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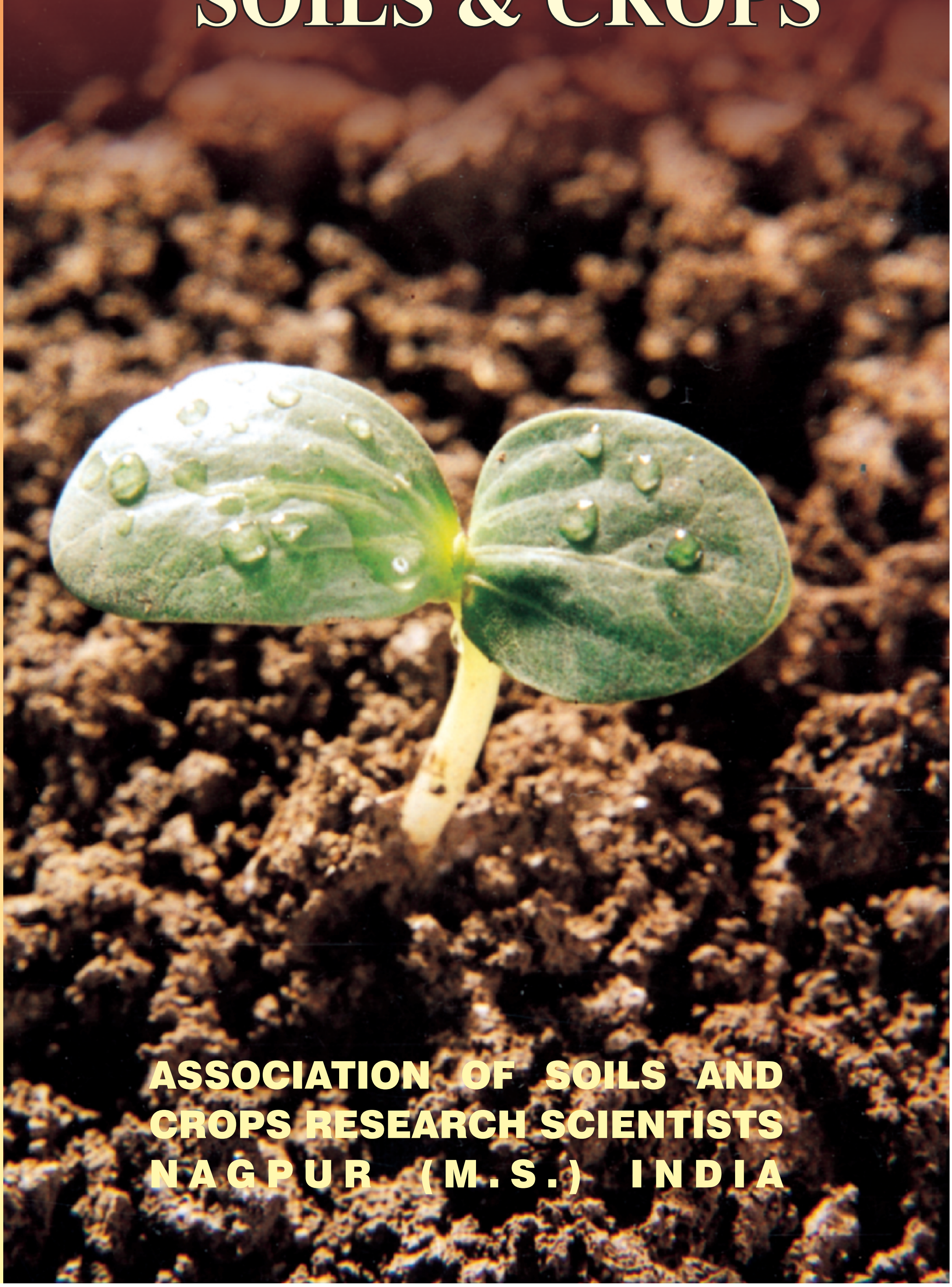

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EFFECT OF ESTABLISHMENT METHODS AND NITROