any other isolates under study. Sanei and Razavi (2011) observed that *C. gloeosporioides* population is homogeneous and that isolates closely related and produced vegetative compability among all isolates without production of perithecia.

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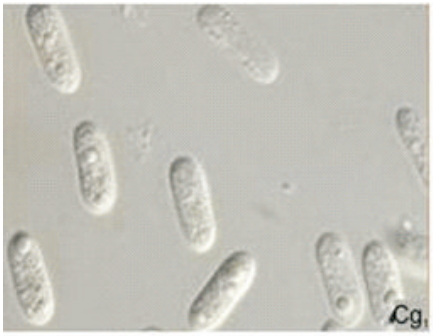
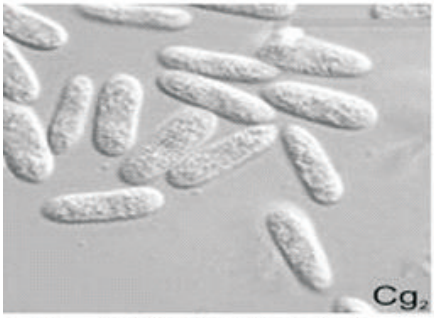


Conidia of *Catharanthus roseus*

Colony of *Catharanthus roseus* Cg1

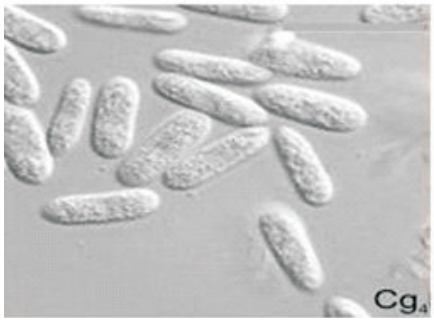


Conidia of *Capsicum annuum*

Colony of *Capsicum annuum* Cg2

Conidia of *Citrus reticulata*

Colony of *Citrus reticulata* Cg3

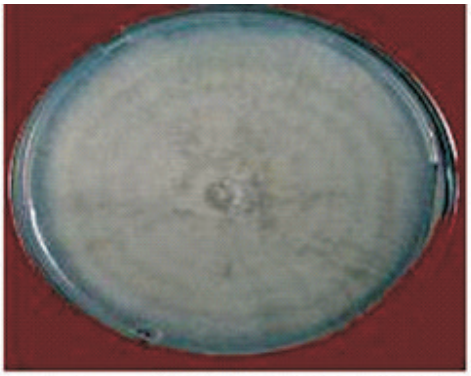


Conidia of *Psydium guavajava*

Colony of *Psydium guavajava* Cg4

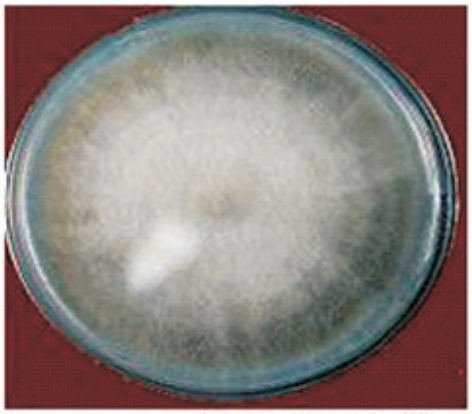
Plate 1. Morphological characters and compatibility of *Colletorichum gloeosporioides* isolates on different hosts

Conidia of *Phaseolus aureus*

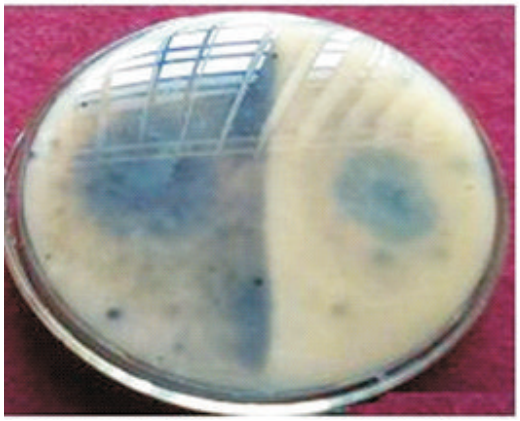


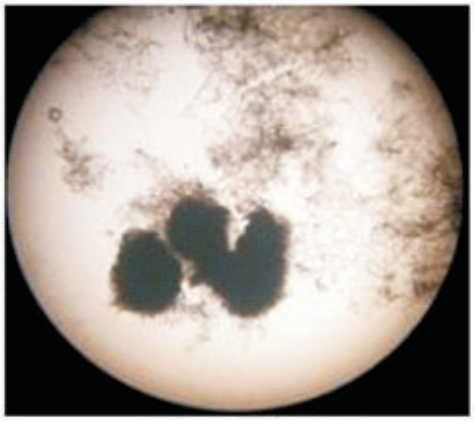
Colony of *Phaseolus aureus* Cg5

Conidia of *Mangifera indica*



Colony of *Mangifera indica* Cg6





Compatibility between two different isolates of *C. gloeosporioides*

Plate 2. Morphological characters and compatibility of *Colletotrichum gloeosporioides* isolates on different hosts

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LAND USE / LAND COVER APPRAISAL USING MULTI-TEMPORAL SATELLITE DATA IN LAKHANI TAHSIL OF BHANDARA DISTRICT, MAHARASHTRA

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ABSTRACT

Land use/land cover information in the form of maps and statistical data plays vital role in planning, management and better utilization of natural resources. Present study involves mapping of land use / land cover categories and cropping pattern in the Lakhani tahsil of Bhandara district, Maharashtra using geospatial technologies, essentially involving Remote Sensing (RS) and Geographical Information System (GIS). A systematic on screen visual image interpretation approach was used to delineate the land use / land cover classes using ERDAS Imagine and ARCGIS software. The present study was undertaken in 2008-2009 and it was focused on demarcating boundaries of different land use/land cover units with the help of keys of interpretation, registered on satellite imagery. LULC categories were invariably distributed all over the study area. *Zaid* cropping was predominant in southern part all along the river and in north west part where irrigation were available. Central region was occupied by *kharif* crops. Eastern and Western rim of the tahsil was occupied by dense and open forest. Rainfed agriculture occupies about 47.71 per cent of the area while *rabi* with 6.88 per cent. Wasteland being non-culturable areas was spread over 4.50 per cent area, dominated by dense and open scrub. Forest land comprises of 10264.05 ha of area constituting 23.46 per cent of the study area. Dense forest are dominant in the study area having spread over 3756.20 ha of land.

(Key words: Lakhani tehsil, geospatial, land use / land cover, Remote Sensing and geographical information system)

INTRODUCTION

Present investigation is carried out in the Lakhani tahsil owing to availability of multi-date satellite data. Study area being the part of semi-arid agro ecological region exhibits dominance of rainfed cropping coupled with patches of *rabi* cropped areas wherever irrigation facilities are available. Land use is referred to as human's activities and the various uses, which are carried on land. Land cover is referred to as natural vegetation, water bodies, rock/soil, artificial cover and others resulting due to land transformation. Since both land use / land cover (LULC) are closely related and are not mutually exclusive, they are interchangeable as the former is inferred based on the land cover and on their contextual evidence. Remote sensing (RS) and Geographical Information System (GIS) have the potential to support such demarcation and delineation of boundaries between the different LULC on the satellite image, by providing data and analytical tools. LULC classes and their aerial distributions are fundamental data required for a wide range of natural resources studies (Stefanov *et al*., 2001 and Prenzel and Treitz, 2004). The geospatial technologies constituting GIS and RS have been combined to analyze LULC classes which is easier and faster than the traditional methods of surveying (Da Costa and Cintra , 1999 and Saxena *et al*., 2000). LULC and subsequent change detection has become a central component in current strategies for managing natural resource and monitoring environmental changes (Tiwari and Saxena, 2011).

MATERIALS AND METHODS

Study area

Study has been undertaken in Lakhani tahsil (Fig.1) of Bhandara district which is located in between 20° 51' 26" N to 21° 9' 46" N Latitudes and 79° 45' 50" E to 79° 57' 17" E Longitudes, covering Survey of India toposheets 55 O/16 and 55 P/13 with an aerial extent of 43,750 ha.

Satelite Data

Multi-temporal, geo-rectified, IRS P6, LISS-III data of 23 m spatial resolution acquired during *kharif, rabi* and *zaid* seasons of 2006-2007 (Table 1) are used for delineation of LULC categories in the year 2008-2009. Figure 3, depicts the False Colour Composite of satellite data pertaining to *kharif, rabi* and *zaid* season.

Ancillary Data

Ancillary data in the form of Survey of India (SOI) topographic maps on 1: 50,000 scale (55 O/16, 55 P/13), existing land use / land cover information on Maharashtra (Anonymous, 2008), Bureau of

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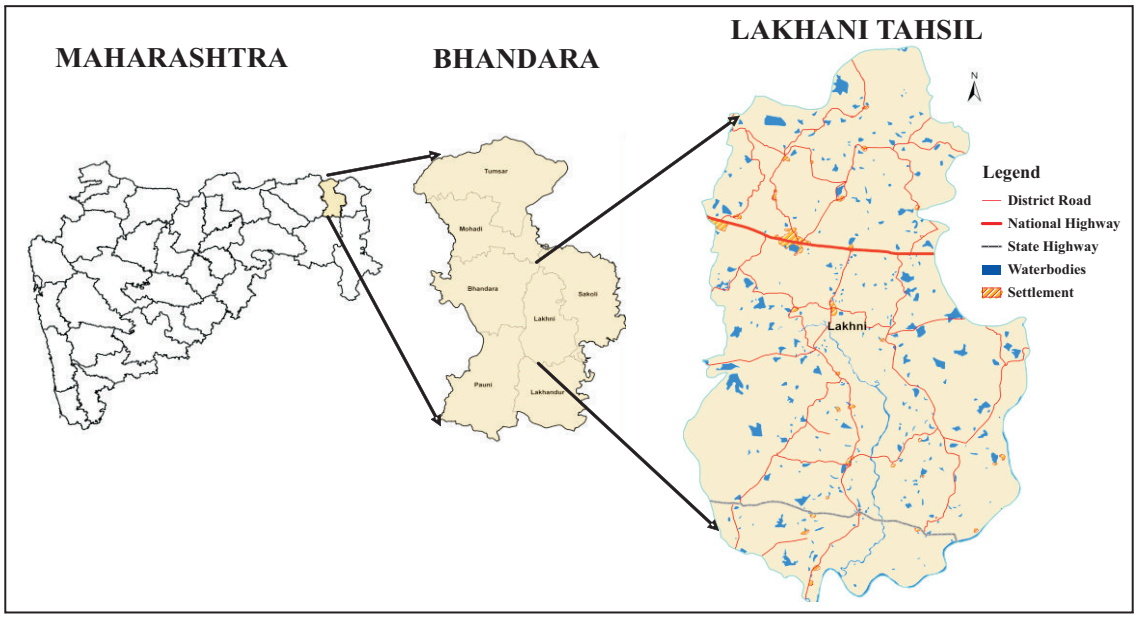

Fig. 1. Location map of the study area

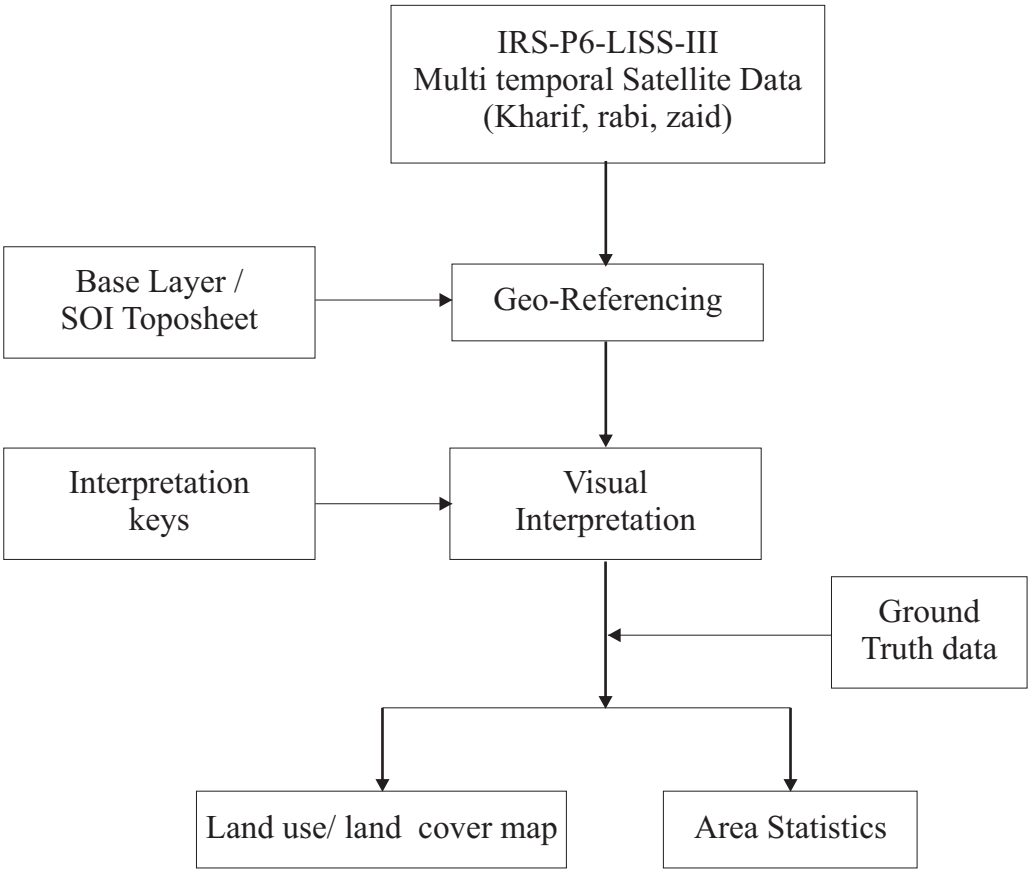

Fig. 2. Flow chart of methodology

Economics and Statistics data (Anonymous 2005), Anonymous (2001) and other published relevant material were used as reference, to enrich the interpretation. Near real time ground truth data is collected to validate and finalize the interpretation.

Methodology

The process of georeferencing of satellite images has been done using SOI topographical maps by identifying the ground control points (GCPs) from the maps and the corresponding points on the image and finally applying the map-image transformation model. The images were geometrically rectified and registered to the Transverse Mercator WGS 1984 projection. Digitization of the administrative and cultural features from the SOI maps and satellite data was done using ARC GIS software. In the present study on screen visual interpretation techniques adopted to delineate different LULC classes on the images. Methodology followed for extraction of information from satellite data is essentially of standard visual interpretation based on tone, texture, pattern, shape and size (Lillesand and Kiefer, 2002). Ancillary data and terrain features were also used for improving the classification accuracy (Boyed *et al*., 1996, and Malingreau *et al*., 1996). The methodologies adopted in this study are illustrated in figure 2.

RESULTS AND DISCUSSION

Medium scale map on 1:50000 scale, offer an extensive diagnosis of land use / land cover categories in terms of areas. Broadly sixteen categories are delineated in the study area on basis of color, tone and other keys of interpretation reflected on the images of multi date nature. Area mapped under different land use land cover categories are presented in table 2 and their spatial distribution is depicted in figure 4. Broader LULC categories like agriculture, wasteland and forest are discussed under different heads.

Agriculture Area

Present study reveals that the area under *kharif* crop is 20865.46 ha (47.71 per cent of Total Geographical Area) and comprises the largest proportion within a agriculture categories, indicating dominance of rainfed cropping. Mostly paddy crop is grown as *kharif* crop in the study area. *Rabi* crop obviously occupy very less area i. e. 3008.54 ha (6.88 per cent of TGA), mostly gram, wheat and vegetables are taken in the study area. Summer vegetables are mostly taken along with the river, nala and where the irrigation facilities are available. The zaid cropped area occupy 4256.49 ha (9.73 per cent of TGA) in the tahsil. Overall agricultural activities are spread over 28,657.58 ha area which is about 65.52 per cent of the total geographical area of the Lakhani tahsil.

Wasteland

These are mainly non-culturable areas occupying 1972.37 ha (4.50 per cent) land. Major wasteland categories occurring in the areas are dense scrub (1287.25 ha), open scrub (576.80 ha), grazing land (53.76 ha) and industrial and mining areas (54.56 ha). These lands can be stabilized and brought to the productive use with intensive soil and water conservation measures.

Forest

Forest is second dominant land use of the study area, occupying 10264.05 ha land constituting 23.46 per cent of the study area, including tree clad areas (un-notified forest). Forest in the area is mostly of dense category estimated in the tune of 8.59 per cent followed by 1.86 per cent of open category of forest land. Forest loss and degradation occur due to human interference, urbanization, cattle grazing, noise pollution, air pollution and so on (Yadav *et al.*, 2012).

Study demonstrates the effectiveness of geospatial technology where RS and GIS are the key components in identification, mapping and assessment of land LULC. The outcome of study represents a valuable resource for decision makers to implement different plans for cropping pattern, soil and water conservation measures etc. to increase the biomass for living beings in the area.

Table 1. Satellite data used in the study

Sr. No.	Sensor	Path	Row	Date of pass
1	**LISS-III**	**100**	**57**	**28 November, 2006**
2	**LISS-III**	**100**	**57**	**15 January, 2007**
3	**LISS-III**	**100**	**57**	**21 April, 2007**

Table 2. Area under different land use / land cover categories during 2006-2007

Sr. No.	Land use/land cover Categories	Area ha	Area % TGA
1	*Kharif* cropped area	20865.46	47.71
2	*Rabi* cropped area	3008.54	6.88
3	Zaid cropped area	4256.49	9.73
4	Current Fallow	26192	0.60
5	Horticultural plantation	265.17	0.61
6	Built-up area	918.88	2.10
7	Industrial and Mining area	54.56	0.12
8	Dense Forest	3756.19	8.59
9	Open Forest	815.62	1.86
10	Forest Plantation	180.04	0.41
11	Scrub Forest	515.04	1.18
12	Tree clad area	4997.16	11.43
13	Grazing Land	53.76	0.12
14	Dense Scrub	1287.25	2.94
15	Open Scrub	576.80	1.32
16	Waterbodies	1920.43	4.39
	Total Area	**43733.29**	**100.00**

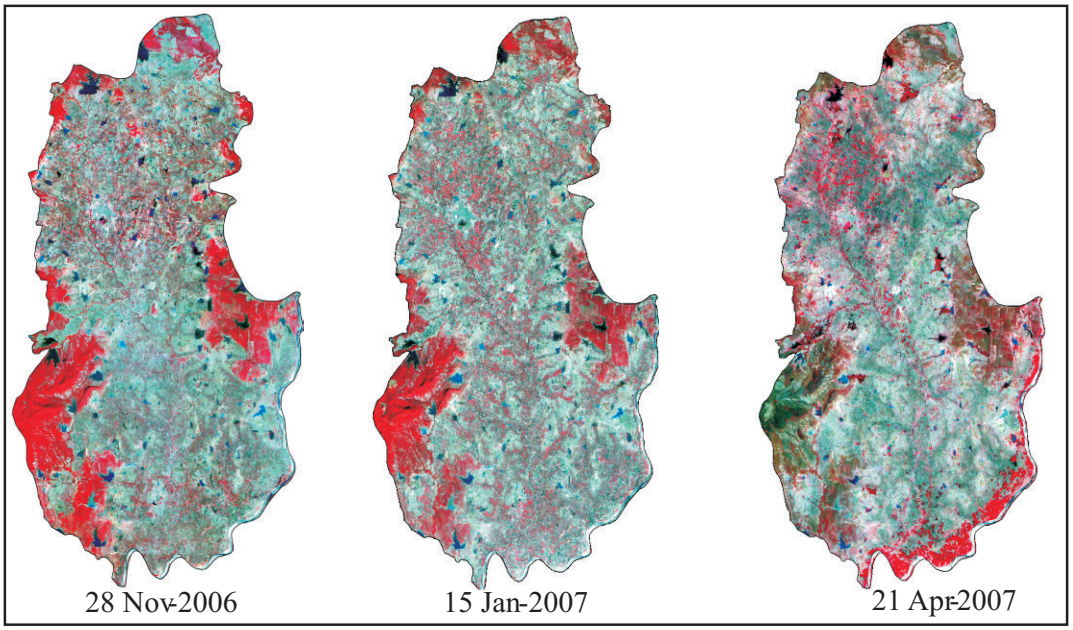

Fig. 3. IRS-P6 LISS-III FCC of *kharif, rabi* and *zaid* season

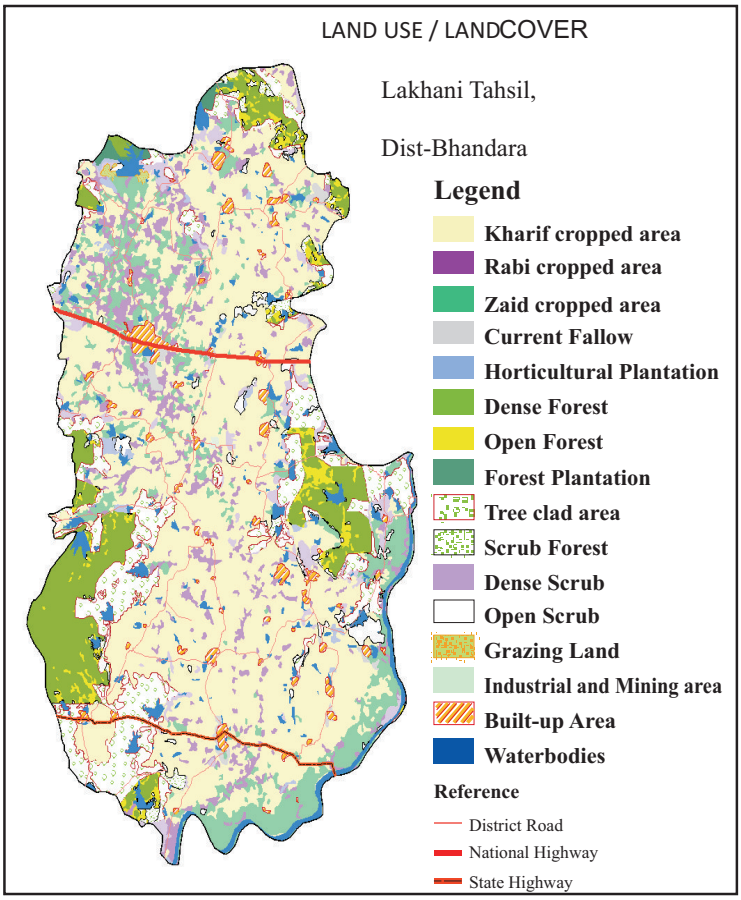

Figure 4. Map showing the Land use/Land cover categories for the year 2006-2007

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PATHOGENOCITY OF ISOLATES OF *Colletotrichum gloeosporioides* BY CROSS INOCULATION

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ABSTRACT

The present investigation was carried out during the year 2010-2011 at Plant Pathology Section, College of Agriculture, Nagpur. Six different *Colletotrichum gloeosporioides* isolates were isolated from (sadafulli) *Catharanthus roseus* (Cg_1), (chilli)*Capsicum annuum* (Cg_2),(citrus) *Citrus reticulata* (Cg_3),(guava) *Psydium guavajava* (Cg_4),(mungbean) *Phaseolus aureus* (Cg_5) and (mango) *Mangifera indica* (Cg_6) respectively. Pathogenicity of these isolates was proved on their respective hosts.The purified culture of spore suspension of pathogen from various six isolates were used for cross inoculation upto 20 days.Under study, it was observed that isolates of sadafulli, mungbean, mango and chilli produced disease symptoms on all the test hosts except citrus and guava. Isolates of citrus produced disease symptoms on all test hosts except guava and isolates of guava produced disease symptoms on all test hosts except citrus. Six isolates produced early diseased symptoms on chilli i.e.12 days after cross inoculation . The duration for disease initiation for all the test isolates in order of increased duration was noticed 15.35, 16.16 and 19.60 days on mungbean, sadafulli and mango respectively. 20 days were required for disease initiation in citrus and guava each.

(Key words: *Colletotrihum gloeosporioides*, cross inoculation study,host range)

INTRODUCTION

Ainsworth (1971) classified fungi for general purpose in two catagories i.e. sexual (perfect) and asexual (imperfect) fungi which belongs to subdivision Deuteromycotina. They were further subdivided into subclasses hypomycetes, Coelomycetes and blastomycetes. Comparatively small number of Deuteromycotina have been correlated with their sexual status. *Colletotrichum gloeosporioides* is the common species responsible for causing economically important disease in cereals, cucurbits, legumes, forage crops, fruits and vegetables. The symptoms includes anthracnose, leaf spot, blight, stem canker, ring spot, dieback, pod blight, twig blight, fruit rot and seedling blight(Agrios, 2005).

Disease caused by *Colletotrichum gloeosporioides* has a substantial impact on world agriculture and horticulture sciences, which reduces economic value of the produce. *C. gloeosporioides* has a wide host range in the tropic and sub tropic (Cai *et al*., 2009, Cannon *et al*., 2012, Phoulivong *et al,*. 2010, Noireung *et al*., 2012, Peng *et al.,*2012) and it has great capacity to produce diseases in different crops. Reddy and Babu (1988) observed the infection of *C. gloeosporioides* on fruits of lemon causing fruit rot. Chakrobarty *et al.* (1989) reported that *C.lindemuthianum* caused anthracnose of french beans(*Phaseolus vulgaris*).They further found that this pathogen was capable of infecting *Vigna radiata , V.unguiculata* ,*Phaseolus multiflores* and *Macrotyloma.* Sanders and Korsten (2003) during cross inoculation studies, revealed that mango isolates of *C.gloeosporioides* could cause infection on strawberries, pepper, guava and papayas but not on citrus. Patel and Joshi (2005) studied the host range of *C.gloeosporioides* causing leaf spot of turmeric. They also observed the infection on mango leaves with typical leaf spots. Keeping in the mind the wide host range of this pathogen,isolates were obtained from their various natural hosts and their cross inoculation was done artificially to know their pathogenocity .

MATERIALS AND METHODS

The present investigation was carried out during the year 2010-2011 at Plant Pathology Section, College of Agriculture, Nagpur.

Materials required

Collection of samples

The sample of diseased leaves of sadafuli (*Catharanthus roseus*) , guava (*Psydium guavajava*) , citrus (*Citrus reticulata*), mungbean (*Phaseolus aureus*), and mango (*Mangifera indica*) and chilli fruit (*Capsium annuum*),showing symptoms of *Colletotrichum* infection were collected from the fields of College of Agriculture,Nagpur.

Preparation of inoculums of isolates

The diseased fragments obtained from the

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above mentioned host were grown on sterilized PDA pour pretriplate for seven days to isolates the pathogen. After the growth of fungus, they were observed in compound microscope for identification . A germinated single spore was picked up with a sterilized needle and transferred onto PDA to obtain a pure culture following the procedure described by Cai *et al*. (2009). Sterilized water was added on the plates and the fungal growth was scrapped with the help of sterilized scalpel. The suspension was homogenised and decant was taken in a flask. After vigorous shaking,it was filtered through triple folded muslin cloth to remove the media and mycelial fragments.The purified culture of spore suspension from various six isolates were then used for cross inoculation studies.

Cross Inoculation

C. gloeosporioides has wide host range with other crops. The isolates of *C. gloeosporioides* from different crops were cross inoculated on different host crops .The six hosts were grown in earthen pots which was filled with sterilized soil. The hosts were regularly irrigated till they were well established. About ten days were required in general for their establishment in the pots. Thereafter, they were used for disease inoculation .Before inoculating the plant, they were covered by hessian cloth.The leaves were washed with distilled water and dried.The epidermal layer of leaves was broken by rubbing carborendum powder on surface of leaves with the help of cotton swab. The leaves were then washed with sterilized water and the pathogen was inoculated by smearing the spore suspension on their leaves except chilli .The inoculated plants were envelopped with polythene bags for 48 hrs in order to provide humidity for disease development.The chilli plants planted in pots were grown under the disease free condition and after they bear fruits, these fruits were used for inoculation.A chilli fruit was placed in sterilized petriplates for each isolate and then the spore suspension of different isolates were inoculated with the help of pin pricks method followed by the procedure of Lin *et al.*(2002) . The samples were inoculated using the wound/drop inoculation method which included pin-pricking the fruits to a 1 mm depth with a sterile needle in the middle portion of fruit and then placing 6 ml of conidia suspension onto the wound described by Freeman and Shabi (1996). Five such sets of petriplates for each isolate were prepared after inoculation and petriplates were kept in humidified chamber. On appearance of typical symptoms of the disease on inoculated fruits and leaves, reisolation of pathogens from infected tissue was made to confirm the pathogen. Complete process was repeated five times on leaves from each potted plant for artificial inoculation comprising two older leaves, two middle leaves and one yonger leaf respectively. Observations regarding infection were recorded daily after inoculation upto 20 days .

RESULTS AND DISCUSSION

Isolation

Collection of disease samples and isolation of pathogen *C. gloeosporioides* isolates from various hosts viz., sadafuli (*Catharanthus roseus*), chilli (*Capsium annuum)*, citrus(*Citrus reticulata*), guava(*Psydium guavajava*), mung bean (*Phaseolus aureus*) and mango(*Mangifera indica*)were identified on the basis of morphological characters.

Pathogenicity testing

All of the isolates were identified using morphological characters, colony growth rate, and conidial character confirmed by Phoulivong *et al*. (2010). The usual tissue isolation technique was followed to isolate the pathogen from infected plant parts showing fruit rot on chilli fruit and anthracnose symptoms on leaves of other hosts. Potato dextrose agar was used as basal medium for isolation of fungus. The pathogen was identified as *C. gloeosporioides* on the basis of symptoms viz., pink, white, grayish colony colour, conidia hyline oblong cylindrical with oil globule in the centre (Plate 1).

Cross Inoculation

The data about the results on cross inoculation are tabulated in table1.The isolates of sadafuli (*Catharanthus roseus)* had great capability to produce symptoms on mango, mung and chilli besides sadafuli but did not produce symptoms on citrus and guava upto 20 days after cross inoculation . Isolates of chilli (*Capsicum annuum)* produced symptoms on mango, mung and Sadafuli beside chilli but did not produce symptoms on citrus and guava. Isolates of mung *(Vigna radiata)* and mango (*Mangifera indica*) produced symptoms on mango, mung, chilli and sadafuli but did not produce symptoms on citrus and guava. This study was consistent with inoculation studies by Sanders and Korsten (2003), they showed that isolates of

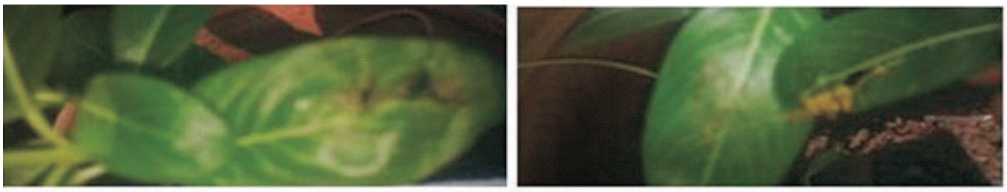
Table 1.Cross inoculation of different *C. gloeosporioides* isolates on various hosts

Sr.No.	Isolates	Sadafuli	Chilli	Citrus	Guava	Mung	Mango
1	Cg1	+	+	-	-	+	+
2	Cg2	+	+	-	-	+	+
3	Cg3	+	+	+	-	+	+
4	Cg4	+	+	-	+	+	+
5	Cg5	+	+	-	-	+	+
6	Cg6	+	+	-	-	+	+

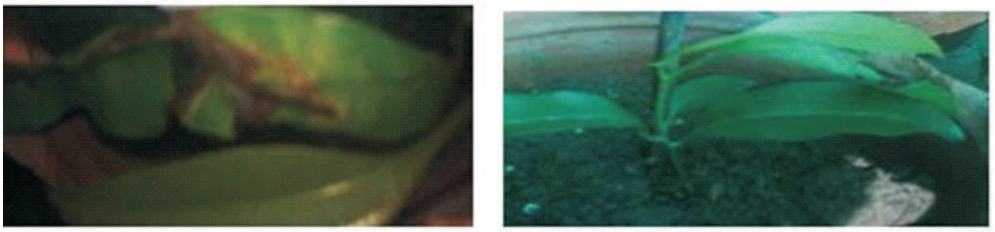
+ Present of disease - Absence of disease

Table2.Duration of development of disease symptoms with spot size on different hosts

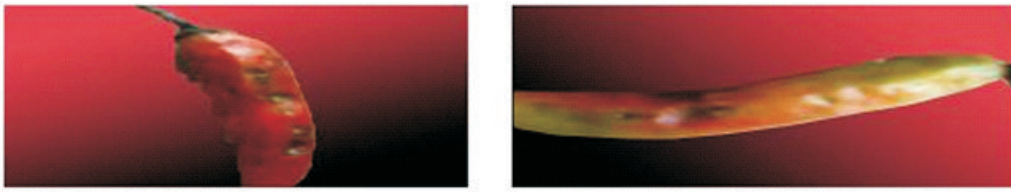
Sr.No.	Isolates	Days After Initiation (DAI)						Spot Size (mm)					
		Sadafuli	Chilli	Citrus	Guava	Mung	Mango	Sadafuli	Chilli	Citrus	Guava	Mung	Mango
1	Cg1 Sadafuli	14	13			16	19	1-2	2-3			1-1.5	2-3
2	Cg2 Chilli	15	12			17	18	1-3	3-4			2-3	2-3
3	Cg3 Citrus	15	12	20		18	19	2-3	2-3	1-2		2-3	2-2.5
4	Cg4 Guava	16	10		20	15	20	1-2.5	2-5		1-2	1-3	2-3
5	Cg5 Mung	18	13			14	20	2-3	1-2			1-2	2-2.5
6	Cg6 Mango	19	12			12	18	3-4	3-4			2-3	3-4
	Mean	16.16	12	20	20	15.35	19.60						



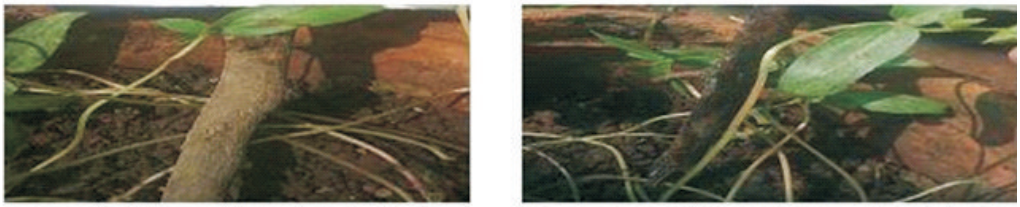
Symptoms on *Catharanthus roseus*



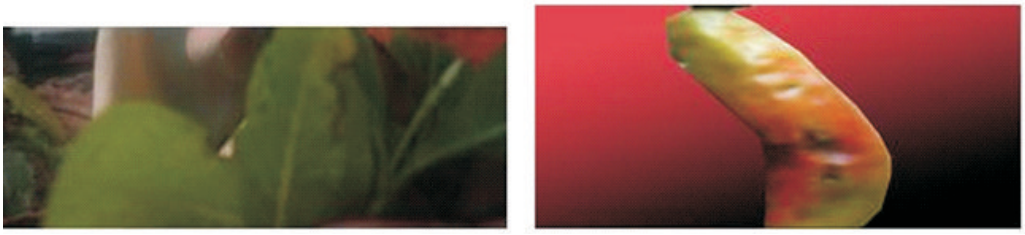
Symptoms on *Mangifera indica*



Symptoms on *Capsicum annuum*



Symptoms on *Phaseolus aureus*



Symptoms on different hosts *Catharanthus roseus* and *Capsicum annuum*

Plate 1. Cross infective response of *Colletotrichum gloeosporioides* isolates of different hosts

C. gloeosporioides from mango could produce symptoms on other hosts such as guava, chili,pepper and papaya. Although mango isolates of *C. gloeosporioides* were highly pathogenic. Cross inoculation studies showed that putative isolates of *C. gloeosporioides* from mango could produce symptoms on other hosts such as guava, chili and papaya. Isolates of guava produced disease symptoms on all test hosts except citrus. Isolates of citrus produced disease symptoms on all the test hosts except guava. Peng *et al.* (2012) also showed that *C. gloeosporioides* infected citrus leaves severally.From the above results, it is revealed that isolates from sadafuli, chilli, mung bean and mango were not capable of producing disease on citrus and guava. Thus, none of the isolates except themselves could produce disease symptoms on citrus and guava. The shortest duration of 12 days on an average was required for producing diseased symptoms by all the isolates on chilli. Than *et al*.(2008) found that *C. gloeosporioides* produced anthracnose symptoms in shortest duration with in 14 days. On other hand , maximum mean duration of 19.60 days was required on mango by these six isolates. Mung bean and sadafuli took 15.35 and 16.16 days respectively for disease initiation by all the six isolates .Isolates of citrus and guava took 20 days on their native hosts. On mungbean, spot size of disease ranged from 1 to 3 mm for the isolates from different hosts. On sadafuli it ranged from 1 to 4 mm, on mango 2 to 4 mm and on chilli to 2 to 5 mm. The spot size on citrus and guava ranged between 1 and 2mm (Table 2).

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RESPONSE OF TUBEROSE TO DIFFERENT CONCENTRATIONS OF GIBBERELLIC ACID

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ABSTRACT

The present investigation was conducted at Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 2008-09. Healthy bulbs of tuberose of uniform size were planted at a spacing of 30 x 30 cm. The experimental material consisted of 12 treatments (Control = water soaking and water spray, bulb soaking and spraying with 25, 50, 75, 100, 125 ppm of GA_3) along with 3 replications in Randomized Block Design. The soaking was done 24 hrs before planting and spraying was done thrice on 40, 55 and 70 days after planting. Bulb soaking in GA_3 @ 125 ppm was the significantly superior treatment in increasing the plant height and number of leaves plant^{-1} and it was followed by bulb treatment with GA_3 @ 100 ppm. So far as bulb sprouting is concerned, bulb soaking in water initiated early sprouting whereas increased levels of GA_3 for bulb soaking correspondingly delayed sprouting. Bulb soaking in GA_3 @ 125 ppm was also found to be the best for early initiation of flowering, maximum length and diameter of fully opened florets and maximum spike length. Bulb production was also higher in the same treatment. The next treatment in this respect was GA_3 @ 100 ppm. Whereas foliar spray of GA_3 @ 125 ppm concentration on 40, 55 and 70 days after planting gave maximum number of florets spike^{-1}, weight of florets spike^{-1}, number of spike plant^{-1} and vase life. The results thus indicate that bulb soaking showed be accompanied with foliar spray of GA_3 @ 125 ppm followed by 100 ppm.

(Key words: Tuberose, GA_3, bulb soaking, foliar spray)

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.) is one of the potentially valuable cut flower and is an important commercial flower of our country. It has got considerable importance and it is cultivated commercially for its varied uses. It is now used as cut flower since the flower remains fresh for a long time and stands long distance transportation and fills a useful place in the flower market. It is also grown for garden decoration in pots, beds and borders.

It is propagated by bulbs and hence bulb production needs to be increased for more monitory returns to growers. The plant growth regulators play an important role in controlling many physiological attributes of plant. Growth regulators are exploited in commercial cultivation of many cut flower crops for breaking dormancy of bulbs in tuberose and gladiolus, increase plant height, number of leaves, number of flowers plant^{-1}, yield of flowers, and quality of flowers and yield of corm (Nagaraja, 1999). The gibberellic acid (GA_3) is known to influence the growth by causing stem cell elongation and cell division and thereby promote flowering. It also enhances early flowering and maximum yield of flowers with long flower stalk. Hence, soaking of bulbs in GA_3 before planting and its foliar application improves the growth and flowering of tuberose and maximizes yield of spikes and flowers (Kumar and Singh, 2005; Tyagi and Singh, 2006). Therefore, the present investigation was undertaken to study the response of tuberose to different concentrations of gibberellic acid on growth and yield attributes of tuberose.

MATERIALS AND METHODS

The present study was undertaken during 2008-09 at Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, with 12 treatments. The details of the treatments are given in the table 1.

The individual bulb, having diameter 2-3 cm was selected for planting. The selected bulbs were soaked for 24 hours in gibberellic acid solution as per the treatments. After 24 hours, they were taken out from solution and allowed to dry in shade for 2 hours. For control treatment, the bulbs were soaked in distilled water. First foliar spray was applied at 40 days after planting (DAP) and second and third spray were applied thereafter at 15 days interval. The stock solution of 1000 ppm of gibberellic acid was prepared by dissolving 1g of substance in little quantity of acetone and then distilled water was added to make the volume as one litre. From this stock solution, required strength and quantity of growth regulator was made as per requirement.

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The treated bulbs were planted in plots at 5 cm depth, by keeping the spacing of 30 cm between the rows and also between bulbs in rows as per treatment of different concentrations of gibberellic acid. The protective irrigations were given at timely interval as and when required. The field was kept free from weeds by adopting hand weeding from time to time. Fertilizer was applied to all plots in the form of urea, single super phosphate and muriate of potash @ 200 kg N, 300 kg P, and 200 kg K ha^{-1}. Out of this, full dose of P, K and 1/3rd dose of nitrogen were applied at the time of planting. The remaining dose of nitrogen was applied in two split doses i.e. first dose at 45 days after planting and second dose at 90 days after planting.

Observations were recorded on growth parameters viz., days required for sprouting of bulbs, plant height (cm), number of leaves $plant^{-1}$, flowering parameters viz., days required for opening of first pair of floret on spike from planting, blooming period (Days), length of spike (cm), length of rachis (cm), vase life of flower stalk (Days). Similarly yield parameters like number of florets $spike^{-1}$, number of spikes ha^{-1}, yield of florets ha^{-1} (q), number of bulbs ha^{-1} and weight of bulb ha^{-1} (q) were recorded and statistically analyzed (Gomez and Gomez, 1984). The appropriate standard error of mean (S.E. m) and the critical difference (C.D.) were calculated at 5% level of probability.

RESULTS AND DISCUSSION

Growth parameters

The data regarding the growth characters as influenced by the different concentrations of GA_3 applied through bulb soaking and foliar application are presented in table 1.

It is revealed from the data that the bulb soaking in water was the best and significantly superior treatment over rest of the treatments in respect of early sprouting of bulbs (10.56 days) followed by soaking bulbs in 25 ppm GA_3 (12.29 days), 50 ppm GA_3 (12.42 days), 75 ppm GA_3 (13.46 days) and 100 ppm GA_3 (14.52 days). The maximum days were required for sprouting of bulbs in the treatment, where bulbs were soaked in 125 ppm GA_3 (16.09 days). Thus, these results indicate that increased dose of soaking of bulbs in GA_3 prolonged the sprouting. Generally gibberellins are thought to have a primary role in overcoming dormancy. Even if gibberellin levels are adequate to allow sprouting, if abscissic acid (ABA) is present in sufficient quantity, it will block the effect of the gibberellins and prolong dormancy, which might have delayed sprouting. Delay in sprouting at higher concentrations of GA_3 had been reported earlier by Tiwari and Singh (2002) that bulbs of tuberose soaked in GA_3 at 50, 100, 200 and 250 ppm delayed flowering as compared to control.

From the data, it was observed that, at 120 days after planting maximum plant height (57.03 cm) was recorded in the treatment soaking of bulbs in 125 ppm GA_3 which was significantly superior over all treatments and it was followed by the treatment bulb soaking in 100 ppm GA_3 (55.16 cm). However, minimum plant height was observed in the treatment soaking of bulbs in water (48.74 cm) followed by the treatment foliar spray of water (49.55 cm). In case of number of leaves, maximum number of leaves $plant^{-1}$ (60.22) at 120 days after planting was recorded in the treatment bulb soaking in 125 ppm GA_3 followed by the treatment bulb soaking in 100 ppm GA_3 (58.92) which were at par with each other. Minimum number of leaves $plant^{-1}$ was observed in the treatment of bulb soaking in water (51.82). With consequent increase in concentrations of GA_3, the maximum plant height and number of leaves at 120 days after planting were observed under bulb soaking in 125 ppm GA_3 bulb soaking treatment followed by 100 ppm GA_3 bulb soaking. It is clearly showed that GA_3 stimulates vegetative growth by cell multiplication and cell elongation. The foliar application of GA_3 at different doses did not significantly influence various growth parameters. Tiwari and Singh (2002) reported that bulbs of tuberose treated with GA_3 (200 ppm) resulted in increased plant height and maximum number of leaves, Panwar et al. (2006) observed that maximum plant height (39.81 cm) in Mexican Single and (39.76 cm) in Pearl Double and more number of leaves (64.65) in cv. Mexican Single and (64.66) in cv. Pearl Double were obtained by the application of GA_3 at 100 ppm in tuberose.

Flowering parameters

The data regarding the flowering characters as influenced by the different concentrations of GA_3

applied through bulb soaking and foliar application are presented in table 2.

The data revealed that, minimum days required for opening of first pair of florets on spike (119.31 days) was recorded in the treatment bulb soaking in 125 ppm GA_3 which was significantly superior over all other treatments and it was followed by the treatment foliar spray of 125 ppm GA_3 (122.21 days). Maximum days required for opening of first pair of florets on spike was observed in the treatment foliar spray of water (134.38 days). The blooming period was found significantly maximum in the treatment foliar spray of 125 ppm GA_3 (17.78 days) which was followed by the treatment bulb soaking in 125 ppm GA_3 (17.62 days). However, these treatments were at par with each other. Minimum blooming period was observed in the treatment bulb soaking in water (12.36 days). Dalal *et al*. (2009) also recorded the best flower quality in gerbera when sprayed with 150 ppm GA_3.

A persual of the data presented in the table 3 revealed that, the maximum length of spike was recorded in the treatment bulb soaking in 125 ppm GA_3 (102.19 cm) which was significantly superior over all treatments followed by foliar spray of 125 ppm GA_3 (98.05 cm) while minimum length of spike was observed in the treatment foliar spray of water (67.33 cm). The significantly maximum length of rachis was also recorded in the treatment bulb soaking in 125 ppm GA_3 (34.66 cm) which was followed by the treatment foliar spray of 125 ppm GA_3 (34.02 cm), bulb soaking in 100 ppm GA_3 (33.35 cm) and foliar spray of 100 ppm GA_3 (32.91 cm), which were at par with each other. Minimum length of rachis was observed in the treatment foliar spray of water (27.93 cm). Chopde *et al.* (2012) also found maximum rachis length in gladiolus when sprayed with highest concentration of GA_3 at 150 ppm.

The significantly maximum vase life was recorded in the treatment foliar spray of 125 ppm GA_3 (12.82 days) and it was followed by the treatment foliar spray of 100 ppm GA_3 (12.22 days), bulb soaking in 125 ppm GA_3 (12.04 days), 100 ppm GA_3 (11.86 days) and foliar spray of 75 ppm GA_3 (11.78 days). However, these treatments were at par with each other. Minimum vase life was observed in the treatment bulb soaking in water (8.79 days). The favourable effect of GA_3 might be attributed to greater amount of carbohydrate accumulation and increased metabolic activities. It is in the line of the work done by Panwar *et al*. (2006) who reported that maximum spike length (82.49 cm) in Mexican Single and (81.92 cm) in Pearl Double was obtained by the application of GA_3 100 ppm as bulb soaking in tuberose.

Yield parameters

The data in respect of yield of tuberose as influenced by application of GA_3 are presented in the table 3.

Data presented in table 3 revealed that, the significantly maximum number of florets spike^{-1} was recorded in the treatment foliar spray of 125 ppm GA_3 (41.21) and it was followed by the treatment bulb soaking in 125 ppm GA_3 (41.10), foliar spray of 100 ppm GA_3 (41.02) and bulb soaking in 100 ppm GA_3 (40.66). However, these treatments were at par with each other. Minimum number of florets spike^{-1} was observed in the treatment bulb soaking in water (35.16). The total number of spikes ha^{-1} was significantly maximum in the treatment foliar spray of 125 ppm GA_3 (4.43) followed by the treatment bulb soaking in 125 ppm GA_3 (4.22) and bulb soaking in 100 ppm GA_3 (3.82). While, minimum number of spikes ha^{-1} was observed in the treatment bulb soaking in water (1.50) where no GA_3 was used. The yield of florets ha^{-1} was significantly maximum in the same treatment of foliar spray of 125 ppm GA_3 (179.21 q) which was significantly superior over all treatments except the treatment bulb soaking in 125 ppm GA_3 (167.49 q) with which it was at par. Whereas, minimum yield of florets was recorded in bulb soaking in water (51.44 q).

Wagh *et al*. (2012) also observed striking influence with the highest concentration at 100 ppm GA_3 on number of florets spike^{-1} in tuberose over control. The application of GA_3 might be attributed to the improved physiological efficiency of the plant such as in improvement of photosynthesis, control of transpiration and photorespiration, efficient water and nutrient uptake and resistance to environmental stresses, thus leading to improved overall growth and flowering of the plant. In case of bulb yield, there was significant reduction of bulb numbers with declining concentrations of GA_3 in bulb soaking as well as foliar spray applications.

Table 1. Effect of GA_3 on growth parameters in tuberose

	Treatment s (GA_3-ppm)	Days required for sprouting of bulbs	Plant height (cm)	No. of leaves plant $^{-1}$
1.	Bulb soaking in water	10.56	48.74	51.82
2.	Bulb soaking in 25 ppm GA_3	12.29	51.11	53.96
3.	Bulb soaking in 50 ppm GA_3	12.42	52.04	54.31
4.	Bulb soaking in 75 ppm GA_3	13.46	54.28	56.42
5.	Bulb soaking in 100 ppm GA_3	14.52	55.16	58.92
6.	Bulb soaking in 125 ppm GA_3	16.09	57.03	60.22
7.	Foliar spray of water	12.29	49.55	53.02
8.	Foliar spray with 25 ppm GA_3	10.36	50.26	55.03
9.	Foliar spray with 50 ppm GA_3	12.28	52.14	55.36
10.	Foliar spray with 75 ppm GA_3	11.47	52.94	56.22
11.	Foliar spray with 100 ppm GA_3	11.61	53.89	57.01
12.	Foliar spray with 125 ppm GA_3	12.32	55.14	57.89
	SE (m) $\pm$	0.554	0.422	0.779
	CD (P=0.05)	1.556	1.186	2.189

Table 2. Effect of GA_3 on flowering parameters in tuberose

	Treatment s (GA_3-ppm)	Days required for opening of first pair of florets on spike after planting	Blooming period (Days)	Length of spike (cm)	Length of rachis (cm)	Vase life of flower stalk (Days)
1.	Bulb soaking in water	130.94	12.36	69.54	28.34	08.79
2.	Bulb soaking in 25 ppm GA_3	129.86	14.25	73.87	30.16	10.32
3.	Bulb soaking in 50 ppm GA_3	127.25	16.01	79.65	32.48	10.65
4.	Bulb soaking in 75 ppm GA_3	125.65	15.98	84.58	31.05	10.54
5.	Bulb soaking in 100 ppm GA_3	123.37	17.03	97.16	33.35	11.86
6.	Bulb soaking in 125 ppm GA_3	119.31	17.62	102.19	34.66	12.04
7.	Foliar spray of water	134.38	13.22	67.33	27.93	08.90
8.	Foliar spray with 25 ppm GA_3	131.25	13.77	73.72	29.76	10.54
9.	Foliar spray with 50 ppm GA_3	131.25	14.33	82.95	30.77	11.36
10.	Foliar spray with 75 ppm GA_3	127.00	16.55	85.07	32.24	11.78
11.	Foliar spray with 100 ppm GA_3	123.91	16.84	92.89	32.91	12.22
12.	Foliar spray with 125 ppm GA_3	122.21	17.78	98.05	34.02	12.82
	SE (m) $\pm$	0.869	0.226	1.377	0.749	0.444
	CD (P=0.05)	2.443	0.635	3.867	2.106	1.248

Table 3.Effect of GA_3 on yield parameters in tuberose

Treatments (GA_3-ppm)	No. of florets spike^{-1}	Total no. of spikes ha^{-1} (lakhs)	Yield of florets ha^{-1} (q)	Total no. of bulbs ha^{-1} (lakhs)	Weight of bulbs ha^{-1}
1. Bulb soaking in water	35.16	1.50	51.44	7.38	179.62
2. Bulb soaking in 25 ppm GA_3	38.34	1.94	71.39	7.77	189.71
3. Bulb soaking in 50 ppm GA_3	39.89	2.41	94.24	8.11	193.82
4. Bulb soaking in 75 ppm GA_3	40.16	2.92	115.02	8.44	205.55
5. Bulb soaking in 100 ppm GA_3	40.66	3.82	149.89	8.91	212.96
6. Bulb soaking in 125 ppm GA_3	41.10	4.22	167.49	9.13	226.85
7. Foliar spray of water	35.72	1.62	54.32	7.16	174.69
8. Foliar spray with 25 ppm GA_3	38.33	2.20	80.76	7.68	187.96
9. Foliar spray with 50 ppm GA_3	40.01	2.81	106.69	7.79	200.00
10. Foliar spray with 75 ppm GA_3	39.98	2.76	109.36	7.90	208.33
11. Foliar spray with 100 ppm GA_3	41.02	3.41	135.49	8.28	220.67
12. Foliar spray with 125 ppm GA_3	41.21	4.43	179.21	8.93	223.14
SE (m) $\pm$	0.365	0.224	8.433	0.023	0.923
CD(P=0.05)	1.026	0.628	23.685	0.065	2.592

However, bulb soaking with 125 ppm GA_3 resulted in maximum number of bulbs ha^{-1} (9.13 lakh) which was significantly superior over all treatments and it was followed by the treatment foliar spray of 125 ppm GA_3 (8.93 lakh). However, minimum number of bulbs ha^{-1} was observed in the treatment foliar spray of water (7.16 lakh) and maximum weight of bulbs ha^{-1} was recorded in the treatment bulb soaking in 125 ppm GA_3 (226.85 q) which was significantly superior over all treatments and it was followed by the treatment foliar spray of 125 ppm GA_3 (223.14 q). However, minimum weight of bulbs ha^{-1} was observed in the treatment foliar spray of water (174.69 q). The present results are in agreement with the findings of Siraj and Al- Safar (2006) in gladiolus and Shankar *et al*. (2011) in tuberose. They also observed more bulb yield when bulbs were soaked in 150 ppm GA_3 concentration.

Gibberellic acid is known to induce cell elongation, thus leading to increase plant height and number of leaves which might have led to overall improved rate of photosynthesis and nutrient and water uptake. As a result of this increased availability of the metabolites to the developing bulbs, there might have been improvement in number and weight of bulbs.

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EXPLOITATION OF LOCAL LINES OF MUSTARD FOR RECOMBINATION BREEDING

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ABSTRACT

Twenty local lines of mustard were crossed with three testers during *rabi* 2011 to obtain 60 crosses which were evaluated during *rabi* 2012 by growing in RBD with three replications on the farm of Agricultural Botany section, College of Agriculture, Nagpur. Analysis of variance for experimental design in crosses revealed highly significant mean squares due to genotypes for all the characters except days to maturity, which indicates significant variation among the experimental material. The significant mean squares due to lines for days to first flower, days to maturity, plant height, number of primary branches plant^{-1}, number of siliquae plant^{-1}, seed yield plant^{-1} and due to line x tester for days to first flower, number of primary branches plant^{-1}, number of siliquae plant^{-1}, 1000 seed weight and seed yield plant^{-1} revealed the presence of gca among lines and sca among crosses. Estimation of variances and degree of dominance revealed the predominance of non additive or dominance genetic component for all the characters studied except days to maturity. But mustard being self pollinated crop only additive genetic component could be exploited worth fully, hence preference in this study was given to additive genetic component. Among lines ACNM 20, ACNM 21, ACNM 3 and ACNM5 were identified as good combiners for seed yield plant^{-1} and number of siliquae plant^{-1}. Based on the performance of crosses three crosses ACNM 18 x BioYSR, ACNM 19 x Geeta and ACNM 16 x Geeta were identified as potential crosses for their exploitation in recombination breeding. It is suggested from this study that, six three way crosses viz.,(ACNM 18 x BioYSR) x ACNM 20, (ACNM 19 x Geeta) x ACNM 20, (ACNM16 x Geeta) x ACNM 20, (ACNM 18 x BioYSR) x ACNM 21, (ACNM 19 x Geeta) x ACNM 21, (ACNM16 x Geeta) x ACNM 21 and two double crosses (ACNM 18 x BioYSR) x (ACNM 19 x Geeta) and (ACNM 18 x BioYSR) x (ACNM 16 x Geeta) involving the identified superior crosses and parents should be performed and carried over further by Single seed descent method if the genetic base is to be broadened.

(Keywords : Mustard, local lines, gca and sca effects, variances)

INTRODUCTION

Indian mustard (*Brassica juncea*) called as rai, raya or laha is an important oil seed crop belonging to Brassicae group. Oil content in Indian mustard seeds varies from 30 to 48 per cent. Crop Brassica encompass many diverse type plants, which are grown as vegetables, fodder or sources of oil and condiments. In India, the area, production and productivity were 6.69 million hectares, 6.60 million tonnes and 1145 kg ha^{-1} respectively (Anonymous, 2011). In Maharashtra area, production and productivity were 1200 hectares, 4000 tonnes and 308 kg ha^{-1} (Anonymous, 2011). In recent years though there has been an increase in the area and production of rapeseed mustard, the average productivity in India is quite low in comparison to that in some of the developed countries. In India, however production of edible oil is grossly short of the requirements. Consequently, large quantities have to be imported for making up the shortfall, which in turn is a heavy drain on foreign exchange resources. Vigorous efforts therefore are needed to increase the yield level and to achieve self sufficiency. Yield is one of the most important economic characters and is the product of multiplicative interaction of contributing characters. Hence, the important objective in mustard improvement is oriented to develop varieties which have high yielding potential.

The concept of combining ability analysis is important in designing plant breeding programmes. Information on combining ability provides guidelines to the plant breeders in selecting the elite parents and desirable cross combinations and at the same time reveals the nature of gene action involved in the inheritance of various traits and thereby helps in formulation of breeding methodology to be used. The nature of gene action would help in predicting the effectiveness of selection in population. A distinct type of gene action, its magnitude and constitution of genetic architecture is of fundamental importance to the plant breeder.

Keeping in view the above facts this work was executed to evaluate 20 local lines of mustard and the crosses involving these lines.

MATERIALS AND METHODS

Twenty Local lines viz. ACNM 1, ACNM 2, ACNM 3, ACNM 4, ACNM 5, ACNM 6, ACNM 8,

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ACNM 10, ACNM 11, ACNM 12, ACNM 13, ACNM 14, ACNM 15, ACNM 16, ACNM 17, ACNM 18, ACNM 19, ACNM 20, ACNM 21and ACNM 22 collected from different places of Vidarbha were crossed with three testers Geeta, RH- 819 and Bio YSR to obtain 60 crosses during *rabi* 2011.

Sixty F_1 crosses obtained were grown during *rabi* 2012 in randomized complete block design with three replications. Single row was allotted for each cross which consisted of twenty plants with a spacing 45 x 15 cm. Recommended package of practices were followed as per schedule to raise healthy crop during both *rabi* 2011 and 2012. Five plants from each F_1 cross were randomly selected from each replication for recording observations like days to first flower, days to maturity, plant height (cm), number of primary branches plant^{-1},1000 seed weight (g), number of siliquae plant^{-1} and seed yield plant^{-1}(g). The data were subjected to statistical and biometrical analysis as the methodology given by Panse and Sukhatme (1954) and Kempthrone (1957).

RESULTS AND DISCUSSION

Analysis of variance for the experimental design as observed from table 1 revealed the presence of substantial genetic variability among the genotypes i.e. crosses. The results on mean performance of 60 crosses reported in table 2 revealed that the cross ACNM 18 x BioYSR produced maximum seed yield plant^{-1} of 15.27 g, maximum number of siliquae plant^{-1}(225) and high number of primary branches (5.07) and 1000 seed weight (4.73 g) and attained maturity within 95.87 days. This was followed by cross ACNM 21 x BioYSR producing high seed yield plant^{-1} of 11.73 g, 224.60 siliquae plant^{-1}, 5.27 primary branches plant^{-1} and attained maturity within 99.13 days. The crosses ACNM 20 x BioYSR and ACNM 19 x Geeta also exhibited high seed yield plant^{-1} (10.81g and 10.31g), high siliquae plant^{-1} (216 and 218 respectively), number of primary branches plant^{-1} (5.03 and 5.07) and 1000 seed weight (4.63 g and 4.45 g respectively) and attained maturity within 97.73 and 94.27 days respectively. Hence, these four crosses ACNM 18 x BioYSR, ACNM 21 x BioYSR, ACNM 20 x BioYSR and ACNM 19 x Geeta were identified as superior crosses based on mean performance.

Analysis of variance for combining ability is presented in table 3. Mean squares due to lines were significant for all characters except number of primary branches and 1000 seed weight. Mean squares due to testers were non significant for all the characters studied. Mean squares due to line x tester were highly significant for days to first flower, number of primary branches plant^{-1},1000 seed weight and seed yield plant^{-1} at both the levels of significance and number of siliquae plant^{-1} was significant only at 5 % level of significance. Mean squares due to line x tester were non significant for days to maturity and plant height. The significant mean squares for lines and for line x tester for yield and most of the yield component indicates the presene of gca among lines and sca among crosses. Such significant variation for gca and sca were also reported by Nair *et al*. (2005), Singh (2007), Patel *et al.* (2005) in mustard. Mean squares due to lines were higher than that of testers for all characters studied which indicated greater contribution of lines towards gca for these traits.

Random effect model adopted in the present study allows the estimation of variance components which helps to know precisely the relative importance of additive and dominance component in the control of different characters. σ^2 H (Dominance genotypic variance) was found to be maximum for number of siliquae plant^{-1}(486.62) followed by plant height (152.25), days to first flower (8.93) and seed yield plant^{-1}(3.35), σ^2 D (Additive genetic variance) was found to be high for number of siliquae plant^{-1}(17.51), followed by plant height (7.13), days to first flower (0.25). Dominant or non additive genetic variance was found to be more than additive genetic variance for days to first flower, plant height, number of primary branches plant^{-1}, number of siliquae plant^{-1}, 1000 seed weight and seed yield plant^{-1} except days to maturity indicating predominance of non additive genetic component in the inheritance of these characters. This can also be confirmed from the average degree of dominance for these characters which ranged from 20.38 for 1000 seed weight to 6.53 for plant height. These results were in accordance with the findings of Goswami and Behl (2005), Aher *et al*. (2009) and Parmar *et al*. (2011) who also reported the predominance of non additive genetic component for the inheritance of seed yield plant^{-1} and important yield component like number of siliquae plant^{-1} and 1000 seed weight etc.

The data regarding general combining ability effects are presented in table 4. Estimates of gca effects in this study revealed that among the lines ACNM 21 was found to be best general combiner for seed yield plant^{-1}, number of siliquae plant^{-1}, plant height, days to maturity and days to first flower. This was followed by ACNM 20 for seed yield plant^{-1}, number of siliquae plant^{-1}, plant height and days to first flower. ACNM 3 and ACNM 5 were also found to be good general combiners for seed yield plant^{-1} and number of siliquae plant^{-1}. Hence, these four lines ACNM 20, ACNM 21, ACNM 3 and ACNM 5 were identified as good combiners and would therefore, be useful as desirable parents for enhancing the yield potential through assembling favourable genes for desirable yield components.

Study of sca effects (Table 5) revealed that none of the crosses showed significant sca effects in the desirable direction for all the characters studied. Wide variability for sca effects was observed among the crosses for different characters. It is worth to note here that among the crosses showing significant sca in desirable direction in most of the characters involved one parent as good general combiner. Out of the 60 crosses studied, the cross ACNM 21 x BioYSR showed positive significant sca for seed yield plant^{-1}, number of siliquae plant^{-1} and number of primary branches plant^{-1}. Four other crosses ACNM 20 x BioYSR, ACNM 12 x Geeta, ACNM 15 x RH- 819, ACNM 22 x RH- 819 recorded positive significant sca effect for seed yield plant^{-1} and 1000 seed weight. Predominance of non additive genetic control for seed yield plant^{-1} and its component characters except days to maturity and positive significant sca effect observed in above four crosses indicated potential of heterosis breeding for improving the productivity in this crop by the use of above four crosses. The cross ACNM 21 x Geeta exhibited negative significant sca effect for seed yield plant^{-1}, number of siliquae plant^{-1} and number of primary branches plant^{-1}. Another cross ACNM 6 x Geeta exhibited negative significant sca effect for seed yield plant^{-1}, 1000 seed weight and days to first flower. Simillarly, crosses ACNM 20 x Geeta and ACNM 20 x RH- 819 recorded negative significant sca effect for seed yield plant^{-1} and 1000 seed weight. These four crosses ACNM 21 x Geeta, ACNM 6 x Geeta, ACNM 20 x Geeta and ACNM 20 x RH- 819 having negative significant sca effects can be exploited for recombination breeding, if they exhibit high mean performance for the seed yield plant^{-1} and number of siliquae plant^{-1}.

In predominantly self pollinated crop like mustard the breeder is restricted to produce true breeding varieties only, as the non additive portion of phenotypic variation is non fixable in later generation. A breeder would therefore prefer to identify the crosses which have low sca effects but have high mean performance and involves good general combiner as parents. The crosses ACNM 18 x BioYSR, ACNM 19 x Geeta and ACNM 16 x Geeta exhibited high mean (15.27, 10.31 and 9.19 g) for seed yield plant^{-1} with low negative sca effect (- 0.29, 0.37 and - 0.39) for the same character as observed from table 8. These crosses also possessed high mean (225, 218 and 180.87) for number of siliquae plant^{-1} with low sca effects (-9.60, - 3.76 and -11.23). The above three crosses were also found to posses low sca effect for days to first flower. Hence, these three crosses ACNM 18 x BioYSR, ACNM 19 x Geeta and ACNM 16 x Geeta appeared to be the most potential crosses and showed the involvement of additive gene action which is the general situation observed in self pollinated crop. The genotype of inherent superiority can be produced from this population by blending and fixing maximum favourable genes.

To broaden the genetic base it is necessary to produce three way cross or double cross involving the selected crosses and good general combining parents viz.,(ACNM18 x BioYSR) x ACNM 20, (ACNM 19 x Geeta) x ACNM 20, (ACNM 16 x Geeta) x ACNM 20, (ACNM 18 x BioYSR) x ACNM 21, (ACNM 19 x Geeta) x ACNM 21, (ACNM 16 x Geeta) x ACNM 21,(ACNM 18 x BioYSR) x (ACNM 19 x Geeta) and (ACNM18 x BioYSR) x (ACNM16 x Geeta) which may be utilized for deriving superior transgrates for seed yield plant^{-1}, number of siliquae plant^{-1} and early flowering. Hence, it is suggested from this study that the above mentioned three way and double crosses should be effected in the next season and should be forwarded through single seed descent method to identify desirable recombinant lines.

Table 1. Analysis of variance for the experimental design in crosses

Sources	d.f.	Mean squares						
		Days to first flower	Days to maturity	Plant height (cm)	No.of primary branches plant^{-1}	No. of siliquae plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)
Replication	2	14.51	73.88	1780.21	1.35	853.93	0.034	0.99
Crosses	59	26.28**	7.12	600.19**	0.82**	2064.22**	1.36**	10.41**
Error	118	2.42	11.46	228.50	0.12	769.09	0.011	1.33

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

Table 2. Mean performance of crosses for different characters in mustard

Sr. No.	Crosses	Days to first flower	Days to maturity	Plant height (cm)	No.of Primary branches plant^{-1}	No.of siliquae plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)
1	ACNM 1x Geeta	42.27	96.87	178.33	3.87	128.00	4.81	7.35
2	ACNM 2 x Geeta	42.13	96.27	190.47	5.53	186.40	3.73	8.01
3	ACNM 3 x Geeta	40.20	96.13	176.47	4.73	155.00	4.43	8.49
4	ACNM 4 x Geeta	44.67	96.27	190.53	5.20	184.00	3.72	8.77
5	ACNM 5 x Geeta	39.87	95.07	181.13	4.07	129.87	5.07	8.56
6	ACNM6 x Geeta	37.80	94.93	170.60	4.07	152.67	3.71	7.63
7	ACNM 8 x Geeta	39.87	94.60	180.40	4.60	187.20	3.27	9.85
8	ACNM22 x Geeta	38.00	94.47	180.20	4.73	193.33	3.40	8.27
9	ACNM 10 x Geeta	38.33	95.20	181.13	4.07	172.47	3.51	7.37
10	ACNM11 x Geeta	42.73	94.93	177.83	5.27	153.67	3.67	8.33
11	ACNM12 x Geeta	38.60	93.27	180.33	4.70	175.53	3.76	8.13
12	ACNM13 x Geeta	37.87	93.87	162.00	4.00	158.80	3.45	6.69
13	ACNM14 x Geeta	41.93	93.07	183.07	4.80	194.80	4.07	8.61
14	ACNM15 x Geeta	40.87	93.13	170.00	4.87	170.47	3.55	7.62
15	ACNM16 x Geeta	40.53	96.27	182.40	4.80	180.87	3.64	9.19
16	ACNM17 x Geeta	38.60	93.93	158.93	4.20	126.67	3.84	5.78
17	ACNM18 x Geeta	42.47	96.47	181.07	3.73	136.07	5.17	8.96
18	ACNM19 x Geeta	43.80	94.27	195.33	5.07	218.00	4.45	10.31
19	ACNM20 x Geeta	42.33	93.80	180.67	3.67	128.53	4.79	6.71
20	ACNM21 x Geeta	38.60	93.67	168.33	3.47	126.07	3.83	4.73
21	ACNM 1x RH-819	35.40	93.13	157.67	3.40	114.27	4.43	6.58
22	ACNM 2x RH-819	36.47	93.07	160.40	4.20	127.67	3.53	4.41
23	ACNM 3 x RH-819	35.27	94.20	152.07	4.07	134.47	4.49	7.08
24	ACNM 4 x RH-819	38.67	93.60	154.27	4.43	153.87	3.49	6.58
25	ACNM 5 x RH-819	35.80	93.53	153.60	3.93	125.33	4.69	7.39
26	ACNM 6 x RH-819	35.47	94.60	149.00	4.00	123.00	4.35	6.31
27	ACNM 8 x RH-819	41.67	94.33	168.13	4.40	159.07	4.01	8.01
28	ACNM 22 x RH-819	35.27	92.87	162.53	4.60	145.07	3.71	6.45
29	ACNM10 x RH-819	35.13	91.93	149.73	4.13	157.87	2.99	6.53
30	ACNM11 x RH-819	41.20	94.53	171.00	4.53	154.87	3.47	5.61
31	ACNM12 x RH-819	35.07	93.93	161.87	4.13	170.27	4.46	9.39
32	ACNM13 x RH-819	36.67	93.47	163.73	4.27	169.00	3.75	6.76
33	ACNM14 x RH-819	37.33	92.47	166.67	4.40	141.47	3.28	5.73
34	ACNM15 x RH-819	37.47	92.07	159.33	4.20	129.87	3.43	4.08
35	ACNM16 x RH-819	36.13	93.40	151.87	4.27	133.87	3.19	4.03
36	ACNM17 x RH-819	37.53	93.07	149.47	3.73	122.20	4.49	5.57
37	ACNM18 x RH-819	37.47	93.80	164.73	3.67	135.27	4.75	7.32
38	ACNM19 x RH-819	37.47	91.47	163.87	4.73	170.47	3.86	6.75
39	ACNM20 x RH-819	39.00	94.53	166.40	3.80	122.00	4.73	6.71
40	ACNM21 x RH-819	37.93	92.20	164.40	3.67	148.07	3.23	6.09
41	ACNM 1x BioYSR	41.73	94.80	190.60	3.87	139.40	4.64	7.82
42	ACNM 2 x BioYSR	43.47	93.53	184.27	4.40	149.27	2.98	5.55
43	ACNM 3 x BioYSR	39.07	93.47	168.87	3.80	139.60	4.43	6.81
44	ACNM 4 x BioYSR	41.93	93.47	176.60	4.87	175.93	3.31	7.51
45	ACNM 5 x BioYSR	40.33	95.53	192.53	3.60	151.87	5.45	7.87
46	ACNM 6 x BioYSR	41.53	95.47	190.53	4.40	140.47	4.59	6.70
47	ACNM 8 x BioYSR	43.20	93.73	184.80	4.90	133.27	2.97	4.99
48	ACNM22 x BioYSR	42.40	94.73	190.07	4.60	170.13	3.10	6.44
49	ACNM10 x BioYSR	43.13	94.33	190.40	4.67	170.53	3.33	9.37
50	ACNM11 x BioYSR	41.73	93.60	184.93	4.93	164.07	2.84	6.33

Table 2 continued.....

Sr. No.	Crosses	Days to first flower	Days to maturity	Plant height (cm)	No.of Primary branches plant^{-1}	No.of siliquae plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)
51	ACNM12 x BioYSR	42.53	94.60	196.80	4.20	159.13	4.21	7.96
52	ACNM13 x BioYSR	41.60	94.80	185.40	4.33	169.27	3.33	6.75
53	ACNM14 x BioYSR	44.47	94.20	191.53	5.00	179.93	3.07	7.57
54	ACNM15 x BioYSR	44.53	96.13	185.53	5.40	184.80	2.95	7.61
55	ACNM16 x BioYSR	43.33	95.53	185.73	5.27	208.93	3.09	8.15
56	ACNM17 x BioYSR	41.40	93.07	182.80	4.73	202.60	3.00	9.17
57	ACNM18 x BioYSR	44.87	95.87	197.40	5.07	225.00	4.73	15.27
58	ACNM19 x BioYSR	43.20	98.87	188.53	3.80	138.53	4.91	7.39
59	ACNM20 x BioYSR	44.47	97.73	195.40	5.03	216.00	4.63	10.81
60	ACNM21 x BioYSR	44.93	99.13	198.07	5.27	224.60	3.41	11.73
	General mean	40.12	94.42	175.34	4.38	157.56	3.88	7.47
	SE (m)	1.27	2.76	12.34	0.28	22.64	0.08	0.94
	SE (d)	0.89	1.95	8.72	0.20	16.01	0.061	0.66
	CD (5%)	2.51	5.45	24.37	0.56	44.72	0.171	1.86
	CD (1%)	3.31	7.20	32.17	0.74	59.03	0.225	2.45

Table 3. Analysis of variance for combining ability

Sources	d.f.	Mean squares						
		Days to first flower	Days to maturity	Plant height (cm)	No.of primary branches plant^{-1}	No. of siliquae plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)
Lines	19	53.42**	15.49**	1383.66**	1.19	4072.75**	1.65	18.75**
Testers	2	11.49	7.33	173.77	0.28	749.30	0.62	6.15
Lines x Testers	38	13.49**	2.91	230.92	0.66**	1208.04*	1.27**	6.46**
Error	118	2.43	11.45	228.50	0.12	769.09	0.011	1.33
	σ^2 gca	0.12	0.04	3.57	0.002	8.76	0.0009	0.04
	σ^2sca	8.93	-0.61	152.25	0.21	486.62	0.39	3.35
	σ^2 gca vs σ^2sca	0.81	1.49	0.99	0.65	0.88	0.60	0.81
	σ^2D	0.25	0.08	7.13	0.003	17.51	0.002	0.08
	σ^2H	8.93	-0.62	152.25	0.21	486.62	0.39	3.36
Average degree of dominance		8.50	4.40	6.53	11.68	7.45	20.38	9.39

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

Table 4. General combining ability effects of parents

Sr. No.	Genotypes Lines	Days to first flower	Days to maturity	Plant height (cm)	No.of siliquae plant^{-1}	Seed yield plant^{-1}(g)
1	ACNM 1	1.40*	2.001	6.41	-1.09	0.47
2	ACNM 2	0.65	1.001	5.41	-2.05	0.84*
3	ACNM 3	-1.39*	0.33	5.23	26.77**	1.02**
4	ACNM 4	-0.39	-0.39	-1.95	5.11	0.24
5	ACNM 5	0.98	-0.26	3.14	24.48*	0.99**
6	ACNM 6	1.49**	0.46	3.09	-9.32	0.87*
7	ACNM 8	-1.35*	-0.88	- 6.46	- 34.61**	- 1.47**
8	ACNM 22	-3.33**	-0.79	-19.77**	-18.89**	-1.45**
9	ACNM 10	-2.48**	-0.27	-18.44**	-21.76*	-0.24
10	ACNM11	-2.93**	-1.31	-14.24**	-4.96	-1.28**
11	ACNM12	-3.77**	-1.13	-11.24**	2.68	-0.18
12	ACNM13	3.08**	1.58	21.79**	28.92**	2.92**
13	ACNM14	-2.15**	-1.15	-10.35*	-14.98	-0.55
14	ACNM15	0.92	-0.91	4.41	-11.98	-0.98**
15	ACNM16	0.32	-0.26	3.98	-1.76	-0.08
16	ACNM17	2.25**	0.22	13.12*	-9.61	-1.43**
17	ACNM18	2.34**	0.24	15.37**	7.02	0.41
18	ACNM19	3.40**	0.62	12.14*	20.44*	-0.17
19	ACNM20	3.07**	0.40	13.29*	54.62**	3.39**
20	ACNM21	4.07**	4.16**	18.65**	18.82*	2.50**
	SE(i)±	**0.57**	**1.15**	**5.27**	**9.53**	**0.36**

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

Table 5. Specific combining ability effects of crosses

S.N.	Crosses	Days to first flower	No.of primary branches plant^{-1}	No.of siliquae plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)
1	ACNM 1x Geeta	0.88	-0.78**	-23.49	0.39**	-0.41
2	ACNM 2 x Geeta	4.03**	0.82**	33.46*	-0.54**	0.64
3	ACNM 3 x Geeta	1.28	0.20	7.84	-0.22*	1.55*
4	ACNM 4 x Geeta	3.14**	0.68**	-4.03	-0.05	0.80
5	ACNM 5 x Geeta	0.96	0.05	17.73	0.22*	0.33
6	ACNM6 x Geeta	-2.88**	0.05	-16.60	-0.75**	-2.38**
7	ACNM 8 x Geeta	3.69**	0.22	10.55	0.34**	0.89
8	ACNM22 x Geeta	-0.19	0.04	-6.03	-0.40**	-1.42*
9	ACNM 10 x Geeta	-1.70	-0.11	-5.49	0.25**	0.35
10	ACNM11 x Geeta	-1.79	0.25	-2.56	0.22*	0.44
11	ACNM12 x Geeta	-1.15	-0.07	14.99	0.54*	2.29**
12	ACNM13 x Geeta	0.57	0.20	6.19	-0.37**	-0.29
13	ACNM14 x Geeta	-0.35	-0.33	-2.34	0.21*	0.58
14	ACNM15 x Geeta	-2.97**	-0.24	7.46	-0.49**	-0.21
15	ACNM16 x Geeta	-1.24	-0.22	-11.23	-0.06	-0.39
16	ACNM17 x Geeta	-0.70	-0.17	-2.51	0.94**	0.85
17	ACNM18 x Geeta	0.80	0.14	10.93	-0.23*	1.67**
18	ACNM19 x Geeta	-1.79	-0.51**	-3.76	0.12	-0.37
19	ACNM20 x Geeta	0.28	0.31	1.73	-0.61**	-2.52**
20	ACNM21 x Geeta	-0.86	-0.53**	-32.87*	0.49**	-2.39**
21	ACNM 1x RH-819	0.95	0.75**	29.11	-0.48**	0.24
22	ACNM 2x RH-819	-0.56	-0.45**	-26.46	1.01**	0.42
23	ACNM 3 x RH-819	-0.38	0.19	8.18	0.12	-0.05
24	ACNM 4 x RH-819	-0.78	-0.02	12.05	0.24	0.59
25	ACNM 5 x RH-819	0.10	-0.02	-12.39	-0.09	-0.68
26	ACNM 6 x RH-819	1.19	-0.56**	-12.99	0.79**	0.79
27	ACNM 8 x RH-819	0.17	-0.11	2.29	-0.41**	-1.09
28	ACNM 22 x RH-819	-1.18	-0.24	-5.02	0.76**	1.24*
29	ACNM10 x RH-819	-1.82	-0.18	-13.62	0.10	-0.75
30	ACNM11 x RH-819	-1.72	-0.34	4.45	-0.29**	0.51
31	ACNM12 x RH-819	0.66	-0.07	7.94	0.02	-0.36
32	ACNM13 x RH-819	-0.56	0.13	4.40	-0.41**	-0.35
33	ACNM14 x RH-819	-0.16	0.59**	27.07	-0.48**	0.01
34	ACNM15 x RH-819	1.04	-0.18	-6.99	1.13**	1.51*
35	ACNM16 x RH-819	1.84	0.71	19.31	-0.98**	0.29
36	ACNM17 x RH-819	1.17	0.19	-15.51	-0.47**	-0.88
37	ACNM18 x RH-819	-0.38	0.27	-1.33	-0.51**	-1.38*
38	ACNM19 x RH-819	1.28	0.02	1.11	0.06	0.44
39	ACNM20 x RH-819	-1.45	-0.36	-10.39	-0.50**	-1.51*
40	ACNM21 x RH-819	0.62	-0.34	-11.19	0.42**	1.01
41	ACNM 1x BioYSR	-1.82	0.02	-5.62	0.09	0.17
42	ACNM 2 x BioYSR	-3.47**	-0.38*	-7.00	-0.47**	-1.06
43	ACNM 3 x BioYSR	-0.89	-0.40*	-16.02	0.10	-1.49*
44	ACNM 4 x BioYSR	-2.36**	-0.66**	-8.02	-0.19	-1.39*
45	ACNM 5 x BioYSR	-1.07	-0.02	-5.33	-0.12	0.35
46	ACNM 6 x BioYSR	1.69	0.51**	29.60	-0.05	1.59*
47	ACNM 8 x BioYSR	-3.87**	-0.11	-12.84	0.07	0.21
48	ACNM 22 x BioYSR	1.38	0.20	11.04	-0.36**	0.19
49	ACNM 10 x BioYSR	3.53**	0.29	19.11	-0.35**	0.40
50	ACNM11 x BioYSR	3.51**	0.11	-1.89	0.07	-0.96
51	ACNM12 x BioYSR	0.49	0.13	-22.93	-0.56**	-1.93**
52	ACNM13 x BioYSR	-0.002	-0.33	-10.60	0.78**	0.64
53	ACNM14 x BioYSR	0.53	-0.27	-24.73	0.27**	-0.59
54	ACNM15 x BioYSR	1.93	0.42*	-0.47	-0.65**	-1.31*
55	ACNM16 x BioYSR	-0.60	-0.49**	-8.09	1.05**	0.10
56	ACNM17 x BioYSR	-0.47	-0.03	18.02	-0.46**	0.023
57	ACNM18 x BioYSR	-0.42	-0.40	-9.60	0.74**	-0.29
58	ACNM19 x BioYSR	0.51	0.49**	2.64	-0.18	-0.07
59	ACNM20 x BioYSR	1.18	0.04	8.67	1.12**	4.04**
60	ACNM21 x BioYSR	0.24	0.87**	44.07**	-0.92**	1.39*
	SE(ij) ±	**0.19**	**0.19**	**16.49**	**0.94**	**0.62**

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

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EFFECT OF NITROGEN, PHOSPHORUS AND SULPHUR LEVELS ON SUMMER SESAME YIELD, ECONOMICS AND RESIDUAL FERTILITY STATUS OF SOIL

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ABSTRACT

The experiment was laid out during summer season of 2011-2012 at Agriculture College, Nagpur in split plot design with three fertilizer levels as main plot treatments viz., 100% RDF(25:25:0 kg NPK ha^{-1}). 125% RDF (31.25:31.25:0 kg NPK ha^{-1}) and 150% RDF (37.5:37.5:0 NPK ha^{-1}) and five sulphur levels as subplot treatments viz., 0 (Control), 10, 20,30,40 kg S ha^{-1}. There were 15 treatment combinations replicated three times. The soil was clayey in texture with pH 7.76 indicating slightly alkaline in reaction. Seed yield (kg ha^{-1}) were significantly more due to 150% RDF over 100% RDF followed by 125% RDF. The GMR and NMR were also recorded significantly more due to 150% RDF over 100% RDF. But NMR due to 125% RDF was at par with 150% RDF. The B:C ratio (1.63) was higher with 150% RDF. Residual available sulphur was not influenced significantly. But residual available N and P were significantly more due to 150% RDF over rest of the values. Maximum seed yield (kg ha^{-1}) was recorded in 40 kg S ha^{-1} which was at par with 30 kg S ha^{-1}. GMR was also recorded significantly more due to 40 kg S ha^{-1}application over other treatments. But in case of NMR highest values were recorded due to application of 20 kg S ha^{-1} which was at par with 30 kg S ha^{-1}. Maximum benefit:cost ratio was recorded by 20 kg S ha^{-1} (1.73). Residual available N, P and S were significantly more due to application of 40 kg S ha^{-1} over rest of the values. Interaction effects of fertilizer levels with sulphur were found to be non significant in respect of yield of sesame.

(Key words: Nitrogen, phosphosus, sulphur, sesame)

INTRODUCTION

Sesame is an important oilseed crop as major source of high quaity edible oil in India, sesame is grown on an area of 18.09 lakh ha with an annual production of 6.4 lakh tonnes (Damodaran and Hedge, 2010). The average yield of sesame in India is very low i.e. 354 kg ha^{-1}. In Maharashtra state, area under sesame crop was 560 ha with the production of 199 tones and productivity of 355 kg ha^{-1} in 2010-11. Vidarbha has 117 ha area with 40 tones production with an average productivity of 368 kg ha^{-1} in2010-11 in *kharif* and *rabi* seasons (Anonymous, 2012). Adoption of improved varieties and suitable crop management practices are important factors for imporving crop productivity. Intensive crop cultivation requires the use of chemical fertilizers, which are not only very short in supply, but they are expensive in developing country like India. The farmers usually apply nitrogen and phosphorus in limited quantity but not potassium and sulphur. The availability of sulphur is not able to fulfill the crop requirements which reflect in poor performance of the crop. In view of the importance of fertilizer application along with sulphur in sesame cultivation, the experiment was planned with th objetives to study the effect of fertilizer and sulphur levels on yield, economy and its effect on residual soil fertility and quality of sesame.

METERIALS AND METHODS

The experiment was laid out in split plot design during summer season of 2011-2012 at Agronomy Farm, College of Agriculture, Nagpur with three fertilizer levels viz., 100% RDF (25:25:0 kg NPK ha^{-1}), 125% RDF (31.25:31.25:0 NPK ha^{-1}) and 150% RDF (37.5:37.5:0 kg NPK ha^{-1}) as main plot treatments and five sulphur levels viz., 0 (Control), 10,20,30 and 40 kg S ha^{-1} as subplot treatments. There were 15 treatment combinations replicated three times. The soil of experiemtntal plot was low in available nitrogen (263.60 kg ha^{-1}), low in available phosphorus (20.32 kg ha^{-1}) and organic carbon (0.52 %), very high in available potassium (414.42 kg ha^{-1}) as regards to fertility status and neutral in reaction (pH 7.76). The soil of the experiment field was clayey in texture and was deficient in available sulphur (6.02 mg kg^{-1}) as against the medium range of 10-20 mg kg^{-1}. During the growing season of crop the maximum temperature varied from 27.0^{0}C to 42.1^{0}C and minimum temperature ranged from 11.5^{0}C to 27.7^{0}C. The relative humidity at morning varied from 21 to 39 where as it was 10 to 41% in evening during the period of crop season.

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Sesame variety AKT-101 was used at spacing of 30 cm x 10 cm. Gross plot was 3.60 m x 4.80 m and net plot was 2.40 m x 3.60 m. The observations were taken in respect of seed yield (q ha^{-1}). Stover yield (kg ha^{-1}), harvest index (%) and yield was recorded from each net plot and converted to kg ha^{-1}. The gross monetary and net monetary returns along with B:C ratio were calculated. The residual fertility status in respect of available N,P and K was estimated at harvest for each net plot as per the method suggested by alkaline permanganate method (Subbiah and Asija, 1956), Olsen's method (Jackson, 1967) and flame emission spectrometer (Jackson, 1967) method respectively.

RESULTS AND DISCUSSION

Seed yield, stover yield (kg ha^{-1}) and harvest index (%)

Data regarding mean seed and stover yield (kg ha^{-1}) and harvest index (%) as influenced by different treatments are presented in table 1.

Effect of fertilizer levels

Seed yield (kg ha^{-1}) was significantly influenced by fertilizer levels. Seed yield (kg ha^{-1}) was maximum in 150% RDF and was significantly superior over 100% RDF and but was at par with 125% RDF. Similar results were found by Purushotham *et al.* (2009) who found that application of 40 kg N in the form of urea was beneficial in getting higher yield in sesame. While Throve *et al.* (2011) reported that, the grain yield was increased significantly with every successive increase in the level of fertility and was the highest with 37.5 kg N ha^{-1} + 18.5 P_2O_5 ha^{-1} which was 39.3 per cent higher than control in sesame. Also Narkhede *et al*. (2001) revealed that, application of NPK (40:30:20 kg ha^{-1}) in combination with farmyard manure produced significantly higher grain yield of sesame. Stover yield (kg ha^{-1}) was significantly influenced by fertilizer level. Stover yield (kg ha^{-1}) was maximum in 150% RDF which was significantly superior over 100% RDF and at par with 125% RDF. Purushotham *et al.* (2009) also reported significantly more stover yield due to 150% RDF in sesame. Treatment 100% RDF gave highest harvest index (26.3%) followed by 125% RDF and 150% RDF.

Effect of sulphur levels

Seed yield (kg ha^{-1}) was maximum in 40 kg S ha^{-1} which was significantly superior over other treatments but at par with 30 kg S ha^{-1} and 20 kg S ha^{-1}. Supply of sulphur might have also promoted floral initiation, resulting in higher number of capsules $plant^{-1}$, number of seeds $plant^{-1}$ and ultimately it enhance seed yield. The increase in seed yield may be attributed to stimulatiory effect of applied sulphur on the synthesis of protein, which in turn might have accelerated photosynthesis, imporved most of the yield contributing components which ultimately resulted in significantly higher seed yield. Subrahmaniyam *et al.* (1999) also found that application of sulphur applied at the rate of 35 kg ha^{-1} with FYM at the rate of 5 t ha^{-1} recorded the maximum and significantly increased seed yield in summer sesame. Similarly Duary and Mandal (2005) observed significant increase in seed yield of sesame due to 40 kg sulphur ha^{-1}. Stover yield (kg ha^{-1}) was maximum in 40 kg S ha^{-1} which was significantly superior over 10 kg S ha^{-1} but at par with 30 kg S ha^{-1} and 20 kg S ha^{-1}. Application of S 40 kg ha^{-1} recorded highest harvest index (26.1) which was at par with 30 kg S ha^{-1}.

Interaction effect

Interaction effects were not significant.

Economics studies

The data in respect of GMR, NMR and B:C ratio as influenced by nitrogen, phosphorus and sulphur levels are presented in table 1.

Effect of fertilizer levels

The gross monetary returns was highest in 150% RDF (Rs. 27882 ha^{-1}) and significantly superior over 100% RDF and 125% RDF. The higher yield due to 150% RDF might have contibuted to the higher gross monetary return as evidenced form the yield data. Maximum net monetary returns in 150% RDF (Rs. 10814 ha^{-1}) was recorded and was found significantly superior over treatment 100% RDF but was at par with 125% RDF. The increasing cost of fertilizer and sulphur and the diminishing rate of returne might have influenced the net return where the 125% RDF was at par with 150 RDF. Application of 150% RDF recorded highest benefit:cost ratio (1.63) followed by 125% RDF (1.62 and 100% RDF (1.59).

Table 1. Yield, economics and residual soil status at harvest of sesame as influenced by the fertilizer and sulphur levels

Treatments	Yield			Economics				Residual fertility status			
	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Cost of cultivation (Rs. ha^{-1})	Cost of Monetary returns (Rs. ha^{-1})	Net Monetary returns (Rs. ha^{-1})	Benefit : Cost ratio	Available sulphur (mg kg^{-1})	Available nitrogen (mg kg^{-1})	Available phosphorus (mg kg^{-1})	Available potash (mg kg^{-1})
Fertilizer levels											
F_1 -100% RDF	430	1204	26.31	16297	25920	9623	1.59	7.64	268.49	20.82	412.62
F_2 -125% RDF	447	1313	25.43	16678	26945	10267	1.62	7.94	270.46	21.39	412.66
F_3 -150% RDF	463	1382	25.11	17068	27882	10814	1.63	8.37	272.96	22.02	412.73
SE (m)	4.02	28.74	--	--	210	210	--	0.21	3.65	0.28	0.79
C D at 5%	16.74	82.52	--	--	824	824	--	--	--	0.79	--
Sulphur levels											
S_0 - 0 kg S ha^{-1}	415	1270	24.62	14370	24009	9639	1.67	7.29	265.26	19.68	410.82
S_1 - 10 kg S ha^{-1}	431	1281	25.17	15310	25941	10631	1.69	7.22	267.21	20.46	411.67
S_2 - 20 kg S ha^{-1}	453	1299	25.98	16010	27697	11687	1.73	7.95	270.23	21.26	412.43
S_3 - 30 kg S ha^{-1}	465	1316	26.10	16710	28216	11506	1.69	8.37	272.89	22.31	413.66
S_4 - 40 kg S ha^{-1}	471	1333	26.11	17410	28714	11304	1.65	9.07	277.61	23.33	414.71
SE ± (m)	5.97	20.10	--	--	358	358	--	0.15	1.66	0.32	1.21
C D (=0.05)	17.41	61.86	--	--	1045	1045	--	0.44	4.86	0.93	--
Interaction											
SE± (m)	10.33	8.83	--	--	620	620	--	0.26	4.08	0.55	1.72
C D (=0.05)	--	--	--	--	--	--	--	--			--
Initial soil status								6.02	263.60	20.32	414.42

Effect of sulphur levels

Gross monetary return was significantly influenced due to sulphur levels. Application of 40 kg S ha^{-1} recorded significantly highest gross monetary returns of Rs. 28714 ha^{-1} over 10 kg S ha^{-1} and control but was at par with 30 kg S ha^{-1} and 20 kg S ha^{-1}. But net monetary return was maximum (Rs. 11687 ha^{-1}) and significantly more due to 20 kg S ha^{-1} over control and 10 kg ha^{-1} sulphur treatments. Sulphure treatments 30 and 40 kg S ha^{-1} were found at par with 20 kg S ha^{-1}. Thus, 20 kg S ha^{-1} dose found to be better.

Maximum benefit : cost ratio was recorded by 20 kg S ha^{-1} (1.73). While 10 kg S ha^{-1} and 30 kg S ha^{-1} recorded same values (1.69) followed by control (1.67) where as 40 kg S ha^{-1} (1.65) was lowest amongst all treatments. Deshmukh *et al.* (2005) found higher B:C ratio in sesame with the application of 15 kg S ha^{-1} which supports the present finding.

Interaction effect

Interaction effect was found non-significat.

Chemical studies

Soil fertility status

Data regarding residual soil fertility status after harvest in terms of available nutrients as influenced by different treatments are presented in table 1 and intial status is also shown.

Effect of fertilizer levels

Available sulphur, available nitrogen and available potassium had no significant effect due to different fertilizer level treatments, but available phosphorus were found significantly superior in 150% RDF than 125% RDF and 100% RDF.

Effect of sulphur levels

Available sulphur, available nitrogen and available phosphorus in soil after harvest were significantly influenced by different sulphur levels. Available N,P and S were significantly higher in 40 kg S ha^{-1} over rest of the treatments. The available potash was not influenced significantly by sulphur levels.

Interaction effect

Interaction effects were found to be non-significant.

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LINE x TESTER ANALYSIS IN LINSEED (*Linum usitasissimum* L.)

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ABSTRACT

A line x tester analysis in linseed was carried out at All India Coordinated Research Project on Linseed, Dr.P.D.K.V, Nagpur during *rabi* 2011-13 with eight lines *viz*., A-95B, EC-1392, EC-1424, IC-15888, GS-234, JRF-4, JRF-5 and F-14 and four testers *viz*., NL-97, PKVNL-260, Padmini and Neelum. The mean squares due to lines were significant for all characters like days to 50 per cent flowering, days to maturity, plant height, number of branches plant^{-1}, number of capsules plant^{-1}, seed yield plant^{-1} and 1000-seed weight. The mean squares due to testers were significant for all characters except days to maturity and plant height. The mean squares due to line x tester interactions were significant for all characters except days to maturity and number of branches plant^{-1}. The study of GCA indicated that the genotypes namely EC-1392, GS-234, JRF-4 and Padmini were good combiners for, early 50% flowering, number of capsules plant^{-1}, branches plant^{-1} and seed yield plant^{-1}. Hence, these parents were identified for their use in crossing programme for achieving further improvement. The study indicated that the cross combinations namely JRF-4 x Padmini, GS-234 x NL-97 and GS-234 x PKV-NL-260 with high mean performance, high positive GCA of parents along with high negative significant SCA effect were identified for exploitation through recombination breeding for obtaining higher seed yield. It is also recommended to produce three way or double crosses viz., (JRF-4 X Padmini) x EC-1392, (JRF-4 X Padmini) x GS-234, (JRF-4 X Padmini) x (GS-234 X NL-97), (JRF-4 X Padmini) x (GS-234 X PKVNL-260), (GS-234 X NL-97) x (GS-234 X PKVNL-260) for deriving superior transgrates.

(Keywords: Combining ability, seed yield, component characters, linseed)

INTRODUCTION

In terms of production and value, oilseed crops are second major agriculture crops next to food grains in India. Linseed (*Linum usitatissimum* L.) is an oldest domesticated and economically important industrial nonedible oilseed crop which is being cultivated for seed and its fiber since centuries**.** To boost up further the production and productivity of linseed, exploitation of heterosis may play a significant role in the years to come. Further, for developing better genotypes through hybridization, the choice of suitable parents is a matter of great concern. Combining ability analysis is one of the powerful tools to test the value of parental lines to produce superior hybrids and for recombinants. Linseed being a self pollinated crop, the technique of line x tester of Kempthorne (1957) for combing ability analysis is very important for screening lines with rapidity. Keeping this background in view, the present study was undertaken.

MATERIALS AND METHODS

Experimental material for the present study consisted of twelve linseed genotypes involving four testers, NL-97, PKVNL-260, Padmini, Neelum and eight lines *viz*., A-95B, EC-1392, EC-1424, IC-15888, GS-234, JRF-4, JRF-5 and F-14 which were crossed in line x tester mating design during *rabi* 2011-12. The resulting 32 hybrids along with their parents were raised during *rabi* 2012-13 at All India Coordinated Research Project on Linseed, Dr.P.D.K.V, Nagpur, in a randomized block design with two replications. Single line progeny rows were raised of 3m length spaced at 45 cm between rows and 30 cm between plants. Normal recommended cultural practices and plant protection measures were followed. Five competitive plants were randomly selected for recording biometrical measurements on days to 50% flowering, days to maturity, plant height, number of branches plant^{-1}, number of capsules plant^{-1}, 1000 seed weight and seed yield plant^{-1}. The average values for all the traits were then used for statistical analysis. The combining ability analysis was carried out as suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

Analysis of variance (Table 1) for combining ability revealed that mean squares due to lines and testers were highly significant for all the characters resulting in a considerable amount of genetic variability in the experimental material. Mean squares due to lines were higher than those of testers for most of the characters under study which indicated that genetic variability among the lines was much

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Table 1. Analysis of variance for combining ability in linseed

Source of variation	d.f	Mean squares						
		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	1000 seed weight	Seed yield plant^{-1}
Crosses	31	24.92**	8.95*	175.61**	1.18**	437.38**	1.90**	3.20**
Lines(Males)	7	67.24**	26.43**	468.06**	2.21**	701.89**	5.08**	6.32**
Testers(Females)	3	12.69*	1.02	54.66	3.26**	1101.71**	2.03**	3.43**
Lines xTesters	21	12.56*	4.25	95.41**	0.54	254.30**	0.82*	2.14**
Error	31	3.63	5.28	29.04	0.36	31.40	0.28	0.41
GCA vs. SCA (Baker,1978)		0.86	0.87	0.85	0.91	0.88	0.90	0.82

*** Significant at 5%** **** Significant at 1%**

Table 2. General combining ability effects of the parents for different characters

Sr. No	Genotypes	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant	1000 seed weight (g)	Seed yield plant (g)
	(Testers)							
1	NL -97	-0.28	-	-	0.26	7.52**	0.08	0.03
2	PKV -NL -260	1.28*	-	-	-0.30	-8.29**	0.47**	0.05
3	Padmini	-0.78	-	-	0.50**	6.75**	-0.31*	0.53**
4	Neelum	-0.22	-	-	-0.45**	-5.98**	-0.24	-0.60**
	S.E. (gj) ±	0.48	-	-	0.15	1.40	0.13	0.13
	(Lines)							
1	A -95B	-2.28**	-1.70*	-1.56	-0.69**	-10.23**	-0.28	-1.14**
2	EC -1392	-1.66*	-1.20	13.22**	0.06	15.40**	-1.00**	0.36*
3	EC -1424	-1.78*	-1.70*	-4.19*	-0.47*	-0.67	1.03**	0.17
4	GS -234	1.4 7*	-0.20	2.98	0.38	13.07**	-0.78**	1.73**
5	IC -15888	-3.28**	0.05	-8.68	0.26	-1.61	0.13	-0.58**
6	JRF -4	-0.41	-0.20	-9.31**	0.91**	-2.41	-0.51*	0.48*
7	JRF -5	2.72**	1.17	0.98	-0.44*	-7.43**	1.18**	-0.60**
8	F -14	5.22**	3.80**	6.56**	-0.02	-6.11**	0.24	-0 .41*
	S.E. (gi) ±	0.67	0.81	1.91	0.21	1.98	0.19	0.18

* Significant at 5% ** Significant at 1%

Note: – Not estimated as the mean squares due to testers were non-significant for days to maturity and plant height

Table 3. Specific combining ability effects of the progenies for different character

Sr. No.	Genotypes	Days to 50% flowering	Plant height (cm)	Number of capsules plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)
1	A - 95BxNL-97	2.66*	5.89	- 8.27 *	- 0.62	- 0.63
2	A - 95BxPKVNL-260	- 2.41	6.69	16.39**	0.74	2.19**
3	A - 95BxPadmini	0.16	- 5.44	1.15	- 0.32	- 0.66
4	A - 95BxNeelum	- 0.41	- 7.14	- 9.27*	0.20	- 0.90*
5	EC - 1392xNL-97	- 0.47	- 9.23*	7.89	0.96*	0.28
6	EC - 1392xPKVNL-260	- 1.53	- 3.29	- 5.90	- 0.38	- 0.67
7	EC - 1392xPadmini	0.53	8.43*	4.72	- 0.65	0.99**
8	EC - 1392xNeelum	1.47	4.09	- 6.71	0.08	- 0.60
9	EC - 1424xNL-97	3.66**	2.88	- 6.03	0.28	- 1.39**
10	EC - 1424xPKVNL-260	0.59	8.13*	5.28	- 0.16	0.74*
11	EC - 1424xPadmini	- 1.34	- 3.66	- 2.56	0.23	0.57
12	EC - 1424xNeelum	- 2.9 1*	- 7.35	3.32	- 0.35	0.08
13	GS - 234xNL-97	- 4.59**	- 3.84	- 7.37	0.23	0.57
14	GS - 234xPKVNL-260	- 0.16	- 4.2	- 15.26**	- 0.46	- 1.37**
15	GS - 234xPadmini	3.41	3.52	11.40**	0.28	0.59
16	GS - 234xNeelum	1.34	4.52	11.23*	- 0.05	0.21
17	IC - 15888xNL-97	0.16	5.37	1.40	- 0. 52	- 0.18
18	IC - 15888xPKVNL-260	2.59	1.61	- 17.73**	0.04	- 0.78*
19	IC - 15888xPadmini	- 1.34	- 4.47	1.73	- 0.23	- 0.55
20	IC - 15888xNeelum	- 1.41	- 2.51	14.60**	0.70	1.51**
21	JRF - 4xNL-97	- 1.72	0.29	10.90*	- 0.83*	1.15**
22	JRF - 4xPKVNL-260	- 2.28	- 0.06	17.02**	- 0.0 2	0.83*
23	JRF - 4xPadmini	1.78	- 0.69	- 14.67**	0.51	- 1.43**
24	JRF - 4xNeelum	2.22	0.46	- 13.25**	0.34	- 0.55
25	JRF - 5xNL-97	0.16	4.51	4.58	- 0.52	- 0.24
26	JRF - 5xPKVNL-260	3.59**	1.45	3.59	0.89*	- 0.14
27	JRF - 5xPadmini	- 1.34	- 0.13	- 6.45	- 0.27	0.09
28	JRF - 5xNeelum	- 2.41	- 5.83	- 1.72	- 0.10	0.29
29	F - 14xNL-97	0.16	- 5.87	- 3.10	1.02*	0.44
30	F - 14xPKVNL-260	- 0.41	- 10.33*	- 3.38	- 0.67	- 0.80*
31	F - 14xPadmini	- 1.84	2.44	4.68	0.46	0.40
32	F - 14xNeelum	2.09	13.75**	1.80	- 0.81*	- 0.04
	SE (sij) ±	1.35	3.81	4.96	0.41	0.35

Note : sca effects were not estimated for days to maturity and number of branches plant^{-1} as line x tester interactions were non-significant

Table 4. Mean performance, gca effects of parents and sca effects of superior crosses

Crosses	*per se*	GCA effects		SCA effects
		P_1	P_2	
Number of capsules plant^{-1}				
JRF-4 X Padmini	69.65	-2.41	6.75**	-14.67**
GS-234 X NL-97	93.20	13.07**	7.52**	-7.32
Seed yield plant^{-1} (g)				
JRF-4 X Padmini	3.75	0.48**	0.53**	-1.43**
GS-234 X PKVNL-260	4.58	1.73**	0.05	-1.37**

more than in testers. Ratnaparkhi *et al.* (2005) and Singh *et al.* (2009) have used relative magnitude of GCA/SCA mean squares as index of relative role of additive and non-additive variation which guides in the choice of breeding plan. The ratio of GCA vs SCA effects obtained were closer to unity for all the traits which indicates more importance of additive genetic component than non-additive genetic component.

The data presented in table 2 reveals that among the testers Padmini was found to be good general combiner for the characters *viz*., number of branches plant^{-1}, number of capsules plant^{-1}, seed yield plant^{-1}. Among the lines, GS-234 had highest GCA effects for seed yield plant^{-1} and its attributes along with number of capsules plant^{-1}. EC-1392 had highest GCA effects for seed yield, number of capsules plant^{-1} and early 50% flowering. JRF-4 had desirable GCA effects for plant height, number of branches plant^{-1} and seed yield plant^{-1}. These parents can be used in further breeding programmes in linseed. Sprague (1966) reported that when general combining ability effects are significant additive or additive x additive gene effects are responsible for the inheritance of that particular trait. In the present study most of the yield attributing traits had significant GCA effects which revealed that they are of fixable nature and by adopting simple selection these traits can be improved in linseed and the parents which are good general combiners for yield and its attributing traits could be used in further crossing programme.

Data regarding estimates of SCA effects are presented in table 3 which indicated that out of 32 crosses none of the cross showed consistently high SCA effect for all the characters under study. Singh *et al*. (2008) and Jadhav *et al*. (2011) reported that the crosses showing high mean performance, high GCA effects of the parents involved in the cross and SCA effects may serve as better source population for deriving superior segregates. The significant effects observed in different crosses for different characters had the combination of high x high, high x poor, poor x high and poor x poor combining parents. It is important to note here that among the crosses showing significant effects in desirable direction with respect to all the traits either involved or did not involve one or both the parents as good general combiners. In the present study (Table 4) the cross combination JRF-4 X Padmini showed high positive GCA effects of parents, high mean performance with negative significant effect for number of capsules plant^{-1} and seed yield plant^{-1}. The cross GS-234 X NL-97 showed high positive GCA effects of parents, high mean performance with high negative SCA effects for number of capsules plant^{-1}. For seed yield plant^{-1} the cross combinations JRF-4 X Padmini and GS-234 X PKVNL-260 showed high positive GCA, high mean performance with high negative significant SCA effect. The parents involved in these crosses were found to be good general combiners for important economic traits.

To broaden the genetic base it is necessary to produce three way or double crosses viz., (JRF-4 X Padmini) x EC-1392, (JRF-4 X Padmini) x GS-234, (JRF-4 X Padmini) x (GS-234 X NL-97), (JRF-4 X Padmini) x (GS-234 X PKVNL-260), (GS-234 X NL-97) x (GS-234 X PKVNL-260) which may be utilized for deriving superior transgrates for seed yield plant^{-1}, number of capsules plant^{-1}, 1000 seed weight, number of branches plant^{-1} through pedigree or single seed descent method (SSD). Also, selective intermating in F_2 generations should be adapted to break undesirable associations so as to increase the frequency of desirable recombinant lines in segregating generations.

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SENSORY STUDY OF KHOA SOLD IN WARDHA CITY (MS) INDIA

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ABSTRACT

The present investigation was carried at Animal Husbandry and Dairying section, College of Agriculture, Nagpur during year 2012-13 to study the sensory quality of khoa sold in Wardha city. The market khoa samples were collected from four sources viz., East, West, North and South region of Wardha city. The overall sensory quality score of East, West, North and South region khoa were 83.02, 86.39, 80.13 and 83.33 out of 100, respectively. The sensory quality of khoa sold in West region was good having 86.39 overall score and showed slightly salty and nutty flavour, However, the khoa sold in East, North and South region were fair in sensory quality and had 83.02,80.13 and 83.33 overall acceptability, respectively and showed acidic and slightly burnt flavour with mealy to gritty texture, presence of visible foreign matter and slightly mouldy appearance.

(Key words: Wardha city, sensory quality and khoa)

INTRODUCTION

Khoa is a concentrated milk product. It is rich in total solids and hence highly nutritiouns food in the diet of human beings. India is the largest producer of milk in the world since 1999 with annual production over 127.29 millions tones in 2011-12 (Anonymous, 2012). But out of total milk production only 55 per cent of milk is converted into product. So, it is needed to convert more and more milk in to milk product to satisfy demand of consumer. The dairy sector in the India has shown remarkable development in the past decade and India has now become one of the largest producers of milk and value added dairy product in the world.

Khoa is obtained by rapidly evaporating milk in shallw pans to total solids content of about 72 per cent. It is major intermediate base product for a variety of sweets. The product could be preserved for serveral days under refrigerated condition and is also used as base for different kinds of sweets like Pedha, Burfi, Gulabjamun, Kalakand etc.

The demand for milk and milk product of Wardha city is high and day by day it is increasing rapidly. In the city, wholesalers, halwai, hoteliers etc. prepare khoa by purchasing milk from milkmen of different areas. While other purchase readymade khoa producers of surrounding areas i.e. Goras bhandar, mangal sangrahalay. The main business of purchase of khoa at Wardha is in the hands of few wholesale dealers and retailers.

By considering nutritional significance and economical importance of khoa, it becomes 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 mater basis.

The introduction of modern process technologies for large production of Indian milk products including mithais (sweets) has provided an opportunity to the organized dairy sector to expand its market and ensure financial stability and steady growth. This development is also having a trickle down effect on the entrepreneurs in the traditional dairy sector who are modernizing their age-old mithai-making methods and coming out with new product formalities. 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).

It has been recognized that enjoyment of food is essential for good health. Enjoyment would mean choice and acceptance and not always nutrition and wholesomeness of foods. The consumers appreciation of food quality is thus all important. For the consumer the perceivable sensory attributes - colour, appearance, feel, aroma, taste and texture are deciding factors in good acceptance. Thus, the quality is that "which the consumer likes best" and the grade of quality is understood more by the degree of desirable sensory attributes and the absence of undesirable features. It is thus, clear that the sensory attributes are the validating parameters for the good quality foods. There is no instrument which can perceive, analyze, integrate and interpret a large number of sensory attributes at the same time like

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human sensory organs. Consequently, it becomes imperative that all foods before they are released for sale are subjected to sensory evaluation by a panel of trained judges. Keeping these in mind, present paper was focused on sensory aspects of khoa sold in various areas of Wardha city.

MATERALS AND METHODS

Collection of samples

In all 60 samples of khoa were examined during the course of investigation which were collected from four different regions viz., East, West, North and South regions of Wardha city thrice at fortnightly interval. So, 5 samples of each region were analyzed in every fortnight and replicated thrice. These khoa samples were collected by adopting stratified randomization technique. The samples were collected with due care to avoid contamination during collection process. Vegetable parchment paper bags were used for the purpose. After obtaining samples they brought to laboratory and then each separate sample was mixed thoroughly. These homogenized samples of khoa were kept in refrigerator overnight and then they were used for sensory evaluation, the very next day after the collection of khoa samples.

Sensory evaluation

Koha samples from Wardha market were subjected to organoleptic (i.e. Sensory) evaluation. The quality of khoa was judged by sensory evaluation in respect of colour, texture and body, flavour, taste appearance by panel of 5 judges, with the help of 100 point numeric scale scores prescribed by Pal and Gupta (1985). Similarly, overall acceptability of product was determined by 9 point Hedonic scale as suggested by Nelson and Trout (1964). A score of 1 indicated least acceptability (lower end) and a score of 9 indicated the most acceptability (higher end) as per Hedonic scale.

1.100 Point numeric score (Pal and Gupta 1985)

Attributes	Allotted out of 100 score
Flavour	45
Body and texture	35
Colour and appearance	20

2.9 point hedonic scale as prescribed by Nelson and Trout (1964).

Sr. No.	Scale	Score	Sample No. 1 2 3 4
1.	Liked extremely	9	
2.	Liked very much	8	
3.	Liked moderately	7	
4.	Liked slightly	6	
5.	Neither liked nor dislike	5	
6.	Dislike Slightly	4	
7.	Dislike moderately	3	
8.	Dislike very much	2	
9.	Dislike extermely	1	

Note : Score of 5.5 and above indicate acceptability within the socre of 1 to 9.

RESULTS AND DISCUSSION

Sensory quality of khoa

The results on the organoleptic quality of khoa based in 100 point numeric scale collected from Wardha city are presented in table 1.

Flavour

The flavour score of khoa samples collected from four different localities of Wardha city i.e. East, West, North and South regions were observed in the range of 30.61 to 39.18, 39.81 to 41.14, 37.04 to 38.36 and 35.72 to 38.63 with an average of 38.81, 40.52, 37.58 and 36.94 respectively. These differences were found to be significant for flavour scores. However, maximum average flavour score was contributed by West region khoa, whereas the lowest value was contributed by South region khoa, West region khoa was significantly superior over East, North and South regions khoa for average flavour scores. Out of four sources, North and South regions khoa in Wardha city, received lower score for flavour with comments of slightly acidic flavour.

Kulkarni and Hembade (2010) reported that flavour of Ambajogai, Dharur, Wadwani, Khoa samples showed significantly more acceptability than other tauka khoa samples. Typical mild cooked flavour similar to the prescribed from the boiled milk is more acceptable. Similarly Kurand *et al.* (2011) reported that of three sources of khoa which was sold in Washim city, Karanja and Risod received adverse comments, which were 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 of khoa samples collected from East, West, North and South regions was observed in range of 27.05 to 28.11, 29.11 to 30.19, 26.67 to 28.30 and 29.41 to 30.42 with an average of 27.54, 29.61, 27.76 and 29.91 respectively. It was noticed that minimum and maximum average body and texture were exhibited in East region khoa and South region khoa, respectively. These differences were found to be significant for body and texture socres. So South khoa was significantly superior over East, West and North regions khoa in respect of body and texture scores, East, West and North region khoa were found to be mealy to gritty in texture.

It was further noticed that there was significant variation in average score of body and texture of khoa samples collected from East, West, North and South in first, second and third fortnight.

Kurand *et al*. (2011) noticed that the average body and texture socres of Washim districts khoa ranged from 29.17 to 32.18. They noticed that minimum and maximum average score for body and texture were exhibited 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. The present findings in this respect are almost in conformity with these results.

Colour and appearance score

The score for colour and appearance of khoa samples collected from East, West, North and South area of Wardha city were observed in the range of 16.27 to 17.02, 15.81 to 16.62, 14.73 to 15.67 and 15.37 to 16.92 with an average of 16.70, 16.20, 15.25 and 16.30 respectively. The maximum score was recorded by East region khoa followed by South, West and North regions khoa. The average scroes obtained for colour and appearance of market khoa differed significantly. East region khoa was found to be significantly superior over West, North and South in respect of average colour and appearance score. The samples from West, North and South regions khoa showed slightly brown and black specks with 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 lightly brown and black specks of burnt spots, slightly moldy and there appeared visible foreign matter like news paper pieces which adversely affected the scores for this sensory attribute. The present revelations conform their observations to more or less extent.

Overall acceptability

It was observed from table 1, that the average overall acceptability of khoa sold in Wardha city ranged from 80.13 to 86.39 out of 100. However, the mean values of overall acceptability scores of East, West, North and South regions khoa recorded in range of 82.37 to 83.93, 86.05 to 86.78, 78.47 to 82.94 and 81.64 to 84.74 with an average of 83.02, 86.39, 80.13 and 83.33 per cent respectively. The highest score was recorded in West region khoa, while lowest score was recorded in North region khoa. Out of 100, the differences of score obtained for khoa sources were found to be significant, and West region khoa was found to be significantly superior over East, North and South regions 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 in Washim for khoa were found to be significantly superior over Karanja and Risod khoa in respect of overall acceptability (Kurand *et al*., 2011). Besides this, Kakade *et al.* (2013) observed that overall acceptability score of khoa sold in East, West, North and south regions of Nagpur district was 82.02,86.39, 80.13 and 83.33 per cent on an average respectively.

Table 1. The overall sensory score of khoa samples collected from Wardha city (out of 100)

(Mean of 15 samples)

Sources	Flavor (45)	Body and Texture (35)	Colour and Appearance (20)	Overall Acceptability (100)
		East		
1	39.18	27.29	16.27	82.48
2	38.64	28.02	16.64	83.30
3	30.61	27.05	16.68	82.37
4	39.08	28.11	17.02	83.93
5	38.51	27.25	16.91	83.03
Mean	38.81	27.54	16.70	83.02
		West		
1	39.81	30.14	16.35	86.31
2	40.92	29.20	15.81	86.23
3	39.98	30.19	16.62	86.78
4	40.84	29.11	16.10	86.05
5	41.14	29.44	16.18	86.58
Mean	40.57	29.61	16.20	86.39
		North		
1	37.56	29.74	15.63	82.94
2	37.04	27.21	15.67	79.59
3	37.40	28.30	15.29	79.16
4	37.53	25.55	14.73	78.47
5	38.36	26.67	14.94	80.17
Mean	37.58	27.76	15.25	80.13
		South		
1	35.72	30.26	15.34	82.00
2	36.04	29.41	16.19	81.64
3	36.56	29.50	16.45	82.10
4	37.73	30.42	16.88	84.16
5	38.63	29.94	16.92	84.74
Mean	36.94	29.91	16.30	83.33
SE (m) ±	0.26	0.77	0.52	0.74
CD at 5%	0.87	1.81	0.81	1.67

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IMPACT OF DIFFERENT FERTILITY GRADIENTS AND NUTRIENTS MANAGEMENT ON PRODUCTIVITY OF RAINFED Bt COTTON IN VERTISOLS

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ABSTRACT

A field experiment was conducted for two years from 2010-2011 and 2011-2012 at Research farm of Department of Soil Science and Agricultural Chemistry, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola with an objective to study the response of NPK fertilization on productivity by rainfed Bt cotton under created different fertility gradients. Three FYM blocks of 0, 5 and 10 t FYM ha^{-1} were created across the fertility gradients. Increase in seed cotton yield by 86.2 to 183.3, 59.4 to 133.6 and 54.5 to 120.6 per cent, respectively over mean of control plot with the addition of 0, 5 and 10 t FYM ha^{-1} along with NPK, respectively irrespective of fertility gradients. The highest seed cotton yield (20.76 q ha^{-1}) was obtained [1] with the application of 100:50:50 kg NPK ha^{-1} under 10 t FYM ha^{-1} in low fertility gradient. Whereas,under medium and high fertilty gradient with the application of 100:50:25 kg NPK ha^{-1} recorded seed cotton yield of 19.59 q ha^{-1} and 19.36 q ha^{-1} with 5 t FYM ha^{-1} and no use of FYM, respectively. It can be inferred from these results that under low fertility status of soil 10 t FYM ha^{-1} along with 100:50:50 or 100:50:25 kg NPK ha^{-1} is to be applied. In medium fertility status of soil, FYM dose may be reduced to 5 t ha^{-1} at the same rate of NPK application. Under high fertility status, the higher yields may be received even without application of FYM.

(Key words: Bt cotton, fertility gradients, FYM, productivity, vertisols)

INTRODUCTION

Cotton is an important fibre crop of global significance, which is cultivated in tropical and sub-tropical regions of more than eighty countries the world over. Cotton is widely grown on black cotton soils in Vidarbha region of Maharashtra. At present, genetically modified cotton is widely accepted by Indian farmers. In India, cotton production has changed tremendously with introduction of Bt cotton in 2002 under rainfed conditions. Out of 110.00 lakh ha area, 88 per cent area (96.14 lakh ha) is occupied by Bt cotton hybrids (Anonymous, 2011). Average productivity of cotton in India is low (553 kg lint ha^{-1}) as compared to world average of 725 kg lint ha^{-1} (Anonymous, 2008). India accounts for more than 26 per cent of total global production of cotton and accounts for 28.18% of global cotton area (Anonymous, 2008). Fertilizer consumption ratio was highly unbalanced (N: $P_2 0_5$: $K_2 0$, 6 : 2.4 : 1) during 2007-08 as against favourable ratio of 4:2:1 implying, thereby, that farmers started adding more nitrogen and proportionately less phosphatic and potassic fertilizers. In many areas the imbalanced fertilization is the root cause for decreased crop yields and soil fertility status (Muralidharudu *et al*.,2010). At present requirement of nutrients in crop production are 35 Mt and only 25.15 Mt of fertilizer nutrients are being used (Subba Rao *et al*., 2009). Therefore, combined use of chemical fertilizers and organics becomes essential to meet the nutrient requirement and reduce the negative balance. Balanced fertilization means application of appropriate quantity of nutrients in required proportions at right time, applied though right method. Organics are not only useful in improving physico-chemical composition of soil but also help in reducing the load of chemical fertilizers. It is, therefore, very essential to bring economy in the use of inorganic fertilizer by their judicious use in combination with organic manures for enhancing yield potential of cotton (Deshmukh *et al.,* 2011).

Rainfed Bt cotton is widely cultivated on Vertisol in Vidarbha region of Maharashtra. There is an ample scope to boost Bt cotton productivity by adopting strategy of integrated nutrient management, specially under rainfed condition. However, Integrated Plant Nutrition System studies under different fertility gradients have not been conducted. With a view to assessing the response of the various nutrients for achieving higher productivity, three fertility gradients were created by applying variable levels of nutrients to exhaust crop maize and then

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various nutrient management treatments were thought necessary to be applied to rainfed Bt cotton during the present study.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* season of 2010-11 and 2011-12 at Research Farm of Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola by adopting fertility gradient approach. The soil of experimental field is clayey in texture with pH 8.23 and is non saline (EC 0.26 dS m^{-1}) belonging to vertisol. The initial status of soil were low in available N (163.07 kg ha^{-1}), low in available P (15.25 kg ha^{-1}) and very high in available K (515.2 kg ha^{-1}), low in organic carbon (5.2 g kg^{-1}) and calcium carbonate observed was 6.82 per cent.

Following the inductive methodology of Ramamoorthy *et al* .(1967), field was divided into three equal strips with the size of each strip being 83.2 x 13.8 m and three fertility gradients were created in the field by applying graded doses of 0, 0, 0 kg NPK ha^{-1}, 120, 60, 60 kg NPK ha^{-1} and 240, 120, 120 kg NPK ha^{-1} fertilizers to Maize crop which was taken as an exhaust crop during January 2010 to April 2010 only with a view to creating variable fertility levels in the experimental field for Bt cotton. After harvest of the maize crop, the field was ploughed and prepared well for planting of Bt cotton as a test crop both during *kharif* 2010 and *kharif* 2011 without disturbing the three fertility gradient strips.

Three FYM blocks were created across three fertility gradient strips by applying 10 t FYM, 5 t FYM and no FYM in each strip which was divided into 24 plots. Size of plots was 5.85 m x 5.40 m, thus in each fertility gradient strip, there were three blocks of 8 plots each of 0, 5 and 10 t FYM ha^{-1} in which three levels of NPK. i.e. 25, 50 and 100 kg N ha^{-1}, 12.5, 25 and 50 kg P_2O_5 ha^{-1} and 12.5, 25 and 50 kg K_2O ha^{-1}. Further FYM blocks were divided into 24 equal plots with 21 NPK treatments and 3 control treatments on randomized basis, such that, all the 24 treatments were laid along the FYM blocks and also along the fertility gradients and thus making a total 72 plots over the three strips with three FYM blocks. Thus, IPNS components like NPK alone, NPK + 5 t ha^{-1} FYM and NPK + 10 t ha^{-1}etc. were created. Plan of treatments structure is depicted in Fig 1. and details of treatments are presented in table 1 to 4.

Pre-sowing soil samples (0.20 cm) were collected from each strip of variable fertility gradient before the superimposition of treatments during the first year. However, during the second year, pre-sowing soil samples (0-20cm) were collected from each plot. These soil samples were analysed for available nitrogen (Subbiah and Asija, 1956), available phosphorus and available potassium (Jackson, 1967).

The sowing of test crop Bt cotton(var NHH-44) was undertaken on 23rd June, 2010 and 29th June, 2011 with fractional factorial RBD . The treatment wise quantity of N, P and K fertilizers were applied through urea, single super phosphate and muriate of potash. As per the treatments, half dose of nitrogen, full dose of phosphorus and potassium were applied at the time of dibbling of cotton seed and remaining half dose of nitrogen was applied 30 days after sowing. The inorganic fertilizers were applied at 10 cm away from the dibbling spot of cotton seed at the depth of 5 cm by ring method and covered with the soil. Seed rate of 3 kg ha^{-1} was used for 90cm x 45cm spacing. Systemic insecticide Imidacloprid-2000 was sprayed at 30 and 50 days after sowing for the control of sucking pests. Total rainfall of 1032 mm was received during the year 2010-11 in 41 rainy days whereas in 2011-12 it was 515.3 mm in 38 rainy days. Four pickings were taken from mid of November to mid of January. Seed cotton yield from four pickings and cotton stalk yield after last picking were recorded plot wise. The data on seed cotton yield and cotton stalk yield are compiled in table 1 to 4.

RESULTS AND DISCUSSION

Seed cotton yield under different FYM blocks

The data on seed cotton yield of Bt cotton as influenced by different fertility gradients and chemical fertilizers under different FYM blocks are presented in table1. The results showed that there was an increase in seed cotton yield with increasing levels of N, P_20_5 and K_20 fertilizers. The mean yield of treated plots were 16.19, 17.47 and 18.11 q ha^{-1} in no use of FYM, 5 t and 10 t FYM ha^{-1}, respectively which showed the additional effect of added FYM in combination of NPK treatments. It is very clear from the data that the increase in seed cotton yield by 86.2

to 183.3, 59.4 to 133.6 and 54.5 to 120.6 per cent over mean of control plot was achieved with the addition of 0, 5 and 10 t FYM ha^{-1} along with NPK, respectively irrespective of fertility gradients.

The highest seed cotton yield (20.76 q ha^{-1}) was obtained with application of 100:50:50 kg NPK ha^{-1}under 10 t FYM ha^{-1} block irrespective of fertility gradient. Whereas, it was obtained with application of 100:50:25 kg NPK ha^{-1} recorded seed cotton yield of 20.23 q ha^{-1} under 5 t FYM ha^{-1} and the highest value of seed cotton yield (19.97 q ha^{-1}) was recorded with application of 100:50:50 kg NPK ha^{-1} under no use of FYM. Due to addition of FYM in each block, this might have masked the effect of native soil fertility due to its buffering capacity by different fertility gradients.

Data on seed cotton yield further indicated that, application of 100:50:50 kg NPK ha^{-1} resulted in an increase in seed cotton yield by 9.73, 19.31 and 14.70 per cent over 50:25:25 kg NPK ha^{-1} RDF under 0, 5 and 10 t FYM blocks,respectively irrespective of fertility gradients.This has clearly indicated that addition of FYM alone and in combination with adequate and balanced fertilizer nutrition of plant might have favourably influenced the plant growth which ultimately resulted in increased seed cotton yield. Hosmath *et al*. (2011) reported pooled results for Bt cotton under rainfed ecosystem on vertisol which indicated that integrated supply of nutrients through recommended dose of fertilizers (30:15:15) + FYM (7.5 t ha^{-1}) had significantly increased Bt cotton yield (1066.3 kg ha^{-1}). They also reported that addition of FYM to RDF increased the seed cotton yield by 24.36 per cent over recommended dose of fertilizer which may be due to balanced use of chemical fertilizers coupled with FYM.

Cotton stalk yield under different FYM blocks

The data on cotton stalk yield of Bt cotton as influenced by different fertility gradients and chemical fertilizers under different FYM blocks are presented in table 2. The mean yield of cotton stalk in treated plots were 25.72, 27.48 and 29.23 q ha^{-1} in no use of FYM, 5 t and 10 t FYM ha^{-1}, respectively. Irrespective of fertility gradients, the increase in cotton stalk yield by 41.0 to 106.2, 31.4 to 95.3 and 42.6 to 89.5 per cent , was recorded over mean of control plot with the addition of 0, 5 and 10 t FYM ha^{-1} respectively. The highest cotton stalk yield (32.64 q ha^{-1}) was obtained with application of 100:25:50 kg NPK ha^{-1} under 5 t FYM ha^{-1} irrespective of fertility gradients. Whereas, it was obtained with application of 100:50:25 kg NPK ha^{-1} with cotton stalk yield of 31.50 q ha^{-1} in no use of FYM ha^{-1} and it was (32.31 q ha^{-1}) achieved with application of 100:50:50 kg NPK ha^{-1} under 10 t FYM ha^{-1}.

The yield of cotton stalk in NPK treated plots increased by 58.9, 64.4 and 71.4 per cent in irrespective of fertility gradients over mean of control plot with the addition of 0, 5 and 10 t FYM ha^{-1} respectively.Deshmukh *et a*l.(2011) observed the increase in cotton stalk yield by 82, 67 and 71 per cent with 0, 5 and 10 t FYM ha^{-1} respectively under different NPK treatments over no nutrient treatment.

Seed cotton yield under different fertility gradients

The data on the seed cotton yield with conjoint use of FYM with NPK in different soil fertility gradients are presented in table 3. The results showed that the seed cotton yield of Bt in NPK treated plots ranged from 13.13 to 20.76,13.81 to 20.20 and 13.81 to 19.97 with a mean value of 16.89, 17.37 and 17.79 q ha^{-1}, in low, medium and high fertility gradient, respectively irrespective of FYM blocks.

The increase in seed cotton yield by 56.1 to 146.8, 69.2 to 147.5 and 61.7 to 133.8 per cent was achieved in low, medium and high soil fertility gradients ,respectively over mean of control plot. The highest seed cotton yield (20.76 q ha^{-1}) was obtained with application of 100:50:50 kg NPK ha^{-1} in low fertility gradients irrespective of FYM blocks. Whereas,under medium and high fertilty gradients highest seed cotton yield of 20.20 q ha^{-1} and 19.97 q $ha^{-1}$was obtained with application of 100:50:50 kg NPK ha^{-1}.These results showed that there was relatively more increase in seed cotton yield with an increase in NPK fertilizer application in low fertility gradient as compared to high fertility gradient.The FYM applied in different strips has its effect on the availability of nutrients by enhancing the native pool of nutrients in soil in addition to an increase the efficiency of applied nutrients through fertilizers. The response to applied nutrients is dependent on number of factors, among them fertility of soil is one of the

most important factor (Dave *et al.,* 1990). Panchbhai (2010) reported that the response of N, P and K fertilizers was decreased with increase in fertility status of soil for banana crop.

Cotton stalk yield under different fertility gradients

The data on the cotton stalk yield in different soil fertility gradients due to conjoint application of FYM with NPK fertilizers are presented in table 4. The results showed that the cotton stalk yield of Bt cotton in NPK treated plots irrespective of FYM application were ranged from 21.48 to 32.31, 21.96 to 32.64 and 22.83 to 32.57 with average value were 26.72, 27.18 and 27.84 q ha^{-1}, respectively from low to high soil fertility gradients. The increase in cotton stalk yield by 28.5 to 93.3, 39.1 to 106.7 and 38.4 to 97.5 per cent, respectively over mean of control plots irrespective of FYM blocks in low, medium and high soil fertility gradients, respectively. The highest cotton stalk yield (32.64 q ha^{-1}) was obtained with application of 100:25:50 kg NPK ha^{-1} in medium fertility gradient under 5 t FYM ha^{-1}. Kadu *et al.* (2001) reported that the response of onion to addition of NPK fertilizers decreased consistently with increasing fertility gradients from 00% RDF to 200 % RDF.

With a view to summarizing the results for best performance of various treatments under various FYM blocks and under different fertilizer gradients, the results gave indications as follows.

Under no FYM blocks, the highest seed cotton yield of 19.97 q ha^{-1} was obtained with 100:50:50 kg NPK ha^{-1}fertilizer followed by 100:50:25 kg NPK ha^{-1}both under high fertility gradients. Under 5 t FYM ha^{-1}, the highest seed cotton yield(20.20 q ha^{-1}) was achieved with the application of 100:50:50 kg NPK ha^{-1}followed by 50:50:50 kg NPK ha^{-1}(20.01q ha^{-1}) and 100:50:25kg NPK ha^{-1} (19.59 q ha^{-1}) .These three NPK levels achieving higher seed cotton yield under 5 t FYM ha^{-1} belonged to medium fertility gradients (100 RDF to maize crop).However, under 10 t FYM ha^{-1}, higher yield of seed cotton was received when NPK was applied @ 100:50:50 , 100:50:25 and 100:25:50 kg NPK ha^{-1} under low fertility gradient with yield levels of 20.76, 20.35 and 20.24 q ha^{-1}, respectively.

Similar trends like seed cotton yield were noticed in case of cotton stalk yield.

The highest yield of seed cotton(20.76 q ha^{-1}) under low fertility gradient was obtained under 100:50:50 kg NPK ha^{-1} followed by 100:50:25 and 100:25:50 kg NPK $ha^{-1}$with yield of 20.35 and 20.24 q ha^{-1}, respectively. These higher yields were received when NPK was applied along with 10 t FYM ha^{-1}. Under medium fertility gradients, the higher yields of seed cotton were received under 5 t FYM ha^{-1} when NPK was applied @ 100:50:50, 50:50:50 and 100:50:25 kg ha^{-1} with yield values of 20.20, 20.01 and 19.59 q ha^{-1}, respectively. However, under high fertility gradient, higher yields were achieved when NPK was applied @ 100:50:50 kg ha^{-1} (19.97q ha^{-1}) and 100:50:25 kg ha^{-1}(19.36 q ha^{-1}) under no FYM block. The higher yield was also obtained under 10 t FYM ha^{-1} when NPK was applied @100:25:25 kg ha^{-1} (19.72 q ha^{-1}) and 50:50:25 kg ha^{-1}(19.09 q ha^{-1}) and under 5 t FYM ha^{-1} higher yield of 19.43 q ha^{-1} was achieved when NPK was applied @ 100:25:12.25 kg ha^{-1}. Similar trends like seed cotton yield were noticed in case of cotton stalk yield.

In nutshell, it can be opined that under low fertility status of soil 10 t FYM ha^{-1} along with 100:50:50 or 100:50:25 kg NPK ha^{-1} is to be applied. In medium fertility status of soil, FYM dose may be reduced to 5 t ha^{-1} at the same rate of NPK application. Under high fertility status, the higher yields may be received even without application of FYM.

Table 1. Seed cotton yield (q ha^{-1}) of rainfed Bt as influenced by NPK fertilizers due to different fertility gradients under different FYM blocks

Treatments NPK, (kg ha $^{-1}$)	Seed cotton yield (q ha $^{-1}$)											
	0 t FYM				5 t FYM				10 t FYM			
	2010	2011	mean	% increase over mean of control	2010	2011	mean	% increase over mean of control	2010	2011	mean	% increase over mean of control
$N_0 P_{25} K_{25}$	13.44	14.78	14.11^2	100.1	12.20	15.42	13.81^1	59.4	12.93	16.14	14.54^0	54.5
$N_{25} P_{12.5} K_{12.5}$	10.75	15.51	13.13^0	86.2	12.57	18.58	15.58^2	79.9	12.39	17.94	15.17^1	61.2
$N_{25} P_{12.5} K_{25}$	11.38	16.24	13.81^2	95.9	13.53	17.60	15.57^1	79.8	13.67	17.91	15.79^0	67.8
$N_{25} P_{25} K_{12.5}$	11.83	16.78	14.31^0	102.9	14.75	16.81	15.78^2	82.2	15.10	18.83	16.97^1	80.3
$N_{25} P_{25} K_{25}$	14.46	17.03	15.75^1	123.4	13.78	17.54	15.66^0	80.8	16.81	18.58	17.70^2	80.1
$N_{25} P_{50} K_{25}$	13.39	17.03	15.21^2	115.7	15.06	17.63	16.35^1	80.8	15.87	19.44	17.66^0	87.7
$N_{50} P_0 K_{25}$	13.86	16.96	15.41^1	118.6	16.84	19.47	18.16^0	109.7	15.53	18.80	17.17^2	82.4
$N_{50} P_{25} K_0$	13.53	18.27	15.90^0	125.5	15.90	18.80	17.35^2	100.3	15.67	19.60	17.64^1	87.4
$N_{50} P_{12.5} K_{12.5}$	11.68	15.13	13.41^0	90.2	12.73	19.22	15.98^2	84.5	14.32	18.74	16.53^1	75.6
$N_{50} P_{12.5} K_{25}$	14.15	18.66	16.41^1	132.7	13.12	19.18	16.15^0	86.5	15.40	18.99	17.20^2	82.8
$N_{50} P_{12.5} K_{50}$	14.65	17.63	16.14^1	128.9	13.90	18.90	16.40^0	89.4	17.72	20.32	19.02^2	102.1
$N_{50} P_{25} K_{12.5}$	13.82	17.16	15.49^0	119.7	15.59	20.83	18.21^2	110.3	16.56	19.84	18.20^1	93.4
$N_{50} P_{25} K_{25}$	15.62	20.77	18.20^1	158.1	14.98	18.87	16.93^0	117.3	16.91	19.28	18.10^2	92.3
$N_{50} P_{25} K_{50}$	12.39	19.09	15.74^0	123.3	16.10	21.15	18.63^2	115.1	16.56	20.86	18.71^1	98.8
$N_{50} P_{50} K_{25}$	14.34	18.77	16.56^1	134.9	17.46	18.33	17.90^0	100.7	18.13	20.04	19.09^2	100.9
$N_{50} P_{50} K_{50}$	16.24	20.73	18.49^2	162.3	18.39	21.62	20.01^1	131.0	18.86	20.98	19.92^0	111.7
$N_{100} P_{25} K_{12.5}$	15.50	17.25	16.38^0	132.3	17.62	21.24	19.43^2	124.4	17.81	21.46	19.64^1	108.7
$N_{100} P_{25} K_{25}$	17.73	19.91	18.82^1	166.9	18.82	20.99	19.69^0	127.4	18.39	21.05	19.72^2	111.9
$N_{100} P_{25} K_{50}$	16.38	18.42	17.40^2	146.8	17.50	21.49	19.50^1	125.2	18.10	22.38	20.24^0	115.1
$N_{100} P_{50} K_{25}$	18.11	20.61	19.36^2	174.6	18.29	20.89	19.59^1	133.6	18.53	22.16	20.35^0	116.2
$N_{100} P_{50} K_{50}$	18.91	21.02	19.97^2	183.3	19.48	20.92	20.20^1	133.2	19.80	21.72	20.76^0	120.6
$N_{00} P_{00} K_{00}$	04.36	9.49	6.93^0	--	07.85	10.09	8.97^2	--	08.00	10.92	9.46^1	--
$N_{00} P_{00} K_{00}$	05.10	8.54	6.82^1	--	07.15	10.45	8.80^0	--	08.18	10.34	9.28^2	--
$N_{00} P_{00} K_{00}$	06.08	8.70	7.39^2	--	07.05	9.34	8.20^1	--	07.16	11.87	9.52^0	--
Mean of treated plots	14.38	17.99	16.19	--	15.63	19.31	17.47	--	16.45	19.76	18.11	--
Mean of control plots	05.18	8.91	7.05	--	07.35	9.96	8.66	--	07.78	11.04	9.41	--

0= Low fertility gradient, 1= Medium fertility gradient, 2= High fertility gradient

Table 2. Cotton stalk yield (q ha^{-1}) of rainfed Bt as influenced by NPK fertilizers due to different fertility gradients under different FYM blocks

Treatments NPK, (kg ha $^{-1}$)	Cotton stalk yield (q ha $^{-1}$)											
	0 t FYM				5 t FYM				10 t FYM			
	2010	2011	mean	% increase over mean of control	2010	2011	mean	% increase over mean of control	2010	2011	mean	% increase over mean of control
$N_0 P_{25} K_{25}$	21.27	24.38	22.83^{2}	49.9	20.16	25.90	23.03^{1}	37.8	22.16	26.47	24.31^{0}	42.6
$N_{25} P_{12.5} K_{12.5}$	17.95	25.01	21.48^{0}	41.0	18.70	27.03	22.87^{2}	36.9	20.02	28.80	24.41^{1}	43.2
$N_{25} P_{12.5} K_{25}$	22.16	26.81	24.49^{2}	60.8	18.83	25.08	21.96^{1}	31.4	22.78	28.84	25.81^{0}	51.4
$N_{25} P_{25} K_{12.5}$	18.95	26.84	22.90^{0}	50.4	23.19	26.58	24.89^{2}	48.9	23.97	30.91	27.44^{1}	60.9
$N_{25} P_{25} K_{25}$	21.49	25.70	23.60^{1}	54.9	21.53	26.43	23.98^{0}	43.5	26.75	30.66	28.70^{2}	68.3
$N_{25} P_{50} K_{25}$	22.56	28.97	25.77^{2}	69.2	23.93	29.16	26.55^{1}	58.9	25.66	32.46	29.06^{0}	70.4
$N_{50} P_{0} K_{25}$	20.26	24.44	22.35^{1}	46.7	25.93	30.18	28.06^{0}	67.9	25.04	30.27	27.66^{2}	62.2
$N_{50} P_{25} K_{0}$	22.78	30.33	26.56^{0}	74.4	24.30	30.29	27.30^{2}	63.4	26.09	32.51	29.30^{1}	71.8
$N_{50} P_{12.5} K_{12.5}$	18.83	24.72	21.78^{0}	43.0	19.94	30.27	25.10^{2}	50.2	20.57	29.88	25.23^{1}	48.0
$N_{50} P_{12.5} K_{25}$	21.70	28.18	24.94^{1}	63.7	21.10	30.01	25.56^{0}	52.9	25.26	30.68	27.97^{2}	64.0
$N_{50} P_{12.5} K_{50}$	22.14	25.67	23.91^{1}	56.9	20.89	26.15	23.52^{0}	40.7	25.85	28.84	27.34^{2}	60.3
$N_{50} P_{25} K_{12.5}$	20.02	25.17	22.60^{0}	48.4	26.59	32.74	29.67^{2}	77.6	25.40	31.90	28.65^{1}	68.0
$N_{50} P_{25} K_{25}$	25.70	34.06	29.88^{1}	96.2	24.50	32.10	28.30^{0}	69.3	26.52	32.70	29.61^{2}	73.7
$N_{50} P_{25} K_{50}$	19.04	30.01	24.53^{0}	61.1	21.49	31.18	26.33^{2}	57.6	24.02	32.54	28.28^{1}	65.9
$N_{50} P_{50} K_{25}$	20.89	29.85	25.37^{1}	66.6	27.58	30.93	29.26^{0}	75.1	27.81	31.18	29.50^{2}	73.0
$N_{50} P_{50} K_{50}$	25.26	33.04	29.15^{2}	91.4	27.74	32.76	30.25^{1}	81.0	25.98	31.81	28.90^{0}	69.5
$N_{100} P_{25} K_{12.5}$	28.42	26.58	27.50^{0}	80.6	30.54	34.60	32.57^{2}	94.9	28.72	33.93	31.33^{1}	83.7
$N_{100} P_{25} K_{25}$	27.14	31.40	29.27^{1}	92.2	28.83	32.87	30.85^{2}	84.6	28.62	31.60	30.11^{0}	76.6
$N_{100} P_{25} K_{50}$	27.47	30.77	29.14^{2}	91.3	31.02	34.26	32.64^{1}	95.3	28.63	34.60	31.62^{0}	85.4
$N_{100} P_{50} K_{25}$	29.69	33.11	31.40^{2}	106.2	29.25	35.20	32.23^{1}	92.9	29.47	34.82	32.15^{0}	88.6
$N_{100} P_{50} K_{50}$	29.63	32.07	30.35^{2}	99.3	30.39	34.03	32.21^{1}	92.7	29.47	35.15	32.31^{0}	89.5
$N_{00} P_{00} K_{00}$	10.90	20.42	15.66^{0}	--	13.58	19.94	16.76^{2}	--	14.85	21.62	18.231	--
$N_{00} P_{00} K_{00}$	10.63	17.19	27.82^{1}	--	14.85	21.43	18.14^{0}	--	13.96	19.21	16.582	--
$N_{00} P_{00} K_{00}$	14.21	18.04	16.13^{2}	--	12.59	17.88	15.24^{1}	--	13.37	19.28	16.330	--
Mean of treated plots	23.02	28.42	25.72	--	24.59	30.37	27.48	--	27.01	31.45	29.23	--
Mean of control plots	11.91	18.55	15.23	--	13.67	19.75	16.71	--	14.06	20.04	17.05	--

0= Low fertility gradient, 1= Medium fertility gradient, 2= High fertility gradient

Table 3. Seed cotton yield (q ha^{-1}) of rainfed Bt as influenced by conjoint use of FYM and chemical fertilizers under different fertility gradients

Treatments NPK, (kg ha $^{-1}$)	Seed cotton yield (q ha $^{-1}$)											
	Low fertility gradient				Medium fertility gradient				High fertility gradient			
	2010	2011	mean	% increase over mean of control	2010	2011	mean	% increase over mean of control	2010	2011	mean	% increase over mean of control
$N_0 P_{25} K_{2.5}$	12.93	16.14	14.54^{2}	72.9	12.20	15.42	13.81^{1}	69.2	13.44	14.78	14.11^{0}	65.2
$N_{25} P_{12.5} K_{12.5}$	10.75	15.51	13.13^{0}	56.1	12.39	17.94	15.17^{2}	85.9	12.57	18.58	15.58^{1}	82.4
$N_{25} P_{12.5} K_{25}$	13.67	17.91	15.79^{2}	87.7	13.53	17.60	15.57^{1}	90.8	11.38	16.24	13.81^{0}	61.7
$N_{25} P_{25} K_{12.5}$)	11.83	16.78	14.31^{0}	70.1	15.10	18.83	16.97^{2}	107.9	14.75	16.81	15.78^{1}	84.8
$N_{25} P_{25} K_{25}$	13.78	17.54	15.66^{1}	86.2	14.46	17.03	15.75^{0}	93.0	16.81	18.58	17.70^{2}	107.2
$N_{25} P_{50} K_{25}$	15.87	19.44	17.66^{2}	110.0	15.06	17.63	16.35^{1}	100.3	13.39	17.03	15.21^{0}	78.1
$N_{50} P_{0} K_{25}$	16.84	19.47	18.16^{1}	116.0	13.86	16.96	15.41^{0}	80.8	15.53	18.80	17.17^{2}	101.0
$N_{50} P_{25} K_{0}$	13.53	18.27	15.90^{0}	89.0	15.67	19.60	17.64^{2}	116.2	15.90	18.80	17.35^{1}	103.2
$N_{50} P_{12.5} K_{12.5}$	11.68	15.13	13.41^{0}	59.4	14.32	18.74	16.53^{2}	102.6	12.73	19.22	15.98^{1}	87.1
$N_{50} P_{12.5} K_{25}$	13.12	19.18	16.15^{1}	92.0	14.15	18.66	16.41^{0}	101.0	15.40	18.99	17.20^{2}	101.4
$N_{50} P_{12.5} K_{50}$	13.90	18.90	16.40^{1}	95.0	14.65	17.63	16.14^{0}	97.8	17.72	20.32	19.02^{2}	122.7
$N_{50} P_{25} K_{12.5}$	13.82	17.16	15.49^{0}	84.2	16.56	19.84	18.20^{2}	123.0	15.59	20.83	18.21^{1}	113.2
$N_{50} P_{25} K_{25}$	14.98	18.87	16.93^{1}	101.3	15.62	20.77	18.20^{0}	123.0	16.91	19.28	18.10^{2}	111.9
$N_{50} P_{25} K_{50}$	12.39	19.09	15.74^{0}	87.1	16.56	20.86	18.71^{2}	129.3	16.10	21.15	18.63^{1}	118.1
$N_{50} P_{50} K_{25}$	17.46	18.33	17.90^{1}	112.8	14.34	18.77	16.56^{0}	102.9	18.13	20.04	19.09^{2}	123.5
$N_{50} P_{50} K_{50}$	18.86	20.98	19.92^{2}	136.9	18.39	21.62	20.01^{1}	145.2	16.24	20.73	18.49^{0}	116.5
$N_{100} P_{25} K_{12.5}$	15.50	17.25	16.38^{0}	94.7	17.81	21.46	19.64^{2}	140.7	17.62	21.24	19.43^{1}	127.5
$N_{100} P_{25} K_{25}$	18.82	20.99	19.91^{1}	136.7	17.73	19.91	18.82^{0}	130.6	18.39	21.05	19.72^{2}	130.9
$N_{100} P_{25} K_{50}$	18.10	22.38	20.24^{2}	140.6	17.50	21.49	19.50^{1}	139.0	16.38	18.42	17.40^{0}	103.7
$N_{100} P_{50} K_{25}$	18.53	22.16	20.35^{2}	141.9	18.29	20.89	19.59^{1}	140.0	18.11	20.61	19.36^{0}	126.7
$N_{100} P_{50} K_{50}$	19.80	21.72	20.76^{2}	146.8	19.48	20.92	20.20^{1}	147.5	18.91	21.02	19.97^{0}	133.8
$N_{00} P_{00} K_{00}$	04.36	9.49	6.93^{0}	--	08.00	10.92	9.46^{2}	--	07.85	10.09	8.97^{1}	--
$N_{00} P_{00} K_{00}$	07.15	10.45	8.80^{1}	--	05.10	8.54	6.82^{0}	--	08.18	10.34	9.26^{2}	--
$N_{00} P_{00} K_{00}$	07.16	11.87	9.52^{2}	--	07.05	9.34	8.20^{1}	--	06.08	8.70	7.39^{0}	--
Mean of treated plots	15.05	18.72	16.89	--	15.60	19.13	17.37	--	16.40	19.17	17.79	--
Mean of control plots	06.22	10.60	8.41	--	06.72	9.60	8.16	--	07.37	9.71	8.54	--

0= 0 t FYM ha^{-1}, 1= 5 t FYM ha^{-1} and 2 =10 t FYM ha^{-1}

Table 4. Cotton stalk yield (q ha^{-1}) of rainfed Bt as influenced by conjoint use of FYM and chemical fertilizers under different fertility gradients

Treatments NPK, (kg ha $^{-1}$)	Cotton stalk yield (q ha $^{-1}$)											
	Low fertility gradient				Medium fertility gradient				High fertility gradient			
	2010	2011	mean	% increase over mean of control	2010	2011	mean	% increaes over mean of control	2010	2011	mean	% increase over mean of control
$N_0 P_{25} K_{2.5}$	22.16	26.47	24.31^2	45.9	20.16	25.90	23.03^1	45.8	21.27	24.38	22.83^0	38.4
$N_{25} P_{12.5} K_{12.5}$	17.95	25.01	21.48^0	28.5	20.02	28.80	24.41^2	54.6	18.70	27.03	22.87^1	38.7
$N_{25} P_{12.5} K_{25}$	22.78	28.84	25.81^2	54.4	18.83	25.08	21.96^1	39.1	22.16	26.81	24.49^0	48.5
$N_{25} P_{25} K_{12.5}$	18.95	26.84	22.90^0	37.0	23.97	30.91	27.44^2	73.8	23.19	26.58	24.89^1	50.9
$N_{25} P_{25} K_{25}$	21.53	26.43	23.98^1	43.5	21.49	25.70	23.60^0	49.5	26.75	30.66	28.70^2	74.0
$N_{25} P_{50} K_{25}$	25.66	32.46	29.06^2	73.9	23.93	29.16	26.55^1	68.0	22.56	28.97	25.77^0	56.3
$N_{50} P_0 K_{25}$	25.93	30.18	28.06^1	67.9	20.26	24.44	22.35^0	41.5	25.04	30.27	27.66^2	67.7
$N_{50} P_{25} K_0$	22.78	30.33	26.56^0	58.9	26.09	32.51	27.30^2	72.9	24.30	30.29	29.30^1	77.7
$N_{50} P_{12.5} K_{12.5}$	18.83	24.72	21.78^0	30.3	20.57	29.88	25.23^2	59.8	19.94	30.27	25.10^1	52.2
$N_{50} P_{12.5} K_{25}$	21.10	30.01	25.56^1	52.9	21.70	28.18	24.94^0	57.9	25.26	30.68	27.97^2	69.6
$N_{50} P_{12.5} K_{50}$	20.89	26.15	23.52^1	40.7	22.14	25.67	23.91^0	51.4	25.85	28.84	27.34^2	65.8
$N_{50} P_{25} K_{12.5}$	20.02	25.17	22.60^0	32.2	25.40	31.90	28.65^2	81.4	26.59	32.74	29.67^1	79.9
$N_{50} P_{25} K_{25}$	24.50	32.10	28.30^1	79.2	25.70	34.06	29.88^0	78.8	26.52	32.70	29.61^2	79.6
$N_{50} P_{25} K_{50}$	19.04	30.01	24.53^0	46.8	24.02	32.54	28.28^2	79.1	21.49	31.18	26.33^1	59.7
$N_{50} P_{50} K_{25}$	27.58	30.93	29.26^1	75.1	20.89	29.85	25.37^0	60.7	27.81	31.18	29.50^2	78.9
$N_{50} P_{50} K_{50}$	25.98	31.81	28.90^2	72.9	27.74	32.76	30.25^1	91.6	25.26	33.04	29.15^0	76.8
$N_{100} P_{25} K_{12.5}$	28.42	26.58	27.50^0	64.6	28.72	33.93	31.33^2	98.4	30.54	34.60	32.57^1	97.5
$N_{100} P_{25} K_{25}$	28.62	32.87	30.85^1	86.4	27.14	31.40	29.27^0	85.3	28.83	31.60	30.11^2	82.6
$N_{100} P_{25} K_{50}$	28.63	34.60	31.62^2	89.2	31.02	34.26	32.64^1	106.7	27.47	30.77	29.14^0	76.7
$N_{100} P_{50} K_{25}$	29.47	34.82	32.15^2	92.4	29.25	35.20	32.23^1	104.1	29.69	33.11	31.40^0	90.4
$N_{100} P_{50} K_{50}$	29.47	35.15	32.31^2	93.3	30.39	34.03	32.21^1	103.9	29.63	32.07	30.35^0	84.0
$N_{00} P_{00} K_{00}$	10.90	20.42	15.66^0	--	14.85	21.62	18.23^2	--	13.58	19.94	16.76^1	--
$N_{00} P_{00} K_{00}$	14.85	21.43	18.14^1	--	10.63	17.19	13.91^0	--	13.96	19.21	16.58^2	--
$N_{00} P_{00} K_{00}$	13.37	19.28	16.33^2	--	12.59	17.88	15.24^1	--	14.21	18.04	16.13^0	--
Mean of treated plot	22.42	29.59	26.72	--	25.47	30.29	27.18	--	25.18	30.50	27.84	--
Mean of control plot	13.04	20.38	16.71	--	12.69	18.90	15.79	--	13.92	19.06	16.49	--

0 = 0 t FYM ha^{-1}, 1= 5 t FYM ha^{-1} and 2 =10 t FYM ha^{-1}

L_2			L_1			L_0		
T_{15}	T_7		T_{14}	T_8		T_{20}	T_3	
T_{13}	T_{23}		T_4	T_{17}		T_{21}	T_1	F_2
T_{10}	T_5		T_9	T_{12}		T_{24}	T_6	
T_{11}	T_{18}		T_{22}	T_2		T_{16}	T_{19}	
T_{14}	T_2		T_{16}	T_{24}		T_5	T_{15}	
T_9	T_{22}		T_{21}	T_6		T_{13}	T_7	F_1
T_4	T_{12}		T_{19}	T_{20}		T_{23}	T_{11}	
T_8	T_{17}		T_1	T_3		T_{10}	T_{18}	
T_{16}	T_{21}		T_{10}	T_{23}		T_{12}	T_9	
T_{19}	T_3		T_{11}	T_{15}		T_{14}	T_8	F_0
T_{24}	T_6		T_5	T_7		T_4	T_{17}	
T_{20}	T_1		T_{18}	T_{13}		T_2	T_{22}	

Fig 1. Plan of treatments structure under different fertility gradients and FYM blocks

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COMBINING ABILITY ANALYSIS FOR SHOOT FLY RESISTANCE IN SORGHUM

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ABSTRACT

The present investigation was carried out in *rabi* 2011-12 to estimate the amount of heterosis, heterobeltiosis, and the general and specific combining ability for selection of potential parents and crosses and to ascertain the nature of gene action operating in inheritance of some important quantitative characters associated with shoot fly resistance. The experimental material comprised of nine divergent parents and their 36 F_1 progenies obtained by crossing these nine divergent parents in half-diallel fashion. Observations were recorded on grain yield, number of eggs plant^{-1} at 14 and 21 DAE, seedling vigour at 14 DAE, leaf glossiness at 14 and 21 DAE, dead heart at 14 and 28 DAE, trichome density at 14 DAE, chlorophyll content index at 21 DAE and recovery percentage. The cross M-35-1 X SPV 504 exhibited highest heterosis for seed yield plant^{-1} and the crosses Ringni X M-35-1, MS 104B X CSV 18R and MS 104B X AKR MS45B exhibited superior heterosis and heterobeltiosis for most of the shoot fly resistance traits. It is seen from general combining ability effects that the parents IS 18551, IS 2312, SPV 504, Ringni and AKSV 13R showed desirable gca effect for most of the shoot fly resistance traits.

Crosses exhibiting highest positive significant sca effects for almost all the shoot fly resistance traits included CSV 18R X IS 18551, Ringni X AKR MS45B and IS 2312 X IS 18551 in F_1. So these crosses may be forwarded further to develop genotypes with shoot fly resistance. Positively significant sca effects for grain yield were recorded by 22 crosses.

(Key words : Combining ability, heterosis, gene action, seedling vigour,leaf glossiness, dead heart percentage)

INTRODUCTION

Sorghum is prone to several diseases and pests which cause considerable reduction in grain yield. Sorghum shoot fly is one such pests which reduce the grain yield tremendously. The monsoon sorghum though susceptible, escapes the incidence, but winter sorghum is prone to attack due to high shoot fly population during winter mainly due to crop being grown under residual moisture conditions. The produce of *rabi* being superior, faces no marketing problems and hence fetches good market price. Narrow genetic base in *rabi* sorghum coupled with zero inputs in the form of fertilizers or pest control measures along with photo sensitivity and cold sensitivity reduces the economic gain in *rabi* sorghum. Thus, resistance breeding is the most viable option in reducing the losses due to shoot fly in *rabi* sorghum.

Resistance to shoot fly appears to be a complex trait. Recent reviews on shoot fly resistance reveals that components governing resistance are non preference and recovery resistance. Non preference for oviposition is the primary mechanism of resistance to shoot fly.

Ovipositional non preference and deadheart formation are related phenomena in the sense that less egg laying results in deadheart (Sharma *et al.,* 1977).Therefore, identifying the genotypes possessing resistance to shoot fly and also giving high yield is a permanent and reliable control against shoot fly. In view of the above, the present study was undertaken to identify donor parents for various component characters associated with shoot fly resistance through combining ability analysis and to estimate the magnitude of heterotic response in respect of shoot fly resistant traits and grain yield.

MATERIALS AND METHODS

The experimental material consisted of nine diverse genotypes crossed in diallel fashion to secure 36 F_1's. These F_1 's along with parents were sown in randomized complete block design, replicated thrice during *rabi* 2011-2012. The experimental material was deliberately planted late for inviting high and uniform shoot fly pressure and further infestor rows of susceptible line AKRMS 45B and interlard-fishmeal technique were also used for creating shoot fly pressure. (Taneja and Leuschner, 1985 and Nwanze, 1997). Data were recorded for grain yield plant $^{-1}$ (g) seedling vigour at 14 DAE, leaf glossiness at 14 DAE, trichome density on 14 DAE, chlorophyll content index at 21 DAE, number of eggs plant^{-1} at 14 and 21 DAE, dead heart percentage at 14 and 28 DAE

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and recovery percentage for five randomly selected plants in each F_1 and parents. Seedling vigour and leaf glossiness were measured on scale 1-5 as suggested by Sharma *et al.* (1997). Trichome density was also calculated as per the procedure outlined by Sharma *et al.* (1997). Chlorophyll content index was recorded using SPAD 502 chlorophyll meter. All the recommended cultural operations were carried out to raise a good crop. All the necessary data transformations were done for seedling vigour, leaf glossiness, dead heart percentage and recovery percentage. Data were subjected to statistical analyses as per Griffing (1956), method-2, model-1.

RESULTS AND DISCUSSION

Heterosis

In crops plants, heterosis was defined by Stebbing (1957) as 'greater adaptedness to human needs which had been obtained in a particular environment, through artificial selection followed by hybridization. Plant breeders have extensively exploited heterosis in enhancing the yield in a number of cross as well as self pollinated crops. Heterosis could also serve more practical purpose in providing the breeders a way of increasing disease resistance in resistance breeding programmes.

Heterotic crosses showing substantial and significant heterobeltiosis for dead heart percentage along with their expression for other characters over mid and better parents are indicated in table 1.

From the data of heterosis and heterobeltiosis for dead heart percentage, it was observed that hybrids with high magnitude of heterosis or heterobeltiosis have not necessarily showed better *per se* performance or vice versa. Hence, selection of superior crosses should necessarily be based not only on magnitude of heterosis but also on actual performance of hybrids for dead heart percentage at 28 DAE, so that appropriate selection can be made without errors.

The first cross Ringni X M-35-1 exhibited significant negative heterosis and heterobeltiosis for dead heart percentage at 28 DAE. The same cross also exhibited significant desirable heterosis for five characters and heterobeltiosis for four other important characters. The second cross MS 104 X CSV 18R recorded significant negative heterosis and heterobeltiosis for dead heart percentage at 28 DAE. This cross also registered desirable significant heterosis for six component traits and desirable significant heterobeltiosis for four component traits.

Another cross MS 104B X AKRMS 45B exhibited non significant negative heterosis and heterobeltiosis for dead heart percentage at 28 DAE. The same cross also exhibited significant desirable heterosis for eleven component characters and desirable significant heterobeltiosis for ten component traits. The next cross Ringni X AKRMS 45B showed non significant desirable negative heterosis and significant positive heterobeltiosis for dead heart percentage at 28 DAE. The same cross recorded significant desirable heterosis and heterobeltiosis for ten and six component traits respectively. Another cross CSV 18R X IS 18551 exhibited desirable non significant negative heterosis and heterobeltiosis for dead heart percentage at 28 DAE. This cross exhibited significant desirable heterosis for ten and significant desirable heterobeltiosis for two component traits.

Some other promising crosses exhibiting non significant positive heterosis and significantly low positive heterobeltiosis for dead heart percentage at 28 DAE and number of eggs at 14 DAE, number of eggs at 14 DAE and 21 DAE, dead heart percentage at 14 DAE. These crosses were AKRMS 45B X CSV 18R, AKSV 13R X MS 104B, M-35-1 X SPV 504 X MS 104B and SPV 504 X AKSV 13R. These crosses need to be exploited in further generations for isolating shoot fly resistance lines.

Combining ability

Data regarding combining ability analysis was carried out for all traits related to shoot fly resistant characters of F_1 diallel progenies are presented in table 2. The variance existing due to treatments was further partitioned using appropriate expectations of the observed mean squares into components of variations attributable to general combining ability (gca) variance and specific combining ability (sca) variance. For all the characters under study, both gca and sca estimates were found significant. Their ratio of less than unity demonstrated preponderance of non-additive type gene action in both F_1 diallel set for all the characters under study. The variance due to general combining ability were smaller than variances of specific

combining ability for all the characters under study. Thus, predominance of sca variances indicated that shoot fly resistance appears to be largely non-additive, though there are some evidences for additive type. These were in line with the results of Nimbalkar and Bapat (1987) who reported that egg laying and dead heart were under the control of non additive gene action. Aruna and Padmaja (2009) also reported that non additive gene action played important role in governing glossiness, seedling vigour and proportion of plants with dead hearts. Sharma *et al.* (1977) observed that resistance to shoot fly was quantitative in inheritance and mainly governed by additive genes. Borikar and Chopde (1981) also observed higher gca variances for dead heart percentage, eggs plant^{-1}, plant recovery and grain yield plant^{-1} and thus indicated the predominance of additive gene action for these traits. Patil *et al.* (2005) also indicated the predominance of additive gene effects for glossiness, trichome density and per cent dead hearts. Dhillon *et al.* (2006) indicated the predominance of additive gene effects for leaf glossiness, trichomes and plants with dead hearts. Aruna *et al.* (2011) indicated the presence of both types of gene action for all the characters studied.

Data regarding general combining ability effects in desirable direction for the traits related to shoot fly resistance are presented in table 2. Dabholkar *et al.* (1989) revealed significance of mean squares due to gca and sca for number of eggs laid and dead hearts at 14, 21 and 28 DAE.

It is seen from the table 2 that, four parents viz., IS 18551, IS 2312, SPV 504 and AKSV 13R proved to be best general combiners for all the shoot fly resistance related traits under study. The parent IS 18551 has been found to possess desirable gca for all the shoot fly resistance characters such as number of eggs plant^{-1} at 14 and 21 DAE, dead heart percentage at 14 and 28 DAE, trichome density, seedling vigour, leaf glossiness, recovery percentage and chlorophyll content index in F_1 diallel progenies

Another parent IS 2312, transmitted favourable genes for almost all the shoot fly resistance related characters in F_1 diallel set. This parent (IS 2312) has been found to possess desirable gca for all the shoot fly resistance characters such as number of eggs plant^{-1} at 14 and 21 DAE, dead heart percentage at 14 and 28 DAE, trichome density at 14 DAE, seedling vigour at 14 DAE, leaf glossiness at 14 DAE, recovery percentage of infested plants, chlorophyll content index at 21 DAE and grain yield plant^{-1} in F_1 diallel progenies. Third parent SPV 504 was identified to contribute favourable genes in F_1 diallel crosses for number of eggs plant^{-1} at 14 and 21 DAE, dead heart percentage at 28 DAE, and recovery percentage in F_1 diallel progenies. The parent Ringni was found to be capable of transmitting favourable genes for number of eggs plant^{-1} at 14 and 21 DAE, recovery percentage,grain yield plant^{-1} in F_1 diallel progenies. The parent AKSV 13R also possessed favourable genes for dead heart percentage at 28 DAE, trichome density at 14 DAE, number of eggs at 14 DAE, number of eggs at 28 DAE and grain yield plant^{-1} in F_1.

Thus, from summary performance indicated above for shoot fly resistance characters, the above mentioned five parents can also be categorized as good general combiners i.e. IS 18551, IS 2312, SPV 504, Ringni and AKSV 13R. Since high general combining effects correspond with additive and for additive x additive interaction (Griffing 1956) and represents the fixable genetic component of variation, these parents appear to be worthy of exploitation in recombination breeding programme. Shivanna *et al.* (1996) also identified IS 2312 as one of the best general combiners in both F_1 and F_2 for eggs plant^{-1}, dead heart percentage and trichome density. Khandare *et al.* (2013) recorded minimum dead heart percentage at 28 DAE on resistant check IS 18551.

Deviation from the performance of a cross as expected on the basis of general combining ability of the two parents, Sprague and Tatum (1942) used the term "Specific combining ability" (sca). According to this, the superior parental combinations having significantly high specific combining ability effects for dead heart percentage and its component traits are presented in table 3. General combining ability is relatively more important than specific combining ability in previously unselected material. Specific combining ability (SCA) on the other hand assumes a greater importance in the material, which has been previously selected for general combining ability.

First cross that exhibited significant desirable sca effects in F_1 diallel set for characters related to shoot fly resistance was CSV 18R X IS 18551. This

Table 1.Heterosis (H1) and Heterobeltiosis (H2) for 9 x 9 diallel set of sorghum

Sr. No.	Crosses	Grain yield plant^{-1}		Number of eggs plant^{-1} at 14 DAE		Numbers of eggs plan^{-1} at 21 DAE	
		H_1	H_2	H_1	H_2	H_1	H_2
1	Ringni X M-35-1	53.52**	35.32**	4.59	11.28**	25.93**	47.12*
2	Ringni xSPV 504	124.95**	83.28**	22.88**	40.78**	75.32**	170.00**
3	Ringni X AKSV 13R	111.61**	104.07**	21.89**	42.00**	66.48**	98.67**
4	Ringni X MS 104B	110.12**	96.89**	-40.89**	0.00	-21.98**	21.15
5	Ringni XAKRMS 45B	104.97**	88.96**	-60.62**	-3.76	-41.49**	17.31
6	Ringni X CSV 18R	88.25**	68.17**	-15.92**	5.26	-62.70**	-44.23**
7	Ringni X IS 2312	159.43**	156.14**	19.23**	65.33**	62.34**	150.00**
8	Ringni X IS 18551	-11.36*	-17.07**	85.11**	216.36**	118.54**	251.06**
9	M-35-1 X SPV 504	216.34**	188.66**	28.06**	57.28**	69.31**	220.00**
10	M-35-1 X AKSV 13R	13.67**	-2.89	37.60**	72.00**	57.01**	124.00**
11	M-35-1 X MS 104B	168.31**	151.27**	-57.17**	-33.33**	-49.72**	-35.25**
12	M-35-1 X AKRMS 45B	208.90**	194.12**	-53.22**	4.00	-32.74**	9.35
13	M-35-1 X CSV 18R	71.90**	69.64**	6.29	24.00**	4.05	29.50**
14	M-35-1 X IS 2312	113.14**	90.00**	-37.78**	-6.67	-29.10*	34.00
15	M-35-1 X IS 18551	101.69**	89.18**	-17.07*	54.55**	-13.98	70.21*
16	SPV 504 X AKSV 13R	81.24**	43.60**	8.37	10.00	60.00**	100.00**
17	SPV 504 X MS 104B	95.24**	67.93**	-27.62**	47.57**	10.78	198.00**
18	SPV 504 X AKRMS 45B	119.85**	91.93**	-41.29**	76.70**	-1.93	256.00**
19	SPV 504 X CSV 18R	70.96**	53.89**	1.65	49.51**	15.18	196.00**
20	SPV 504 X IS 2312	66.10**	36.69**	68.59**	100.00**	190.00**	190.00**
21	SPV 504 X IS 18551	54.19**	32.80**	51.90**	118.18**	137.11**	144.68**
22	AKSV 13R X MS 104B	118.89*	98.29**	-41.49**	22.00*	-18.37**	60.00**
23	AKSV 13RX AKRMS 45B	-12.28**	-21.77**	-57.86**	30.00**	-36.60**	64.00**
24	AKSV 13R X CSV 18R	78.52**	54.47**	24.00**	86.00**	24.11**	133.33**
25	AKSV 13R X IS2312	27.80**	21.75**	54.29**	80.00**	104.84**	156.00**
26	AKSV 13R X IS18551	83.51**	65.99**	121.94**	212.73**	178.69**	261.70
27	MS 104-B X AKRMS 45B	59.78**	57.01**	-66.43**	-55.84**	-50.00**	-39.27**
28	MS 104-B X CSV 18R	-52.42**	-54.80**	-39.65**	-22.00**	-27.23**	-25.12**
29	MS 104-B X IS 2312	88.21**	78.49**	-41.33**	53.33	-16.73**	124.00**
30	MS 104-B X IS18551	25.71**	25.92**	-3.76	225.45**	30.83	270.21**
31	AKRMS 45-B X CSV 18R	32.76**	28.26**	-50.91**	-12.00*	-34.23**	-17.39**
32	AKRMS 45-B X IS 2312	39.17**	29.82**	-39.53**	138.67**	-6.34	240.00**
33	AKRMS 45-B X IS 18551	-51.37**	-52.14**	-44.06**	190.91**	-12.22	236.17**
34	CSV 18R X IS 2312	82.35**	64.76**	10.55	102.67**	17.51*	202.00**
35	CSV 18R X IS 18551	174.41**	161.11**	-63.92**	-16.36	-62.20**	2.13
36	IS 2312 X IS 18551	58.94**	68.39**	27.69**	50.96**	-64.95**	-63.83*
	SE(m)±	**2.24**	**2.99**	**0.007**	**0.01**	**0.014**	**0.02**
	CD at 5%	**2.959**	**3.416**	**0.159**	**0.184**	**0.229**	**0.265**
	CD at 1%	**3.905**	**4.509**	**0.21**	**0.243**	**0.303**	**0.35**

* Significant at 5 per cent

** Significant at 1 per cent

Table 1.Contd….

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Sr. No.	Crosses	Seedling vigour at 14 DAE		Leaf glossiness at 14 DAE	
		H_1	H_2	H_1	H_2
1	Ringni X M-35-1	-12.60*	-10.44	-7.24	-4.95
2	Ringni xSPV 504	3.59	13.82	7.12	22.70**
3	Ringni X AKSV 13R	-5.51	0.00	-5.51	0.00
4	Ringni X MS 104B	-18.09**	-10.44	-18.09*	-10.44
5	Ringni XAKRMS 45B	-23.62**	-16.48*	-25.12**	-16.48**
6	Ringni X CSV 18R	-14.66**	-10.44	-14.66**	-10.44
7	Ringni X IS 2312	-4.73	23.68*	-4.73	23.68*
8	Ringni X IS 18551	47.52**	108.00**	47.52**	108.00**
9	M-35-1 X SPV 504	11.37	25.66**	20.48**	41.84**
10	M-35-1 X AKSV 13R	17.51**	27.61**	17.51**	-21.47**
11	M-35-1 X MS 104B	-30.71**	-26.18**	-37.10**	0.00
12	M-35-1 X AKRMS 45B	-10.57*	-4.71	-7.95	17.28*
13	M-35-1 X CSV 18R	10.49*	13.09*	14.58**	-40.31**
14	M-35-1 X IS 2312	-16.07*	12.28	-25.25**	0.00
15	M-35-1 X IS 18551	-3.09	41.00**	-21.65**	28.00*
16	SPV 504 X AKSV 13R	-3.49	0.00	-15.79**	35.46**
17	SPV 504 X MS 104B	8.15	30.92**	7.00	53.19**
18	SPV 504 X AKRMS 45B	8.70	31.58**	18.36**	35.46**
19	SPV 504 X CSV 18R	3.41	19.74**	12.02*	29.08**
20	SPV 504 X IS 2312	43.61**	67.54**	42.75**	23.68*
21	SPV 504 X IS 18551	11.90	41.00**	17.01*	52.00**
22	AKSV 13R X MS 104B	-25.59**	-13.50	-19.79**	32.52**
23	AKSV 13RX AKRMS 45B	-19.79**	-6.75	11.63*	-6.75
24	AKSV 13R X CSV 18R	14.60*	27.61**	-16.25**	17.18*
25	AKSV 13R X IS2312	1.81	23.68**	-37.91**	51.75**
26	AKSV 13R X IS18551	58.17**	108.00**	31.56**	100.00**
27	MS 104-B X AKRMS 45B	-24.54**	-24.54**	-9.09**	-40.74**
28	MS 104-B X CSV 18R	-8.17	-4.50	-38.46**	8.00
29	MS 104-B X IS 2312	-7.88	33.33**	30.91**	59.65**
30	MS 104-B X IS18551	3.67*	116.00**	15.19*	100.00**
31	AKRMS 45-B X CSV 18R	-8.17	-4.50	-5.66	-9.00
32	AKRMS 45-B X IS 2312	21.21**	75.44**	7.69	75.44**
33	AKRMS 45-B X IS 18551	3.16	63.00**	23.46**	91.00**
34	CSV 18R X IS 2312	21.66**	67.54**	21.66**	67.54**
35	CSV 18R X IS 18551	-24.00**	14.00	-33.33**	0.00
36	IS 2312 X IS 18551	-6.54	0.00	6.54	91.00
	SE(m)±	**0.011**	**0.02**	**0.01**	**0.01**
	CD at 5%	**0.211**	**0.123**	**0.197**	**0.223**
	CD at 1%	**0.278**	**0.321**	**0.260**	**0.300**

* Significant at 5 per cent

** Significant at 1 per cent

H_1 Heterosis over mean of parents

H_2 Heterosis over mean of better parents

Table 1.Contd….

Table 1.Contd….

Sr. No.	Crosses	Trichomes density at 14 DAE		Chlorophyll content index at 21DAE	
		H_1	H_2	H_1	H_2
1	Ringni X M-35-1	-14.37**	-43.63**	6.46*	7.33*
2	Ringni xSPV 504	-44.30**	-93.73**	6.00*	6.24
3	Ringni X AKSV 13R	-54.41**	-62.41**	7.23*	8.53*
4	Ringni X MS 104B	3.49	-31.27**	0.11	4.52
5	Ringni XAKRMS 45B	37.46**	-22.78**	2.50**	4.09
6	Ringni X CSV 18R	-25.60**	-40.54**	3.73*	5.72
7	Ringni X IS 2312	-21.39**	-25.35**	6.21*	9.27*
8	Ringni X IS 18551	-88.41**	-91.72**	16.41**	20.88**
9	M-35-1 X SPV 504	-67.04**	-78.62**	10.70**	11.86**
10	M-35-1 X AKSV 13R	-80.04**	-87.97**	13.32**	15.64**
11	M-35-1 X MS 104B	297.60**	304.88**	2.72	6.35*
12	M-35-1 X AKRMS 45B	110.53**	46.34**	11.49**	17.99**
13	M-35-1 X CSV 18R	-100.00**	-100.00**	5.81*	4.68
14	M-35-1 X IS 2312	125.41**	44.79**	-0.014	3.60
15	M-35-1 X IS 18551	6.12**	-39.74**	0.97	5.74
16	SPV 504 X AKSV 13R	-13.78**	-27.07**	2.23	3.23
17	SPV 504 X MS 104B	-26.32**	-51.81**	5.26*	10.15**
18	SPV 504 X AKRMS 45B	-93.51**	-96.38**	2.56	9.74**
19	SPV 504 X CSV 18R	-38.75**	-52.17**	6.60*	8.89**
20	SPV 504 X IS 2312	-50.00**	-51.04**	11.63**	4.58**
21	SPV 504 X IS 18551	-46.59**	-61.09**	6.18	10.01**
22	AKSV 13R X MS 104B	-7.85**	-44.11**	0.73	4.96
23	AKSV 13RX AKRMS 45B	-7.19**	-49.87**	-1.73	6.25
24	AKSV 13R X CSV 18R	-87.73**	-91.48**	12.7**	16.28**
25	AKSV 13R X IS2312	-53.13**	-59.65**	9.52**	11.31**
26	AKSV 13R X IS18551	-91.82**	-93.21**	20.71**	23.81**
27	MS 104-B X AKRMS 45B	152.99**	74.12**	-3.33	-1.25
28	MS 104-B X CSV 18R	-5.83	-27.10**	8.45**	11.04**
29	MS 104-B X IS 2312	31.90**	-14.58**	-0.4	7.11**
30	MS 104-B X IS18551	-88.39**	-93.38**	13.87**	23.65**
31	AKRMS 45-B X CSV 18R	-49.73**	-69.68**	4.78	9.65**
32	AKRMS 45-B X IS 2312	-70.63**	-83.68**	8.91**	19.82**
33	AKRMS 45-B X IS 18551	-71.38**	-84.93**	7.33**	19.25**
34	CSV 18R X IS 2312	-45.82**	-58.33**	11.17**	16.64**
35	CSV 18R X IS 18551	33.33**	-16.23**	-3.17	2.55
36	IS 2312 X IS 18551	-20.40**	-41.23**	6.15*	7.11*
	SE(m)±	**0.001**	**0.001**	**1.34**	**1.78**
	CD at 5%	**0.065**	**0.072**	**2.283**	**2.637**
	CD at 1%	**0.0824**	**0.0952**	**3.014**	**3.480**

* Significant at 5 per cent

** Significant at 1 per cent

H_1 Heterosis over mean of parents

H_2 Heterosis over mean of better parents

Table 1.Contd….

Table 1.Contd….

Sr. No.	Crosses	Dead heart percentage at 14 DAE		Dead heart percentage at 28 DAE		Recovery percentage	
		H1	H2	H1	H2	H1	H2
1	Ringni X M-35-1	15.17	25.56	-22.73**	-18.49**	4.45	-8.41
2	Ringni xSPV 504	20.74	25.21	24.73**	32.56**	-2.26	-0.6
3	Ringni X AKSV 13R	20.46	23.23	34.19**	51.58**	-14.58*	-22.68**
4	Ringni X MS 104B	38.08**	98.35**	9.47*	27.52**	-4.11	-7.18
5	Ringni XAKRMS 45B	2.71	56.87**	-2.02	18.56**	31.47**	-8.99
6	Ringni X CSV 18R	-10.65	31.61	12.21*	43.36**	-4.51	-14.67*
7	Ringni X IS 2312	14.80	39.50	50.33**	108.48**	-15.2*	-21.45**
8	Ringni X IS 18551	90.17**	144.11**	72.25**	169.66	-52.00**	-57.16**
9	M-35-1 X SPV 504	34.38**	41.03**	43.04**	60.85**	-34.83**	-42.02**
10	M-35-1 X AKSV 13R	28.11**	43.15**	26.58**	51.72**	-56.19**	-64.72**
11	M-35-1 X MS 104B	-12.72	12.89	15.72**	27.20**	51.48**	36.74**
12	M-35-1 X AKRMS 45B	-15.18	16.23	17.65**	34.11**	39.03**	4.97
13	M-35-1 X CSV 18R	41.55**	87.46**	19.99**	44.06**	-56.77**	-57.70**
14	M-35-1 X IS 2312	-29.23	-4.87	36.07**	101.95**	43.47**	17.83*
15	M-35-1 X IS 18551	17.22	17.96	7.67	81.15**	31.9**	4.97
16	SPV 504 X AKSV 13R	-15.08	-9.83	8.44	14.87*	8.29	-3.41
17	SPV 504 X MS 104B	-9.61	24.02	6.38	32.82**	-10.97	-12.41
18	SPV 504 X AKRMS 45B	10.12	60.39**	9.13*	41.79**	-51.86**	-66.36**
19	SPV 504 X CSV 18R	16.58	63.89**	8.83*	49.66**	-3.34	-12.33**
20	SPV 504 X IS 2312	43.54**	82.02**	70.14**	119.12**	-17.04**	-24.32**
21	SPV 504 X IS 18551	17.02	57.00**	66.72**	141.18**	-3.01	-14.69*
22	AKSV 13R X MS 104B	17.09	73.26**	3.95	39.01**	-7.79	-18.92**
23	AKSV 13RX AKRMS 45B	10.73	74.37**	7.73*	50.19**	18.29**	-22.43**
24	AKSV 13R X CSV 18R	29.26	96.19**	27.86**	89.10**	-66.28**	-72.38**
25	AKSV 13R X IS2312	30.21	54.12*	82.44**	119.73**	-26.23**	-28.06**
26	AKSV 13R X IS18551	115.55**	169.24**	128.43**	207.52**	-72.39**	-72.83**
27	MS 104-B X AKRMS 45B	-27.45**	-23.93**	-4.58	-1.34	45.63**	2.72
28	MS 104-B X CSV 18R	-25.42**	-23.96**	-6.70*	1.20	-21.43**	-27.67**
29	MS 104-B X IS 2312	-25.26**	37.48	14.96*	93.06**	8.05	-2.86
30	MS 104-B X IS18551	30.37	156.54**	50.16**	187.86**	-69.02**	-73.13**
31	AKRMS 45-B X CSV 18R	-20.08**	-17.84*	2.08	6.92*	-26.09*	-45.00**
32	AKRMS 45-B X IS 2312	9.54	115.71**	22.66**	115.82**	-16.03	-44.26**
33	AKRMS 45-B X IS 18551	9.23	130.48**	37.27**	176.38**	-18.27*	-46.80**
34	CSV 18R X IS 2312	-3.91	81.76**	27.65**	139.97**	-15.50*	-29.38**
35	CSV 18R X IS 18551	-52.98**	-4.79	-0.05	114.56**	35.74**	9.82
36	IS 2312 X IS 18551	23.81	29.74	54.36	69.90**	5.39	3.24
	SE(m)±	**5.693**	**7.59**	**4.483**	**5.98**	**2.73**	**3.63**
	CD at 5%	**4.712**	**5.441**	**4.182**	**4.829**	**3.257**	**3.76**
	CD at 1%	**6.22**	**7.183**	**5.52**	**6.374**	**4.299**	**4.964**

* Significant at 5 per cent H_1 Heterosis over mean of parents

** Significant at 1 per cent H_2 Heterosis over mean of better parents

Table 2. Analysis of variance for the combining ability of F_1 crosses in 9 x 9 diallel set

Sr. No.	Characters / Degrees of freedom	Sources					
		GCA 8	SCA 36	Error 88	σ^2 gca	σ^2 sca	σ^2 gca / σ^2 sca
1	Grain yield plant^{-1}	208.17**	387.35**	1.496	18.789	385.857	0.049
2	Seedling vigour at 14 DAE	0.17**	0.09**	0.008	0.015	0.082	0.183
3	Leaf glossiness at 14 DAE	0.20**	0.11**	0.007	0.018	0.105	0.170
4	Trichomes density	2.75**	1.63**	0.001	0.250	1.624	0.154
5	Chlorophyll content index	10.11**	6.09**	0.891	0.838	5.202	0.161
6	Number of eggs plant^{-1} at14 DAE	0.60**	0.22**	0.009	0.054	0.212	0.252
7	Number of eggs plant^{-1} at 21 DAE	1.12**	0.38**	0.004	0.102	0.379	0.268
8	Dead heart percentage at 14 DAE	129.24**	29.57**	3.78	11.404	25.773	0.442
9	Dead heart percentage at 28 DAE	137.30**	36.34**	2.988	12.21	33.349	0.366
10	Recovery percentage	90.70**	67.51**	1.813	8.081	65.692	0.123

** Significant at 1% level

Table 3. Estimates of general combining ability effects of parents from F_1 crosses

Sr. No.	Parents	Grain yield plant^{-1}	Seedling vigour at 14 DAE	Leaf glossiness at 14 DAE	Trichome density at 14 DAE	Chlorophyll content index at 21 DAE	Number of eggs plant^{-1} at 14 DAE	Number of eggs plant^{-1} at 21 DAE	Dead heart percentage at 14 DAE	Dead heart percentage at 28 DAE	Recovery percentage
1	Ringni	6.854 **	-0.013	-0.009	-0.032 **	-0.492	-0.075 **	-0.084 **	-0.522	0.150	0.832 *
2	M-35-1	4.598 **	0.045	0.023	-0.131 **	0.219	0.002	-0.103 **	-0.909	1.032 *	-1.091 **
3	SPV 504	1.631 **	0.028	-0.040	-0.084 **	-0.268	-0.087 **	-0.101 **	-0.862	-1.267 *	0.952 *
4	AKSV 13R	1.692 *	-0.004	0.042	0.137 **	-0.268	-0.039	-0.112 **	-0.168	-1.358 **	0.359
5	MS 104-B	-0.176	.086 **	0.133 **	-0.193 **	0.729 **	0.155 **	0.217 **	3.210 **	2.576 **	-0.205
6	MS 45-B	-4.685 **	0.120 **	0.137 **	-0.787 **	1.792 **	0.461 **	0.721 **	4.672 **	3.189 **	-5.515 **
7	CSV 18R	-4.178 **	0.140 **	0.136 **	-0.344 **	0.635 *	0.151 **	0.095 **	3.923 **	5.416 **	-2.402 **
8	IS 2312	2.962 **	-0.210**	-0.221 **	0.439 **	-1.275 **	-0.283 **	-0.304 **	-5.362 **	-5.809 **	4.492 **
9	IS 18551	-5.436 **	-0.192**	-0.201 **	0.996 **	-1.073 **	-0.285 **	-0.330 **	-3.982 **	-3.930 **	2.578 **
SE (m) (gi)		**0.348**	**0.025**	**0.023**	**0.008**	**0.268**	**0.027**	**0.002**	**0.554**	**0.491**	**0.383**
CD 5% (gi)		**0.691**	**0.049**	**0.046**	**0.016**	**0.533**	**0.054**	**0.036**	**1.100**	**0.976**	**0.761**
CD 1% (gi)		**0.916**	**0.066**	**0.061**	**0.021**	**0.706**	**0.072**	**0.047**	**1.459**	**1.293**	**1.008**
SE (m) (gi-gj)		**0.522**	**0.037**	**0.035**	**0.011**	**0.402**	**0.041**	**0.027**	**0.831**	**0.737**	**0.574**
CD 5% (gi-gj)		**1.037**	**0.074**	**0.069**	**0.022**	**0.799**	**0.107**	**0.054**	**1.651**	**1.464**	**1.14**
CD 1% (gi-gj)		**1.374**	**0.097**	**0.092**	**0.029**	**1.058**	**0.081**	**0.071**	**2.188**	**1.94**	**1.511**

cross exhibited significant desirable sca effects for number of eggs plant^{-1} in 14 DAE, dead heart percentage at 14 DAE, trichome density at 21 DAE, seedling vigour 14 DAE, leaf glossiness, recovery percentage, chlorophyll content index and grain yield plant^{-1} . The next cross, Ringni X AKRMS 45B, recorded significant desirable sca effects for most of the shoot fly resistance traits in F_1. These characters included number of eggs plant^{-1} at 14 DAE, trichome density, seedling vigour, leaf glossiness, recovery percentage, chlorophyll content index at 21 DAE and grain yield plant^{-1} .

The third cross IS 2312 X 1S 18551 exhibited non significant but negative sca effect for dead heart percentage at 14 DAE, but exhibited negative significant sca effect for dead heart percentage at 28 DAE. The same cross also showed significant desirable sca effect for trichome density, seedling vigour, leaf glossiness and recovery percentage and grain yield plant^{-1}.

Some other promising crosses showing desirable sca for dead heart percentage at 28 DAE included AKSV 13R X MS 104B, AKRMS 45B X CSV 18R, M-35-1X IS18551, MS 104B XAKRMS 45B, SPV 504 X CSV 18R , SPV 504 X AKSV 13R and MS 104B X CSV 18R in F_1 diallel crosses. These cross also exhibited desirable sca effects for some of the component characters in F_1 diallel progenies.

Thus, it could be concluded that, three specific combinations viz., CSV 18R X IS 18551, Ringni X AKRMS 45B and IS 2312 X IS 18551 were observed to be most desirable, since it had significant desirable sca effects in desirable direction in F_1 diallel set.

When the performance of all the desirable combinations or crosses are reviewed, it has been observed that these crosses involved parents having all three possible combinations of gca effects i.e. high x high, high x low and low x low. It was also observed that two parents with high gca effects may not necessarily give superior combinations. But, highly superior combinations have involved at least one parent of high gca effects.

Thus, It is seen from general combining ability effects that the parents IS 18551, IS 2312, SPV 504, Ringni and AKSV 13R showed desirable gca effect for most of the shoot fly resistance traits in F_1 diallel progenies and can be used as donor parents for improvement of traits related to shoot fly resistance . Crosses exhibiting highest positive significant sca effects for almost all the shoot fly resistance traits included CSV 18R X IS 18551, Ringni X AKR MS45B and IS 2312 X IS 18551 in F_1 diallel progenies. So these crosses may be forwarded by pedigree method further to develop genotypes with shoot fly resistance.

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EFFECT OF PINCHING AND CYCOCEL ON GROWTH AND FLOWER YIELD OF ANNUAL CHRYSANTHEMUM

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ABSTRACT

The present investigation was conducted at Horticulture Section, College of Agriculture, Nagpur during the year 2009-10.The experiment was laid out in Factorial Randomized Block Design consisting of sixteen treatment combinations with three replications. There were four pinching treatments viz., No pinching, pinching at 30 DAT, pinching at 45 DAT and pinching at 30 and 45 DAT and four levels of cycocel viz., control, cycoel 1000 ppm, cycoel 1500 ppm and cycoel 2000 ppm were taken. Among the pinching treatments, pinching at 30 and 45 DAT had recorded more reduction in plant height whereas, maximum number of branches plant^{-1}, diameter of stem, plant spread, number of flowers plant^{-1} , flower yield plant^{-1} and ha^{-1} were recorded with pinching at 30 DAT. As regard foliar application of cycocel, significantly maximum reduction in plant height was recorded at cycocel 2000 ppm. However, cycocel application at 1000 ppm had beneficial for increasing number of branches plant^{-1}, diameter of stem, plant spread, number of flower plant^{-1}, flower yield plant^{-1} and ha^{-1}.

(Key words: Pinching**, cycocel, annual chrysanthemum)**

INTRODUCTION

Among the flowers, the annual chrysanthemum has its own importance. It is one of the most important flower crop grown in India. Maharashtra is one of the leading states in flower production. It has a great demand during various functions, festivals, marriages and floral decorations. In Maharashtra, annual chrysanthemum is more popular among the farmers because of easy cultivation for cut as well as loose flowers. The growers are attracted towards cultivation of annual chrysanthemum as it produces marketable flowers of attractive colours in a short time. In Vidarbha region, the demand of annual chrysanthemum flowers for various purposes increasing tremendously. For production of economical yield of annual chrysanthemum flowers, it is necessary to adopt a proper agro-technique by applying standard cultural practices and growth retardants. Pinching and use of growth retardants plays an influencing role in growth and flower production in flower crops. Therefore, the present investigation was undertaken to study the "Effect of pinching and cycocel on growth and flower yield of annual chrysanthemum".

MATERIALS AND METHODS

The present study was undertaken during 2009-10 at Horticulture Section, College of Agriculture, Nagpur with four levels of pinching viz., No pinching (P_0), pinching at 30 DAT (P_1), pinching at 45 DAT (P_2) and double pinching at 30 and 45 DAT (P_3) and four levels of cycocel viz., control (C_o), cycoel (C_1) 1000 ppm, cycoel (C_2)1500 ppm and cycoel (C_3) 2000 ppm in Factorial Randomized Block Design with three replications. The seedlings of annual chrysanthemum were raised on raised bed in the nursery. The seedlings aged of 30 days old were planted in the field at spacing of 45 cm between rows and 30 cm between plants. The protective irrigations were given at timely interval as and when required. The field was kept free from weeds by adopting hand weeding at time to time. Fertilizer dose was applied at the @ of 150:50:50 kg NPK ha^{-1}. Urea, single super phosphate and muriate of potash were applied as a source of nitrogen, phosphorus and potash respectively. Half dose of nitrogen and full dose of phosphorus and potash was applied as a basal dose at the time of transplanting and remaining half dose of nitrogen was given one month after transplanting. In pinching treatments, 3-5 cm terminal growing portion of plant was pinch out as per treatment i.e. viz., No pinching, pinching at 30 DAT, pinching at 45 DAT and double pinching at 30 and 45 DAT. Regarding application of cycocel, required quantity of cycocel was dissolved in distilled water for preparation of stock solution and then diluted it as per treatment before spraying. The spraying was done in the morning hours with the help of hand sprayer at 30 DAT as per the treatments. Observations on growth parameters were recorded at 90 DAT viz., plant height (cm), number of primary branches plant^{-1}, stem diameter (cm) and plant spread (cm), similarly yield

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parameters like fresh weight of flower, number of flowers plant^{-1}, flower yield plant^{-1} (g) and flower yield ha^{-1} (q) were recorded and statistically analyzed (Gomez and Gomez, 1984). The appropriate standard error of mean S.E. (m) and the critical difference (C.D.) were calculated at 5% level of probability.

RESULTS AND DISCUSSION

Effect of pinching
Growth parameters

Data (Table 1) revealed that pinching treatments significantly influenced on growth parameters in annual chrysanthemum. Significantly maximum reduction in plant height (79.89 cm) was recorded in double pinching at 30 and 45 DAT followed by pinching at 45 DAT and 30 DAT. Whereas, maximum height of plant was recorded in no pinching treatment (88.29 cm). Significantly highest number of primary branches plant^{-1} (32.35), diameter of main stem (2.82 cm) and plant spread (40.99 cm) were recorded with the treatment pinching at 30 DAT followed by pinching at 45 DAT and in double pinching at 30 and 45 DAT. Whereas, number of branches plant^{-1}, diameter of main stem and plant spread (21.07, 2.62 cm and 32.83 cm respectively) were recorded minimum in no pinching treatment.

From above results, pinching treatments were helpful for beneficial effect to all the growth parameters. Pinching reduced the plant height and enhanced the side branches due to removal of apical dominance, which might have favoured in increasing the stem diameter, primary branches and spread of plant. The above results are similar to the findings of Sharma *et al*. (2006) and Maharnor *et al*. (2011) in African marigold. They reported that pinching at 30 DAT recorded the maximum vegetative growth.

Effect of cycocel

From above findings, fresh weight of flower, number of flowers plant^{-1}, flower yield plant^{-1} and ha^{-1} were recorded maximum in pinching at 30 DAT compared to no pinching treatment. This might be due to early pinching encourages the side branches due to removal of apical dominance, which might have favoured in increasing the primary branches and spread of plant and ultimately the flower yeild. These results are close conformity with the findings of Sehrawat *et al*. (2003) and Sharma *et al.* (2012) who reported that pinching at 30 DAT had recorded maximum flower yield in African marigold.

Growth parameters

Data collected from experimentation (Table 1) indicated that the applications of cycocel at various levels were found highly effective to influence the vegetative growth of annual chrysanthemum. Maximum retardation in plant height was recorded with cycocel at 2000 ppm i.e. 81.99 cm followed by cycocel 1500 ppm and cycole 1000 ppm when compared with control treatment. The reduction in plant height with the application of cycocel might be due to inhibitory role of growth retardants on cell division and cell elongation of apical meristematic cells and also on gibberellins synthesis. Similar results were reported by Khandelwal *et al*. (2003). They reported that, 2000 ppm cycocel had recorded maximum reduction in plant height.

Significantly more number of primary branches plant^{-1} (30.41), diameter of main stem and plant spread (39.86 cm) were recorded in cycocel 1000 ppm followed by cycocel 1500 ppm and cycocel 2000 ppm. However, minimum number of branches plant^{-1}(26.78), diameter of main stem (2.72 cm) and plant spread (34.89 cm) were recorded in control treatment. The increase in number of branches plant^{-1} with cycocel treatments might be due to reduction in terminal shoot growth and increase in number of branches plant^{-1}. Similar results were also reported by Amit Kumar *et al.* (2012) in African marigold. They reported that, 2400 ppm cycocel had beneficial effect for increasing number of branches, diameter of stem and plant spread.

Yield parameters

Data presented in table 1 revealed that, foliar applications of cycocel at different levels were significantly influenced on yield contributing parameters in annual chrysanthemum. Significantly maximum weight of fresh flower (2.21 g), number of flowers plant^{-1} (110.83), flower yield plant^{-1} (245.94 g) and flower yield ha^{-1} (182.05 q) were recorded with cycocel 1000 ppm, which was followed by the treatments cycocel 1500 ppm and cycocel 2000 ppm. However, minimum weight of fresh flower (2.02 g),

Table 1. Growth and yield parameters of Annual chrysanthemum as influenced by pinching and cycocel

Treatments	Plant height (cm)	Number of primary branches plant^{-1}	Diameter of main stem (cm)	Plant Spread (cm)	Fresh weight of flower (g)	No. of flowers plant^{-1}	Flower yield plant^{-1} (g)	Flower yield ha^{-1}(q)
Factor A: Pinching (Days After Transplanting)								
P_0- No Pinching	88.29	21.07	2.62	32.83	1.89	94.08	178.04	131.80
P_1- Pinching at 30 DAT	83.98	32.35	2.82	40.99	2.42	113.22	273.52	202.48
P_2- Pinching at 45 DAT	82.21	31.27	2.81	38.53	2.17	110.08	238.92	176.86
P_3-Pinching at 30 & 45 DAT	79.89	30.38	2.74	37.93	2.11	108.52	228.72	169.32
SE (m) ±	0.322	0.277	0.009	0.213	0.015	1.001	2.97	2.20
CD at 5%	0.930	0.799	0.027	0.615	0.045	2.889	8.58	6.36
Factor B: Cycocel (ppm)								
C_0-Control	85.41	26.78	2.72	34.89	2.06	97.56	202.88	150.2
C_1-1000 ppm	84.02	30.41	2.77	39.86	2.21	110.83	245.94	182.05
C_2- 1500 ppm	82.94	29.35	2.75	38.54	2.14	109.18	235.78	174.54
C_3- 2000 ppm	81.99	28.51	2.73	37.01	2.15	108.31	234.56	173.65
SE (m) ±	0.322	0.277	0.009	0.213	0.015	1.001	2.97	2.20
CD at 5%	0.930	0.799	0.027	0.615	0.045	2.889	8.58	6.36
Interaction Effect: AxB								
SE (m) ±	0.645	0.554	0.018	0.426	0.031	2.003	5.94	4.41
CD at 5%	--	--	--	--	--	-	--	--

number of flowers plant^{-1} (97.56), flower yield plant^{-1} (202.88 g) and ha^{-1} (150.20 q) were recorded with control treatment.

From the above findings it was revealed that, maximum flower yield was recorded in cycocel treatment at 1000 ppm. The increase in yield with cycocel spray might be due to more number of branches plant^{-1} thus, ultimately increased the flower yield plant^{-1}, plot^{-1} and ha^{-1}. Similar results were also reported by Amit Kumar *et al*. (2012) who reported that cycocel at 2000 ppm treated plant produced maximum flower yield in African marigold.

Interaction effect

Interaction effect of pinching and cycocel on growth and yield parameters was found to be non significant.

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EFFECT OF BLENDING OF AIR POTATO (*Dioscorea bulbifera*) PULP ON KULFI PREPARATION

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ABSTRACT

The present investigation was carried at Animal Husbandry and Dairy Science, College of Agriculture, Nagpur during the year 2012 -13.The air potato pulp was utilized in preparation of kulfi due to its high nutritive value. Milk was standardized to 4.00 per cent fat, and the kulfi was prepared with different levels of air potato pulp viz., 0 (T_1), 2.5 (T_2), 5.0 (T_3), and 7.5 per cent (T_4). The sensory attributes (flavour, body and texture, colour and appearance and melting point) were evaluated for acceptability of air potato kulfi with the help score card by the panel of judges. The results indicated that kulfi prepared by blending with 7.5 per cent air potato pulp was more acceptable. It was followed by 5 per cent and 2.5 per cent blended air potato kulfi. Hence, it can be inferred that best quality air potato kulfi can be prepared by using 7.5 per cent air potato pulp (92.50 parts kulfi mix + 7.5 part air potato pulp) which contained 8.47 per cent fat, 36.38 per cent total solids, 3.56 per cent protein and 1.77 per cent ash. It appeared that addition of air potato pulp increased the total solids and ash content in kulfi blended with 2.5 to 7.5 per cent air potato pulp.

(Key words: Kulfi, air potato, sensory attributes)

INTRODUCTION

A frozen indigenous milk products are popular in India. Kulfi is the frozen milk product which is like as ice cream and nutritious. Kulfi is prepared by concentration of milk to a particular level mixed with sugar and other variable ingredients and then frozen. It is available in mostly summer day only. Ice-cream and other frozen products are popular through out the world. But in India, low consumption of ice cream is due to poor economical structure of society. In India, ice-cream is considered as an item of luxury as it is costly product, so kulfi can be substituted for ice cream in villages (Maurya and Singh, 2007). Kulfi has a good nutritive value. Among milk products, kulfi is also rich source of calcium, phosphorus and other minerals of vital importance in building good bones and teeth. The protein content of kulfi also rated high in both quality and quantity.

Air potato (*Dioscorea bulbifera*) is one of the vegetable aerial tuber. These tubers are like small oblong potato and cultivated in tropical countries of the world and also find the place in the diet of rural people especially in eastern Vidarbha region of Maharashtra state. It is an excellent source of proteins, vitamins, minerals and it also has medicinal value. On an average, air potato contains 65-73%, 22-29%, 0.03-0.27%, 1.12-2.78%, 0.65-1.40% and 0.67-2.06% moisture, carbohydrate, fat, crude protein, fibre and ash respectively 100 $^{-1}$ g of edible air potato (Bose *et al*., 2003).

Air potato production is more in the month of February to March, because this seasonal crop is mainly cultivated in *kharif* season. Thus, we can divert air potato to the dairy industry for preparation of kulfi. Due to high nutrient value of air potato, it may increase the nutritive quality of kulf during summer days. Therefore, present investigation was aimed at incorporation of air potato pulp in kulfi mix to improve the quality of kulfi.

MATERIALS AND METHODS

During the entire study fresh, clean, whole cow milk was obtained from Animal Husbandry and Dairy Science section, College of Agriculture, Nagpur. The milk was strained through clean muslin cloth and transferred into well cleaned and sterilized flat bottom stainless steel vessel and standardized at 4 per cent fat. The fresh, clean air potato was purchased from local market and steam cooked in pressure cooker and smashed into solid pulp. Clean, crystalline sugar was obtained from local market. Sugar @ 15% by weight of Kulfi mix was common in all treatments. Good quality stabilizer was purchased from the market. Stabilizer i.e. sodium alginate@ 0.3% by weight was commonly added in all treatments. Plain Kulfi mix, prepared by using 4 per cent fat contained milk by adding sugar, sodium alginate and concentrated upto 2:1 ratio followed by cooling at 15-20^{0}C was the control treatment (T_0). Other treatments, included different combinations with air potato pulp viz., 2.5 per cent air potato pulp in kulfi

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mix (T_2),5.00 per cent air potato pulp in kulfi mix (T_3) and 7.5 per cent air potato pulp in kulfi mix (T_3). Analytical grade chemicals were used for chemical analysis. Fat content was determined by Gerber's method as per IS: 1224 (Part-I) (Anonymous,1977). Total solid content was determined by Gravimetric method as per IS: 1479 (Part II) (Anonymous,1961). Protein content was determined as per the semi-micro Kjeldahl method recommended in IS: 1479 (Part II) 1961. (Anonymous,1961). Ash content was determined as per the method recommended in IS: 1163, (Anonymous,1973).

The product for sensory characteristics viz., colour and appearance, melting quality, flavour, body and texture of each treatment was evaluated by using score card method prescribed by Pal and Gupta (1984). The maximum scores for various sensory attributes considered are stated bellow.

1. Flavour	-	45
2. Body and Texture	-	30
3. Colour and Appearance	-	10
4. Melting Quality	-	15
Total	-	100

The experiment was laid out in CRD with 4 treatments in 5 replications. The data were analyzed statistically according to method described by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

The chemical quality of air potato pulp kulfi was evaluated with respect to fat, total solids, protein and ash content and data are presented in table 1.

Fat content

It is revealed from table 1 that mean of fat content in kulfi sample was significantly ($P<0.05$) affected due to addition of air potato pulp at different levels. Fat contents in the treatments no addition of air potato pulp to kulfi mix i.e. plain kulfi, 2.5 per cent air potato pulp in kulfi mix, 5.00 per cent air potato pulp in kulfi mix and 7.5 per cent air potato pulp in kulfi mix were 10.28, 9.49, 9.26 and 8.47 per cent respectively. The fat percentage was significantly highest (10.28 per cent) in kulfi prepared without addition of air potato pulp i.e. plain kulfi, while fat content was lowest (8.47 per cent) in kulfi prepared with addition of 7.5 per cent air potato pulp.

The results of present investigation thus, indicated that with the increase in levels of air potato pulp, there was significant reduction in the fat percentage of kulfi. Similarly, Humane (2012) reported that with the addition of sweet potato pulp in kulfi, there was decrease in fat content in kulfi and vice-versa.

Total solids

The mean total solid content in kulfi under treatments no addition of air potato pulp to kulfi mix, 2.5 per cent air potato pulp in kulfi mix, 5.00 per cent air potato pulp in kulfi mix, and 7.5 per cent air potato pulp in kulfi mix, were 36.00, 36.16, 36.26 and 36.38 per cent respectively. The simultaneous increase in total solid content from plain kulfi i.e. no addition of air potato pulp to kulfi mix to 7.5 per cent air potato pulp in kulfi mix might be due to high total solids content of air potato pulp. The highest total solid content was found in kulfi mix having 7.5 per cent air potato pulp (36.38 per cent), while the lowest total solid content was observed in plain kulfi i. e no addition of air potato pulp to kulfi mix (36.00 per cent). It was observed that increase in the levels of air potato pulp also increased the total solid content of kulfi. Humane (2012) reported that the increase in levels of sweet potato pulp resulted into increase in total solid content of kulfi.

Protein

The mean protein content in plain kulfi i.e. no addition of air potato pulp to kulfi mix ,2.5 per cent air potato pulp in kulfi mix ,5.00 per cent air potato pulp in kulfi mix and 7.5 per cent air potato pulp in kulfi mix were 4.07, 3.95, 3.81 and 3.56 per cent respectively. The highest protein content was noticed in plain kulfi (control ,4.07 per cent) prepared without air potato pulp and the lowest (3.56 per cent) in 7.5 per cent air potato pulp in kulfi mix. It was observed that increase in levels of air potato pulp decreased the protein content of kulfi. The decreasing trend of protein in kulfi might be due to low protein content of air potato i.e. 1.6 per cent (Das *et al*.,1989).

Jadhav (2002) prepared kulfi with mango and sapota pulp. He reported that with the increase in levels of mango and sapota pulp, there was significant

decrease in protein content of kulfi. The result of Zade (2011) also indicated that with the increased levels of pineapple juice, there was decrease in protein content of kulfi and vice - versa. Similarly, Humane (2012) further reported that with increased levels of sweet potato pulp, there was decrease in protein content of kulfi and vice-versa. These findings are comparable with the findings of present investigation with respect to protein content.

Ash

It is evident from table 1 that the ash content of kulfi was significantly (P<0.05) affected due to addition of air potato in the preparation of kulfi. The mean ash content of kulfi prepared with no addition of air potato pulp to kulfi mix. i. e. plain kulfi**,** 2.5 per cent air potato pulp in kulfi mix , 5.00 per cent air potato pulp in kulfi mix and 7.5 per cent air potato pulp in kulfi mix **t**reatments were 1.23, 1.36, 1.52 and 1.77 per cent respectively. The highest ash content (1.77 per cent) was observed in 7.5 per cent air potato pulp in kulfi mix treatment, whereas the lowest ash content (1.23 per cent) was observed in plain kulfi i.e. (No addition of air potato pulp to kulfi mix**,** treatment). Humane (2012) reported that the increased levels of sweet potato pulp increased ash content in kulfi.

Sensory evaluation of kulfi

The results with respect to sensory evaluation of air potato pulp kulfi (flavour, body and texture, colour and appearance and melting quality) are presented in table 2.

Flavour

It is observed from table 2 that the flavour of kulfi was significantly (P<0.05) affected due to addition of different levels of air potato pulp. The mean score for flavour attribute of kulfi were 32.6, 36.80, 40.40 and 42.40 out of perfect score of 45 under treatments plain kulfi (No addition of air potato pulp to kulfi mix)**,** 2.5 per cent air potato pulp in kulfi mix 5.00 per cent air potato pulp in kulfi mix, and 7.5 per cent air potato pulp in kulfi mix respectively. The significantly highest score of 42.40 was obtained in kulfi prepared with 7.5 per cent air potato pulp treatment, while the lowest score (32.60) was obtained in plain kulfi prepared without addition of air potato pulp. Humane (2012) reported that the increase in the levels of sweet potato pulp increased the flavour content score of kulfi.

Results showed that the kulfi prepared with 7.5 per cent level of air potato pulp was significantly superior over the 2.5 and 5 per cent levels. It showed that the increase in the levels of air potato pulp increased the score of flavour content of kulfi.

Body and texture

The score of body and texture of kulfi was affected significantly (P<0.05) due to addition of different levels of air potato pulp. The average score for body and texture attributes of kulfi were 24.50, 26.10, 26.60 and 27.40 under plain kulfi, 2.5, 5.00 and 7.5 per cent air potato pulp in kulfi mix respectively. The significantly highest score (27.40) was received by the kulfi prepared with 7.5 per cent air potato pulp which was the most superior treatment in respect of body and texture of kulfi and at par with kulfi mix having 5 per cent air potato pulp but significantly superior over the other treatments while the lowest score (24.50) was received by plain kulfi without addition of air potato pulp. These results are in line with the results of Patil (1995). He noticed the more or less similar trends for body and texture with respect to body and texture of ice cream made by incorporation of different levels of sweet potato pulp. He found that with the increase in levels of sweet potato pulp the smoothness of the ice cream increased. Similarly, Humane (2012) reported that the increase in levels of sweet potato pulp increased the body and texture of kulfi.

Colour and apperance of kulfi

The average score for colour and appearance attribute of kulfi prepared under various treatments viz., plain kulfi(No addition of air potato pulp to kulfi mix**),** 2.5 per cent air potato pulp in kulfi mix**,** 5.00 per cent air potato pulp in kulfi mix, and 7.5 per cent air potato pulp in kulfi mix, were 8.70, 8.20, 7.30, and 7.20 respectively. The highest score of 8.70 was obtained by kulfi without addition of air potato pulp as compared to other treatments. Colour and appearance score of plain kulfi was superior over rest of the treatments. Humane (2012) reported that with increase in the levels of sweet potato pulp, the score of colour and appearance of kulfi content decreased.

Table 1. Chemical composition of air potato pulp kulfi

Treatments	Fat	Total solids	Protein	Ash
T_1 (No addition of air potato pulp to kulfi mix)	10.28[a]	36.00[c]	4.07[a]	1.23[d]
T_2 (2.5 per cent air potato pulp in kulfi mix)	9.49[b]	36.16[b]	3.95[b]	1.36[c]
T_3 (5.00 per cent air potato pulp in kulfi mix),	9.26[c]	36.26[b]	3.81[c]	1.52[b]
T_4 (7.5 per cent air potato pulp in kulfi mix)	8.47[d]	36.38[a]	3.56[d]	1.77[a]
SE ±	0.082	0.043	0.014	0.012
CD at 5%	0.247	0.131	0.044	0.037

Table 2. Table for sensory evaluation of kulfi as affected by different levels of air potato pulp

Treatments	Flavour (45)	Body and texture (30)	Colour and appearance (10)	Melting quality (15)	Total score (100)
T_1	32.60c	24.50d	8.70a	12.00c	77.8
	(72.00)	(81.00)	(87.00)	(80.00)	(80.00)
T_2	36.80b	26.10c	8.20b	12.60c	83.7
	(81.00)	(87.00)	(82.00)	(80.00)	(82.50)
T_3	40.40a	26.60b	7.30c	12.80b	87.10
	(89.00)	(88.00)	(73.00)	(85.00)	(83.75)
T_4	42.40a	27.40a	7.20c	13.20a	90.2
	(94.00)	(91.00)	(72.00)	(88.00)	(86.25)
SE ±	1.190	0.355	0.239	0.574	-
CD at 5%	3.580	1.065	0.718	1.217	-

(*Figures in paranthesis in per centage to total score of each attributes)

Melting quality

The average score for melting quality attributes of kulfi prepared under the treatments viz., plain kulfi i. e.No addition of air potato pulp to kulfi mix**,** 2.5 per cent air potato pulp in kulfi mix**,** 5.00 per cent air potato pulp in kulfi mix, and 7.5 per cent air potato pulp in kulfi mix were 12.00, 12.60, 12.80 and 13.20 respectively. The melting quality of kulfi was affected significantly ($P<0.05$) due to mixing of air potato pulp. The highest score of 13.20 was obtained by the kulfi mix with 7.5 per cent of air potato pulp. The score declined with lower content of air potato pulp with the lowest score (12.00) in plain kulfi prepared without addition of air potato pulp. The present results are in agreement with the results of Patil (1995). He reported that as the levels of air potato pulp increased the melting resistance of ice cream prepared with air potato pulp increased. Humane (2012) reported that as the levels of sweet potato pulp increased, the score of melting resistance of kulfi also increased.

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EFFECT OF PHOSPHORUS AND POTASSIUM ON SEED QUALITY AND SEED YIELD OF AFRICAN MARIGOLD

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ABSTRACT

An experiment to study the effect of phosphorus and potassium on seed quality and seed yield of African marigold was carried out at Horticulture Section, College of Agriculture, Nagpur, during January 2013 to May 2013 with sixteen treatment combinations in factorial randomized block design. The treatments comprised of four levels each of phosphorus and potassium @, 0, 25, 50 and 75 kg ha^{-1}. 100 kg ha^{-1} of nitrogen was applied as a common dose for all the treatments and phosphorus and potassium were applied as per the treatments. The results of present investigation revealed that, individual application of 75 kg ha^{-1} each of phosphorus and potassium produced significantly maximum longevity of intact flower, weight of seed flower^{-1} and test weight of seed with respect to quality parameters and maximum number of seeds flower^{-1}, seed yield plant^{-1}, seed yield plot^{-1} and seed yield hectare^{-1} with respect to seed yield parameters. Combined application of treatment 75 kg ha^{-1} phosphorus and 75 kg ha^{-1} potassium had given better seed quality and more seed yield than other treatments . The interaction effects were also significant with respect to number of seeds flower^{-1} and seed yield plant^{-1}, plot^{-1} and hectare^{-1}. For these parameters the best treatment combination was 75 kg P ha^{-1} + 75 kg K ha^{-1} it was followed by 75 kg P ha^{-1} + 50 kg K ha^{-1} and 50 kg P ha^{-1} + 75 kg K ha^{-1}.

(Key words: African marigold, phosphorus, potassium, longevity of flower, seed quality, seed yield)

INTRODUCTION

The total area under floriculture crops in India was around 191 thousand hectare with the production of 1031 thousand metric tonnes of loose flowers and 69027 lakh number of cut flowers (Anonymous, 2012).

In India Marigold is one of the most commonly grown flowers and used extensively on religious and social functions in different forms. Marigold is native of Central and South America especially Mexico and it belongs to family 'Asteraceae'. The African marigold (*Tagets erecta* L.) is hardy annual, about 90 cm tall, erect and produces branches. The florets, single to fully double, are of large size with globular heads. The flower colour varies from lemon yellow or yellow, golden yellow or orange. Because of its size, shape and colour, the African marigold is popular among the people.

Among the chemical fertilizers, phosphorus and potassium are the important fertilizers which are essential for the growth and flowering of marigold. Phosphorus has a great role in energy storage and transfer. Phosphorus is a constituent of nucleic acid, phytin and phospho - lipids, it is important component of seed and it promotes early flowering and good quality of the plants (Das, 2009). Potassium helps in formation of proteins and chlorophyll which are important for photosynthesis and it increases the quality of flower (Das, 2009). In marigold, these fertilizers can also manipulate seed quality and seed yield of the plant. Hence, in order to find out the optimum doses of phosphorus and potassium fertilizers under Nagpur conditions for enhanced flower longevity, seed quality and seed yield, the present investigation was under taken.

MATERIALS AND METHODS

The present investigation was carried out at Horticulture section, College of Agriculture Nagpur during January 2013 to May 2013 to study the effect of phosphorus and potassium on growth and flowering of African Marigold. The research was carried out on the variety African double orange. Sixteen treatment combinations with four levels of phosphorus (0, 25, 50 and 75 kg ha^{-1}) and four levels of potassium (0, 25, 50 and 75 kg ha^{-1}) were tested in factorial randomized block design with three replications. The seeds of marigold were sown in the nursery beds in the month of December. Marigold seedlings of uniform size were transplanted 30 days after sowing at the spacing of 45 cm x 30 cm in the month of January, 2013. Half of the recommended dose of 100 kg N ha^{-1} and full doses of phosphorus and potassium were supplied as per the treatments and were applied at the time of transplanting. The remaining 50 kg N ha^{-1} was applied at 30 days after transplanting. Package of practices including irrigation were adopted as per recommendation.

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Five plants were selected randomly from each plot for recording various seed quality parameters *viz*., longevity of intact flower, weight of seed flower and test weight of seed and seed yield parameters like number of seeds flower^{-1}, seed yield plant^{-1}, seed yield plot^{-1} and seed yield hectare^{-1}. Data were statistically analysed in FRBD (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

The data presented in table 1 revealed that, different levels of phosphorus and potassium had significant effect on all quality and seed yield parameters of African marigold .

Seed quality parameters

Significantly highest longevity of intact flower (14.12 days), weight of seeds flower^{-1} (1.24 g) and test weight of seed (4.34 g) were recorded at higher level of phosphorus i.e. 75 kg P ha^{-1} which was found at par with the treatment 50 kg P ha^{-1} (13.66 days, 1.18 g and 4.17 g respectively). This might be due to increase in uptake of nutrients. Phosphorus is a constituent of many energy rich compounds in plants and also involved in active root growth and helps in uptake of other nutrients resulting in increased quality of plant product. Whereas, application of 0 kg P ha^{-1} had resulted in significantly minimum longevity of intact flower (9.80 days), weight of seeds flower^{-1} (0.80 g), and test weight of seed (3.23 g). These results are in close conformity with the results of Swaroop *et al*. (2007) who reported that the weight of the seeds flower^{-1} and 1000 seed weight were maximum with the application of phosphorus at 75 kg hectare^{-1} in marigold.

With respect to potassium the treatment 75 kg K ha^{-1} had provided significantly maximum longevity of intact flower (13.54 days). Maximum weight of seeds flower^{-1} (1.20 g) and test weight of seed (4.21 g) was also recorded in the same treatment which was at par with the treatment 50 kg K ha^{-1} (13.01 days, 1.12 g and 4.06 g respectively), This increase in quality parameters might be due to the effect of potassium, as potassium is involved in synthesis of peptide bond and protein and carbohydrate metabolism and also participates in rapid cell division and differentiation.Whereas, application of 0 kg K ha^{-1} had significantly minimum longevity of intact flower (10.71 days), weight of seeds flower^{-1} (0.91 g) and test weight of seed (3.42 g). These results are in close conformity with the results of Gnyandev (2006) who reported increase in 1000 seed weight and germination percentage with the application of higher dose of fertilizer i,e.150 kg K ha^{-1} in China aster.

The interaction effect due to phosphorus and potassium on seed quality parameters like longevity of intact flower, weight of seeds flower^{-1} and test weight of seed were found to be non significant.

Seed yield parameters

The seed yield parameters like number of seeds flower^{-1} (310.55), seed yield plant^{-1} (10.10 g), seed yield plot^{-1} (202.16 g) and seed yield hectare^{-1} (7.50 q) were found maximum with the individual application of 75 kg P ha^{-1} which was found at par with the treatment 50 kg P ha^{-1} (299.79, 9.56 g, 191.11 g and 7.08 q respectively). This might be due to abundant availability of phosphates in the rooting medium, which is constituent of certain nucleic acids in the plant and plays important role in seed formation. Whereas, application of 0 kg P ha^{-1} had produced significantly minimum number of seeds flower^{-1} (230.45), seed yield plant^{-1} (6.16 g), seed yield plot^{-1} (121.10 g) and seed yield hectare^{-1} (4.51 q). The results were in close conformity with the findings of Swaroop *et al*. (2007) who reported that the seed yield flower^{-1} and plant^{-1} and 1000 seed weight were maximum with phosphorus 75 kg hectare^{-1} in marigold.

Among the different levels of potassium applied, significantly maximum number of seeds flower^{-1} (301.37), seed yield plant^{-1} (9.75 g), seed yield plot^{-1} (194.90 g) and seed yield hectare^{-1} (7.24 q) were found with the individual application of 75 kg K ha^{-1} which was found at par with the treatment 50 kg K ha^{-1} (290.31,9.17 g, 183.26 g and 6.79 q respectively). This might be due to the increased supply of potassium which plays important role in protein synthesis and enhances the maturity of plant parts. Whereas, application of 0 kg K ha^{-1} had produced significantly minimum number of seeds flower^{-1} (245.58), seed yield plant^{-1} (6.75 g), seed yield plot^{-1} (132.95 g) and seed yield hectare^{-1} (4.94 q) . These results are in close conformity with Pal and Gosh (2010) who had obtained maximum seed yield plant^{-1} and seed yield hectare^{-1} with the application of 200 kg K hectare^{-1} .

Table 1. Effect of phosphorus and potassium on seed quality and seed yield parameters of African marigold

Treatments	Longevity of Intact flower (days)	Weight of seeds flower^{-1} (g)	Test weight of seed (g)	Number of seeds flower^{-1}	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (g)	Seed yield hectare (q)
Phosphorus							
P_1 – 0 kg P ha^{-1}	9.80	0.80	3.23	230.45	6.16	121.10	4.51
P_2 – 25 kg P ha^{-1}	11.68	1.01	3.66	263.91	7.95	158.80	5.90
P_3 – 50 kg P ha^{-1}	13.66	1.18	4.17	299.79	9.56	191.11	7.08
P_4 – 75 kg P ha^{-1}	14.12	1.24	4.34	310.55	10.10	202.16	7.50
SE (m) ±	0.14	0.01	0.07	1.56	0.19	3.11	0.13
CD (P= 0.05)	0.40	0.04	0.20	4.51	0.55	8.98	0.39
Potassium							
K_1 – 0 kg K ha^{-1}	10.71	0.91	3.42	245.58	6.75	132.95	4.94
K_2 – 25 kg K ha^{-1}	12.00	1.00	3.71	267.44	8.10	162.06	6.01
K_3 – 50 kg K ha^{-1}	13.01	1.12	4.06	290.31	9.17	183.26	6.79
K_4 – 75 kg K ha^{-1}	13.54	1.20	4.21	301.37	9.75	194.90	7.24
SE (m) ±	0.14	0.01	0.07	1.56	0.19	3.11	0.13
CD (P= 0.05)	0.40	0.04	0.20	4.51	0.55	8.98	0.39
Interaction effect							
P x K							
SE (m) ±	0.28	0.03	0.14	3.13	0.38	6.23	0.27
CD (P= 0.05)	-	-	-	9.03	1.11	17.97	0.78

Table 2. Interaction effect of phosphorus and potassium on seed yield parameters of African marigold

Treatment combinations	Number of seeds flower^{-1}	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (g)	Seed yield hectare^{-1} (q)
0 kg P ha^{-1} + 0 kg K ha^{-1}	215.68	5.28	97.20	3.69
0 kg P ha^{-1} + 25 kg K ha^{-1}	226.22	5.96	119.27	4.44
0 kg P ha^{-1} + 50 kg K ha^{-1}	235.94	6.64	132.38	4.92
0 kg P ha^{-1} + 75 kg K ha^{-1}	243.95	6.78	135.53	5.01
25 kg P ha^{-1} + 0 kg K ha^{-1}	230.72	6.10	121.93	4.51
25 kg P ha^{-1} + 25 kg K ha^{-1}	256.95	7.13	142.53	5.28
25 kg P ha^{-1} + 50 kg K ha^{-1}	275.54	8.77	175.47	6.49
25 kg P ha^{-1} + 75 kg K ha^{-1}	292.44	9.79	195.26	7.30
50 kg P ha^{-1} + 0 kg K ha^{-1}	270.28	8.13	162.53	6.02
50 kg P ha^{-1} + 25 kg K ha^{-1}	283.24	9.27	185.23	6.86
50 kg P ha^{-1} + 50 kg K ha^{-1}	317.92	10.14	202.87	7.51
50 kg P ha^{-1} + 75 kg K ha^{-1}	327.74	10.69	213.80	7.91
75 kg P ha^{-1} + 0 kg K ha^{-1}	265.66	7.51	150.13	5.56
75 kg P ha^{-1} + 25 kg K ha^{-1}	303.34	10.06	201.20	7.45
75 kg P ha^{-1} + 50 kg K ha^{-1}	331.86	11.10	222.32	8.25
75 kg P ha^{-1} + 75 kg K ha^{-1}	341.35	11.75	235.00	8.73
Interaction effect				
P x K				
SE (m) ±	3.13	0.38	6.23	0.27
CD (P= 0.05)	9.03	1.11	17.97	0.78

The interaction effect due to phosphorus and potassium on seed yield parameters like number of seeds flower^{-1} ,seed yield plant^{-1}, seed yield plot^{-1} and seed yield hectare^{-1} were found significant. The interaction effect of phosphorus and potassium on number of seeds flower^{-1} revealed that maximum and significantly more value (341.45) was obtained under the treatment combination of 75 kg P ha^{-1} + 75 kg K ha^{-1}. It was followed by 75 kg P ha^{-1} + 50 kg K ha^{-1} and 50 kg P ha^{-1} + 75 kg K ha^{-1} and were at par with each other and significantly superior over rest of the treatment combinations. With respect to seed yield plant^{-1} ,the maximum seed yield plant^{-1} was obtained under the treatment combination of 75 kg P ha^{-1} + 75 kg K ha^{-1} followed by 75 kg P ha^{-1} + 50 kg K ha^{-1} and 50 kg P ha^{-1}+ 75 kg K ha^{-1} ,all the three being at par but significantly superior over rest of the treatment combinations. As far as seed yield plot^{-1} and seed yield hectare^{-1} is concerned, the maximum yield was recorded in the treatment combination 75 kg P ha^{-1} + 75 kg K ha^{-1}. It was followed by 75 kg P ha^{-1} + 50 kg K ha^{-1} being at par with each other. The later treatment was at par with 50 kg P ha^{-1} + 75 kg K ha^{-1} and significantly superior over rest of the treatment combinations.

From the study and given data it can be inferred that, application of 75 kg ha^{-1} each of phosphorus and potassium improved the seed quality and yield parameters of African marigold.

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GROWTH AND YIELD OF SUMMER AFRICAN MARIGOLD AS INFLUENCED BY PINCHING AND GIBBERELLIC ACID

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ABSTRACT

A field experiment was conducted at Main garden, Department of Horticulture, Dr. PDKV, Akola to study the effect of pinching and foliar application of gibberellic acid on growth and yield of African marigold. Experiment comprising four levels of pinching i.e. no pinching, pinching at 15 DAT, pinching at 22 DAT and pinching at 30 DAT and four levels of gibberellic acid i.e. 100 ppm, 200 ppm , 300 ppm and water spray (control) during summer season of the year 2010-11 and 2011-12. Among the pinching treatments, significantly more reduction in height of plant was recorded in the treatment pinching at 22 DAT whereas, pinching at 15 DAT was found to be best for improving other growth parameters viz., number of branches plant^{-1} , diameter of main stem and leaf area at 50% flowering stage and flower yield parameters viz., number of flowers plant^{-1}, flower yield plant^{-1}, plot^{-1} and ha^{-1}. In respect of foliar application of gibberellic acid, gibberellic acid 300 ppm was recorded significantly maximum vegetative growth parameters viz., height of plant, number of branches plant^{-1} , diameter of main stem and leaf area at 50% flowering stage and flower yield parameters viz., number of flowers plant^{-1}, flower yield plant^{-1}, plot^{-1} and ha^{-1}.

(Key words: Pinching, gibberellic acid, growth, foliar application)

INTRODUCTION

In past years, flowers were not of much economic importance. Today floriculture is recognized as a lucrative business since it has higher potential unit^{-1} area than most of the field crops and even horticultural crops both for domestic market and export. Among commercial important flowers, marigold (*Tagetes erecta* Linn.), a member of Asteraceae family, is one of most important annual flowers, cultivated commercially in India as bedding plants, loose flower for making garland, wreath, religious offering, natural colour pigments, insect and nematodes repellants, nutrient supplement for poultry feed and cut flower purpose. It occupies special importance due to its hardiness, easy culture, low pest attack and wider adaptability to varied agro-climatic condition.

In case of pinching, if the terminal portion of shoot is removed early, the emergence of side branches starts earlier and more number of flowers are produced. In recent years, a number of plant growth regulators have been used in the field of agriculture in specially horticulture for increasing, reducing or modifying the physiological process within plant and which ultimately affect the growth, flowering and yield. Gibberellins fall in growth promoter groups. The most drastic effect of gibberellins is the transformation of dwarf plants into tall ones by increasing in stem elongation. Effect of pinching and using gibberellic acid was ascertained for improving the flower production in African marigold during summer season. The proper time of pinching of terminal shoot and use of proper concentration of gibberellic acid as a foliar spray can be helpful in achieving the twin objectives of proper vegetative growth and maximum flower production during summer season. Accordingly, the present investigation was undertaken to find out the appropriate pinching time and suitable concentration of gibberellic acid on vegetative growth and flower yield in African marigold during summer season under Vidarbha conditions.

MATERIALS AND METHODS

Field experiment was conducted during summer season of the year 2010-11 and 2011-12 at main garden, University Department of Horticulture, Dr. P.D.K.V., Akola with the objective to study the effect of pinching and foliar application of gibberellic acid on growth and flower yield in African marigold.

The experiment was laid out in Factorial randomized block design with sixteen treatment combinations replicated thrice. Treatment comprising of four pinching levels viz., P_0 - no pinching, P_1 - pinching at 15 DAT, P_2 - pinching at 22 DAT and P_3 - pinching at 30 DAT and four concentrations of gibberellic acid viz., G_0 - control, G_1 - 100 ppm, G_2 - 200 ppm and G_3 - 300 ppm. Seeds of African marigold var. African Double Orange were procured from market. The raised beds were prepared

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after mixing the well rotten FYM. The seeds were sown on bed at a distance of 10 cm between the row and 2 to 3 cm within the row. Four weeks old healthy, stocky seedlings were used for transplanting. Transplanting was done at spacing of 45 cm x 30 cm. The recommended dose of fertilizers ($N:P_20_5:K_20$ @ 100:50:25 kg ha^{-1}) were applied in the form of urea, single supper phosphate and muriate of potash. Full dose of single supper phosphate and muriate of potash and ½ dose of urea was applied at the time of transplanting and remaining ½ dose of urea was applied at one month after transplanting.

Regarding pinching treatments, 4-5 cm terminal portion of growing tip was nipped out as per treatment time i.e. 15, 22 and 30 DAT. The foliar application of gibberellic acid was done twice at 15 DAT and 30 DAT as per treatment concentration. The observations regarding growth parameters viz., height of plant, number of branches $plant^{-1}$, diameter of main stem were recorded at 90 DAT and leaf area was recorded at 50% flowering stage and yield parameters like number of flower $plant^{-1}$, flower yield $plant^{-1}$, $plot^{-1}$ and ha^{-1} were recorded at the time of harvesting. Collected data was statistically analyzed as per Gomez and Gomez (1984). The appropriate standard error of mean SE(m) and the critical difference (CD) were calculated at 5% level of probability.

RESULTS AND DISCUSSION

The results obtained from present investigation are presented below on the basis of pooled mean of two years experimentation (2010-11 and 2011-12).

Effect of pinching

Growth parameters

The data presented in table 1 revealed that, pinching treatments reduced plant height. Significantly maximum reduction in plant height (75.49 cm) was recorded in pinching at 22 DAT followed by treatment of pinching at 15 DAT and 30 DAT. The treatment of no pinching had recorded significantly maximum plant height (92.12 cm). The reduction in the plant height in pinched plant might be due to the removal of apical meristematic tissue which inhibits the apical dominance and diverts plant metabolites from vertical growth to horizontal growth. The similar results were quoted by Pushkar and Singh (2012) in African marigold. They found that pinching at 20 DAT had recorded maximum reduction in plant height in African marigold.

As regards number of branches (18.70), diameter of stem (1.81cm) and leaf area (25.05 cm^2) had recorded significantly maximum with pinching at 15 DAT followed by pinching at 30 DAT and pinching at 22 DAT. However, no pinching treatment was recorded significantly minimum number of branches (16.52), diameter of main stem (1.72 cm) and leaf area (21.35 cm^2). This might be due to in pinching, apical portion of main stem was pinched out which arrested vertical growth and reduced the plant height, increased side branches, thicker stem diameter and also increased leaf area. These results are also closed conformity with earlier studied quoted by Sharma *et al*. (2012) and Maharnor *et al*. (2011) who quoted that early pinching i.e. at 30 DAT had more effective for increasing number of branches and stem diameter in African marigold.

Yield parameters

Data regarding yield parameters are presented in table 2. Significantly maximum number of flowers $plant^{-1}$(32.60), yield of flowers $plant^{-1}$ (231.80 g) $plot^{-1}$ (6.95 kg) and $hectare^{-1}$ (17.16 t) were registered under the treatment of pinching at 15 DAT followed by pinching at 22 DAT and pinching at 30 DAT. Whereas, minimum number of flowers $plan^{-1}$ (24.68), yield of flowers $plant^{-1}$(182.55 g), $plot^{-1}$(5.47 g) and $hectare^{-1}$(13.51 t) were recorded in no pinching treatment. This might due to the early pinching produced more number of branches due to development of large auxiliary shoots with flowers located terminally. The results are in agreements with Pushkar and Singh (2012) in marigold who reported that pinching of marigold plant at 20 DAT was more effective for increasing yield of marigold flower.

Effect of foliar application of gibberellic acid

Growth parameters

Pooled data of two years of experiment showed that, gibberellic acid treatment resulted in outstanding increase in all vegetative growth parameters studied under the experiment. The growth parameters such as height of plant (89.14 cm), number of branches $plant^{-1}$(18.82), diameter of stem (1.83 cm) and leaf area (26.13 cm^2) were recorded significantly maximum with foliar application of gibberellic acid 300 ppm followed by foliar

Table 1. Growth parameters of summer African marigold as influenced by pinching and gibberellic acid

Treatments	Height of plant at 90 DAT (cm)			Number of branches plant^{-1} at 90 DAT			Diameter of main stem at 90 DAT (cm)			Leaf area at 50 % flowering stage (cm^2)		
	2010-11	2011-12	Pooled mean	2010-11	2011-12	Pooled mean	2010-11	2011-12	Pooled mean	2010-11	2011-12	Pooled mean
Factor A – Pinching (P)												
P_0 – No pinching	89.15	95.10	92.12	16.33	16.70	16.52	1.70	1.74	1.72	21.07	21.40	21.35
P_1 – Pinching at 15 DAT	79.45	79.11	79.28	18.60	18.70	18.65	1.79	1.82	1.81	25.03	25.08	25.05
P_2 – Pinching at 22 DAT	75.46	75.52	75.49	17.19	17.03	17.11	1.74	1.75	1.75	22.98	23.26	23.12
P_3 – Pinching at 30 DAT	85.52	84.24	84.88	18.03	17.35	17.69	1.76	1.78	1.77	23.98	24.12	24.05
SE (m)±	0.91	1.19	1.17	0.26	0.10	0.13	0.008	0.006	0.007	0.40	0.34	0.263
CD at 5%	2.63	3.45	3.41	0.76	0.31	0.35	0.023	0.018	0.019	1.17	1.01	0.745
Factor B – Gibberellic acid foliar spray (G)												
G_0 – Control (Water spray)	73.99	75.01	74.50	15.73	16.61	16.17	1.69	1.72	1.71	17.83	18.14	17.98
G_1 – GA_3 100 ppm	81.11	82.75	81.93	17.14	17.16	17.15	1.73	1.76	1.75	24.02	24.18	24.10
G_2 – GA_3 200 ppm	84.68	86.33	85.51	17.98	17.68	17.83	1.76	1.78	1.77	25.25	25.33	25.29
G_3 – GA_3 300 ppm	88.40	89.88	89.14	19.30	18.33	18.82	1.81	1.84	1.83	25.95	26.31	26.13
SE (m)±	0.91	1.19	1.17	0.26	0.10	0.13	0.008	0.006	0.007	0.40	0.34	0.26
CD at 5%	2.63	3.45	3.41	0.76	0.31	0.35	0.023	0.018	0.019	1.17	1.01	0.74
Interaction effect (A X B)												
SE (m)±	1.82	2.39	2.01	0.53	0.21	0.34	0.016	0.013	0.012	0.81	0.69	0.52
CD at 5%	-	-	-	-	-	-	-	-	-	-	-	-

Table 2. Yield contributing parameters of summer African marigold as influenced by pinching and gibberellic acid

Treatments	Number of flowers plant^{-1}			Flower yield plant^{-1} (g)			Flower yield plot^{-1} (kg)			Flower yield ha^{-1} (t)		
	2010-11	2011-12	Pooled mean	2010-11	2011-12	Pooled mean	2010-11	2011-12	Pooled mean	2010-11	2011-12	Pooled mean
Factor A – Pinching (P)												
P_0 – No pinching	24.35	25.01	24.68	184.54	180.55	182.55	5.53	5.41	5.47	13.66	13.37	13.51
P_1 – Pinching at 15 DAT	31.10	34.10	32.60	228.30	235.31	231.80	6.84	7.06	6.95	16.90	17.43	17.16
P_2 – Pinching at 22 DAT	27.98	32.21	30.09	200.36	206.75	203.55	6.01	6.20	6.10	14.84	15.31	15.07
P_3 – Pinching at 30 DAT	29.69	32.62	31.15	192.05	197.33	194.69	5.76	5.91	5.83	14.22	14.61	14.41
SE (m)±	0.36	0.35	0.25	2.50	2.93	1.96	0.14	0.16	0.11	0.18	0.29	0.19
CD at 5%	1.04	1.03	0.77	7.23	8.47	5.55	0.40	0.47	0.31	0.54	0.84	0.56
Factor B – Gibberellic acid foliar spray (G)												
G_0 – Control (Water spray)	24.65	28.29	26.47	165.90	174.81	170.36	4.97	5.24	5.11	12.28	12.94	12.61
G_1 – GA_3 100 ppm	26.74	29.89	28.31	186.92	194.60	190.76	5.60	5.83	5.71	13.84	14.41	14.12
G_2 – GA_3 200 ppm	29.18	32.19	30.68	212.48	215.39	213.93	6.37	6.46	6.41	15.73	15.95	15.84
G_3 – GA_3 300 ppm	31.74	33.17	32.45	239.94	235.16	237.55	7.19	7.05	7.12	17.77	17.41	17.59
SE (m)±	0.36	0.35	0.25	2.50	2.93	1.96	0.14	0.16	0.11	0.18	0.29	0.19
CD at 5%	1.04	1.03	0.77	7.23	8.47	5.55	0.40	0.47	0.31	0.54	0.84	0.56
Interaction effect (A X B)												
SE (m)±	0.72	0.71	0.51	5.01	5.87	3.92	0.28	0.32	0.21	0.37	0.58	0.38
CD at 5%	-	-	-	-	-	-	-	-	-	-	-	-

application of gibberellic acid 200 and 100 ppm. Whereas, minimum height of plant (74.50 cm), number of branches plant^{-1}(16.17), diameter of stem (1.71 cm) and leaf area (17.98 cm^2) were recorded in control treatment.

Thus, from above results, it was found that plant growth parameters increased with the increase in gibberellic acid concentrations. This might be due to the fact that gibberellic acid increased the growth of plant by increasing internodal length and cell enlargement and enhanced the apical dominance indirectly by increasing auxin content. The increasing leaf area might be due to increasing plant height and number of branches. Similar results were recorded by earlier workers Taygi and Kumar (2006), Swaroop *et al. (*2007) and Ramesh Kumar *et al.* (2010) in marigold. They found that GA_3 200 ppm had recorded maximum vegetative growth parameters in African marigold plant.

Yield parameters

The data from table 2 showed that, significantly maximum number of flowers plant^{-1} (32.45), yield of flowers plant^{-1}(235.16 g), plot^{-1}(7.12 kg) and hectare^{-1}(17.59 t) were registered under foliar application of gibberellic acid 300 ppm followed by foliar application of gibberellic acid 200 ppm and 100 ppm. The minimum number of flowers plant^{-1} (26.67), yield of flowers plant^{-1}(170.36 g), plot^{-1} (5.11 kg) and hectar^{-1}(12.61 t) were harvested in control treatment. The increase in yield and yield parameters with GA_3 spray might be due to better crop growth, number of branches plant^{-1}, leaf area and maximum number of flowers plant^{-1} and thus ultimately increased the flower yield. Further it can be said that it might be due to better translocation of more metabolites from source to sink. Similar results were also reported by Amit Kumar *et al.* (2012) in marigold who reported that foliar application of 350 ppm GA_3 was more effective for increasing all flower yield parameters in African marigold.

Interaction effect

The pooled data presented in table 1 and table 2 exhibited non-significant differences for all growth and yield parameters due to an interaction of the pinching and foliar treatment of gibberellic acid.

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CORRELATIONS FOR SHOOT FLY RESISTANCE IN SORGHUM

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ABSTRACT

The present investigation was carried out to to identify various component characters association with shoot fly resistance. The experimental material comprised of nine divergent parents and their 36 F_1 and 36 F_2 progenies . The F_1 were obtained by crossing the nine divergent parents in half-diallel fashion during *rabi* 2010-11 and F_2 were obtained by selfing half of the F_1 seeds in *Kharif* 2011-12 . Observations were recorded on grain yield plant^{-1}, ,number of eggs plant^{-1} at 14 and 21 DAE, seedling vigour at 14 DAE, leaf glossiness at 14 DAE, dead heart at 14 and 28 DAE, chlorophyll content index at 21 DAE and recovery percentage of infested plants.

At the phenotypic and genotypic levels, seedling vigour at 14 DAE, leaf glossiness at 14 DAE, chlorophyll content at 21 DAE and dead heart per cent at 14 and 28 DAE had significant and positive association with number of eggs plant $^{-1}$both at 14 and 21 DAE, whereas negative significant association was found with trichome density at14 DAE and recovery percentage of infested plants. Thus, selection on the basis of minimum number of eggs, seedling vigour, leaf glossiness, chlorophyll content and dead heart per cent and more trichome density at 14 DAE and recovery per cent would be effective for shoot fly resistance. In the present investigation, it could be concluded that the selection would consequently help in shoot fly resistance in breeding programme effectively. On the basis of this selection criteria the parents IS 18551, IS 2312, AKSV 13R and SPV 504 were found promising and the superior F_1 and F_2 progenies were, IS 2312 X IS 18551 and CSV 18R X IS 18551.

(Key words : Seedling vigour, trichome density, recovery percentage, dead heart percentage)

INTRODUCTION

Sorghum in the subtropics has a hostile environment where unreliable rainfall, poor soils, pests, diseases and weed constantly exert a harsh selection pressure. Insect pests are the major biotic constraints for production and productivity of sorghum. Among insects, shoot fly (*Atherigonia soccata*) *is* a major grain yield limiting factor that causes damage when the sowings are delayed. The early sown crop escapes from shoot fly damage, but the late sown crop is most affected. Agronomic practices, natural enemies, synthetic insecticides and host plant resistance have been employed for shoot fly management to minimize the losses. Insecticide application is beyond the reach of resource poor farmers and further it is not practically possible on large area. Hence, host plant resistance can play major role in minimizing the extent of losses and is compatible with other tactics of pest management, including the use of natural enemies and chemical control.

Correlation studies help the breeder to decide which character should be chosen for selection to bring about the maximum increase in desirable traits. Correlation between shoot fly resistance and their related characters determined to identify the traits significantly associated with shoot fly resistance. The genetic contribution of each character in building up total genetic architecture of resistance would provide a realistic basis for allocation of weightage to each of these traits which would help in genetic improvement of sorghum.

MATERIALS AND METHODS

The nine diverse parents Ringni, Maldandi (M-35-1) , SPV 504, AKSV 13R(PKV Kranti), MS 104B , MS 45B, CSV 18R, IS 2312 and IS 18551 (two of them resistant, two susceptible and rest elite) were crossed in diallel fashion to develop 36 F_1's during *rabi* 2010-11. Few seeds of these crosses were used for advancing the generation in *kharif* 2011-12. The experimental material comprised of nine parents, 36 F_1's and 36 F_2 progenies in randomized block design with three replications during *rabi* 2010-11 at Sorghum Research Unit, Dr. P.D.K.V., Akola. This experimental material was deliberately planted late for inviting high and uniform shoot fly pressure and interlard-fishmeal technique was also used for creating shoot fly pressure. (Taneja and Leuschner, 1985 and Nwanze, 1985). Each F_1 and parents were raised in two rows, each F_2 was raised in four rows having 3 m length with recommended inter and intra row spacing of 45 cm x 15 cm, respectively. The data were recorded for grain yield plant $^{-1}$ (g), seedling vigour at 14 DAE, leaf glossiness at 14 DAE,

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trichome density on 14 DAE, chlorophyll content index at 21 DAE, number of eggs plant^{-1} at 14 and 21 DAE, dead heart percentage at 14 and 28 DAE and recovery percentage of infested plants for five randomly selected plants in each F_1 and parents and 15 randomly selected plants in each F_2. Seedling vigour and leaf glossiness were measured on scale 1-5 and trichome density was calculated as per the procedure outlined by Sharma *et al.* (1997). Chlorophyll content index was recorded using SPAD 502 chlorophyll meter. All the recommended cultural operations were carried out to raise a good crop. All the necessary data transformations were done for seedling vigour, leaf glossiness, dead heart percentage and recovery percentage of infested plants. The simple genotypic and phenotypic correlation coefficients were worked out from the respective variances and covariances as per the formulae suggested by Hays *et al*. (1995).

RESULTS AND DISCUSSION

Shoot fly resistance is a complex character being dependent on a number of other influencing components. The knowledge of association of different shoot fly resistance contributing components is of significant importance in resistance breeding programme. This study provides reliable information on nature, extent and effectivity of selection.

The data regarding simple correlation coefficients in F_1 and F_2 (*i.e*. genotypic and phenotypic) between all possible combinations of traits are presented in table 1 and 2 respectively.

In general, the genotypic correlation coefficients were higher than that of the phenotypic correlation coefficients. This is in agreement with the reports that confirm the limited role of environment in modifying the total expression of the genotypes. (Nandpuri *et al*., 1973).

At the phenotypic and genotypic levels, grain yield plant^{-1} exhibited non significant correlation with all the characters under study in F_1 progenies but exhibited positive significant correlation with chlorophyll content in F_2 progenies. The character, number of eggs plant^{-1} at 14 DAE, showed positive and significant association with number of eggs plant^{-1} at 21 DAE, seedling vigour, leaf glossiness, dead heart percentage at 14 DAE and dead heart percentage at 28 DAE in both F_1 and F_2 progenies and positive and significant association with chlorophyll content index only in F_1 and negative and non significant association with chlorophyll content index only in F_2 progenies . It also showed negative and significant association with trichome density and recovery percentage in both F_1 and F_2 progenies. Karanjkar *et al.* (1992) also observed that percentage of shoot fly eggs on 14th day after emergence exhibited significant positive correlation with shoot fly dead hearts similar to the present results but positive correlation with leaf trichome density which was different from the present findings.

Number of eggs plant^{-1} at 21 DAE, showed positive and significant association with seedling vigour, leaf glossiness, dead heart percentage at 14 DAE and dead heart percentage at 28 DAE in both F_1 and F_2 progenies and positive and significant association with chlorophyll content index only in F_1 and negative and non significant association with chlorophyll content index only in F_2 progenies. It also showed negative and significant association with trichome density and recovery percentage in both F_1 and F_2 progenies. Patel and Sukhani (1990) observed positive and highly significant correlation between shoot fly eggs plant^{-1} and per cent dead hearts which was similar to the present findings. Oviposition exhibited positive correlation with dead hearts at 14 and 21 DAE and negative correlation with trichome density as per Apotikar *et al*. (2011).

Trichome density recorded positive and significant correlations with recovery percentage and it showed negative and significant association with seedling vigour, leaf glossiness and dead heart percentage at 14 DAE and 28 DAE in both F_1 and F_2 progenies and negative and significant association with chlorophyll content index only in F_1,and positive and non significant association with chlorophyll content index only in F_2 progenies. Maiti *et al.* (1980) observed trichome density as a possible factor for resistance but its correlation with dead heart were low and non significant which was not as observed in the present study. Sandhu *et al.* (1988) also observed that number of trichomes unit^{-1} area was negatively correlated with number of eggs plant^{-1} and dead heart percentage. Shekharappa (2007) also observed

negative and significant correlation between number of trichomes on the lower surface and mean per cent dead heart.

Seedling vigour recorded significant and positive association with leaf glossiness, dead heart percentage at 14 and 28 DAE and negative association with recovery percentage in both F_1 and F_2 progenies and positive and significant association with chlorophyll content index only in F_1 and positive and non significant association with chlorophyll content index in F_2 progenies. Jayanthi *et al.* (2002) indicated that high early growth rate was associated with shoot fly resistance.

A highly positive and significant association was observed between leaf glossiness and dead heart percentage at 14 and 28 DAE and negative association with recovery percentage in both F_1 and F_2 progenies. The same character exhibited positive and significant association with chlorophyll content index in F_1 and non significant positive association in F_2 diallel progenies. Results of Gomashe *et al.* (2010) showed positive correlation of leaf glossiness with shoot fly oviposition and dead heart as found in the present findings. Omori *et al.* (1983) also concluded that glossy seedling expression could be used as a simple and reliable criterion for resistance.

Recovery percentage exhibited negative and significant correlations with dead heart percentage at 14 and 28 DAE in both F_1 and F_2 diallel progenies. Further it also exhibited negative and significant correlations with chlorophyll content index in F_1 and negative and non significant correlations with chlorophyll content index in F_2 diallel progenies. Kenneth (1969) reported that recovery resistance had a slight negative correlation with the number of seedlings damage. Dogget *et al.* (1970) also reported high correlation between recovery percentage and yield. Blum (1969) also reported that tiller survival of shoot fly resistance in sorghum was associated with fast growth of tillers.

Chlorophyll content index exhibited positive and significant correlation with dead heart percentage at 14 DAE and 28 DAE in F_1 and positive and non significant correlations with dead heart percentage at 14 DAE and 28 DAE in F_2 diallel progenies. Dead heart percentage at 14 DAE showed positive and significant association with dead heart percentage at 28 DAE both in F_1 and F_2 diallel progenies. Chlorophyll content index exhibited significant and positive correlation with dead heart percentage at 14 DAE and 28 DAE as reported by Singh and Jotwani (1980) which was in conformity with the present findings.

From practical point of view, dead heart percentage is the basically important character in shoot fly resistance breeding. It exhibited positive significant association with number of eggs plant^{-1} at 14 and 28 DAE, seedling vigour and leaf glossiness at 14 DAE and negative significant correlation with trichome density at 14 DAE and recovery percentage of infested plants. Similar trend of negative and significant correlation between percentage of dead heart and glossiness of leaves was observed by Nawanze *et al.* (1990). But, Halalli (1985) reported that dead heart percentage was positively correlated with total egg count plant^{-1} and trichome unit^{-1} leaf area. Results of Patil *et al.* (2006) also showed that dead heart was positively correlated with non-glossiness, percentage of plants having eggs, number of eggs plant^{-1} and negatively correlated with trichome density and seedling height at 14 DAE. Similar trend of positive association of dead heart with number of eggs plant^{-1} was also observed in the present study.

In the present investigation, it could be concluded that the that proper selection procedure to select genotypes for shoot fly resistance would, thus, result in selection of plants with lesser dead hearts, lesser number of eggs, lesser leaf glossiness, lesser seedling vigour, lesser chlorophyll content, more trichomes on lower surface of leaves and more recovery percentage. Kamatar *et al.* (2010) suggested that ideal ideotype must have high seedling vigour, narrow, erect, pale green leaves, dry central whorl, higher seedling and plant height and more number of trichomes on upper and lower leaves. Such selection would consequently help in shoot fly resistance breeding programme effectively. The mean values for shoot fly resistance traits indicated that the parents IS 18551, IS 2312, AKSV 13R and SPV 504 were found promising and hence may be utilized as parents for development of shoot fly resistant lines. The F_1 and F_2 progenies viz., IS 2312 X IS 18551 and CSV 18R X IS 18551 were found superior and hence may be forwarded by pedigree method to develop shoot fly resistant genotypes.

Table1 . Estimates of genotypic, phenotypic and environmental correlation coefficients in F_1.

Characters		Number of eggs plant^{-1} at 14 DAE	Number of eggs plant^{-1} at 21 DAE	Trichome density per mm^2 at 14 DAE	Seedling vigour at14 DAE	Leaf glossiness at 14 DAE	Recovery percentage of infested plants	Chlorophyll content index at 21 DAE	Dead heart percentage at 14 DAE	Dead heart percentage at 28 DAE
Grain yield plant^{-1} (g)	G	-0.201	-0.273	0.148	-0.252	-0.244	0.193	-0.016	-0.138	0.032
	P	-0.188	-0.267	0.146	-0.228	-0.220	0.182	-0.007	-0.122	0.033
Number of eggs plant^{-1} 14 DAE	G		0.893**	-0.817**	0.886**	0.841**	-0.825**	0.803**	0.826**	0.716**
	P		0.847**	-0.779**	0.752**	0.728**	-0.771**	0.649**	0.708**	0.622**
Number of eggs plant^{-1} 21 DAE	G			-0.637**	0.718**	0.683**	-0.681**	0.615**	0.699**	0.533**
	P			-0.629**	0.638**	0.619**	-0.651**	0.503**	0.631**	0.506**
Trichome density per mm^{2}14 DAE	G				-0.887**	-0.847**	0.924**	-0.897 **	-0.805**	-0.792**
	P				-0.800**	-0.784**	0.891**	-0.747 **	-0.716**	-0.731**
Seedling vigour 14 DAE	G					0.886**	-0.895**	0.874**	0.809**	0.785**
	P					0.753**	-0.788**	0.646**	0.650**	0.647**
Leaf glossiness 14 DAE	G						-0.860**	0.801**	0.807**	0.709**
	P						-0.764**	0.592**	0.662**	0.610**
Recovery percentage	G							-0.885**	-0.811**	-0.758**
	P							-0.708 **	-0.679**	-0.655**
Chrorophyll count at index at 21 DAE	G								-0.758**	-0.885**
	P								-0.568**	-0.696**
Deatheart per centage at 14 DAE	G									-0.849**
	P									-0.769**

** Significant at 4% and 1% level respectively

'r' value at 5% - 0.294 and at 1% = 0.380

G,P and E = Genotype, Phenotypic and environmental correlation co efficient

Table 2 . Estimates of genotypic, phenotypic and environmental correlation coefficients in F_2

Characters		Number of eggs plant^{-1} 14 DAE	Number of eggs plant^{-1} 21 DAE	Trichome density per mm^2	Seedling vigour 14 DAE	Leaf glossiness 14 DAE	Recovery percentage of infested plants	Chlorophyll content index at 21 DAE	Dead heart percentage 14 DAE	Dead heart percentage 28 DAE
Seed yield plant^{-1} (g)	G	-0.204	-0.226	0.128	0.007	0.028	0.250	1.000**	0.166	0.119
	P	-0.198	-0.225	0.128	0.010	0.029	0.228	1.000**	0.156	0.114
Number of eggs plant^{-1} 14 DAE	G		0.923**	-0.646 **	0.729**	0.759**	-0.787**	-0.204	0.553**	0.593**
	P		0.888**	-0.630 **	0.605**	0.676**	-0.701 **	-0.198	0.488**	0.546**
Number of eggs plant^{-1} 21 DAE	G			-0.602 **	0.642**	0.691**	-0.800**	-0.226	0.489**	0.504**
	P			-0.596 **	0.574**	0.622**	-0.719 **	-0.225	0.449**	0.461**
Trichome density per mm^2 at 14 DAE	G				-0.785 **	-0.842 **	0.903**	0.128	-0.758**	-0.761 **
	P				-0.692 **	-0.768 **	0.825**	0.128	-0.699**	-0.691**
Seedling vigour 14 DAE	G					1.00**	-0.787 **	0.007	0.809**	0.850**
	P					0.818**	-0.631 **	0.010	0.690**	0.704**
Leaf glossiness 14 DAE	G						-0.859 **	0.028	0.884**	0.901**
	P						-0.694 **	0.029	0.702**	0.730**
Recovery percentage of infested plants	G							0.250	-0.678**	-0.701**
	P							0.228	-0.564**	-0.575 **
Chlorophyll content index at 21 DAE	G								0.166	0.119
	P								0.156	0.114
Dead heart percentage 14 DAE	G									0.998**
	P									0.881**

*, ** Significant at 5% and 1% level respectively 'r' value at 5%=0.294 and at 1%=0.380

G , P and E – Genotypic , phenotypic and environmental correlation coefficient

Table 3. Mean performance of promising parents, F_1 and F_2 crosses for some important characters

Parents/ Crosses	Number of eggs plant^{-1} 14 DAE	Number of eggs plant^{-1} 21 DAE	Dead heart percentage 14 DAE	Dead heart percentage 28 DAE	Trichome density at 14 DAE	Seedling vigour at 14 DAE	Leaf glossiness at 14 DAE	Recovery percentage of infested plants	Chlorophyll content index at 14 DAE
Parents									
IS 18551	0.47**	0.55**	(10.86)** 3.67	(12.36)** 4.67	6.04**	(1.00)** 1.00	(1.00)** 1.00	(35.05)** 32.33	38.63**
IS 2312	0.50**	0.75**	(11.90)** 4.33	(14.85)** 6.67	2.88**	(1.14)** 1.33	(1.14)** 1.33	(33.10)** 29.88	39.33**
SPV 504	0.50**	1.03**	(18.28) 10.00	(23.40)** 16.00	2.76**	(1.52) 2.33	(1.41) **2.00	(30.26)** 25.47	41.42*
AKSV 13R	0.75**	1.00**	(16.27)** 8.00	(20.92)** 13.00	3.99**	(1.62) 2.67	(1.62) 2.67	(34.66)** 32.38	40.62*
F_1									
IS 2312 X IS 18551	0.17**	0.83**	(14.09)** 6.00	(20.14)** 12.00	3.55**	(1.00)** 1.00	(1.14)**1.33	(33.41)** 30.39	41.38*
CSV 18R X IS 18551	0.40**	0.46**	(10.34) **3.33	(21.76)** 14.00	5.06**	(1.14)** 1.33	(1.00)** 1.00	(36.25)** 36.31	39.62**
Ringni X CSV 18R	0.58**	1.40	(22.40) 15.00	(40.39) 42.00	1.54	(1.62) 2.67	(1.62) 2.67	(22.11) 14.29	43.98
M-35-1 X IS 2312	0.67**	0.70**	(11.32)** 4.00	(22.69)** 15.00	4.17**	(1.27)** 1.67	(1.14)** 1.33	(35.81)** 34.28	40.75*
M-35-1 X IS 18551	0.80**	0.85**	(12.81)** 5.00	(23.44)** 16.00	3.64**	(1.41)* 2.00	(1.14)** 1.33	(34.65)** 32.43	40.85*
M-35-1 X MS 104B	0.90**	1.00**	(22.68) 15.00	(41.55) 44.00	3.32**	(1.41)* 2.00	(1.27)** 1.67	(33.16)** 28.62	44.97
SPV 504 X AKSV 13R	1.00*	1.10**	(14.67)** 7.00	(24.27)** 17.00	2.90**	(1.52) 2.33	(1.27)** 1.67	(30.88)** 26.39	41.93
F_2									
IS 2312 X IS 18551	0.37**	0.60**	(15.32)**7.00	(20.09)**12.00	1.74	(1.00)**1.00	(1.00)**1.00	(27.95)19.40	43.05
CSV 18R X IS 18551	0.40**	0.63**	(18.94)**10.67	(22.52)**14.67	3.93**	(1.14)**1.33	(1.14)**1.33	(35.81)**34.30	39.24*
Ringni XAKRMS 45B	0.56**	0.72**	(25.80)19.00	(29.72)24.67	3.33**	(1.41)*2.00	(1.27)**1.67	(35.16)** 33.21	39.50*
Ringni X MS 104B	0.40**	0.70**	(25.07)18.00	(28.11) 22.33	4.52**	(1.14)**1.33	(1.27)**1.67	(36.53)** 35.48	39.00*
M-35-1 X IS 2312	0.42**	1.52	(38.63)39.00	(38.63)39.00	0.69	(1.82)3.33	(1.91)3.67	(18.28)10.12	42.13
M-35-1 X SPV 504	0.60**	0.75**	(26.46)20.00	(33.16)30.00	3.24**	(1.52)2.33	(1.38)**2.00	(34.64)**32.38	39.89
SPV 504 X CSV 18R	0.70**	0.77**	(28.59)23.00	(29.27)24.00	2.66**	(1.91)3.67	(1.91)3.67	(32.16)*28.42	41.20
Ringni X IS 18551	0.72**	0.84**	(26.49)20.00	(31.05)26.67	3.13**	(1.62)2.67	(1.62)2.67	(32.96)*29.72	40.89

Note: Figures in parenthesis are transformed values, * Significant at 5% level and ** Significant at 1% level over general mean and others are non significant

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ECOFRIENDLY MANAGEMENT OF LINSEED BUDFLY *Dasyneura lini* Barnes

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ABSTRACT

Due to awareness about the harmful effects of chemical insecticides, the present experiment was conducted on the ecofriendly management of linseed budfly, *Dasyneura lini* Barnes at the experimental farm of Entomology Section, College of Agriculture, Nagpur, during *rabi* season of 2012-13. The experiment was laid out in randomized block design (RBD) with nine treatments replicated thrice, Neelum, linseed budfly susceptible variety, was selected for investigation for the ecofriendly management of budfly. Two foliar applications of insecticides. the first at 30 days after germination and the second at 15 days thereafter were undertaken. The observations were recorded on the basis of total number of capsules and damaged capsules after 7 and 14 days after each sprying to record budfly infestation level in capsules.

In the present investigation, all the treatments were found statistically significant and superior over the control in reducing the per cent capsule damage of linseed budfly. The treatment azadirachtin 1500 ppm was found most effective in restricting the cumulative per cent capsule damage to the extent of 15.43 per cent. The second most effective treatment was neem seed extract 10 per cent which restricted the damage to 16.75 per cent followed by neem seed extract 5 per cent (18.50 per cent). However, both the treatments were found at par with each other. The treatment karanj seed extract 5 per cent stood next in order of efficacy recording 18.79 per cent infestation followed by tobacco leaf extract 5 per cent (20.59 per cent). However, minimum effective treatment was garlic extract 2 per cent (20.59 per cent) followed by green chilli extract 2 per cent which recorded the infestation 22.28 per cent and *Lantena camera* leaf extract 5 per cent with the infestation of 24.10 per cent.

(Key words: Linseed budfly, azadiractin, neem seed extract and karanj seed extract)

INTRODUCTION

Linseed is one of the most important *rabi* oilseed as well as fibre crop. Presently, it is grown on 5.36 lakh hectares contributing 1.68 lakh tones in production in the oilseed scenario of the country with a productivity level of 408 kg ha^{-1} during 2011-12 (Anonymous, 2012).

Flax means linseed contains about 30-40 per cent oil (Anonymous, 2005) with Omega-3 fatty acid which is the richest source of antioxidant. Linseed works as potential as medicinal food (anti-dietitic, antioxidant and anti-inflammatory functions) (Katare *et al.,* 2012). It has positive impact on breast cancer (Marghescu, *et al.,* 2012). It is also possible to extract fibers from the linseed straw after seed harvesting (Horne, 2010).

Linseed is a crop which badly suffers yield losses due to the attack of various insect pests, of which the budfly (*Dasyneura lini* Brnes) is the most harmful pest at the reproductive phase of crop. Budfly damage is caused by maggots initially to leaf bud and then to flower buds and ultimately to capsules due to gall formation. The gall midge/budfly, *Dasyneura lini* Barnes is most destructive pest of linseed in some parts of India, which adversely affects its yield and quality (Atwal, 1991). About 60 per cent losses were recorded by Chauhan and Srivastava (1975) and 41.18 per cent infestation was recorded by Sultane, 2005. Prasad *et al.* (2005) recorded the lowest infestation of buds (15.53 per cent) by *Daysyneura lini.* Gupta and Rawat (2004) reported the efficacy of neem products against budfly (*Dasyneura lini*) in linseed and found reduction in the incidence of budfly and increase grain yield. Shamshad *et al.* (2002) evaluated the bioefficacy of neem product against linseed budfly, *Dasyneura lini* on linseed cv Neeelum and reported that among the neem products, neem seed kernel extract and Nimbicidine performed better than the other botanical insecticide evaluated.

The increasing concern for environmental safety and global demand for pesticide residue free food has evoked keen interest in pest control through eco-friendly plant products which are easily biodegradable and do not leave any harmful toxic residues besides conserving natural enemies. Keeping the above mentioned facts in mind the present experiment was planned to study the evaluation of plant extract against linseed budfly (*Dasyneura lini* Brnes).

MATERIALS AND METHODS

The experiment was laid out in randomized block design (RBD) with nine treatments replicated

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thrice. Neelum, a linseed budfly variety was selected for investigation. For conducting the experiment, various plant extracts and agricultural implements were used. Total gross plot size was 3.9 x 2.5 m^2 and net plot size was 3.3 x 2.2 m^2. Sowing of linseed crop was done by drilling method with the seed rate of 14 kg ha^{-1} on November 13th 2012. The plant extracts were prepared manually in the insectary premises of Entomology Section, College of Agriculture, Nagpur during the *rabi* season of 2012-2013. The details of the ecofriendly herbal pesticidal treatments are given below :

Details of treatments

T_1	: Neem seed extract	5 per cent
T_2	: Neem seed extract	10 per cent
T_3	: Karanj seed extract	5 per cent
T_4	: Tobacco leaf extract	5 per cent
T_5	: *Lantena camera* leaf extract	5 per cent
T_6	: Garlic extract	2 per cent
T_7	: Green chilli extract	2 per cent
T_8	: Azadirachtin 1500 ppm	2 ml L^{-1}
T_9	: Control	

Two foliar applications of each treatment at the flower bud initiation, first on 30 days after germination and second on 15 days thereafter were made. From each plot, five plants were selected randomly as observational plants and were labelled. Observations were recorded on these plants for the number of total and damaged capsules in each plot on 7 and 14 days after first and second spraying on five randomly selected plants from each plot. The per cent infestation was calculated by using following formula.

$$\text{Per cent capsule damage} = \frac{\text{Number of infested capsules}}{\text{Total number of capsules}} \times 100$$

The data thus obtained, were transformed into square root transformation and then transformed data were statistically analyzed for testing the level of significance (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

The results obtained during the course of investigations are presented and discussed as follows.

Average per cent capsules damaged by linseed budfly 7 days after first spray

The data presented in table 1 revealed that all the treatments were statistically significant and superior over the untreated control.

The treatment azadirachtin 1500 ppm was found statistically most superior and recorded lowest budfly infestation (11.12 per cent) as against control which recorded 23.57 per cent infestation. However, the treatments neem seed extract 10 per cent, neem seed extract 5 per cent and karanj seed extract 5 per cent were found at par with each other and with azadirachtin 1500 ppm and registered the budfly damage to the extent of 13.48, 14.17 and 15.32 per cent respectively.

Raje *et al.* (2006) reported that azadirachtin 1500 ppm was the best treatment for the control of linseed budfly having infestation 10.01 per cent followed by neem seed extract 5 per cent (15.70 per cent) and karanj seed extract 5 per cent (16.51per cent) over the control.

Pal and Nagaich (2012) indicated that azadirachtin 1500 ppm had the lowest linseed budfly infestation of 13.8 per cent, followed by neem seed extract 5 per cent (18.2 per cent). The present findings conform the above revelations.

The treatments tobacco leaf extract 5 per cent, garlic extract 2 per cent, green chilli extract 2 per cent and *Lantena camera* leaf extract 5 per cent reocrded 15.70, 17.17, 17.51 and 18.08 per cent infestation of budfly respectively and were found at par with each other and also with neem seed extract 5 per cent and karanj seed extract 5 per cent (14.17 and 15.32 per cent respectively).

Average per cent capsules damaged by linseed budfly *Dasyneura lini* 14 days after first spray

The data given in table 1 indicated that the treatment azadirachtin 1500 ppm was found the best over all other treatments with infestation of 12.70 per cent followed by neem seed extract 10 per cent, neem seed extract 5 per cent, karanj seed extract 5 per cent which recorded bud fly damage 4.18, 15.14 and 15.98 per cent respectively.

Raje *et al*. (2006) reported that, azadirachtin 1500 ppm (15.80 per cent) was statistically significant and superior treatment among the other botanicals followed by neem seed extract 5 per cent

Table 1. Average per cent capsules damaged by linseed budfly Dasyneura lini at 7 and 14 days after each spray

Treatment	Dose	Average per cent capsules damaged			
		Days after first spraying		Days after second spraying	
		7	14	7	14
Neem seed extract	5%	14.17 (3.82)	15.14 (3.94)	16.20 (23.69)	18.50 (25.45)
Neem seed extract	10%	13.48 (3.73)	14.18 (3.83)	15.58 (23.22)	16.75 (24.10)
Karanj seed extract	5%	15.32 (3.97)	15.98 (4.04)	17.05 (24.31)	18.79 (25.61)
Tobacco leaf extract	5%	15.70 (4.01)	17.54 (4.24)	18.24 (25.25)	20.04 (26.57)
Lantena camera leaf extract	5%	18.08 (4.30)	22.11 (4.75)	23.10 (28.66)	24.10 (29.36)
Garlic extract	2%	17.17 (4.20)	18.24 (4.32)	19.30 (25.99)	20.59 (26.89)
Green Chilli extract	2%	17.51 (4.24)	19.15 (4.42)	20.15 (26.63)	22.28 (28.10)
Azadirachtin 1500 ppm	2 ml l^{-1}	11.12 (3.40)	12.70 (3.62)	13.60 (21.55)	15.43 (23.07)
Control	-	23.57 (4.89)	26.20 (5.16)	30.50 (33.50)	33.33 (35.25)
SE (m)±		0.19	0.19	1.36	1.31
CD at 5%		0.58	0.58	4.07	3.94

(Values in parentheses are square root transformations)

(19.80 per cent), and karanj seed extract 5 per cent (20.69 per cent) respectively. Thus, the present findings are in line with them.

The other treatments viz., Tobacco leaf extract 5 per cent (17.54 per cent), garlic extract 2 per cent (18.24 per cent), green chilli extract 2 per cent (19.15 per cent), Lantena camera 5 per cent (22.11 per cent) were found on par with each other.

Average per cent capsules damaged by linseed budfly *Dasyneura lini* at 7 days after second spray

Data presented in table 1 revealed that all the treatments were statistically significant and superior over the untreated control. The treatment azadirachtin 1500 ppm showed promising expression with the lowest damage of 13.60 per cent. However, other botanical treatments neem seed extract 10 per cent, neem seed extract 5 per cent, karanj seed extract 5 per cent and tobacco leaf extract 5 per cent were found at par with each other and with azadirachtin 1500 ppm which registered linseed budfly damage to the extent of 15.58, 16.20, 17.02 and 18.24 per cent respectively and other treatment were less effective.

These results were similar with the results of Atram (2008) who reported that azadirachtin 1500 ppm gave the lowest infestation of 17.21 per cent, neem seed extract 5 per cent, Karanj seed extract 10 per cent and tobacco leaf extract 5 per cent with infestation recording 19.46, 20.00, 20.50 and 22.75 per cent respectively.

Average per cent capsules damaged by linseed budfly *Dasyneura lini* at 14 days after second spray

The observation recorded on budfly damage to capsules at fourteen days after second spray are presented in table 1. The data revealed that all the treatments were found statistically significant and superior over the control in lowering down the linseed budfly infestationin capsules. The treatment azadirachtin 1500 ppm (15.43 per cent) was found statistically significant treatment over other botanicals except neem seed extract 10 per cent, neem seed extract 5 per cent, karanj seed extract 5 per cent, tobacco leaf extract 5 per cent and garlic extract 2 per cent indicating budfly infestation in capsules to the extent of 16.75, 18.50, 18.79, 20.04 and 20.59 per cent respectively.

Further, treatments green chilli extract 2 per cent and *Lantena camera* leaf extract 5 per cent showed the budfly infestation of 22.28 and 24.10 per cent respectively and were found to be on par with each other, as compared to control (33.33 per cent). Atram (2008) indicated that azadirachtin 1500 ppm (20.37 per cent), was the best and statistically superior treatment for controlling linseed budfly (*Dasyneura lini* Barnes) among all botanicals followed by neem seed extract 10 per cent (18.77 per cent), neem seed extract 5 per cent (16.97 per cent), karanj seed extract 10 per cent (17.31 per cent), and tobacco leaf extract 5 per cent (19.93 per cent).

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EFFECT OF QUIZALOFOP-P-TEFURYL AND IMAZETHAPYR ON YIELD AND YIELD ATTRIBUTES AND ECONOMICS OF SOYBEAN

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ABSTRACT

A field experiment was carried out during the *kharif* season 2011 at Agronomy farm, College of Agriculture, Nagpur to study the effect of different herbicides on yield and yield components and economics in soybean. Weed control through 1 hand weeding at 30 DAS + 1 hoeing at 45 DAS proved most effective in improving yield and yield attributing characters and consequently recorded the highest seed yield (1587 kg ha^{-1}) and straw yield (2704 kg ha^{-1}). However, it was at par with herbicidal weed control treatment imazethapyr @ 75 g a.i. ha^{-1} at 15 DAS +1 hoeing at 30 DAS. Weed management with 1 hand weeding at 30 DAS + 1 hoeing at 45 DAS recorded the highest gross monitory returns (GMR) (Rs. 40096 ha^{-1}) and net monitory returns (NMR) (Rs. 23103 ha^{-1}) followed by the herbicidal weed control treatment imazethapyr @ 75 g a.i. ha^{-1} at 15 DAS +1 hoeing at 30 DAS (GMR Rs. 37173 ha^{-1} and NMR Rs. 20405 ha^{-1}). The highest Benefit:cost ratio was observed with the weed control treatment 1 hand weeding at 30 DAS + 1 hoeing at 45 DAS (2.36) followed by the herbicidal weed control treatment imazethapyr @ 75 g a.i. ha^{-1} at 15 DAS +1 hoeing at 30 DAS (2.22). The later integrated weed management treatments can be adopted, if there is a non availability of labour.

(Key words: Economics, Imazethapyr, Quizalofop-p-tefuryl, soybean, yield)

INTRODUCTION

Soybean crop has a high yield potential of 2500 - 2800 kg ha^{-1}, however, the average yield of soybean in India is 777 kg ha^{-1} which is considered to be very low as compared to world average yield of 1832 kg ha^{-1} (Sharma, 2007). Soybean, a slow growing crop in early stages, faces severe weed competition, yield loss due to weeds ranges from 31% to 84% depending on crop cultivar, nature and density of weed, spacing, duration and time of weed infestation and environmental condition (Kachroo *et al*., 2003).

Presently a number of herbicides like Alachlor, Pendimethalin, Fluchloralin, Metribuzin etc. are commercially available for weed control in soybean. Kamalabai and Nanjappa (2003) earlier reported that all the herbicidal treated plots gave significantly lower weed compared to weedy check. Soltani *et al.* (2009) observed that imazethapyr (100 g a.i. ha^{-1}) was applied as pre and post-emergence in standing crop, post emergence application resulted up to 72, 66, 91, 78 and 71% weed control when applied at one, two, three, four and five-leaf stage respectively. Sanjay *et al.* (2011) reported that tank mix combination of chlorimuron ethyl 9 g + quizalofop-p-terfuryl 40 g a.i. ha^{-1} + 0.2% surfactant (as tank mix) at 20 DAS can be used safely for broad spectrum weed control in irrigated soybean. The use of quizalofop-p-tefuryl 40 g a.i. ha^{-1} alone lowered the dry weight of grasses considerably without affecting the density and dry weight of broad leaf weeds.

Most of these herbicides are applied either before sowing the crop or after emergence of soybean seedling. The sowing duration of most of crops including soybean is very short and soybean crop needs to be sown as early as possible. There is a shortage of time and labour for other work like pre emergence application of herbicides. The farmers give preference to sowing operation of the crop rather than the herbicide application for the control of weeds. Hence, the experiment was conducted to find out the effect of different herbicides on yield and yield attributing characters and also economics of the standing crop.

MATERIALS AND METHODS

A field experiment was carried out during the *kharif* season 2011-12 at Agronomy farm, College of Agriculture, Nagpur. The experiment was laid out in RBD design with eight treatments and three replications. The treatment comprised of weedy check (T_1), 1 hand weeding at 30 DAS + 1 hoeing at 45 DAS (T_2), quizalofop-p-tefuryl @ 60 g a.i. ha^{-1} at 15 DAS (T_3), quizalofop-p-tefuryl @ 60 g a.i. ha^{-1} at 15 DAS + 1 hoeing at 30 DAS (T_4), quizalofop-p-tefuryl @ 75 g a.i. ha^{-1} at 15 DAS (T_5), quizalofop-p-tefuryl @ 75g a.i. ha^{-1} at 15 DAS + 1 hoeing at 30 DAS (T_6), imazethapyr @ 60 g a.i. ha^{-1} at 15 DAS + 1 hoeing at

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30 DAS (T_7) and imazethapyr @ 75 g a.i. ha^{-1} at 15 DAS + 1 hoeing at 30 DAS (T_8).

The soil of the experimental field is characterized by 20.8% sand, 19.5% silt and 58.8% clay in texture with slightly alkaline pH (7.8), moderate in organic carbon status (0.58%), low in available nitrogen (226.10 kg ha^{-1}) , phosphorus content (21.16 kg ha^{-1}) and fairly rich in potassium (410.3 kg ha^{-1}) with electrical conductivity of 0.22 dS m^{-2}. Soybean cultivar JS - 335 was sown on 30th June 2011 with 45 cm x 5 cm spacing. Entire dose of recommended fertilizers 30 kg nitrogen ha^{-1} and 75 kg phosphorus ha^{-1} were applied at the time of sowing. The crop was harvested on 16th October 2011.

Observations on yield attributing parameters viz,. number of pods plant^{-1}, number of seeds plant^{-1}, seed yield plant^{-1}, straw yield plant^{-1}, test weight (g), seed yield and straw yield were recorded treatment wise after harvest of crop and the economics were calculated according to treatments.

RESULTS AND DISCUSSION

The experimental field was mainly infested with weed flora comprised of monocot, dicot weeds and sedges. The most common species were Parthenium hysterophorus, Euphorbia hirta, Digera arvensis, Lagasca mollis among dicot weeds Cynodon dactylon, Echinochloa crusgalli, Ergotis major, Poa annua, Sorghum halepense among the grasses and sedges Cyperus rotundus. Other weeds were present in less number.

The data presented in table 1 revealed that weed control treatment one hand weeding at 30 DAS and one hoeing at 45 DAS recorded significantly more number of pods plant^{-1} (45.13), more number of seeds plant^{-1} (80.3), higher seed yield plant^{-1} (7.77 g), and higher straw yield plant^{-1} (16.67 g) as compared to all other weed control treatments. However, it was at par with herbicidal weed control treatment imazethapyr @ 75 g a.i. ha^{-1} at 15 DAS +1 hoeing at 30 DAS for these yield attributes. Weed control treatments did not have any significant influence on the test weight of soybean. However, numerically the highest test weight of soybean was observed under the treatment one hand weeding at 30 DAS and one hoeing at 45 DAS (10.33) followed by the herbicidal weed control treatment imazethapyr @ 75 g a.i. ha^{-1} at 15 DAS +1 hoeing at 30 DAS (10.10).

The herbicidal weed control treatments did not show any direct effect on yield and yield attributing characters of the standing crop, but the positive results could be due to reduction in dry matter production by weeds under herbicidal and cultural treatments that subsequently increased nutrient and soil moisture availability to the standing crop that increased the number of pods and grain weight and hence, the straw weight plant^{-1} also increased. These are in agreement with Yadav et al. (2009) who reported that the number of pods, number of seeds, weight of seeds and test weight were superior under the weed-free control and among the integrated weed control methods. Application of imazethapyr at 0.075 kg a.i. ha^{-1} at 15 DAS with hoeing at 30 DAS was superior with respect to seed yield.

The weed control treatment one hand weeding at 30 DAS and one hoeing at 45 DAS produced significantly highest soybean seed yield (1587 kg ha^{-1}), higher straw yield (2704 kg ha^{-1}) as compared to all other weed control treatments. However, it was at par with the herbicide weed control treatment imazethapyr @ 75 g a.i. ha^{-1} at 15 DAS +1 hoeing at 30 DAS (1353 kg ha^{-1} and 2574 kg ha^{-1} of seed and straw yield respectively). Weedy check treatment recorded the lowest soybean seed yield and straw yield. Dhane *et al.* (2010) reported that the combination of chemical and cultural weed control measures, treatment imazethapyr @ 100 g a.i ha^{-1} at 15 DAS + one hand weeding at 45 DAS was found to be the next best in weed control, thereby resulted in better yield and yield parameters after the treatment one hand weeding at 30 and 45 DAS.

Economic studies

The data presented in table 2 revealed that weed control treatment one hand weeding at 30 DAS and one hoeing at 45 DAS recorded significantly more GMR (Rs. 40,096 ha^{-1}) and NMR (Rs. 23,103 ha^{-1}) over rest of weed control treatments, except the herbicidal weed control treatment imazethapyr @ 75 g ha^{-1} at 15 DAS + 1 hoeing at 30 DAS which recorded the next best GMR value of Rs. 37,173 ha^{-1} and NMR value of Rs. 20,405 ha^{-1}. It was followed by treatments imazethapyr @ 60 g a.i. ha^{-1} at 15 DAS + 1 hoeing at 30 DAS, quizalofop-P-tefuryl @ 75 g a.i.

Table 1. Effect of different weed control treatments on yield and yield attributing characters in soybean

	Treatments	Number of pods plant^{-1}	Number of seeds plant^{-1}	Seed wt. plant^{-1} (g)	Straw wt. plant^{-1} (g)	Test wt. (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	Weedy check	26.80	43.67	4.17	10.33	8.67	929	1808
T_2	Weed free check (1Hand weeding at 30 DAS and 1Hoeing at 45 DAS)	45.13	80.33	7.77	16.67	10.33	1587	2704
T_3	Quizalofop-P-tefuryl @ 60 g a.i. ha^{-1} at 15 DAS	31.37	51.67	4.93	11.33	9.23	1200	2327
T_4	Quizalofop-P-tefuryl @ 60 g a.i. ha^{-1} at 15 DAS +1Hoeing at 30 DAS	33.40	57.33	5.50	12.00	9.27	1295	2421
T_5	Quizalofop-P-tefuryl @ 75 g a.i. ha^{-1} at 15 DAS	32.10	54.33	5.03	11.67	9.27	1235	2369
T_6	Quizalofop-P-tefuryl @ 75 g a.i. ha^{-1} at 15 DAS +1Hoeing at 30 DAS	35.67	61.67	5.83	12.33	9.30	1318	2461
T_7	Imazethapyr @ 60 g a.i. ha^{-1} at 15 DAS +1Hoeing at 30 DAS	37.73	65.33	6.13	12.67	9.46	1353	2497
T_8	Imazethapyr @ 75 g a.i. ha^{-1} at 15 DAS +1Hoeing at 30 DAS	43.30	75.67	7.30	15.67	10.10	1463	2574
SE (m)		1.66	1.78	0.52	0.95	0.60	66	69
CD at 5%		4.93	5.34	1.54	2.85	-	198	205

Table 2. Economics of different weed control treatments in soybean

	Treatments	Gross monetary returns (Rs. ha	Cost of cultivation (Rs. ha^{-1})	Net monetary returns (Rs. ha	B:C Ratio
T_1	Weedy check	24044	14673	9371	1.64
T_2	Weed free check (1 Hand weeding at 30 DAS and 1 Hoeing at 45 DAS)	40096	16993	23103	2.36
T_3	Quizalofop-P-tefuryl @ 60 g a.i. ha^{-1} at 15 DAS	31025	16817	14208	1.84
T_4	Quizalofop-P-tefuryl @ 60 g a.i. ha^{-1} at 15 DAS + 1 Hoeing at 30DAS	33259	17337	15922	1.92
T_5	Quizalofop-P-tefuryl @ 75 g a.i. ha^{-1} at 15 DAS	31869	17293	14576	1.84
T_6	Quizalofop-P-tefuryl @ 75 g a.i. ha^{-1} at 15 DAS + 1 Hoeing at 30DAS	33834	17813	16021	1.90
T_7	Imazethapyr @ 60 g a.i. ha^{-1} at 15 DAS+1Hoeing at 30 DAS	34656	16501	18155	2.10
T_8	Imazethapyr @ 75 g a.i. ha^{-1} at 15 DAS+1Hoeing at 30 DAS	37173	16768	20405	2.22
SE (m)		1631		1631	
CD at 5%		4845		4845	

ha^{-1} at 15 DAS + 1 hoeing at 30 DAS and quizalofop-P-tefuryl @ 60 g a.i. ha^{-1} at 15 DAS +1hoeing at 30 DAS. The highest Benefit : Cost ratio (B:C) of 2.36 was obtained with the weed control treatment consisting of one hand weeding at 30 DAS + one hoeing at 45 DAS followed by the herbicidal weed control treatment imazethapyr @ 75 g ha^{-1} at 15 DAS + 1 hoeing at 30 DAS (2.22). However, the weedy check treatment recorded the lowest B:C ratio (1.64) as a result of higher crop weed competition which reduced the soybean yield significantly. Yadav *et al.* (2009) earlier reported that the highest gross income (Rs. 41,822 ha^{-1}), net monetary return (Rs. 21,971.50 ha^{-1}), and the highest B:C ratio of 2.11 were recorded under weed free check followed by 2.10 B:C ratio with two hand weedings (at 15 and 30 DAS). Nemade *et al.* (2011) also observed that weed-free check (2 hoeings + 2 hand weedings) recorded the highest gross monetary returns, net monetary returns and benefit:cost ratio. Among integrated treatments, these parameters were numerically highest in post-emergence application of imazethapyr @ 75 g a. i. ha^{-1} at 10 DAS+ one hoeing at 25 DAS.

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DETERMINATION OF NUTRITION PRESCRIPTIONS FOR RAINFED Bt COTTON UNDER DIFFERENT SOIL FERTILITY GRADIENTS IN VERTISOLS OF MAHARASHTRA

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ABSTRACT

Soil test crop response correlation studies were conducted with rainfed Bt cotton (var NHH-44) under integrated plant nutrition system (STCR-IPNS) in vertisol for two seasons of 2010-11 and 2011-12. Fertilizer prescription equations were formulated for rainfed Bt cotton following Ramamoorthy's inductive-cum-targeted yield approach. The nutrient requirement for production of one quintal seed cotton yield of Bt cotton was 3.11, 0.92 and 2.60 kg of N, P_20_5 and K_20, respectively. The per cent contribution from soil and fertilizer nutrients were found to be 17.51and 32.68 for N, 60.30 and 14.70 for P_20_5 and 4.77 and 66.76 for K_20, respectively. While the per cent contribution from fertilizer in presence of FYM was 37.20, 15.50 and 78.9 in respect of N, P_20_5 and K_20, respectively. Whereas, per cent contribution of N, P_20_5 and K_20 from FYM was 4.7, 1.4 and 1.5, respectively.

*(*Key words : Bt cotton, STCR-IPNS, fertilizer prescription equations, vertisols)

INTRODUCTION

Cotton is an important fibre crop of global significance, which is cultivated in tropical and sub-tropical regions of more than eighty countries the world over. Cotton is one of the most important fibre and cash crop widely grown on black cotton soils in Vidarbha. At present genetically modified cotton is widely accepted by Indian farmers. Out of 110.00 lakh ha area, 88 per cent area (96.14 lakh ha) is occupied by Bt cotton hybrids (Anonymous, 2011). Average productivity of India is low (553 kg lint ha^{-1}) as compared to world average of 725 kg lint ha^{-1} (Anonymous, 2008).

India accounts for more than 26 per cent of total global production of cotton and accounts for 28.18% of global cotton area (Anonymous, 2008). Yet fertilizer consumption in India is grossly imbalanced since beginning. Fertilizer consumption ratio is highly unbalanced (N: P_20_5: K_20, 6 : 2.4 : 1) during 2007-08 as against favourable ratio of 4:2:1 implying, thereby, that farmers started adding more nitrogen and proportionately less phosphatic and potassic fertilizers. In many areas the imbalanced fertilization is the root cause for poor crop yields and soil fertility status (Muralidharudu *et al*.,2010). At present requirement of nutrients in crop production are 35 Mt and only 25.15 Mt of fertilizer nutrients are being used. Therefore, combined use of chemical fertilizers and organics becomes essential to meet the nutrient requirement and reduce the negative balance. (Subba Rao *et al*., 2009).

Fertilizer application indicated that the possibility of enhancing production potentials of crop resulted always better than the soil fertility and crop requirement should be based on fertilizing the crops. Such studies are possible only through inductive-cum-targeted yield approach (Ramamoorthy *et al.,*1967) which provides a scientific basis for balanced fertilization not only among the fertilizer nutrients but also with the soil available nutrients.

Rainfed Bt cotton is widely cultivated on Vertisol in Vidarbha region of Maharashtra and so far Soil Test Crop Response –Integrated Plant Nutrition System studies have not been conducted. With a view to determining the nutrient requirement for achieving targeted yield, three fertility gradients were created by applying variable levels of nutrients and then various nutrient management treatments were thought necessary to be applied during the present study and the efforts were made to study the relationship of soil and added fertilizers, their uptake and yield of rainfed Bt cotton under different fertility gradients and to develop a balanced nutrition management strategy under different fertilization for targetted yield of rainfed Bt cotton in Vertisols.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* season of 2010-11 and 2011-12 at Research

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Farm of Department of Soil Science and Agricultural Chemistry , Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola by adopting fertility gradient approach. The soil of experimental field is clayey in texture with pH 8.23 and is non saline (EC 0.26 dS m^{-1}). The initial status of soil were low in available N (163.07 kg ha^{-1}), low in available P (15.25 kg ha^{-1}) and very high in available K (515.2 kg ha^{-1}), low in organic carbon (5.2 g kg^{-1}) and calcium carbonate observed was 6.82 per cent.

Following the inductive methodology of Ramamoorthy *et al* .(1967), field was divided into three equal strips with the size of each strip being 83.2 x 13.8 m and three fertility gradients were created in the field by applying graded doses of 0, 0, 0 kg NPK ha^{-1}, 120, 60, 60 kg NPK ha^{-1} and 240, 120, 120 kg NPK ha^{-1} fertilizers to Maize crop which was taken as an exhaust crop during January 2010 to April 2010 only with a view to creating variable the fertility levels in the experimental field for Bt cotton. After harvest of the maize crop, the field was ploughed and prepared well for planting of Bt cotton as a test crop both during *kharif* 2010 and *kharif* 2011 without disturbing the three fertility gradient strips.

Three FYM blocks were created across three fertility gradient strips by applying 10 t FYM, 5 t FYM and no FYM in each strip which was divided into 24 plots. Size of plots was 5.85 m x 5.40 m, thus in each strip there were three blocks of 8 plots each of 0, 5 and 10 t FYM ha^{-1} in which three levels of NPK. i.e. 25, 50 and 100 kg N ha^{-1}, 12.5, 25 and 50 kg P_2O_5 ha^{-1} and 12.5, 25 and 50 kg K_2O ha^{-1}. Further FYM blocks were divided into 24 equal plots with 21 NPK treatments and 3 control treatments on randomized basis, such that, all the 24 treatments were laid along the FYM blocks and also along the fertility gradients and thus making a total 72 plots over the three strips with three FYM blocks. Thus, IPNS components like NPK alone, NPK + 5 t ha^{-1} FYM and NPK + 10 t ha^{-1} FYM etc. were created.

Pre-sowing soil samples (0.20 cm) were collected from each plots before the superimposition of treatments and were analysed for available nitrogen (Subbiah and Asija,1956), available phosphorus (Jackson, 1967) and available potassium (Jackson, 1967).

The sowing of test crop Bt cotton(var NHH-44) was undertaken on 23rd June, 2010 and 29th June, 2011 with fractional factorial RBD . The treatment wise quantity of chemical fertilizers through urea, single super phosphate and muriate of potash were applied. As per the treatments half dose of nitrogen, full dose of phosphorus and potassium were applied at the time of dibbling of cotton seed and remaining half dose of nitrogen was applied 30 days after sowing. The inorganic fertilizers were applied at 10 cm distance from the dibbling of cotton seed at the depth of 5 cm by ring method and covered with the soil. Seed rate of 3 kg ha^{-1} was used for 90 x 45 cm spacing. Systemic insecticide Imidacloprid-2000 was sprayed at 30 and 50 days after sowing for the control of sucking pests. Total rainfall of 1032 was received during the year 2010-11 in 41 rainy days whereas in 2011-12 it was 515.3 mm in 38 rainy days. Four pickings were taken from mid of November to mid of January. Seed cotton and cotton stalk yield data was recorded plot wise.

The treatment wise 5 plant samples were selected randomly from each net plot and cut near the ground surface at final picking. Plant samples were thoroughly mixed and 0.2 g mixed sample was weighted accurately and transferred into microdigestion tube to which 10 ml di-acid mixture was added and digested in microprocessor based digester. After completion of digestion (clean white), the extract was diluted and filtered through whatman filter paper number 42. These extracts from different treatment plots were used for determination of P and K content. P was estimated from di-acid extract by Vanadomolybdate phosphate acid yellow colour method (Piper, 1966) using U.V. based spectrophotometer. K was estimated from di- acid by using flame photometer (Piper, 1966). Total N content was determined by digesting the plant sample in micro-processor based digestion system using concentrated H_2SO_4 and salt mixture and distillation with automatic distillation system (Jackson,1967). Total uptake was computed using seed cotton and cotton stalk yield data.

Using the data on seed cotton yield, nutrient uptake, initial soil test values and fertilizer doses applied, the basic parameters viz., nutrient requirement (NR, q ha^{-1})), contribution of nutrients from soil (CS), and contribution of nutrients from

fertilizer(CF) and contribution from FYM were calculated as described by Ramamoorthy *et al*.(1967).These basic parameters were used for the formulation of fertilizer prescription equations for deriving the fertilizer doses and the soil test based fertilizer recommendations were prescribed in the form of a ready reckoner for desired yield target of rainfed Bt cotton under NPK alone as well as under INPS.

A. Without FYM application

$$\text{Nutrient requirement for one quintal production (NR) (kg t}^{-1}\text{)} = \frac{\text{Total uptake of nutrient Straw + Seed (kg ha}^{-1}\text{)}}{\text{Seed cotton yield (t ha}^{-1}\text{)}}$$

$$\text{Per cent contribution from Soil available nutrients (CS \%) (NPK)} = \frac{\text{Total uptake of nutrient (NPK) (kg ha}^{-1}\text{) (in control plot)}}{\text{Soil test values for NPK, kg ha}^{-1}\text{ in control plots without FYM}} \times 100$$

$$\text{Contribution from Fertilizer (CF \%)} = \frac{\text{Total uptake of nutrient treated plots without FYM (kg ha}^{-1}\text{)} - \text{STV of treated plots without FYM (kg ha}^{-1}\text{)} \times \frac{\text{\% CS}}{100}}{\text{Fertilizer dose (kg ha}^{-1}\text{) in treated plot without FYM}} \times 100$$

B. With FYM

$$\text{\% CFYM} = \frac{\text{Total uptake of nutrient in control plots FYM (kg ha}^{-1}\text{)} - \text{STV of control plots FYM (kg ha}^{-1}\text{)} \times \frac{\text{\% CS}}{100}}{\text{Total amount of nutrients added through FYM (kg ha}^{-1}\text{)}} \times 100$$

$$\text{\%CF} = \frac{\text{Total uptake of nutrient of treated plots with FYM (kg ha}^{-1}\text{)} - \text{STV of control plots with FYM} \times \frac{\text{\% CS}}{100} - \text{Nutrient added through FYM (kg ha}^{-1}\text{)} \times \frac{\text{\% CFYM}}{100}}{\text{Fertilizer nutrient added with FYM (kg ha}^{-1}\text{)}} \times 100$$

A.Fertilizer prescription equations (without FYM)

$$\text{FN (kg ha}^{-1}\text{)} = \frac{\text{NRN}}{\text{\% CF}} \times T - \frac{\text{\% CS}}{\text{\% CF}} \times \text{STV (S N)}$$

$$\text{F P}_2\text{O}_5\ \text{(kg ha}^{-1}\text{)} = \frac{\text{NRP}}{\text{\% CF}} \times T - \frac{\text{\% CS}}{\text{\% CF}} \times \text{STV (S P)}$$

$$\text{F K}_2\text{O (kg ha}^{-1}\text{)} = \frac{\text{NRK}}{\text{\% CF}} \times T - \frac{\text{\% CS}}{\text{\% CF}} \times \text{STV (S K)}$$

B. Fertilizer prescription equations (with FYM)

$$\text{FN (Kg ha}^{-1}\text{)} = \frac{\text{NRN}}{\text{\% CF(FYM)}} \times T - \frac{\text{\% CS\%}}{\text{\% CF(FYM)}} \times \text{STV (S N)} - \frac{\text{CFYM}}{\text{\% CF(FYM)}} \times \frac{\text{Amount of nutrient added through one tonne of FYM}}{\text{one tonne of FYM}} \times \text{FYM (t ha}^{-1}\text{)}$$

$$\text{FP}_2\text{O}_5\ \text{(Kg ha}^{-1}\text{)} = \frac{\text{NRP}}{\text{\% CF(FYM)}} \times T - \frac{\text{\% CS\%}}{\text{\% CF(FYM)}} \times \text{STV (S P}_2\text{0}_5\text{)} - \frac{\text{CFYM}}{\text{\% CF(FYM)}} \times \frac{\text{Amount of nutrient added through one tonne of FYM}}{\text{one tonne of FYM}} \times \text{FYM (t ha}^{-1}\text{)}$$

$$\text{FK}_2\text{O (Kg ha}^{-1}\text{)} = \frac{\text{NRK}}{\text{\% CF(FYM)}} \times T - \frac{\text{\% CS}}{\text{\% CF(FYM)}} \times \text{STV (S K}_2\text{0)} - \frac{\text{CFYM}}{\text{\% CF(FYM)}} \times \frac{\text{Amount of nutrient added through one tonne of FYM}}{\text{one tonne of FYM}} \times \text{FYM (t ha}^{-1}\text{)}$$

RESULTS AND DISCUSSION

Soil available nutrients

The range and average values of soil available N, P and K nutrients before sowing in three fertility strips are furnished in table1. The mean value of soil available nitrogen was 162.55, 174.05 and 189.19 kg ha^{-1} in 00% RDF , 100 % RDF and 200 % RDF strips, respectively. Soil available phosphorus was 13.64, 16.33 and 20.09 kg ha^{-1} in these strips, respectively. Available potassium also showed increasing trend as 522.19, 581.93 and 632.8 kg ha^{-1} in these strips, respectively with increased soil fertility status. This variation revealed the development of fertility gradients in these strips. Only 16 per cent increase in soil available nitrogen was observed from 00% RDF to 200 % RDF fertility gradient.

There was an increase in soil available P and K from 13.64 to 20.09 and 522.19 to 632.8 kg ha^{-1}, respectively as the gradient from 0 % RDF to 200% RDF gradient. Mohammad Sajid (2007) reported that available N ranged from 150.24 to 209.79 kg ha^{-1} with a mean of 178.29 kg ha^{-1}, which gradually increased with the increase in fertility gradient from 0 % RDF to 200 % RDF gradients.

Seed cotton yield

The data on seed cotton yield of Bt cotton are presented in table 2. The results showed that there was an increase in yield with the increase in NPK doses. The mean yield of treated plots were 16.19, 17.47 and 18.11 in no use of FYM , 5 t FYM ha^{-1} and 10 t FYM ha^{-1}, respectively, which showed the additional effect of added FYM in combination of NPK treatments. The yield of seed cotton in treated plots of 5 t ha^{-1}FYM block increased by 7.91 per cent and 11.86 per cent in10 t FYM ha^{-1} block over no use of FYM block. The seed cotton yield of control plots of 5 t FYM and 10 t FYM ha^{-1} blocks increased by 22.84 and 33.48 per cent, respectively over the

yield of control treatment of no FYM. This has clearly indicated that addition of FYM alone and in combination with NPK fertilizers helped in increasing the seed cotton yield. Similarly, cotton stalk yield of treated plots were 25.72, 27.48 and 29.23 q ha^{-1} in no FYM, 5 t FYM and 10 t FYM ha^{-1}, respectively. Hosmath *et al*. (2011) reported pooled result for Bt cotton under rainfed ecosystem on vertisol that integrated supply of nutrients through recommended dose of fertilizers (30:15:15) + FYM (7.5 t ha^{-1}) significantly increased Bt cotton yield (1066.3 kg ha^{-1}). They reported that addition of FYM increased the seed cotton yield by 24.36 per cent over recommended dose of fertilizer which may be due to balanced use of chemical fertilizers coupled with FYM.

Basic parameters

The basic data viz., the nutrient requirement for producing the one quintal of seed cotton yield (Bt Cotton) , per cent contribution of nutrients from soil and per cent contribution of nutrients from applied fertilizer have been calculated and furnished in table 3. These basic parameters were used for formulating the nutrient prescription equations under NPK alone and under Integrated Plant Nutrition System (IPNS). The nutrient requirement for producing one quintal seed cotton yield of Bt cotton were 3.11 kg N, 0.92 kg P and 2.60 kg K, indicating that N requirement of Bt cotton was the highest followed by K and least in case of P. The per cent contribution from soil and fertilizer nutrients were found to be 17.51 and 32.68 for nitrogen, 60.30 and 14.70 for phosphorus and 4.77 and 66.76 for potassium, respectively. Similarly, the per cent contribution of N, P_20_5 and K_20 from fertilizer nutrients with FYM were 37.20, 15.50 and 78.9, respectively. Per cent contribution of N, P_20_5 and K_20 from FYM were 4.7, 1.4 and 1.5, respectively. Per cent contribution from soil in respect of phosphorus was higher as compared to N and K. Addition of FYM might have helped in increasing the solubility of phosphorus in soil which resulted by better sorption of P nutrient. In the combined addition, the FYM would have provided enough carbon, the source of energy for the build-up of microorganism population, which in turn would have enhanced the contribution of N. Gulati and Yadav (2009) conducted STCR correlation studies with mustard under STCR-IPNS system during *rabi* 2007-08 and they reported that the per cent nutrient utilization efficiencies from soil were found to be 20.08, 28.15 and 8.65 for N, P_20_5 and K_20, respectively. Santhi *et al*.(2010) conducted STCR based INPS studies for Ashwagandha during *rabi* 2008-09 and they reported that the per cent nutrients utilization from fertilizers were found to be 31.30, 17.30 and 62.53 for N, P_20_5 and K_20, respectively. Puri *et al*.(2009) conducted STCR-IPNS studies with onion during *kharif* season of 2006-07 and they reported that per cent contribution from soil were found to 17 for nitrogen, 61 for phosphorus and 18 for potassium. With regard to N and K_20, comparatively more contribution was recorded from fertilizers than from soil. However, in case of P_20_5, the contribution was more from soil than from fertilizer. Split application of N would have resulted in better utilization of applied N, which was indicated by relatively higher response ratio recorded for fertilizer N than P_20_5.The considerable saving in fertilizers by using IPNS based STCR equation for banana had reported by Panchbhai (2010).

Fertilizer prescription equations under IPNS for yield targeting in Bt cotton

Soil test based fertilizer models or equations for targeted yield of rainfed Bt cotton were formulated using the basic parameters and are furnished below. On the basis of these equations, a ready reckoner was prepared for a range of soil test values and yield target of 15 and 20 q ha^{-1} under different fertilization programme (table 4). It is evident from the data that the fertilizer N, P_20_5 and K_20 requirements decreased with the increase in soil test values. It was observed that for a given soil test values, the quantity of nutrients required increased as the targetted yield was increased. Conjoint use of manure and chemical fertilizers for additional benefit and improvement in yield can be recommended to the cultivators by the targeted yield concept.

1. Without FYM (Use of chemical fertilizers alone)

$FN = 9.53\,T - 0.38\,SN$
$FP_20_5 = 6.26\,T - 2.66\,SP$
$FK_20 = 3.89\,T - 0.07\,SK$

Table 1. Range and average values of available nutrients in pre sowing surface soil in different fertility gradients

Sr. No.	Particulars		Fertility gradients (% RDF)		
			L_0 (0%)	L_1 (100%)	L_2 (200%)
1	Available nitrogen (kg ha^{-1})	Range	150.53 to 175.62	163.07 to 188.16	175.60 to 213.25
		Average	162.55	174.05	189.19
2	Available phosphorus (kg ha^{-1})	Range	12.93 to 14.92	15.25 to 17.57	18.56 to 21.22
		Average	13.64	16.33	20.09
3	Available potassium (kg ha^{-1})	Range	492.80 to 548.80	560.0 to 604.8	593.6 to 660.8
		Average	522.19	581.93	632.8

Table 2. Seed cotton yield of rainfed Bt (q ha^{-1}) as influenced by conjoint use of FYM and chemical fertilizers

Parameters	Seed cotton yield , q ha^{-1} (Mean of two years)		
	FYM blocks		
	F_0	F_1	F_2
Mean of treated plot	16.19	17.47	18.11
Mean of control plot	7.05	8.66	9.41
	Cotton stalk yield, q ha^{-1}		
Mean of treated plot	25.72	27.48	29.23
Mean of control plot	15.23	16.71	17.05

Table 3. Nutrient requirement, per cent contribution from soil, fertilizer and FYM for rainfed Bt cotton

Parameters	Major Nutrients		
	N	P_20_5	K_20
Nutrient requirement, kg q^{-1}	3.11	0.92	2.60
Contribution from soil available nutrients ,%	17.51	60.30	4.77
Without FYM			
Contribution from fertilizer nutrients,%	32.68	14.70	66.76
With FYM			
Contribution from fertilizer nutrients with FYM,%	37.20	15.50	78.9
Contribution from FYM,%	4.7	1.4	1.5

Table 4. Fertilizer requirement (kg ha^{-1}) of Bt cotton for different yield target under IPNS and sole use of chemical fertilizers and soil test values

Soil available N, kg ha^{-1}	Nitrogen requirement (kg ha^{-1})			
	Yield target under IPNS		Sole use of chemical fertilizers	
	15 q ha^{-1}	20 q ha^{-1}	15 q ha^{-1}	20 q ha^{-1}
120	80.20	128.55	97.35	145.00
140	70.00	118.35	89.75	137.40
160	59.80	108.15	82.15	129.80
180	49.60	97.95	74.55	122.20
200	39.40	87.75	66.95	114.60
220	29.20	77.55	59.35	107.00
240	19.00	67.35	51.75	99.40
260	8.80	57.15	44.15	91.80
	Phosphorus requirement (kg ha^{-1})			
Soil available P,				
10	62.05	96.20	67.30	98.60
12	54.27	88.42	61.98	93.28
14	46.49	80.64	56.66	87.96
16	38.71	72.86	51.34	82.64
18	30.93	65.08	46.02	77.32
20	23.15	57.30	40.70	72.00
22	15.37	49.52	35.38	66.68
24	7.59	41.74	30.06	61.36
	Potassium requirement (kg ha^{-1})			
Soil available K,				
200	36.80	53.25	44.35	63.80
220	35.60	52.05	42.95	62.40
240	34.40	50.85	41.55	61.00
260	33.20	49.65	40.15	59.60
280	32.00	48.45	38.75	58.20
300	30.80	47.25	37.35	56.80
320	29.60	46.05	35.95	55.40
340	28.40	44.85	34.55	54.00
360	27.20	43.65	33.15	52.60
380	26.00	42.45	31.75	51.20

Where, F and S indicate the fertilizer and soil nutrients, respectively (kg ha^{-1}) and T indicates yield target (q ha^{-1}).

2. With FYM (Conjoint use of chemical fertilizers and FYM)

$FN = 9.67\,T - 0.51\,SN - 0.73\,FYM$
$FP_20_5 = 6.83\,T - 3.89\,SP - 0.30\,FYM$
$FK_20 = 3.29\,T - 0.06\,SK - 0.11\,FYM$

Where, FN, FP_20_5 and FK_20 is fertilizer N, P_20_5 and K_20 in kg ha^{-1}, T is yield target in q ha^{-1} and SN, SP and SK are soil available N, P and K kg ha^{-1} and FYM is Farm Yard manure in t ha^{-1}.

Multiple regression equation for rainfed Bt cotton (for treated plots)

Yield predictions from soil and fertilizer NPK, FYM and interactions were derived for treated plots and are given below

$Y = 1497.96 + 0.070095\,FN^{**} - 0.000247\,FN^2 + 0.086644\,FP^* - 0.000897\,FP^2 + 0.104350\,FK^* - 0.001245\,FK^2{}^* - 0.807798SN + 0.002241\,SN^2 + 6.235900SP - 0.185916\,SP^2 - 5.091112SK^{**} + 0.00441\,SK^2 - 0.227495\,FNSN - 0.42889\,FPSP - 0.108644\,FKSK + 0.332095\,FYM^{**} - 0.014366\,FYM^2$

$\mathbf{R^2 = 0.895}$

* Significance at 5 %, ** Significance at 1%

A significant value of coefficient of determination of R^2 (0.895) value indicated that the 89 per cent variation in seed cotton yield of the treated plots is significantly depending upon the available nutrient in the soil in presence of applied fertilizer nutrients, by using soil test values, fertilizer dose and FYM. The R^2 value of 0.895 indicated good fit for multiple regression equations. Bangar (1990) reported that R^2 values for multiple regression equations above 0.66 indicated good fit, 0.65 to 0.45 as moderate fit and below 0.45 as poor fit. R^2 value of 0.83 was reported in the regression studies to develop the yield targeting equation for onion by Mohammad Sajid (2007).

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INFLUENCE OF INM ON SOIL QUALITY, YIELD AND UPTAKE BY SAFFLOWER IN SOYBEAN-SAFFLOWER CROP SEQUENCE IN VERTISOL

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ABSTRACT

Field Experiments were conducted on ongoing experiment of Long Term Fertilizer Experiment started from 2006-07 at Department of Soil Science and Agricultural Chemistry, Marathwada Krishi Vidyapeeth, Parbhani to study the effect of integrated nutrient management on soil quality, yield and uptake of nutrients (N, P, K, S and Zn) by safflower crop in Soybean-Safflower cropping system during 2009-10 and 2010-11 on Vertisols *(Typic Haplusterts)* . The results of pooled mean of 2009-10 and 2010-11, indicated that the application of 100% NPK + FYM @ 10 t ha^{-1} recorded the highest safflower grain yield (24.57 q ha^{-1}) and straw yield (63.14 q ha^{-1}), followed by the treatment 150% NPK only in which 23.03 and 61.69 q ha^{-1} grain and straw yield respectively were obtained. 22.83 and 59.45 q ha^{-1} grain and straw yield respectively were recorded with the treatment 100 % NPK + 25 kg $ZnSO_4$ treatment. 100 % NPK + FYM @ 10 t ha^{-1} recorded the highest grain and straw yield but statistically it was at par with these treatments and significantly superior over other treatments. The highest total mean uptake of nutrients (Grain + Straw) recorded by safflower crop during 2009-10 and 2010-11 was 101.96, 18.78, 106.15 and 25.48 of NPK and S kg ha^{-1} respectively by the treatment 100 % NPK + FYM @ 10 t ha^{-1}. Soil health was improved by increasing availability of N, P and K from its initial value as 51.10, 3.30, 50.00 respectively with 100 % NPK + FYM @ 10 t ha^{-1}, whereas availability of S and Zn was maintained by this treatment.

(Key words : Safflower, INM, organic manure, yield, uptake)

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) commonly known as kardi (in Marathi) is one of the important *rabi* oilseed crops of the country. India occupies the second place in safflower production in the world. Currently it is grown on an area of 2.29 Lakh ha with the production of 1.42 Lakh tones. Maharashtra accounts for about 68 % area and 65 % production of the country. During *rabi* 2010-11, the area under safflower crop in Maharashtra state was 1.56 Lakh hectares with 0.93 Lakh tones of annual production (Anonymous, 2011). Safflower contains about 36% of oil, which accounts for about 8 per cent of the value of total agriculture produce. It contains 78 per cent linoleic acid, the factor which reduces blood cholesterol. Therefore, the yield of safflower oilseed crop needs to be increased. The deficiency of secondary and micronutrients is widespread in many parts of the country due to intensive agriculture and increasing use of sulphur free fertilizer in large quantities. Soybean- safflower is a profitable cropping system and most of the farmers adopt this cropping system. Apart from management through long term application of organic manure, major nutrient and micronutrients like Zn have started liming the yield and soil health. The soil under study (Vertisol) has fixation of applied zinc due to dominance of smectite minerals, resulting into its deficiency. This deficiency has further aggravated because the land use system was dominated with high yielding and fertilizer responsive varieties of safflower, soybean, sorghum, wheat, paddy and cotton for the last 20-25 years (Babhulkar *et al*., 2000). Sulphur availability in black soil is generally sufficient. However, intensive cropping system coupled with straight fertilizers to the crop lead to larger scale depletion of this nutrient in soil. While, the application of organic manure along with fertilizers recovered S deficiency due to mineralization of organic matter released the S in the available form to the plants (Murthy, 2011). There is an apprehension that the use of chemical fertilizers over the years might impair soil fertility (Thakur *et al.,* 2011). Although, only use of chemical fertilizers is the fastest way of replenishing the nutrient depletion, but escalating fertilizer prices and limited inputs availability deter the farmers from using these inputs to the required level. Conjoint use of organic manures with chemical fertilizers is very essential as this not only increases the level of productivity but also improves soil health and enhances nutrient use efficiency (Verma *et al.,* 2005). Therefore, it was necessary to study the effect of INM on long term

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basis on crop yield and soil health of safflower under soybean-safflower cropping system.

MATERIALS AND METHODS

Long-Term Fertilizer Experiment was started at research farm, Department of Soil Science and Agriculture Chemistry, Marathwada Krishi Vidyapeeth, Parbhani (MS). Experiment was laid out in randomized block design (RBD) with twelve treatments replicated four times under soybean-safflower cropping system in Vertisol during the study years 2009-10 to 2010-11. The treatments were viz., T_1 – 50 % NPK, T_2 – 100 % NPK, T_3 – 150 % NPK, T_4 – 100 % NPK + 2 Hand weedings, T_5 – 100 % NPK + 25 kg $ZnSO_4$, T_6 – 100 % NP, T_7 – 100 % N, T_8 – 100 % NPK + FYM @ 10 t ha^{-1}, T_9 –100 % NPK without sulphur, T_{10} – Only FYM @ 10 t ha^{-1}, T_{11}–Absolute control and T_{12}–Fallow. The soil of the experimental site is Vertisol, particularly montmorillonitic, hyperthermic family of Typic Haplustert (Table 1). The 100% NPK was 30:60:30 kg ha^{-1} for soybean and 60:40:00 kg ha^{-1} for safflower respectively. FYM@ 10 t ha^{-1} and $ZnSO_4.5H_2O$@ 25 kg ha^{-1} was applied to soybean along with recommended dose of fertilizer (RDF) and their residual effect was examined on safflower crop. The soil of experimental field was clayey in texture and alkaline interaction with pH 8.1, EC 0.38 dSm^{-1}, organic carbon 0.5 % and free $CaCO_3$ content 8.5 %. The initial status of available nitrogen, phosphorus, potassium and sulphur was 216.0, 16.0, 766.0 and 30.5 kg ha^{-1} respectively, whereas available Zn was 0.98 mg kg^{-1} before start of the study during 2006-07. The safflower variety PBNS- 12 was used for sowing with 45 cm x 20 cm spacing between row to row and plant to plant and sowing were done on 29th October 2009 and 8th Nov. 2010. In both the years, climatic conditions were normal and favourable to safflower crop. FYM@ 10 t ha^{-1} was applied before 15 days of sowing only for *kharif* soybean crop and NPK were applied to safflower crop through straight fertilizers urea, single super phosphate and muriate of potash as per treatments except in 100% NPK without sulphur wherein part of N and P_2O_5 were supplied through diammonium phosphate to avoid sulphur application. In 100%NPK+HW treatment, only two hand weedings were taken for weed control, without use of any weedicide. Whereas, in other treatments weeds were controlled by the application of weedicide as a glyphosate (Roundup) @ 100 ml 10^{-1} L of water and two hand weedings to control weeds. The soil samples were collected after harvest of safflower trial at 0-15 cm depth from each plot during 2009-10 and 2010-11 and they were air dried, powdered and stored in polythene air tight bag with particular labelling and were used for physico-chemical analysis of soil. Organic carbon was determined by Walkley and Black's method black (1965), electrical conductivity and pH of water saturated pastes were measured by conductivity and pH meter (Jackson, 1973). Available soil nitrogen was determined by alkaline-$KMnO_4$ methods given by A. O. A. C. (Anonymous, 1990). Available P_2O_5 (Olsen P) was determined by sodium bicarbonate ($NaHCO_3$) extraction and subsequent analysis by spectrophotometer (Olsen *et al.*, 1954). Available K was determined by using neutral normal ammonium acetate as an extractant and measured on flame photometer (Piper, 1950). Available sulphur in soil was extracted using 0.15 per cent $CaCl_2$ as an extractant and determined spectrophotometrically using the method as described by Chesnin and Yein (1950). Available Zn was determined using DTPA (Diethylene Triamine Penta Acetic Acid) extraction method developed by Lindsay and Narvell (1978). Grain and straw samples were collected at harvest of safflower crop and oven dried plant samples (Grain and straw) were grind and stored in well labelled air tight polythene bag and were used for estimation of NPKS and Zn contents. The standard procedures for analysis of total nitrogen by Microkjelddhl's method suggested by A.O.A.C. (Anonymous, 1990), phosphorus measurement by Vanadomolybdophosphoric yellow colour method (Jackson, 1973), potassium estimation by Triacid extract on flamephotometer (Piper, 1950), sulphur estimation by Turbidimetric on spectrophotometer (Chesnin and Yein, 1950) and zinc estimation by Tri-acid extract on AAS (Dhyan Singh *et al.,* 2005) in straw/grain samples were adopted. The nutrient uptake was worked out by multiplying the nutrient concentration in straw/grain with straw and grain yield dividing by 100. The data were analyzed by the statistical methods described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Grain and straw yield

The data regarding variations in the yield of grain and straw due to different organic and inorganic input treatments are presented in table 2. The data revealed that the grain yields of safflower were the highest i.e. 23.23 and 25.90 q ha^{-1} with residual effect of 100% NPK+FYM@ 10 t ha^{-1} applied to soybean and 100% NPK applied to safflower during 2009-10 and 2010-11, respectively. It was also observed that the grain yields recorded during both the years of experimentation with 150 % NPK, 100 % NPK+Zn and 100 % NPK + FYM @ 10 t ha^{-1} to soybean were at par with each other and the latter treatment was significantly superior over respective treatments. The yield differences in 100 %NPK, 100 % NPK + 2 Hand weedings, 100 % NPK + Zinc and 100 % NPK without sulphur were also negligible and nonsignificant. The grain yields recorded in 100 % N treatment were also drastically reduced as compared to 100% NPK and 100 % NP treatments during both years. The yield differences in grain yield between 100 % N and absolute control treatments were negligible and statistically at par with each other and stresses the need for balanced application of the essential nutrients. Malik *et al*. (2011) reported that the application of 75% RD + organic manure (Vermicompost) significantly increased seed and stover yield of safflower. The higher grain yield due to higher dose of inorganic alone and in combination with FYM might have increased due to sustained nutrient supply and also due to better utilization of applied nutrients through improved microbial activity that involved nutrient transformation and fixation due to organic manuring (Arbad and Syed Ismail, 2011).

The lower grain yields were recorded by 100% NPK without sulphur treatment during both the years of experimentation may be due to the application of sulphur free source of fertilizer. Though the yield reductions due to exclusion of sulphur from the fertilizer schedule were not significant but the trend indicated the importance of 'S' to be applied to safflower crop for improving the yield and to maintain the 'S' status of soil. The grain yields recorded by 100 % NPK + 25 kg $ZnSO_4$ ha^{-1} treatment were higher as compared to 100 % NPK treatment but were at par with 150 % NPK and 100 %NPK + FYM @ 10 ha^{-1} treatments. These results support the findings of Ravi *et al.* (2010) who reported that the use of Zn as foliar spray or soil application increased safflower yield upto 20% more than control treatment. Babhulkar *et al.* (2000) also reported that the application of 45 kg sulphur and 30 kg Zn ha^{-1} had increased safflower grain yield by 92 per cent over control treatment. This trend indicates the essentiality of sulphur and zinc application to safflower for yield improvement.

The trend in respect of straw yields of safflower was also more or less similar as that of grain yields during 2009-10 and 2010-11. Maximum straw yield was obtained with 100 % NPK+FYM @ 10 t ha^{-1} given to soybean followed by 100% NPK to safflower but was statistically at par with 100 % NPK + Zn and 150% NPK treatments and significantly superior over other treatments. The pooled mean of straw yield of safflower during 2009-10 and 2010-11 clearly showed that the highest straw yield of safflower (63.14 q ha^{-1}) was recorded with 100 % NPK+FYM @ 10 t ha^{-1} treatment given to soybean followed by 100% NPK to safflower closely followed by 150 % NPK, 100 % NPK + Zn treatments. The lowest straw yield of safflower was found with absolute control followed by only FYM @ 10 t ha^{-1} as given to soybean at the time of sowing.

Nutrient uptake

The data regarding nutrient uptake by safflower under different treatments are presented in table 3 and 4. The highest uptake of nitrogen (101.96 kg ha^{-1}), phosphorus (16.78 kg ha^{-1}), potassium (106.15 kg ha^{-1}), sulphur (25.48 kg ha^{-1}) and Zn (101.08 g ha^{-1}) was recorded by the treatment 100 % NPK + FYM @ 10 t ha^{-1} given to soybean and it was at par with the treatment 150% NPK and 100% NPK + Zinc. Whereas, the lowest nutrient uptake was recorded by only 100% N and absolute control treatment. The improvement in the uptake of nutrients due to INM is ascribed to the enhanced soil quality resulting into better availability of nutrients. Babhulkar *et al.* (2000) studied a field experiment laid out in Vertisol and reported that total uptake of N, P, K, S and Zn by safflower significantly increased due to application of both S and Zn upto 45 and 30 kg ha^{-1} as compared to other treatments.

Soil properties

The soil samples were collected after harvest of safflower crop during 2009-10 and 2010-11 and were analyzed for the values of various soil properties and their values are given in table 5, 6, and 7. The increase or decrease of soil properties was compared with initial values obtained during 2006-07 (Table 1). The results indicated that, declined (– 0.17) pH of soil was noticed with the use of only FYM @ 10 t ha^{-1} closely followed by conjunctive use of organic manuring and fertilizer i.e. 100 % NPK + FYM @ 10 t ha^{-1}(-0.13) given to soybean followed by 100% NPK to safflower, whereas increase in EC (0.017) was observed in the plots receiving continuously higher dose of chemical fertilizers i.e. 150 % NPK. It might be due to addition of salts through application of increased doses of inorganic fertilizers. Improvements in soil organic carbon was noticed in the treatment receiving FYM @10 t ha^{-1} (+1.08 g kg^{-1}) and 100% NPK+FYM (+1.05 g kg^{-1}) to soybean crop followed by 100% NPK to safflower. Maximum build up of available N, P, K, S and Zn were noticed in the treatment receiving organic manure (FYM) combined with inorganic fertilizers (100% NPK). In respect to nitrogen availability, it was contributed higher (+ 51) with the integrated use of organic manuring with fertilizer (100% NPK +FYM @ 10 t ha^{-1}) over its initial status. Moreover, the application of 100% N alone and 50% NPK could not show a prominent result in buildup of soil fertility, suggesting less aggregative effect of these treatments. Katkar *et al.* (2011) had conducted a long term experiment initiated in 1988 at Akola (MS) with sorghum-wheat cropping system on Vertisol. After 20 years of experimentation, they observed slight decrease in pH and EC of soil, whereas they noticed increase in organic carbon, availability of N, P, K and S significantly with the application of 100% NPK + FYM @ 10 t ha^{-1} over control. Arbad and Syed Ismail (2011) studied a long term field experiment was conducted with soybean-safflower cropping sequence on Vertisol, results indicated that, there was high decrease in soil pH and EC, after the harvest of soybean and safflower in FYM treated plots and increase in chemically fertilized plots. The highest organic carbon was observed in treatments treated with chemical fertilizers incorporated with FYM or FYM alone. Integrated use of organic manuring and inorganic fertilization i.e. 100% NPK+FYM @ 10 t ha^{-1} was recorded maximum buildup of available N, P, K, S and Zn after harvest of soybean and safflower except 100% N alone, 50% NPK and control plot. Similar results were also reported by Thakur *et al.* (2011) in long-term fertilizer experiments with soybean-wheat cropping sequence in Vertisols. Whereas, the maximum available P was observed in the treatment receiving 100% NPK+FYM @ 10 t ha^{-1} closely near with the treatments 150% NPK and 100% NPK+$ZnSO_4$ @ 25 kg ha^{-1} and these treatments were found at par with each other. Continuous growing of soybean-safflower without application of sulphur containing fertilizers (100% NPK Sulphur) caused decline in available S (-6.33) from its initial value followed by absolute control treatment was noticed higher reduction in available S (-6.46). Further, the application of recommended dose of fertilizer with organic manure i.e. 100% NPK+FYM @ 10 t ha^{-1} to soybean crop followed by 100% NPK to safflower was slightly reduced in available S (-0.38) over its initial status, but it was contributed considerably higher balance than other treatments. Remarkable depletion of available Zn from its initial status in all treatments except the treatment receiving 100 % NPK + $ZnSO_4$ @ 25 kg ha^{-1} as well as inclusion of FYM in the treatment maintained the Zn content in soil.

Table1. The physico-chemical characteristics and mechanical composition of experimental soil recorded initially start of experiment at 2006-07

Mechanical composition	Particulars
Coarse sand (%)	9.20
Sand (%)	18.30
Silt (%)	24.00
Clay (%)	47.50
Textural class	Clayey
Physical properties	
Bulk density (Mg m^{-3})	1.31
Porosity (%)	51.00
Hydraulic conductivity (cm hr^{-1})	2.68
Infiltration rate (cm hr^{-1})	0.84
Chemical properties	
pH	8.1
EC (dSm^{-1})	0.38
Free calcium carbonate (%)	8.50
Organic carbon (%)	0.50
Total nitrogen (%)	0.053
Available nitrogen (kg ha^{-1})	216.0
Available phosphorus (kg ha^{-1})	16.0
Available potassium (kg ha^{-1})	766.0
Available sulphur (kg ha^{-1})	30.5
Available zinc (mg kg^{-1})	0.98

Table 2. Effect of organic manures and inorganic fertilizers on grain and straw yield of safflower in soybean-safflower cropping sequence

	Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
		2009-10	2010-11	Pooled mean	2009-10	2010-11	Pooled mean
T_1	50% NPK	20.08	18.23	19.16	56.57	46.94	51.76
T_2	100% NPK	21.29	22.59	21.94	62.68	51.30	56.99
T_3	150% NPK	22.17	25.08	23.63	66.48	56.90	61.69
T_4	100% NPK+HW	20.37	21.15	20.76	60.82	49.47	55.15
T_5	100% NPK+$ZnSO_4$ @ 25 kg ha^{-1} given to soybean	21.43	24.23	22.83	63.79	55.11	59.45
T_6	100% NP	19.11	19.47	19.29	58.05	47.90	52.97
T_7	100% N	15.97	13.83	14.90	48.37	39.36	43.87
T_8	100% NPK + FYM @ 10 t ha^{-1} given to soybean	23.23	25.90	24.57	69.16	57.12	63.14
T_9	100% NPK – Sulphur	20.18	18.73	19.46	60.27	41.46	50.87
T_{10}	Only FYM @ 10 t ha^{-1} given to soybean	17.77	13.86	15.82	52.40	34.28	43.34
T_{11}	Absolute Control	15.82	12.33	14.08	48.42	30.27	39.35
T_{12}	Fallow	-	-	-	-	-	-
	Mean	19.76	19.58	19.67	58.82	46.37	52.60
	SE m $\pm$	1.017	1.038	1.427	2.950	2.310	3.549
	CD at 0.05	2.930	2.993	3.950	8.510	6.660	9.821
	CV %	10.29	10.60	-	10.03	9.96	-

Table 3. Effect of different treatments on nutrient uptake by safflower crop in soybean - safflower cropping sequence (Grain+Straw)

	Treatments	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
		2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
T_1	50% NPK	86.82	75.78	81.30	14.22	12.52	13.37	91.56	78.81	85.19
T_2	100% NPK	93.92	89.04	91.48	15.41	14.67	15.04	99.71	90.97	95.34
T_3	150% NPK	98.59	98.81	98.70	16.22	16.37	16.30	105.12	100.97	103.05
T_4	100% NPK+HW	90.44	84.37	87.41	14.81	13.92	14.37	96.30	86.59	91.45
T_5	100% NPK+$ZnSO_4$ @25 kg ha^{-1} given to soybean	95.04	95.55	95.30	15.63	15.77	15.70	101.11	97.63	99.37
T_6	100% NP	85.63	79.34	82.49	14.00	13.04	13.52	91.33	82.00	86.67
T_7	100% N	71.41	60.08	65.75	11.70	9.93	10.82	76.07	63.48	69.78
T_8	100% NPK + FYM @ 10 t ha^{-1} given to soybean	103.03	100.89	101.96	16.89	16.67	16.78	109.63	102.67	106.15
T_9	100% NPK – Sulphur	89.63	73.04	81.34	14.59	12.07	13.33	95.41	74.37	84.89
T_{10}	Only FYM @ 10 t ha^{-1} given to soybean	78.45	56.59	67.52	12.89	9.34	11.12	83.33	58.59	70.96
T_{11}	Absolute Control	71.12	50.15	60.64	11.63	8.29	9.96	76.00	51.78	63.89
T_{12}	Fallow	--	--	--	--	--	--	--	--	--
	Mean	87.55	78.51	83.03	14.36	12.96	13.67	93.23	80.71	86.97
	SE±	3.607	3.481	-	0.599	0.593	-	3.911	3.481	-
	CD at 0.05	10.444	10.000	-	1.733	1.630	-	11.259	10.074	-

Table 4. Effect of different treatments on nutrient uptake by safflower crop in soybean–safflower cropping sequence (Grain+Straw)

	Treatments	Sulphur uptake (kg ha^{-1})			Zinc uptake (g ha^{-1})		
		2009-10	2010-11	Mean	2009-10	2010-11	Mean
T_1	50% NPK	22.00	18.89	20.45	87.04	75.11	81.08
T_2	100% NPK	24.00	21.78	22.89	94.74	86.82	90.78
T_3	150% NPK	25.26	24.15	24.71	99.70	96.45	98.08
T_4	100% NPK+HW	23.11	20.74	21.93	91.41	82.59	87.00
T_5	100% NPK+$ZnSO_4$ @25 kg ha^{-1} given to soybean	24.29	23.48	23.89	95.93	93.26	94.60
T_6	100% NP	21.93	19.70	20.82	86.66	78.15	82.41
T_7	100% N	18.37	15.26	16.82	72.29	60.30	66.30
T_8	100% NPK + FYM @ 10 t ha^{-1} given to soybean	26.37	24.59	25.48	104.07	98.08	101.08
T_9	100% NPK – Sulphur	22.88	17.78	20.33	90.52	74.37	82.45
T_{10}	Only FYM @ 10 t ha^{-1} given to soybean	20.07	14.07	17.07	79.19	55.85	67.52
T_{11}	Absolute Control	18.30	12.45	15.38	72.08	49.41	60.75
Mean	Fallow	22.44	19.35	20.89	88.52	77.31	82.92
SE±		0.940	0.815	-	3.777	3.185	-
CD		2.711	2.370	-	10.667	9.259	-

Table 5. Effect of organic manures and inorganic fertilizers on soil properties after harvest of safflower crop in soybean - safflower cropping sequence

	Treatments	pH			EC (dSm^{-1})			Organic carbon ($g\ kg^{-1}$)		
		2009-10	2010-11	change	2009-10	2010-11	change	2009-10	2010-11	change
T_1	50% NPK	8.02	8.03	-0.07	0.222	0.224	+0.006	5.68	5.75	+0.25
T_2	100% NPK	8.05	8.08	-0.02	0.225	0.229	+0.011	5.87	6.25	+0.75
T_3	150% NPK	8.08	8.11	+0.01	0.227	0.235	+0.017	6.16	6.60	+1.10
T_4	100% NPK+HW	8.03	8.06	-0.04	0.221	0.224	+0.006	5.71	6.20	+0.70
T_5	100% NPK+$ZnSO_4$@25 kg ha^{-1} given to soybean	8.09	8.10	0.00	0.228	0.230	+0.012	5.93	6.25	+0.75
T_6	100% NP	8.00	8.04	-0.06	0.223	0.227	+0.009	5.35	5.95	+0.45
T_7	100% N	8.01	8.01	-0.09	0.220	0.223	+0.005	5.26	5.80	+0.30
T_8	100% NPK + FYM @ 10 t ha^{-1} given to soybean	7.91	7.97	-0.13	0.221	0.219	+0.001	6.71	6.55	+1.05
T_9	100% NPK – Sulphur	8.02	8.01	-0.09	0.212	0.216	-0.002	5.63	6.00	+0.50
T_{10}	Only FYM @ 10 t ha^{-1} given to soybean	7.90	7.93	-0.17	0.200	0.198	-0.020	6.11	6.58	+1.08
T_{11}	Absolute Control	8.12	8.11	+0.01	0.223	0.220	+0.002	5.19	5.95	+0.45
T_{12}	Fallow	8.11	8.12	+0.02	0.219	0.219	+0.001	5.60	5.30	-0.20
	Mean	8.02	8.05	-	0.220	0.222	-	5.77	6.09	-
	SE $\pm$	0.014	0.029	-	0.003	0.003	-	0.219	0.159	-
	CD at 0.05	0.038	0.081	-	0.009	0.009	-	0.608	0.440	-
	Initial	8.10	-	-	0.218	-	-	5.50		-

Table 6. Effect of organic manures and fertilizers on soil properties after harvest of safflower in soybean – safflower cropping sequence

	Treatments	Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
		2009-10	2010-11	change	2009-10	2010-11	change	2009-10	2010-11	change
T_1	50% NPK	212.10	215.88	-0.12	16.72	16.95	+0.95	785.10	779.20	+13.2
T_2	100% NPK	223.00	229.79	+13.79	18.00	18.05	+2.05	792.43	788.64	+22.64
T_3	150% NPK	236.26	249.16	+33.16	18.57	19.11	+3.11	810.85	812.16	+46.16
T_4	100% NPK+HW	225.78	227.92	+11.92	18.10	18.16	+2.16	786.30	785.00	+19.00
T_5	100% NPK+$ZnSO_4$ @25 kg ha^{-1} given to soybean	229.62	230.45	+14.45	17.89	17.91	+1.91	790.20	788.05	+22.05
T_6	100% NP	224.17	226.76	+10.76	17.13	17.27	+1.27	771.00	789.83	+23.83
T_7	100% N	226.00	224.30	+8.30	16.11	16.06	+0.06	767.80	764.93	-1.07
T_8	100% NPK + FYM @ 10 t ha^{-1} given to soybean	251.00	267.10	+51.10	18.66	19.30	+3.30	821.16	816.00	+50.00
T_9	100% NPK – Sulphur	227.00	226.68	+10.68	17.70	17.77	+1.77	788.00	783.14	+17.14
T_{10}	Only FYM @ 10 t ha^{-1} given to soybean	229.43	231.55	+15.55	18.00	18.17	+2.17	815.47	811.52	+45.52
T_{11}	Absolute Control	194.36	193.94	-22.06	15.70	15.58	-0.42	745.30	743.23	-22.77
T_{12}	Fallow	210.00	212.43	-3.57	16.00	16.03	+0.03	769.64	761.00	-5.00
	Mean	224.06	228.00	-	17.38	17.53	-	786.94	785.22	-
	SE $\pm$	4.423	2.806		0.735	0.059		6.856	4.149	
	CD at 0.05	12.243	7.765		2.036	0.165		18.976	11.483	
	Initial	216.00	-		16.00	-		766.00		

Table 7. Effect of organic manures and fertilizers on soil properties after harvest of safflower in soybean–safflower cropping sequence

	Treatments	Available 'S' (kg ha^{-1})			Available 'Zn' (mg kg^{-1})		
		2009-10	2010-11	change	2009-10	2010-11	change
T_1	50% NPK	25.87	25.00	-5.50	0.86	0.83	-0.15
T_2	100% NPK	26.42	26.10	-4.40	0.84	0.81	-0.17
T_3	150% NPK	28.78	28.29	-2.21	0.90	0.87	-0.11
T_4	100% NPK+HW	26.67	26.41	-4.09	0.92	0.82	-0.16
T_5	100% NPK+$ZnSO_4$ @25 kg ha^{-1} given to soybean	28.10	28.03	-2.47	1.13	1.21	+0.23
T_6	100% NP	26.92	26.81	-3.69	0.85	0.82	-0.16
T_7	100% N	26.00	25.97	-4.53	0.85	0.84	-0.14
T_8	100% NPK + FYM @ 10 t ha^{-1} given to soybean	29.88	30.12	-0.38	0.91	0.98	0.00
T_9	100% NPK – Sulphur	24.56	24.17	-6.33	0.90	0.86	-0.12
T_{10}	Only FYM @ 10 t ha^{-1} given to soybean	28.00	28.78	-1.72	0.88	0.91	-0.07
T_{11}	Absolute Control	24.10	24.04	-6.46	0.92	0.90	-0.08
T_{12}	Fallow	29.32	29.57	-0.93	0.97	0.95	-0.03
	Mean	27.05	26.94	-	0.911	0.90	
	SE $\pm$	1.379	0.191		0.027	0.024	
	CD at 0.05	3.818	0.528		0.074	0.067	
	Initial	30.50	-		0.98		

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EVALUATION OF LATHYRUS GENOTYPES FOR MORPHO-PHYSIOLOGICAL CHARACTERS AND THEIR CORRELATION WITH YIELD

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ABSTRACT

The experiment was conducted to study the morpho-physiological characters and yield of fifteen lathyrus genotypes viz., Ratan, Prateek, Mahateora, BioR-222, JRL-16, RLK-1045, NLK-5, NLK-36, NLE-40, NLK-48, NLK-73, L-14, L-36, L-42 and L-44 during *rabi* 2012-2013. Plant height, leaf area and total dry matter production were recorded at 30,50, 70 and 90 DAS. RGR and NAR were calculated at 30-50, 50-70 and 70-90 DAS. Observations on days to 50% flowering, days to maturity, yield plant^{-1} and plot^{-1} were also noted. Considering these characters the genotype Ratan was found to be promising genotype for all above characters. Similarly, next to Ratan genotypes Prateek, Mahateora, BioR-222 and NLK-73 were also identified as superior genotypes over remaining ten genotypes under study. Hence, these five genotypes were also recommended for breeding programme and testing in yield trial. Seed yield of lathyrus had highly significant and positive association with the above characters studied.

(Key words: Lathyrus genotypes, morpho-physiological characters, yield)

INTRODUCTION

The *Lathyrus sativus* is locally called as grasspea, khesari dal, peavine or chana matra. It belongs to family Leguminoceae, sub family Papilionoideae. In India, it is grown over an area of about 1.5 million hectares with a total production of about 0.8 million tones and average productivity of 5.33 q ha^{-1}, thus contributing about 4.5% total pulse production of the country. In Maharashtra it is cultivated in Bhandara, Chandrapur, Gadchiroli and Nagpur districts of eastern Vidarbha, accounting to 53,100 hectares area (Anonymous, 2011). Research work on Lathyrus is going on ICAR level at Pusa farm, New Delhi and at IGKVV Raipur (M.P.) to evolve suitable cultivars having high yields and low ODPA content. Being poorly studied crop the need is felt to generate data on morphological, physiological characters and yield of lathyrus.

MATERIALS AND METHODS

The field experiment was undertaken to study the morpho-physiological characters and yield of lathyrus during *rabi* 2012-2013 at the farm of department of Agricultural Botany, College of Agriculture, Nagpur. The experimental material consisted of fifteen lathyrus genotypes (Ratan, Prateek, Mahateora, BioR-222, JRL-16, RLK-1045, NLK-5, NLK-36, NLE-40, NLK-48, NLK-73, L-14, L-36, L-42 and L-44) with three replications. The plot size of experiment was 3.6 m x 2.00 m with the spacing of 30 cm x 10 cm.

Plant height, leaf area and total dry matter production were recorded at 30,50,70 and 90 DAS. RGR and NAR were calculated at 30-50, 50-70 and 70-90 DAS. Observations on days to 50% flowering, days to maturity and yield were also recorded. The data collected were subjected to statistical analysis suggested by Panse and Sukhatme (1954). Using variances and covariances, the simple correlations were calculated by using the formula given by Singh and Choudhary (1994).

$$r_g = \frac{g\,cov\,x\,y}{(\delta_g x)\,(\delta_g y)}$$

r_g = genotypic correlation coefficient

g cov x y = genotypic covariance between the character x and y

$\delta_g x$ = genotypic standard deviation of x

$\delta g y$ = genotypic standard deviation of y

RESULTS AND DISCUSSION

Significant variation exist among the genotypes in terms of all the parameters studied.

Morpho-physiological parameters

Plant height

Data regarding plant height were recorded at four stages viz., 30,50,70 and 90 DAS. Significant

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variation with gradual increase in plant height was recorded at (30-90 DAS) all the stages of observations.

At 30 DAS range of height recorded was 11.05 - 15-99 cm. Significantly highest plant height was recorded in genotypes Ratan and Prateek and lowest in local genotypes L-44 and L-14. The present findings are in consistent with the result obtained by Falco *et al.* (1991) where they concluded that the selected lines were generally taller (73 cm) than local (67 cm). Rest of the genotypes viz., Mahateora, NLK-73, NLK-48, NLK-40, RLK-1045, JRL-16, NLK-5, NLK-36, L-36 and L-42 in a descending manner exhibited moderate plant height and these genotypes were found at par with each other.

At 50 DAS data showed significant variation. Genotype Ratan exhibited highest plant height, next to this genotype Prateek and BioR-222 also showed more plant height. Genotypes Mahateora, NLK-73, NLK-48, NLK-40, RLK-1045, JRL-16, NLK-5 and NLK-36 recorded moderate plant height in a descending manner. Genotypes L-36, L-42 and L-14 recorded less plant height and least by genotype L-44.

The data regarding plant height at 70 DAS showed significant variation among the genotype studied. At this stage genotype Ratan exhibited highest plant height followed by genotypes Prateek and BioR-222 and lowest by local genotype L-36, L-42, L-14 and L-44. Remaining genotypes Mahateora, NLK-73, NLK-48, NLK-40, RLK-1045, JRL-16, NLK-5 and NLK-36 in a descending manner gave moderate plant height at this stage of observation.

At last stage of observation i.e. 90 DAS highest plant height was noted by Ratan, moderate by Prateek, BioR-222, Mahateora, NLK-73, NLK-4 and NLK-40 and lowest by RLK-1045, JRL-16, NLK-5, NLK-36, L-36 and L-42 in descending manner.

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 the 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.

Mondal (2011) found very slow growth rate of mungbean during the vegetative phase in all the four genotypes. A relatively smaller portion of total dry matter (TDM) was produced before flower initiation and the bulk of it after anthesis.

Raut (2012) also reported that genotypes with high yielding capacity recorded more plant height and low yielding genotypes showed minimum plant height in mustard. He also observed that plant height was increased gradually with the age till its maturity in mustard.

At 30, 50, 70 and 90 DAS plant height had positive and highly significant correlation with yield plant^{-1} (r=0.919, 0.939**, 0.962** and 0.893** respectively).

Zode (1998) also found significant and positive correlation of plant height with yield in lathyrus. Raut (2012) recorded significant and positive correlation of plant height with yield at 65 DAS in mustard.

Days to 50% flowering

Data regarding days to 50% flowering gave significant variation. Genotypes NLK-48, NLK-40, RLK-1045, JRL-16, NLK-5, NLK-36, L-36 and L-42 showed late flowering and genotypes Ratan, Prateek, BioR-222, Mahateora and NLK-73 recorded very late flowering in a descending manner.

Zode (1998) also recorded observation on days to 50% flowering in ten genotypes of lathyrus. In his studies RLK-1045 also showed late flowering.

Days to 50% flowering exhibited a highly significant and positive correlation with seed yield (r=0.977**).

Zode (1998) reported significant and positive correlation of days to 50% flowering with seed yield in *Lathyrus sativus*. Mahajan *et al.* (1993) also noted positive and significant correlation of days to 50% flowering with seed yield in soybean.

Days to maturity

Date regarding days to maturity gave significant variation. The variation in days to maturity was statistically significant. Genotype L-44 matured early however, genotypes Ratan Prateek, BioR-222, Mahateora, NLK-73, NLK-48, NLK-40, RLK-1045, JRL-16, NLK-5, NLK-36, L-36, L-42 and L-14 attained maturity late.

Kashyap *et al.* (1991) also reported significant and positive correlation of days to maturity with seed yield in lathyrus.

Days to maturity showed highly significant and positive correlation with seed yield (r=0.880**).

Leaf area

Leaf area depends upon the number and size of leaves. Leaf area plays an important role in the absorption of light radiation and using it in photosynthetic process. Leaf size is influenced by light, moisture and nutrients hence, yield is dependent on leaf area of crop.

Data regarding leaf area were recorded at four growth stages viz., 30,50,70 and 90 DAS. Significant variation with gradual increase in leaf area was recorded at 30-70 DAS and thereafter, leaf area decreased at 90 DAS.

At 30 DAS range of leaf area recorded was 0.33-0.67 dm^2. Significantly highest leaf area was recorded by genotypes Ratan, Prateek, BioR-222, Mahateora and NLK-73, lowest by L-36, L-42, L-14 and L-44 and moderate by NLK-48, NLK-40, RLK-1045, JRL-16, NLK-5 and NLK-36 in a descending manner.

At 50 DAS range of leaf area recorded was 0.56-1.03 dm^2. Significantly highest leaf area was recorded by genotypes Ratan, Prateek, BioR-222, Mahateora, NLK-73, NLK-48, lowest by genotypes L-36, L-42, L-14 and L-44 and moderate by NLK-40, RLK-1045, JRL-16, NLK-5 and NLK-36 in a descending manner.

At 70 DAS range of leaf area recorded was 0.82-1.48 dm^2. Significantly highest leaf area was recorded by genotypes Ratan, Prateek, BioR-222, Mahateora and NLK-73 when compared with rest of the genotypes under study. Moderate leaf area was observed in genotypes NLK-48, NLK-40, RLK-1045, JRL-16, NLK-5, NLK-36 and lowest leaf area was recorded by genotypes L-36, L-42, L-14 and L-44 in a descending manner.

At 90 DAS range of leaf area recorded was 0.73-1.36 dm^2. Significantly highest leaf area was recorded by genotypes Ratan, Prateek, BioR-222, Mahateora and NLK-73 as compared to remainiing genotypes. Similarly NLK-48, NLK-40, RLK-1045, JRL-16 and NLK-5 recorded moderate leaf area and rest of genotypes NLK-36, L-36, L-42, L-14 and L-44 recorded lowest leaf area in a descending manner.

Leaf area increased gradually from first to third stage (30-70 DAS) but thereafter at 90 DAS it decreased in all the genotypes studied. Malek *et al.* (2012) also reported that leaf area increased gradually with the age till 80 DAS in soybean.

Mondal *et al.* (2011) also found similar results in mung bean. They found very slow growth rate of mung bean during vegetative phase and maximum leaf area during pod filling stage in all the genotypes studied.

Leaf area had shown a very high and significant correlation at 30,50, 70 and 90 DAS with yield (r=0.981**. 0.968**, 0.973** and 0.977** respectively).

Zode (1998) reported positive and highly significant correlation of leaf area with seed yield. Raut (2012) also reported significant and positive correlation of leaf area with seed yield in mustard.

Tahir *et al.* (2012) reported positive and significant correlation of leaf area $plant^{-1}$ with seed yield in chickpea.

Dry matter production

Studies on dry matter production were undertaken at four stages i.e. 30,50,70 and 90 DAS. Significant variation with gradual increase (30-50 DAS) was noticed regarding dry matter production.

Thereafter, at 70 and 90 DAS steep increase in dry matter was observed. The data recorded about dry matter production was subjected to statistically significant. Zode (1998) also reported the similar trend in Lathyrus.

At 30 DAS the range of dry matter production recorded was 0.68-0.97 g. Significantly maximum dry matter was recorded in genotype Ratan followed by Prateek, BioR-222, Mahateora, NLK-73, NLK-48, NLK-40, RLK-1045 and JRL-16. These nine genotypes were found at par with each other. Minimum dry matter was noted in genotype L-44 followed by L-42, L-14, L-36, NLK-36 and NLK-5.

The data recorded about dry matter production were found statistically significant at 50 and 70 DAS. The range of dry matter production observed was 1.29 - 1.67 g at 50 DAS and 4.09-6.36 g at 70 DAS. Significantly highest dry matter was recorded in genotype Ratan followed by Prateek, BioR-222, Mahateora, NLK-73, NLK-48 and NLK-40 when compared with rest of genotypes under study. These genotypes were found at par with each other in dry matter production. Similarly genotype L-44 gave lowest dry matter followed by L-14, L-42, L-36, NLK-36, NLK-5, JRL-16 and RLK-1045. All these eight genotypes were found at par with each other at both the stages of observations.

At 90 DAS the trend was all together different. Significantly highest dry matter was recorded in genotypes Ratan and Prateek when compared with rest of genotypes under observations. Next to these two genotypes BioR-222, Mahateora, NLK-73, NLK-48, NLK-40, RLK-1045, JRL-16, NLK-36, L-36, L-42, L-14 and L-44 recorded moderate to lowest dry matter in a descending manner.

Dry matter production increased gradually from first to second sampling and thereafter rapid increase in dry matter production was evidenced at third and fourth stage. Shaik and Bhargava (1984) also recorded 85-90% of the total dry matter accumulated after flowering in mustard. Hassan *et al.* (2005) also recorded highest dry matter accumulation m^{-2} at the time of maturity in sunflower. Similarly Polora *et at.* (1991) reported that dry matter accumulation was lesser in groundnut during first 25 days of growth but at 75 DAS the crop accumulated 48.6% dry matter. With respect to stages it was maximum during pod development stage. In soybean relatively smaller portion of total dry matter (TDM) was produced before flower initiation and the bulk of it after anthesis (Malek *et al.,* 2012). Mondal (2011) stated that high yielding mung bean genotypes possessed large leaf area and high total dry matter production ability.

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. These might be the reasons for variation in total dry matter production at different stages among all the genotypes in the present investigation.

Total dry matter at 30,50,70 and 90 DAS had positive and highly significant correlation of total dry matter with yield (r=0.947**, 0.968** and 0.896** respectively).

Samrao (1988) obtained positive relationship between dry matter and seed yield in lathyrus.

Zode (1998) also reported similar results in lathyrus. He noted positive and hightly significant correlation of dry matter with yield.

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)

RGR recorded at 30-50 DAS, 50-70 DAS and 70-90 DAS. At first stage i.e. 30-50 DAS range of RGR recorded was 0.021-0.049 g g^{-1} day^{-1}. Significantly maximum RGR was observed in genotypes Ratan, Prateek, BioR-222 and Mahateora in a descending manner when compared with rest of the genotypes. Similarly genotypes NLK-73, NLK-48, NLK-40, RLK-1045 and JRL-16 recorded moderate RGR in a descending manner. Genotypes NLK-5, NLK-36, L-36, L-42, L-14, L-44 recorded minimum RGR at this stage of observation.

At 70-90 DAS range of RGR recorded was 0.020-0.64 g g^{-1} day^{-1}. Significantly highest RGR

was noticed in genotype Ratan when compared with rest of the genotypes. Next to this genotype Prateek, BioR-222, Mahateora and NLK-73 also showed maximum RGR and minimum in genotypes L-14 and L-44. Moderate RGR was noticed in genotypes NLK-48, NLK-40,RLK-1045, JRL-16, NLK-5, NLK-36, L-36 and L-42 when compared with other genotypes studied.

Mundada (2000) also reported that mean total RGR of all the three stages when considered it was found that NLK-38, NLK-5 and NLK-48 showed more RGR while NLK-3 showed less RGR in lathyrus.

Mondal (2011) stated that a high yielding mungbean genotype possessed high relative growth rate at vegetative stage as superior yield components.

Correlation studies revealed highly significant and positive association of relative growth rate with yield at 30-50, 50-70 and 70-90 DAS (r=0.949--, 0.969** and 0.976** respectively).

Zode (1998) reported significant and positive correlation of relative growth rate with yield in mustard.

Net assimilation rate (NAR)

Net assimilation rate is closely connected with photosynthetic efficiency of leaves but it was not a pure measure of photosynthesis. The NAR depend upon the excess of dry matter grain, over loss in respiration. Net assimilation rate is an increase in plant dry weight unit^{-1} leaf area unit^{-1} time. NAR recorded at 30-50 DAS, 50-70 DAS and 70-90 DAS. The range of NAR at 30-50 DAS recorded was 0.017-0.030 g dm^{-2} day^{-1}. Significantly maximum NAR was observed in genotype Ratan followed by Prateek and BioR-222. Genotypes Mahateora, NLK-73, NLK-48, NLK-40 also recorded more NAR as compared to rest of the genotypes. Similarly genotypes RLK-1045, JRL-16, NLK-5, NLK-36, L-36, L-42, L-14 and L-44 were found at par with each other and recorded minimum NAR at this stage of observation.

At 50-70 DAS range of NAR recorded was 0.071-0.090 g dm^{-2} day^{-1}. Significantly maximum NAR was recorded in genotype Ratan followed by Prateek, BioR-222, Mahateora, NLK-73, NLK-48, NLK-40, RLK-1045, JRL-16 and NLK-5 in a descending manner when compared with rest of the genotypes. Similarly genotypes NLK-36, L-36, L-42, L-14, L-44 recorded minimum NAR at this stage of observation.

At 70-90 DAS range of NAR recorded was 0.031-0.073 g dm^{-2} day^{-1}. It was significantly highest in genotype Ratan, lowest in L-42 and L-14 and least in L-44 when compared with other genotypes. Similarly maximum NAR was noticed in genotypes Prateek, BioR-222, Mahateora, NLK-73 and NLK-48. Genotypes NLK-40, RLK-1045, JRL-16, NLK-5, NLK-36, L-36, recorded moderate NAR at this stage of observation.

In general the NAR showed significant difference at all the stages in different genotypes. It was lowest at 30-50 DAS, highest at 50-70 DAS and again it decreased at 70-90 DAS stage. Zode (1998) also reported similar results in lathyrus. He observed lowest NAR at 30-50 DAS and highest at 50-70 DAS and again it decrased at 70-90 DAS stage in lathyrus.

Increase in NAR during reproductive phase might be due to increased efficiency of leaves for photosynthesis as a response to photosynthetic apparatus to increase demand for assimilates by growing seed fraction and also due to photosynthetic contribution by pod and sink demand on photosynthetic rate of leaves.

At 30-50, 50-70 and 70-90 DAS correlation studies revealed highly significant and positive correlation of NAR with seed yield (r=0967**, 0.911** and 0.990** respectively).

Zode (1998) found significant and positive correlation of NAR with seed yield in lathyrus. Raut (2012) also reported significant and positive correlation of NAR with seed yield in mustard.

Seed yield ha^{-1}

Data recorded for seed yield ha^{-1} (q) gave significant variation. The genotypes NLK-73, NLK-48, NLK-40, RLK-1045, JRL-16, NLK-5, NLK-36 and L-36 were showed moderate seed yield while, minimum seed yield was recorded by genotypes L-42, L-14, L-44 in a descending manner.

Table 1. Evaluation of lathyrus genotypes for morpho-physiological traits

Genotypes	Plant height (cm)				Leaf area of plants (dm^2)				Total dry matter of plant (g)			
	30 DAS	50 DAS	70 DAS	90 DAS	30 DAS	50 DAS	70 DAS	90 DAS	30 DAS	50 DAS	70 DAS	90 DAS
NLK-5	13.02	19.96	41.29	43.77	0.46	0.70	1.02	0.97	0.78	1.39	4.67	10.00
NLK-36	12.51	18.08	40.91	43.62	0.42	0.69	0.96	0.91	0.76	1.37	4.66	9.97
NLK-40	13.24	21.73	43.36	45.44	0.52	0.83	1.15	1.13	0.89	1.47	5.01	10.32
NLK-48	13.31	21.74	43.88	46.54	0.53	0.88	1.17	1.14	0.89	1.50	5.09	10.44
NLK-73	13.53	22.18	45.51	47.90	0.59	0.89	1.32	1.25	0.90	1.51	5.09	10.56
RATAN	15.99	33.84	57.02	65.99	0.67	1.03	1.48	1.36	0.97	1.67	6.36	13.56
PRATEEK	13.80	27.49	50.28	54.14	0.66	0.95	1.42	1.33	0.95	1.57	6.10	12.98
MAHATEORA	13.68	22.43	47.80	49.44	0.65	0.89	1.34	1.27	0.92	1.51	5.39	11.25
L-14	11.25	15.45	31.72	39.02	0.35	0.58	0.87	0.79	0.71	1.33	4.13	9.49
L-36	12.12	17.59	35.63	43.54	0.41	0.65	0.92	0.88	0.75	1.35	4.40	9.78
L-42	11.53	15.24	32.33	37.69	0.41	0.60	0.89	0.86	0.75	1.33	4.36	9.52
L-44	11.05	12.99	28.74	37.68	0.33	0.56	0.82	0.73	0.68	1.29	4.09	9.14
BioR-222	13.68	26.40	48.88	49.70	0.65	0.93	1.36	1.28	0.94	1.56	5.52	11.25
JRL-16	13.06	21.21	42.16	43.83	0.48	0.72	1.04	1.00	0.87	1.43	4.71	10.12
RLK-1045	13.17	21.63	42.72	44.90	0.50	0.76	1.04	1.00	0.88	1.44	4.99	10.31
SE (m)±	0.782	1.427	2.781	3.038	0.034	0.051	0.073	0.069	0.054	0.071	0.325	0.692
CD at 5%	2.293	4.188	8.159	8.911	0.102	0.151	0.217	0.204	1.160	0.209	0.954	2.031

Table 2. Evaluation of lathyrus genotypes for RGR, NAR and seed yield ha^{-1}

Genotypes	RGR (g g^{-1} day^{-1})			NAR (g dm^{-2} day^{-1})			Seed yield hectare^{-1} (q)
	30-50DAS	50-70 DAS	70-90 DAS	30-50DAS	50-70 DAS	70-90 DAS	
NLK-5	0.0271	0.0517	0.0172	0.0258	0.0818	0.0464	15.97
NLK-36	0.0264	0.0506	0.0169	0.0254	0.0784	0.0438	15.41
NLK-40	0.0351	0.0526	0.0175	0.0272	0.0841	0.0532	17.52
NLK-48	0.0367	0.0532	0.0177	0.0272	0.0849	0.0553	18.08
NLK-73	0.0403	0.0613	0.0204	0.0287	0.0860	0.0581	19.23
RATAN	0.049	0.0894	0.0298	0.0322	0.0896	0.0730	22.59
PRATEEK	0.0471	0.082	0.0273	0.0302	0.0892	0.0627	21.07
MAHATEORA	0.0432	0.0664	0.0221	0.0293	0.0863	0.0600	20.53
L-14	0.0213	0.0445	0.0148	0.0245	0.0758	0.0321	14.21
L-36	0.0244	0.0493	0.0164	0.0248	0.0767	0.0430	15.38
L-42	0.0214	0.0489	0.0163	0.0248	0.0770	0.0385	14.56
L-44	0.0212	0.0429	0.0143	0.0245	0.0714	0.0309	11.34
BioR-222	0.0469	0.0781	0.0261	0.0294	0.0873	0.0617	20.83
JRL-16	0.0315	0.0521	0.0174	0.0258	0.0820	0.0495	16.41
RLK-1045	0.0327	0.0523	0.0174	0.0260	0.0839	0.0519	17.41
SE (m)±	0.0020	0.0033	0.0020	0.0014	0.0036	0.0033	1.029
CD at 5%	0.0060	0.0098	0.0060	0.0041	0.0108	0.0098	3.019

Table 3. Correlation of morpho-physiological prarmeters with yield in lathyrus

Characters	30 DAS	50 DAS	70 DAS	90 DAS
Plant height	0.919**	0.939**	0.962**	--
Days to 50% flowering				0.977**
Days to maturity				0.088**
Leaf area	0.981**	0.968**	0.973**	--
Dry weight	0.947**	0.968**	0.951**	--

Table 4. Correlation of RGR and NAR with yield in lathyrus

	30-50 DAS	50-70 DAS	70-90 DAS
RGR	0.949**	0.969**	0.976**
NAR	0.967**	0.911**	0.990**

r value = * at 5% (0.514)

= ** at 1% (0.614)

Genotypes Ratan, Prateek, BioR-222 and Mahateora recorded maximum seed yield ha^{-1}. The study on the performance of Lathyrus genotypes for morphological, physiological characters at various growth stages and yield revealed that fifteen genotypes of Lathyrus showed significant variation. Out of the fifteen genotypes Ratan, Prateek, BioR-222 and Mahateora were found to be superior when compared to other genotypes.

Next to above four genotypes NLK-73 performed better from local genotypes studied. While reviewing the studied on correlation it was observed that seed yield of Lathyrus had hightly significant and positive association with all above characters studied. Hence, it could be stressed that more emphasis should be given for the above mentioned parameters as they showed very high degree of positive association with seed yield. Out of fifteen genotypes studied genotypes Ratan, Prateek, BioR-222, Mahateora and NLK-73 can also beneficial for cultivation.

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND UPTAKE OF NURTIENTS BY PRE-MONSOON COTTON

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ABSTRACT

A field experiment was carried out at Agriculture College Farm, Nagpur during 2007-2008 in *kharif* season to study the effect of integrated nutrient management on yield and uptake of nutrients by pre-monsoon hybrid cotton (PKV Hy. 4). In the present study total seven different integrated fertilizer treatments viz., T_1-RDF (Recommended Dose of Fertilizer- 100:50:50 kg ha^{-1} NPK), T_2-FYM @ 5 t ha^{-1}+50% RDF, T_3-FYM @2.5 t ha^{-1}+50% RDF, T_4-FYM @2.5 t ha^{-1} blended with 1% Urea and 2.5% SSP+50% RDF, T_5-FYM @2.5 t ha^{-1} blended with 2% Urea and 5% SSP+ 25% RDF, T_6-FYM @2.5 t ha^{-1} blended with 2% Urea and 5% SSP + 25% RDF + three foliar sprays of 2% Urea at square formation, flowering and boll development stage and T_7-FYM @2.5 t ha^{-1} blended with 2% Urea and 5% SSP+ 25% RDF + three foliar sprays of 2% DAP at square formation, flowering and boll development stage. The first treatment i.e. RDF considered as standard in present study. Uptake of N,P and K by cotton was significantly increased and significantly influenced the residual nutrient status of soil in presence of FYM @ 5 t ha^{-1} + 50% recommended dose of fertilizer (RDF) i.e. 50:25:25 kg NPK ha^{-1}. The highest mean value of bolls plant^{-1} (50.95), seed cotton yield (16.77 q ha^{-1}) and straw yield (36.01 q ha^{-1}) found highest in treatment of RDF followed by treatment T_6, mean value of bolls plant^{-1} (47.01), seed cotton yield (14.66 q ha^{-1}) and straw yield (35.69 q ha^{-1}) which contains 25% RDF with FYM @2.5 t ha^{-1} blended with 2% Urea and 5% SSP + 3 foliar sprays of 2% Urea at critical stages of crop like square formation, flowering and boll development. These treatments found superior over other all the treatments.

(Key words: Cotton, FYM, fertilizers, yield, nutrient uptake)

INTRODUCTION

Cotton cultivation and textile industry has occupied a vital position in the agricultural economy of the country. The area under cotton in the world is about 333.50 lakh hectares. India ranks third in global cotton production after the United States and China. With area covering about 212.91 lakh hectare, India accounted for approximately 20% of the world's total cotton area and 12% of global cotton production (Anonymous, 2012).

Cotton is a very important cash crop for Indian farmers. However, average cotton yields in India have been 484 kg ha^{-1}, compared with a world average of 580 kg ha^{-1} (Anonymous, 2012).

Amongst the cotton growing states in India, Maharashtra has the largest area of about 39.41 lakh hectares, rating one-third of the country's cotton area with production level of around 74.72 lakh tones (Anonymous, 2010). To augment the average production of cotton, particularly in Vidarbha region, there is need of adoption of proper cultivation practices and fertilizer treatments. Adequate nutritional supply is essential for higher yield. Among the nutritional element, N, P and K are three major elements needed for vegetative growth and root development (Chimanshette *et al*., 1990) and to reduce physiological diseases and improve quality of fibre (Bauer *et al*., 1993).

The foliar sprays of nitrogenous and phosphatic fertilizers minimise the cost of fertilizer and provide readily available nutrients to the plant (Bhoj *et al*., 1969 and Pandrangi *et al*., 1991). Manures like FYM play important role to maintain the favourable soil physical condition, and adequate supply of nutrients (Manna *et al*., 2006, and Edmeades, 2003). The cotton plant has a taproot that is capable of extracting mobile nutrients like nitrate nitrogen (NO_3-N) from greater depths than many other plants. Also, cotton stores N in leaves during periods of adequacy for later use in the boll fill period. Nitrogen is a part of plant proteins and is essential for the development of all plant organs including shoots, buds, leaves, roots, and bolls. Foliar application of urea may also be an effective method of "fine tuning" N management (Stewart *et al.,* 2012). Similarly foliar application of DAP enhanced the cotton yield (Raju *et al*., 2008). Since cotton production covers a wide range of environments and economic circumstances, the nutritional requirements of the crop vary greatly for achieving targeted yield. Supplying optimal quantities of mineral nutrients and using balanced

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using balanced macro- and micronutrient doses to growing crop plants is one way to improve crop yields (Zubillaga *et al.,* 2002). The present investigation was carried out to study the effect of application of integrated nutrients i.e. fertilizers and FYM with different doses on the uptake of nutrients and yield of cotton crop.

MATERIALS AND METHODS

Field experiment was conducted during the *kharif* season of 2007-2008 on black cotton soil (Clay texture) at Agriculture College Research Farm, Nagpur, located at $21^0$10' N and $79^0$10' E. The soil of the farm is clay (56.3%) in nature and alkaline (pH 8.2), EC was 0.22 dSm^{-1} with Free lime 7.30%, organic carbon content 0.49%, Nitrogen (312.5 kg ha^{-1}) and phosphorus (17.0 kg ha^{-1}) content was low in this soil and the potassium was high (452.5 kg ha^{-1}). The treatments consisted of T_1 – Recommended dose of fertilizer (RDF) i.e. 100:50:50 kg NPK ha^{-1}. T_2 FYM @ 5 t ha^{-1} + 50% RDF, T_3 – FYM @ 2.5 t ha^{-1} + 50% RDF, T_4 – FYM @ 2.5 t ha^{-1} blended with 1% Urea and 2.5% SSP + 50% RDF, T_5 – FYM @ 2.5 t ha^{-1} blended with 2% Urea and 5% SSP + 25% RDF, T_6 – FYM @ 2.5 t ha^{-1} blended with 2% Urea + 5% SSP + 25% RDF + three foliar sprays of 2% Urea at square formation, flowering and boll development stage, T_7 – FYM @ 2.5 t ha^{-1} blended with 2% Urea and 5% SSP + 25% RDF + three foliar sprays of 2% DAP at square formation, flowering and boll development stage. The experiment was laid out in a randomised block design with four replications. Cotton seed (PKV.Hy.4) was sown by dibbling in last week of May (30.05.2006) at the spacing of 0.96 m x 1 m. Half dose of nitrogen and full dose of phosphorus and potash were applied at the time of sowing followed by 25% dose of N at square formation and remaining 25% dose of N at the time of flowering as per treatments. Organic manure i.e. Farm Yard Manure (FYM) @2.5 t and 5.0 t ha^{-1} and blended FYM @2.5 t ha^{-1} were applied treatmentwise and thoroughly mixed in the soil before sowing of crop. The sources of N, P and K were urea, single super phosphate and muriate of potash respectively. Three foliar applications of 2% Urea and 2% DAP was carried out at 55, 85 and 105 days, respectively after sowing. The soil samples were collected from different spots upto 30 cm depth from experimental area with the help of auger. These samples were thoroughly mixed, air-dried in shade and ground in mortar with wooden pastle and passed through 2 mm sieve. The sieved samples were used for chemical analysis to know the initial status of the experimental area. On the same line fresh soil samples (0-30 cm) were collected from all the treatments at harvest of crop to analyze soil nutrient status. Soil properties like soil reaction (pH) was determined by using a Glass electrode pH meter using 1:2.5 soil water ratio (Piper, 1966), electrical conductivity (EC) was determined by using conductivity meter bridge (Piper, 1966), soil organic carbon (OC) was determined by Walkley and Black's rapid titration method (Piper, 1966), free calcium carbonate was determined by rapid titration method (Piper, 1966), total N was determined by modified Kjeldahl's method. Before addition of concentrated sulphuric acid and catalysts, soaking of soil in water for 30 minutes (Piper, 1966), available N was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956), available P was extracted by 0.5 M sodium bicarbonate and phosphorus was determined by using colorimeter (Jackson, 1967) and available K was extracted by neutral ammonium acetate solution and potassium was determined by flame photometer (Jackson, 1967). Also the plant samples from 28 plots were separately taken. While taking the samples from each individual plots, technique of randomization was adopted. Five plants were selected from each plot at harvesting stage. Initially air dried and then oven dried samples powdered in grinding machine. Tri acid extract prepared (Jackson, 1967) for estimation of phosphorus and potassium, total N content in plant sample was estimated by micro-Kjeldahl's method (Piper, 1966), total P was determined colorimetrically by vanadomolybdate phosphoric acid colour method from tri-acid extract (Jackson, 1967) and total K was determined from tri-acid extract using flame photometer (Jackson, 1967).

RESULTS AND DISCUSSION

Data from table 1 compared with table 2 indicated that there was significant effect of the different treatments on number of bolls $plant^{-1}$, seed cotton yield, straw yield and uptake of NPK nutrients by cotton crop. The highest mean value of bolls $plant^{-1}$, seed cotton yield and the straw yield was

observed in the treatment receiving RDF (100:50:50 NPK) and was found to be superior over all the treatments. Thus, the use of RDF found to be suitable for increasing number of bolls plant^{-1}, seed cotton yield and stalk yield.

RDF produced more number of bolls plant^{-1}, and seed cotton yield ha^{-1} followed by the treatment of FYM @ 2.5 t ha^{-1} blended with 2% Urea & .5% SSP+25% DF + three foliar sprays of 2% Urea applied at square formation, flowering and boll development stage. 22.8% increase in seed cotton yield by treatment RDF was observed over the treatment of FYM @ 5 t ha^{-1} + 50% RDF. Nutritional levels increased the stalk yield significantly. Nutritional level of RDF i.e. 100:50:50 kg NPK ha^{-1} produced more stalk yield over other all treatments.

Data regarding uptake of nutrients indicated that the highest mean values of N, P and K uptake were observed in the treatment FYM @ 5 t ha^{-1} + 50% recommended dose of fertilizers. Ii is observed that the application of FYM and fertilizer resulted in higher uptake as compared to fertilizer alone.

The application of 100:50:50 kg NPK ha^{-1} produced higher seed cotton yield and thus this treatment was the best for pre-monsoon cotton. Statistically similar yields were obtained by reducing 75% fertilizer dose i. e. application of 25% RDF with FYM @ 2.5 t ha^{-1} blended with 2% Urea + 5% SSP and three foliar applications of 2% Urea at square formation, flowering and boll development stage in treatment T_6. (FYM @2.5 t ha^{-1} blended with 2% urea and 5% SSP+ 25% RDF+three foliar sprays of 2% urea).

Table 3 depicted that the organic carbon content of soil was significantly build up, recording 17.89% increase in organic carbon due to the application of FYM @ 5 t ha^{-1} + 50% RDF over initial value (0.49%). The application of higher dose of FYM @ 5 t ha^{-1} + 50% RDF increased the available N content by 9.63% over initial value (312.5 kg ha^{-1}). Available phosphorus content in the soil was also significantly increased under all the treatments. The net increase in phosphorus due to the same treatment was 18.65% over initial value (17.0 kg ha^{-1}). The same treatment had also significantly increased the available potassium status of soil (495.20 kg ha^{-1}) over initial value (452.5 kg ha^{-1}), recording 9.0% increase in the initial value of soil. Application of only fertilizer lowered the content of available K in soil as was found in the treatment 100 % RDF. It was also lowered in the treatment FYM @ 2.5 t ha^{-1} blended with 2% Urea & 5% SSP + 25% RDF, FYM @ 2.5 t ha^{-1} blended with 2% Urea & 5% SSP + 25% RDF + three foliar sprays of 2% Urea and FYM @ 2.5 t ha^{-1} blended with 2% Urea & 5% SSP + 25% RDF + three foliar sprays of 2% DAP as compared to initial value.

Data pertaining to the concentration (Table 3) of N, P and K in the plant, the concentration of N and K were found to be non-significant. Application of FYM @ 5 t ha^{-1} + 50% RDF was found to express significant effect on P concentration in plant. Data revealed the non-significant treatment effect in respect of N content in cotton plant. There was slight decrease in values with decrease in level of FYM and fertilizers doses in the treatments. The highest values (1.09 % N, 0.292 % P and 1.07 % K) were observed in the treatment receiving FYM@ 5 t ha^{-1} and 50 per cent recommended dose of fertilizer followed by the treatment FYM @2.5 t ha^{-1}+50% RDF, FYM @2.5 t ha^{-1} blended with 1% Urea and 2.5% SSP+50% RDF and FYM @2.5 t ha^{-1} blended with 2% Urea and 5% SSP+25% RDF. The lowest value of N was observed in the treatment RDF receiving full recommended dose of fertilizer.

There was significant increase in P content with increasing values of FYM and fertilizers. The highest value (0.292 %) was observed in the treatment FYM @ 5 t ha^{-1} and 50 per cent recommended dose of fertilizer followed by the treatment FYM @2.5 t ha^{-1} +50% RDF, and FYM @2.5 t ha^{-1} blended with 1% Urea and 2.5% SSP+50% RDF. The treatment of FYM @2.5 t ha^{-1} blended with 1% Urea and 2.5% SSP+50% RDF, FYM @2.5 t ha^{-1} blended with 2% Urea and 5% SSP+25% RDF and FYM @2.5 t ha^{-1} blended with 2% Urea and 5% SSP+25% RDF + three foliar sprays of 2% Urea were at par with each other. The lowest value (0.205 %) was observed in the treatment 100% RDF and FYM @2.5 t ha^{-1} blended with 2% Urea and 5% SSP+25% RDF + three foliar sprays of 2% DAP.

It was observed that the treatment differences were non-significant for K content in the plant. The highest value (1.07 %) was observed in the treatment

Table 1. Effect of treatments on yield, yields attributing characters and uptake of nutrients by cotton

Treatments	Bolls plant^{-1}	Yield (q ha^{-1})		Uptake of nutrients (kg ha^{-1})		
		Seed cotton yield	Straw yield	N	P	K
T_1 - RDF	50.95	16.77	36.01	31.25	7.38	30.97
T_2 - FYM @5t ha^{-1}+50% RDF	45.85	13.66	32.87	35.85	9.60	35.17
T_3 - FYM @2.5t ha^{-1}+50% RDF	39.89	11.92	29.94	31.94	8.23	31.44
T_4 - FYM @2.5 t ha^{-1} blended with 1% Urea & 2.5% SSP+50% RDF	43.66	13.67	33.84	35.19	9.20	34.86
T_5 - FYM @2.5 t ha^{-1} blended with 2% Urea & 5% SSP+25% RDF	41.03	12.24	31.66	32.78	7.67	32.31
T_6 - FYM @2.5 t ha^{-1} blended with 2% Urea & 5% SSP+25% RDF + three foliar sprays of 2% Urea	47.01	14.66	35.69	34.98	8.39	34.62
T_7 - FYM @2.5 t ha^{-1} blended with 2% Urea & 5% SSP+25% RDF + three foliar sprays of 2% DAP	46.15	14.26	34.77	31.19	7.13	31.29
SE (m) ±	0.92	0.92	0.56	0.60	0.14	0.14
CD at 5%	2.72	2.72	1.66	1.79	0.42	0.42

RDF-Recommended dose of fertilizers, SSP-Single Super Phosphate

Table 2. Initial soil properties of the experimental field

Parameters	pH	EC (dSm^{-1})	Free Lime (%)	Organic carbon (%)	**Available nutrients (kg ha^{-1})**		
					N	P	K
Observed values	8.2	0.22	7.30	0.492	312.5	17.0	452.5

Table 3. Mean values of pH, electrical conductivity (EC), organic carbon (OC) and available nutrients as affected by different treatments at harvest

Treatments	pH	EC (dSm^{-1})	OC (%)	**Available nutrients (kg ha^{-1})**		
				N	P	K
T_1 - RDF	7.9	0.210	0.52	299.0	17.45	419.15
T_2 - FYM @5 t ha^{-1}+50% RDF	7.8	0.192	0.58	342.6	20.17	495.20
T_3 - FYM @2.5 t ha^{-1}+50% RDF	7.8	0.192	0.56	335.9	19.0	456.17
T_4 - FYM @2.5 t ha^{-1} blended with 1% Urea & 2.5% SSP+50% RDF	7.93	0.195	0.55	307.9	19.0	453.20
T_5 - FYM @2.5 t ha^{-1} blended with 2% Urea & 5% SSP+25% RDF	7.93	0.197	0.54	304.2	18.85	428.00
T_6 - FYM @2.5 t ha^{-1} blended with 2% Urea & 5% SSP+25% RDF + three foliar sprays of 2% Urea	8.1	0.202	0.54	301.8	17.35	414.00
T_7 - FYM @2.5 t ha^{-1} blended with 2% Urea & 5% SSP+25% RDF + three foliar sprays of 2% DAP	8.1	0.207	0.53	300.7	17.09	405.70
SE (m) +-	0.41	0.007	0.010	3.78	0.50	8.80
CD at 5%	--	--	0.029	11.98	1.49	26.06

RDF-Recommended dose of fertilizers, SSP-Single Super Phosphate

Table 4. Effect of treatments on concentration of NPK at harvesting stage of cotton stalks

Treatments	N %	P %	K %
T_1 - RDF	0.87	0.205	0.86
T_2 - FYM @5 t ha^{-1}+50% RDF	1.09	0.292	1.07
T_3 - FYM @2.5 t ha^{-1}+50% RDF	1.06	0.275	1.05
T_4 - FYM @2.5 t ha^{-1} blended with 1% Urea & 2.5% SSP+50% RDF	1.04	0.272	1.03
T_5 - FYM @2.5 t ha^{-1} blended with 2% Urea & 5% SSP+25% RDF	1.03	0.242	1.02
T_6 - FYM @2.5 t ha^{-1} blended with 2% Urea & .5% SSP+25% RDF + three foliar sprays of 2% Urea	0.98	0.235	0.97
T_7 - FYM @2.5 t ha^{-1} blended with 2% Urea & 5% SSP+25% RDF + three foliar sprays of 2% DAP	0.92	0.205	0.90
SE (m) ±	0.07	0.013	0.14
CD at 5%	--	0.038	--

FYM @5 t ha^{-1}+50% RDF and the lowest one (0.86 %) in the treatment RDF.

The overall result of the study revealed that the application of FYM @ 5 t ha^{-1} plus 50 per cent recommended dose of fertilizer improved the soil fertility with increasing rate of uptake of N, P and K. The application of 100:50:50 kg NPK ha^{-1} (RDF) which produced higher seed cotton yield was the best for pre-monsoon cotton. Statistically similar yield were obtained by reducing 75 % fertilizer dose i. e. application of 25% RDF with FYM @ 2.5 t ha^{-1} enriched with2 % Urea and 5 % SSP associated with foliar application of 2 % Urea or 2 % spray of DAP at square formation, flowering and boll development stages in treatment T_6. Since the results are based on single year experimentation, the same need to be confirmed by further experimentation at least for two years.

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EFFICACY OF DIFFERENT INSECTICIDES AGAINST POD FLY, *Melanagromyza obtusa (*MALLOCH) ON PIGEONPEA

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ABSTRACT

An experiment on efficacy of different insecticides against pod fly, *Melanagromyza obtusa (*Malloch) on pigeonpea was conducted at Entomology Section, College of Agriculture, Nagpur during the *kharif* season 2011-12. The treatments comprised different insecticides *viz.,* Dimethoate 30 EC(0.03%), Profenophos 50 EC(0.125%), Deltamethrin + Triazophos 1 + 35 EC(0.07%), Imidacloprid 17.8 SL(0.009%), Acetamaprid 20 SP(0.008%), Fipronil 5% SC(0.001%) including untreated control were tested against *M. obtusa*. The results obtained in investigation revealed that deltamethrin + triazophos 0.07% EC was found to be superior and recorded 72.36 and 68.48% larval reduction on 7th and 14th day after spraying, respectively. The application of this treatment showed 2.94% pod damage with 3.25% grain damage at harvest. The next effective treatment was profenophos 50 EC 0.12% with 60.81 and 54.05% larval reduction on 7 and 14 DAS, respectively as well as it recorded 4.31% pod damage and 4.52% grain damage at harvest. Other remaining treatments were also found statistically significant over control.

The treatment, Deltamethrin + Triazophos 0.07% observed as economically most suitable treatment as it has obtained the highest yield(12.45 q ha^{-1}) and also recorded maximum incremental cost:benefit ratio(1:27.64). Although the treatment of profenophos 0.125% (10.30 q ha^{-1}) was the next best in increasing the grain yield followed by acetemaprid 0.008% (9.98 q ha^{-1}), the treatments of acetemaprid 0.008% (1:18.56) and fipronil 0.001% (1:15.46) recorded the higher ICBR. Owing to higher cost, the treatment with profenophos 0.125% (1:7.23) recorded comparatively lower incremental cost:benefit ratio(1:7.23) than other insecticides.

(Key words: Pigeonpea, pod fly, insecticides)

INTRODUCTION

India grows a variety of pulse crops under a wide range of agro-climatic condition and has a pride of being the world's largest producer of pulses. Among these, pigeonpea (*Cajanus cajan* Mill) is one of the most important pulse crops in India and it acts as a main source of protein in the diet of vegetarian people. It is grown mostly for grains, green manuring, fodder and forage as sole crop, intercrop, mixed crop and in sequential cropping system. The studies revealed that main reasons for low productivity of pigeonpea are the cultivation of this crop on marginal lands under poor management condition and mounting pressure of several insect pests (Gowda *et al.,* 2013).

In India, pigeonpea occupies about 34.00 lakh ha area with an annual production of 23.70 lakh tones and productivity of 697 kg ha^{-1}(Anonymous, 2010a).The production of pigeonpea during 2012-13 was 3002.7 and 2013-14 was 3382.2 thousand metric tones(Anonymous,2014). Maharashtra accounted for approximately 30% of pigeonpea cultivation over an area of 11.6 lakh ha with annual production of 8.48 lakh tones and average productivity of 761 kg ha^{-1} (Annonymous, 2010b). In Vidarbha, pigeonpea is mostly cultivated as an inter crop with soybean, cotton, mungbean and urdbean under rainfed condition. The area under pigeonpea was 4.1 lakh ha with production of 4.05 lakh tones and productivity of 987 kg ha^{-1}(Anonymous, 2010c).

Amongst insect pests associated with fruiting phase of crop especially, the pod borer complex *viz*., pod borer (*Helicoverpa armigera* Hubner), tur plume moth (*Exelastis atomosa* Walshingham) and pod fly (*Melanagromyza obtusa* Malloch) cause losses in grain yield ranging from 30 to 100 per cent (Adgkar *et al*., 1993).

M. obtusa (Diptera: Agromyzidae) is a serious pest of pigeonpea and the young larvae of the fly cause damage to developing seeds. Incidence appears at pod initiation and incidence continues upto the maturity of crop. The losses inflicted by pod fly are higher on account of concealed damage habit and often remain unnoticed. The damage is evident on account of pin head exit holes on the pods. The affected grains are shriveled, discoloured with fungal infection rendering them unsuitable for sowing or

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consumption (Shanower *et al*., 1998). The infested seeds soon decay due to microbial activity. *M. obtusa* was reported to damage 22.5% pigeonpea pods in North India, 21% pods in Central India and 13.2 % pods in South India (Lateef and Reed, 1983).

In Maharashtra, losses caused by pod fly ranges between 20 and 30% and in recent years the losses were more than 80% in short duration pigeonpea varieties (Sanap and Patil, 1998). An yield loss of 60 to 80 per cent was recorded due to the podfly, *Melanagromyza obtusa* (Durairaj, 2006).

Application of insecticides forms first line of defense for management of pigeonpea pod fly, as very few natural enemies are effective in pigeonpea ecosystem. The strong inclination towards application of synthetic insecticides for combating pest menace is on account of their immediate effect, convenience of application and easy availability of these agrochemicals (Sharma *et al.*, 2011).

Eight insecticides viz., Neem oil, Spinosad, Indoxacarb, imidacloprid, fenvalerate, Bollcure crude, Bollcure formulated and garlic bulb extract were tested against pod fly in late maturing variety NDA 1. Two sprays of Spinosad @ 75 g.a.i. ha^{-1} first at grain filling state of pods and second at full grain stage were found best in pod fly suppression, followed by Indoxacarb @ 60 g.a.i. ha^{-1} (Fig.31). The least grain and pod damage (%) was registered in case of two sprays of Spinosad 162 ml ha^{-1} application, followed by indoxacarb 0.007% (500 ml ha^{-1}). As regards their effect on crop yield, the former registered 1183 kg ha^{-1} grain yield, followed by Indoxacarb (1044 kg ha^{-1}) against the later. All the insecticides were significantly superior over control (717 kg ha^{-1}), (Anonymous, 2013).

Srujana and Keval(2013) reported that the tur pod fly, Melanagromyza obtusa was found to be predominant during the year of experimentation i.e during 2011-12 and it caused significant economic losses in the grain yield of long duration pigeonpea BAHAR. The three applications of Thimethoxam 25 WG @ 75 g a.i. ha^{-1}, Fipronil 25 EC @ 8 g a.i. ha^{-1}, Thiacloprid 240 SC @ 75 g a.i. ha^{-1}, Imidacloprid 17.8 SL @ 20 g a.i. ha^{-1}, Acetamiprid 20 SP @ 20 g a.i. ha^{-1}, Dimethoate @ 30 g a.i. ha^{-1}, were done. First application was done at 50% flowering stage, second 15 days after the first spraying and last 15 days after the second spraying. All the insecticides tested gave significantly better protection against pod fly compared to untreated control. The per cent pod damage by pod fly was minimum in Thimethoxam 25 WG @ 75 g a.i. ha^{-1} treated plots. Next to this was Fipronil 25 EC @ 8 g a.i. ha^{-1}. Thimethoxam 25 WG @ 75 g a.i. ha^{-1} treated plot gave the lowest per cent grain damage followed by Fipronil 25 EC @ 8 g a.i. ha^{-1}. The treatments showed significant differences in grain yield. The yield ranged from 9.53 q ha^{-1} in Dimethoate 30 EC @ 30 g a.i. ha^{-1} and 13.88 q ha^{-1} in Thiacloprid 240 SC @ 75 g a.i. ha^{-1}.The performance of the grain yield was found in increasing order to Dimethoate 30 EC @ 30 g a.i. ha^{-1} (9.53 q ha^{-1}) < Fipronil 25 EC @ 8 g a.i. ha^{-1} (10.66 q ha^{-1}) < Acetamiprid 20 SP @ 20g a.i. ha^{-1} (11.77 q ha^{-1}) < Imidacloprid 17.8 SL @ 20 g a.i. ha^{-1} (12.00 Kg ha^{-1}) < Thimethoxam 25 WG @ 75 a.i. ha^{-1}. (12.93 q ha^{-1}) < Thiacloprid 240 SC @ 75 g a.i. ha^{-1} (13.88 q ha^{-1}). Whereas in the control plot, the grain yield was found only 7.66 q ha^{-1}.

Considering the importance of pest and efficacy of insecticides, the present investigation was framed with an objective to evaluate the efficacy and economics of different insecticides for the effective management of pigeonpea pod fly.

MATERIALS AND METHODS

The field experiment was conducted on the study entitled "efficacy of different insecticides against pod fly, *Melanagromyza obtusa* (Malloch) on pigeonpea" on the field Entomology Section, College of Agriculture, Nagpur during *kharif* season 2011-2012. Seven different insecticides including untreated control (Table 1) were replicated thrice and incorporated in Randomized Block Design on PKV TARA variety. In all three spray applications were undertaken. The first treatment spray was initiated at the stage of pod initiation (13.12.2011). Whereas the second and the third spray was made at an interval of 15 days on 28-12-2011 and 13-01-2012, respectively. The efficacy of test insecticides was determined by recording the damage due to pod fly at harvest on pod and grain basis.

Pod damage caused by pod fly at harvest

Fifty dry pods from five sampled plants at harvest were randomly collected from each net plot

and carefully observed to determine the damage caused by pigeonpea pod fly. The observations were recorded on the basis of damage caused by larvae of pod fly, *M. obtusa* which was identified by nature of damage caused by them to pods. The pods showing the very minute hole of pin head size and after opening it, showing decoloured seeds along with irregular lines were considered as the damage caused by *M. obtusa* and respective per cent pod damage caused by pod fly at harvest was calculated. Per cent damage was estimated by recording damaged pods out of fifty pods.

Grain damage caused by pod fly at harvest

At harvest, fifty dry pods selected for pod damage were further considered for recording damage to grains. These grains were examined for healthy and infested one and accordingly, and the grains damaged by pod fly were recorded. The grains showing galaries were considered as damaged grains. Per cent grain damage was estimated on the basis of total number of grains from 50 pods and grain damaged due to pod fly in the grains obtained from these pods.

Grain yield and economics

In order to compare the efficacy of different treatments, the grain yield of net plot from each treatment was recorded after harvest of crop. Thus, yield obtained plot^{-1} was converted into quintals hectare^{-1}. The data on grain yield were used to calculate the economic viability of each treatment. The cost of each treatment and labourers required for application were ccalculated as per market rate. Similarly, the income obtained from the sale of grains as per prevailing rates was also calculated from each treatment. The data thus obtained were used to calculate monetary return and incremental cost:benefit ratio (ICBR) of various treatments.

RESULTS AND DISCUSSION

Pod damage caused by *M. obtusa* at harvest

It was observed from the data of pod damage that the results were statistically significant and the treatment Deltamethrin + Triazophos (0.07%) noticed minimum pod damage of 2.94%, followed by Profenophos (0.125%) and Acetmapride (0.008%) showed 4.31% and 4.60% pod damage and were found to be at par among themselves.

The other treatments Dimethoate (0.03%), Imidacloprid (0.009%) and Fipronil (0.001%) recorded 5.29, 5.42 and 6.52 per cent pod damage and among these first two were at par with each other and showed superiority over control (17.8%).

The results on effectiveness of Profenophos, Dimethoate, Imidacloprid on the reduction of pod damage due to *M. obtusa* at harvest were found in accordance with the studies of Dar *et al.* (2009) who tested efficacy of various insecticides such as Acephate 0.07%, Quinalphos 0.05%, Lambda cyhalothrin 0.002%, Profenphos 0.1%, Dimethoate 0.03%, Imidacloprid 0.04%,NSKE 5%, Monocrotophos 0.04%,Endosulfan 0.07%,Garlic extract 2% and Onion extract 2% against the podfly and the results indicated that the pod damage due to pod fly among different treatments varied from 32.3 to 38.3% and found significantly superior over control (48.2%). Insecticides like Dimethoate, Profenophos, Quinalphos and Acephate showed significantly better results than others.

The per cent pod damage ranged from 17.33% in Thimethoxam 25 WG @75 g.a.i. ha^{-1} to 26.66% in Dimethoate 30 EC @ 30 g.a.i. ha^{-1}. While in control plot the damage was 33.33%. All the treatments were found to be superior over control with respect to per cent pod damage. The relative performance of various insecticides was found in order to Thimethoxam 25 WG @ 75 g.a.i. ha^{-1} > Fipronil 25 EC @ 8 g.a.i. ha^{-1} > Thiacloprid 240 SC @ 75 g.a.i. ha^{-1} > Imidacloprid 17.8 SL @ 20 g.a.i. ha^{-1} > Acetamiprid 20 SP @ 20 g.a.i. ha^{-1} > Dimethoate 30 EC @ 30 g.a.i. ha^{-1}. Thimethoxam 25 WG @ 75 g.a.i. ha-1 treated plot gave the lowest percentage damage i.e. 17.33% followed by Fipronil 25 EC @ 8 g.a.i. ha^{-1} (17.66%) and then Thiacloprid 240 SC @ 75 g.a.i. ha^{-1} (20.33%), whereas in control plot damage due to pod fly was (33.33%). (Srujana and Keval, 2013).

Grain damage caused by *M. obtusa* at harvest

The data of grain damage presented in table 1 showed that the results are statistically significant. The application of Deltamethrin+Triazophos 0.07% was found most effective treatment in recording the

minimum grain damage of 3.25 per cent, followed by Profenophos 0.125% and Acetamaprid 0.008% where 4.52 and 5.85% pod damage was recorded, respectively and found to be significantly superior to the rest of the treatments. These results are in accordance with the reports of Das (2001). The ready mix formulation of insecticides like Cyperphos (Cypermethrin 62.5+ profenphos 437.5g a.i. ha^{-1}), Endophos (Endosulfan625 + profenphos 625 g a.i. ha^{-1}) and Spark (Chlorpyriphos 10+ Deltamethrin 350 g a.i. ha^{-1}) were tested by them against pod fly. Among these formulations Cyperphos(Cypermethrin 62.5+ profenphos 437.5g a.i. ha^{-1}) recorded the minimum pod and grain damage due to pod fly and it was 30.59 and 18.63%, respectively. The next best treatments were Spark (Chlorpyriphos 10 + Deltamethrin 350 g a.i. ha^{-1}) and Endophos (Endosulfan625 + profenphos 625 g a.i. ha^{-1}) which recorded the pod damage 24.24 and 15.42% and grain damage 30.58 and 18.63%, respectively.

The next effective treatments were of Dimethoate 0.03% and Imidacloprid 0.009% recording 8.26% and 8.57% grain damage, respectively and showed similarity in effectiveness amongst them, Whereas, Fipronil 0.001% recorded grain damage of 9.60% and was found superior over the untreated control (11.67%).

The difference in per cent grain damage due to treatments applied showed range of per cent grain damage (6.77%) in T5 i.e. Thimethoxam 25 WG @ 75 g.a.i. ha^{-1} to (11.73%) in T2 Dimethoate 30 EC @ 20 g.a.i. ha^{-1}. All the treatments were found superior over control with respect to per cent grain damage. The relative performance of difference insecticides was found in order of Thimethoxam 25 WG @ 75 g.a.i. ha^{-1} > Fipronil 25 EC @ 8 g.a.i. ha^{-1} > Thiacloprid 240 SC @ 75 g.a.i. ha^{-1} > Acetamaprid 20 SP @ 20 g.a.i. ha^{-1} > Imidacloprid 17.8 SL @ 20 g.a.i. ha^{-1} > Dimethoate 30 EC @ 30 g.a.i. ha^{-1}. Thimethoxam 25 WG @ 75 g.a.i. ha^{-1} treated plot gave the lowest grain damage i.e. (8.52%). The per cent grain damage in control was (15.13%). (Srujana and Keval, 2013).

Grain yield of pigeonpea

The data of yield (Table 2) revealed that the results were statistically significant and the highest grain yield was recorded in the treatment of Deltamethrin+Triazophos 0.07% (12.45 q ha^{-1}), damage were further considered for recording followed by Profenophos 0.125% (10.3 q ha^{-1}), Acetamaprid 0.008%(9.98 q ha^{-1}), Dimethoate 0.03%(8.24 q ha^{-1}) and Imidacloprid 0.009%(8.14 q ha^{-1}), which recorded 10.30, 9.98, 8.24 and 8.14 q ha^{-1} yields, respectively and all these four treatments were found statistically at par with each other.

The experimental findings of Srujana and Keval (2013) showed significant differences in grain yield. The yield ranged from 9.53 q ha^{-1} in (T2) i.e. Dimethoate 30 EC @ 30 g.a.i. ha^{-1} to 13.88 q ha^{-1} in (T5) i.e. Thiacloprid 240 SC @ 75 g.a.i. ha^{-1}. It is clear from the experimental data, treatment performance for grain yield was found in order to (T2) Dimethoate 30 EC @ 30 g.a.i. ha^{-1} (9.53 q ha^{-1}) < (T3) Fipronil 25 EC @ 8 g.a.i. ha^{-1} (10.66 q ha^{-1}) < (T1) Acetamiprid 20 SP @ 20 g.a.i. ha^{-1} (11.77 q ha^{-1}) < (T4) Imidacloprid 17.8 SL @ 20 g.a.i. ha^{-1} (12.00 kg ha^{-1}) < (T6) Thimethoxam 25 WG @ 75 g.a.i. ha^{-1} (12.93 q ha^{-1}) (TThiacloprid 240 SC @ 75 g.a.i. ha^{-1} (13.88 q ha^{-1}). Where as in the control plot the grain yield was found only 7.66 q ha^{-1}.

The lowest yield of 4.36 q ha^{-1} was recorded in untreated control. The finding of effectiveness of Deltamethrin+Triazophos 0.07% in recording the higher yield is in accordance with the reports of Tambe *et al.* (1997) they reported that the ready mix formulation of insecticides like Deltamethrin 12.5 g a.i. ha^{-1}+Triazophos 437.5 g a.i. ha^{-1} was found significantly superior over the remaining treatments by reducing pod damage by 19.45% and 18.29%,respectively. The treatment Deltamethrin 12.5 g a.i. ha^{-1} + Triazophos 350 g a.i. ha^{-1} recorded the highest grain yield of pigeonpea(20.12 q ha^{-1}).

Table 1. Cumulative effect of different treatments on per cent larval reduction at 7 and 14 days after spraying

Tr. No.	Treatments	Per cent pod damage**	Per cent grain damage**
T_1	Dimethoate 30 EC 0.03%	5.29 (2.41)	8.26 (2.96)
T_2	Profenophos 50 EC 0.12%	4.31 (2.19)	4.52 (2.24)
T_3	Deltamethrin + Triazophos1+35 EC 0.07%	2.94 (1.85)	3.25 (1.94)
T_4	Imidacloprid 17.8 SL 0.009%	5.42 (2.43)	8.57 (3.01)
T_5	Acetamapride 20 SP 0.008%	4.60 (2.26)	5.85 (2.52)
T_6	Fipronil 5 SC 0.01%	6.52 (2.65)	9.60 (3.18)
T_7	Untreated control	17.80 (4.22)	11.67 (3.42)
	SE(m)±	0.065	0.079
	CD at 5%	0.29	0.23

* Figures in parentheses are the corresponding arc sin transformed values

** Figures in parentheses are the corresponding square root transformed values

Table 2. Incremental Cost : Benefit Ratio (ICBR) in response to treatments

Treat. No.	Treatments	Quantity of insecticide required ha^{-1} for one spray	Market price of Insecticide Rs. ha^{-1}	Cost of treatments		Total cost Rs. ha^{-1} (A)	Yield of pigeon pea (q ha^{-1})	Increased yield over control(q ha^{-1})	Value of increased yield over control (Rs. ha^{-1}) (B)	Net gain over control (C)(B-A)	ICBR (C/A)	Rank
				Cost of Insecticides (3 Spray) Rs. ha^{-1}	Labour charges and rent of sprayer (3 spray)							
T_1	Dimethoate 30 EC 0.03%	500 ml	270 lit^{-1}	405	492	897	8.24	3.88	14744	13847	15.43	IV
T_2	Profenophos 50 EC 0.12%	1250 ml	600 lit^{-1}	2250	492	2742	10.3	5.94	22572	19830	7.23	VI
T_3	Deltamethrin +Triazophos1+35 EC 0.07%	970 ml	460 lit^{-1}	582	492	1074	12.45	8.09	30742	29668	27.62	I
T_4	Imidacloprid17.8 SL 0.009%	250 ml	1200 lit^{-1}	900	492	1392	8.14	3.78	14364	12972	9.31	V
T_5	Acetamapride20 SP 0.008%	200 gm	1000 kg^{-1}	600	492	1092	9.98	5.62	21356	20264	18.56	II
T_6	Fipronil 5 SC 0.01%	100 ml	960 lit^{-1}	288	492	780	7.74	3.38	12844	12064	15.46	III
T_7	Untreated control	--	--	--	--	--	4.36	--	--	--	--	--

Cost of inputs

Labour charges - Rs. 72 day^{-1} man^{-1}
Cost of spray pump - Rs. 20 day^{-1}
Cost of Fipronil 5% SC - Rs.960 lit^{-1}
Cost of Dimethoate 30 EC - Rs.270 lit^{-1}
Cost of Deltamethrin +Triazophos1+35 EC - Rs.460 lit^{-1}
Cost of Profenophos 50 EC - Rs.600 lit^{-1}
Cost of Imidacloprid 17.8 SL - Rs.1200 lit^{-1}
Cost of Acetemapride 20 SP - Rs.1000 kg^{-1}
Market price of pigeonpea - Rs.3800 q^{-1}

Incremental cost:benefit ratio (ICBR) of treatments

The values of ICBR of treatments are presented in table 2. The data indicated that the application of Deltamethrin+Triazophos 0.07% was found as the most economically viable treatment since this treatment recorded very high ICBR of 1: 27.64. It was followed by the insecticidal treatments of Acetampride 0.008%, which recorded the ICBR of 1: 18.56. However, the treatments such as Fipronil 0.001% and Dimethoate 0.03% were also found economically better in recording higher ICBR of 1:15.46 and 1:15.43, respectively than Imidacloprid 0.009% (1: 9.31)and Profenophos 0.125%(1: 7.23). The cost of these insecticides for three sprays was the main reason for less ICBR for treatments Imidacloprid 0.009% (Rs.900)and Profenophos 0.125%(Rs.2250), respectively.

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IDENTIFICATION OF SOYBEAN VARIETIES FOR PRODUCTION OF BETTER QUALITY OF SOYPANEER

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ABSTRACT

Soypaneer can be the best alternative to milk paneer. Present investigation was undertaken to identify soybean varieties which are suitable for the production of better quality of soypaneer in the year 2012-13 at the Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, VNMKV, Prabhani. Well graded grains of various soybean varieties viz., JS-335, MAUS-71, MAUS-61, MAUS-61-2, MAUS-47, MAUS-81, MAUS-158, MAUS-2, MAUS-32, DS-228, JS-9305 and TMAS-98-21 were used for the study. During the preparation of soypaneer, the obtained yield of whey, milk, okara and paneeer were measured. The sensory properties of soypaneer were evaluated with respect to color and appearance, taste, flavour, texture and overall acceptability by the panel of ten judges using nine point Hedonic Scale. The textural properties of soypaneer at room temperature were evaluated using Texture Profile Analyzer Stable Micro Systems. Results showed that soybean variety JS-335 and MAUS-158 gave highest paneer yield (1.34 kg kg^{-1} of dry soybean) followed by MAUS-71 (1.32 kg kg^{-1} dry soybean). Soypaneer prepared from varieties JS-335, MAUS-158 and MAUS-71 was whitish in color which resembled like milk paneer. From the studies it can be inferred that the soybean varieties viz., JS-335, MAUS-158 and MAUS-71 are suitable for the production of better quality of soypaneer with respect to yield, textural (hardness, chewiness, cohesiveness and springiness) and organolyptic properties.

(Key words: Soypaneer, textural properties, sensory evaluation)

INTRODUCTION

Soybean is environment friendly grain legume which provides high quality nutrition. Soybean often called 'golden miracle bean' is the world's foremost provider of protein and oil, used for health food, feed sources and industrial products. The most important factor is non-availability of the soy products in Indian market suiting to Indian eating habits.

Soypaneer is known for its extraordinary nutritional benefits. It is a soft cheese-like food made by curdling soymilk with a coagulant (Raja *et al.,* 2014). From 1 kg of cleaned and dry soybean, about 6-8 liters of milk and after coagulation of milk about 1.25-1.5 kg of soypaneer can be obtained (Khodke, 2006; Mathare *et al.,* 2009). Soypaneer contains 15% protein, 3.6% fat and about 72% moisture content (Arora and Mittal, 1991). Although, milk paneer is popular among consumers, it is expensive and costing around Rs. 300 kg^{-1}. Hence, it is not possible to offer milk paneer for the majority of Indian people. In this context, soypaneer can be an appropriate economical alternative to milk paneer costing around Rs 150 kg^{-1} and gives all nutritional benefits.

Keeping above in view, the present investigation was undertaken during 2012-13 in the Department of Agricultural Process Engineering, College of Agricultural Engineering, VNMKV, Parbhani, to identify suitable varieties of soybean, which can produce soypaneer having better and acceptable quality characteristics.

MATERIALS AND METHODS

Well graded dehulled split dal of 12 soybean varieties viz., JS-335, MAUS-71, MAUS-61, MAUS-61-2, MAUS-47, MAUS-81, MAUS-158, MAUS-2, MAUS-32, DS-228, JS-9305 and TMAS-98-21 were used for the study. Soy milk plant available at College of Agricultural Engineering and Technology, VNMKV, Parbhani was used for the preparation of soymilk. One kg of soybean dal was soaked in water for 6-7 hrs. Soaked dal was washed with clean water. Soaked soybean dal was ground and cooked in water for 20 minutes simultaneously in the cooker cum grinder of soy milk plant. The above mixture was then collected in filter. After filtration of the slurry, 8 litres of soymilk and okara were collected separately. Further soymilk was coagulated with citric acid with 2 g litre^{-1} of milk at 70^{0}C. For this purpose, required quantity of citric acid was dissolved in small amount of water and this coagulant was

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added in milk and mixture was stirred for few seconds and left undisturbed for 15 minutes. Thus, residue in muslin cloth was gently transferred to paneer press. Pressing was done for about 15 minutes in paneer press to remove the whey. Then, muslin cloth was removed and soypaneer block was immediately kept in chilled water.

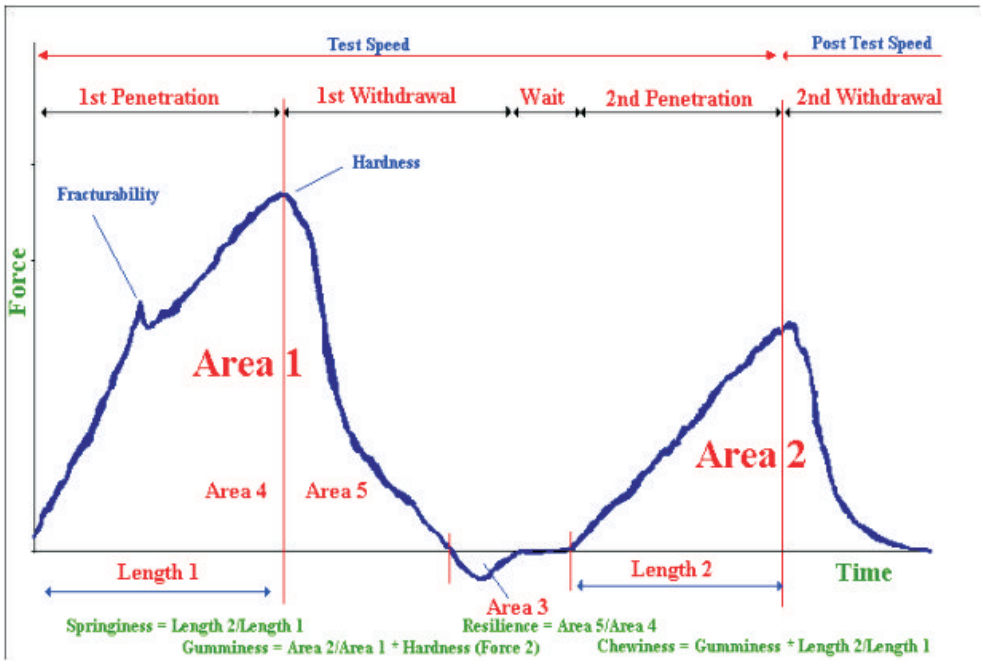
The textural properties of soypaneer at room temperature were evaluated using Texture Profile Analyzer, Stable Micro System, as per the method suggested by Bourne (1968). Textural qualities of soypaneeer like hardness, chewiness, cohesiveness and springiness were determined by texture analyzer through Texture Profile Analysis (TPA). Soypaneer sample of 10 mm thickness was compressed by using 32 mm diameter perplex cylindrical probe until 30% of its orginal thickness. The speed of probe was fixed at 0.5 cm s^{-1} during the pretest, compression and the relaxation of soypaneer sample. During testing, soypaneer sample was held manually against the base plate (Karadbhanje and Bhoyarkar, 2010). The typical textural profile (force-time) curve obtained with one complete run is presented in figure 1. The data obtained from curve were used for the calculation of the textural parameters as described by Bourne, (1968).

Hardness g = Value of the peak (maximum) force of the first compression of the product.

Cohesiveness : Extent to which a material can be deformed before it ruptures depending on the strength of internal bonds and can be determined by :
Cohesiveness = Area under First Compression Area 2 Area under First Compression Area 1 Adhesiveness is the force necessary to remove the material that adheres to the mouth while eating food, Adhesiveness, g. s. = Negative area in the graph (Area 3)
Springiness is the extent to which a product physically springs back after deformation during the first compression; Springiness = Length1/Length2 Chewiness is the energy required for masticating a solid food product to make it ready for swallowing; Chewiness, g= Hardness x Cohesiveness x Springiness.

The obtained hardness of soypaneer was compared within different varieties as it is most domination quality characteristics of soypaneer.

For sensory evaluation, the soypaneer samples prepared form twelve varieties were cut into pieces; having a size of 5 cm x 6 cm. Sensory evaluation was carried out by standard method (Anonymous, 1971). The nine point hedonic scale was used for evaluation for assigning the numerical values for different quality attributes of soypaneer viz., colour and appearance, flavour, taste, body and texture and overall acceptability. The data were analyzed statistically (Panse and Sukhatme, 1989).



RESULTS AND DISCUSSION

Yield of soymilk, soypaneer, okara and whey

The yield of milk and different by products such as okara and whey obtained during preparation of soypaneer are presented in table 1. Milk yield of around 8 litres was obtained from 1 kg^{-1} of dry soybean during preparation of soypaneer. Significant difference was observed in the milk yield obtained from diferent varieties of soybean. The highest milk yield was obtained from JS-335, MAUS-158 and MAUS-71 (8.60 1 kg^{-1} of dry soybean) whereas the lowest milk yield was obtained form MAUS-81, MAUS-61, JS-93-05 (8.00 1kg^{-1} of dry soybean).

The yield of soypaneer was calculated as kilograms of soypaneer kg^{-1} of dry soybean. Significant differences were observed in the yield of soypaneer prepared from different varieties of soybean. The soypaneer obtained from different varieties was ranged from 1.19 kg to 1.34 kg. Highest paneer yield (1.34 kg) was obtained from variety JS-335 and MAUS-158 followed by MAUS-71 (1.32 kg). The lowest yield of soypaneer was obtained from variety DS-228 (1.10 kg) followed by TMAS-91-21 and MAUS-81. Harjai and Singh (2007) also evaluated different soybean varieties for preparation of soymilk and reported that under identical conditions of extrication, yield of soymilk from various varieties was different. Further they reported that soybean varieties PS-1347 gave maximum soymilk (8.60 1kg^{-1}) whereas PS-1042 gave the minimum soymilk (8.37 1kg^{-1}) yield.

Range of okara obtained was 0.93 to 1.77 kg kg^{-1} of dry soybean. Significant difference was observed in the okara obtained from different varieties of soybean. The highest quantity of okara (1.77 kg kg^{-1} of dry soybean) was obtained from variety MAUS-61-2 followed by MAUS-158 and MAUS-2 (1.47 kg kg^{-1}) of dry soybean). The lowest quantity of okara (0.93 and 1.11 kg kg^{-1} of dry soybean) yield was obtained from varieties MUAS-32 and MAUS-61, respectively.

Significant difference was also observed in the yield of whey obtained during preparation of soypaneer from different varieties of soybean. Whey obtained from different verities ranged between 6.01 to 7.70 1 kg^{-1} of dry soybean. The highest whey was obtained from JS-9305 and MAUS-61 (6.90 1 kg^{-1} of dry soybean) variety followed by and MAUS-47 (6.80 1 kg^{-1} of dry soybean). Lowest whey was obtained from MAUS-32 (6.0 1 kg^{-1} of dry soybean) variety of soybean. Soybean varieties JS-335, MAUS-158 and MAUS-71 were found superior than others as concerned to maximum yield of soymilk and soypaneer.

Textural analysis of soypaneer

Textural quality of soypaneer like hardness, chewiness, cohesiveness and springiness were computed through textural profile analysis (TPA). Average value of various textural properties are mentioned in table 2. The data indicates that all textural attributes (hardness, chewiness, cohesiveness) of soypaneer prepared from different varieties of soybean differed significantly except springiness. Mathare *et al.* (2009) also studied different textural properties of soypaneer like hardness, springiness, chewiness, cohesiveness and reported similar trend.

Hardness is the most commonly evaluated characteristic while determining textural properties of paneer. Range of hardness of soypaneer prepared from different varieties was 436.8 to 989. 1 g. Hardness of soypaneer prepared from JS-335, MAUS-158 and MAUS-71 soybean varieties was found higher than that of other varieties and was nearer to the hardness of milk paneer which was considered as standard for its textural qualities. The value for hardness and chewiness (1122 g and 2503.97 g) in case of milk paneer was higher than that of soypaneer. Similar results were also reported by Uprit and Mishra (2004) who studied the textural kinetics of soy fortified paneer during salt treatment process. The soypaneer prepared from JS-335, MAUS-158 and MAUS-71 soybean varieties was superior with respect to all textural properties.

Sensory analysis of soypaneer

The properties of soypaneer evaluated with respect to color and appearance, taste, flavor, body and texture and overall acceptability were also evaluated by panel of ten judges using nine point Hedonic Scale (Anonymous, 1971). Similar procedure for evaluation of sensory properties of milk panner was reported by Rajakumar *et al.* (2010). Table 3 shows average score of values obtained for different parameters by panel of judges.

Table 1. Yield of soypaneer, milk, okara and whey obtained from different varieties of soybean

Sr. No.	Variety	Soymilk ($1kg^{-1}$ of dry soybean)	Soypaneer (kg kg^{-1} of dry soybean)	Okara(kg)	Whey ($1kg^{-1}$ of dry soybean)
1	MAUS-71	8.60	1.32	1.23	6.60
2	MAUS-47	8.40	1.14	1.37	6.80
3	MAUS-158	8.60	1.34	1.47	6.40
4	MAUS-32	8.20	1.18	0.93	6.00
5	MAUS-61-2	8.10	1.24	1.77	6.78
6	MAUS-2	8.40	1.27	1.47	6.68
7	MAUS-81	8.00	1.13	1.34	6.00
8	MAUS-61	8.00	1.30	1.11	6.90
9	JS-335	8.60	1.34	1.22	6.31
10	JS-9305	8.00	1.16	1.23	6.90
11	DS-228	8.30	1.10	1.33	6.50
12	TMAS-98-21	8.10	1.11	1.39	6.60
	SE±	0.128	0.045	0.053	0.125
	CD at 5%	0.377	0.133	0.156	0.377

Table 2. Textural analysis of soypaneer prepared from different varieties of soybean

Sr. No.	Variety	Hardness (g)	Cohesiveness	Springiness	Chewiness
1	MAUS-71	987.3	0.672	1.140	496.7
2	MAUS-47	530.2	0.581	1.135	348.7
3	MAUS-158	982.1	0.655	1.211	310.1
4	MAUS-32	691.4	0.493	1.128	335.3
5	MAUS-61-2	968.8	0.711	1.165	724.1
6	MAUS-2	672.5	0.466	1.145	591.0
7	MAUS-81	464.7	0.499	1.154	298.7
8	MAUS-61	768.2	0.590	1.130	512.8
9	JS-335	989.1	0.660	1.158	305.2
10	JS-9305	561.2	0.564	1.148	350.6
11	DS-228	436.8	0.483	1.137	356.9
12	TMAS-98-21	538.9	0.534	1.152	432.4
13	Milk Paneer	1122	1.730	1.290	2503.97
	SE±	12.18	0.0436	0.0454	26.104
	CD at 5%	36.32	0.1234	--	76.646

Table 3. Sensory scores of soypaneer prepared from different varieties of soybean

Sr. No.	Variety	Color and appearance	Flavor	Taste	Body and texture	Overall acceptability
1	MAUS-71	7.7	7.6	8.0	7.5	8.2
2	MAUS-47	7.3	7.0	7.1	7.0	7.0
3	MAUS-158	7.8	7.6	8.0	7.7	8.4
4	MAUS-32	3.2	4.7	4.0	4.0	4.1
5	MAUS-61-2	6.5	6.8	7.0	7.1	6.9
6	MAUS-2	6.7	5.6	7.5	7.0	7.1
7	MAUS-81	7.6	7.0	7.4	7.1	7.5
8	MAUS-61	5.5	5.6	5.5	6.6	5.3
9	JS-335	8.3	8.7	8.1	7.9	8.6
10	JS-9305	6.3	5.9	7.0	4.0	7.6
11	DS-228	7.2	5.6	4.7	7.1	5.9
12	TMAS-98-21	6.7	7.0	7.7	6.6	7.1
	SE±	0.176	0.184	0.135	0.161	0.144
	CD at 5%	0.518	0.544	0.399	0.475	0.425

Note - Scores on the basis of nine point Hedonic Scale

Soypaneer prepared from variety JS-335, MAUS-158 and MAUS-71 was found whitish in color and resembles like milk paneer. Maximum score of all sensory parameters was obtained for soypaneer prepared from JS-335, followed by MAUS-158 and MAUS-71. The milk obtained from JS-335 was white in color and taste of milk was the best as compared that obtained from other varieties. Flavour of milk obtained from JS-335 variety was also superior amongs all followed by that obtained from MAUS-158 and MAUS-71. The taste and color of milk prepared from MAUS-2 and MAUS-32 was very poor.

From table 3, it is clear that all the soypaneer samples varied significantly for color and appearance, flavor, taste, body and texture and overall acceptability score prepared from all twelve varieties of soybean at 1% level of significance. It can be concluded that the soybean varieties viz., JS-335, MAUS-158 and MAUS-71 were found superior than the other soybean varieties for the production of better quality of soypaneer with respect to organolyptic properties.

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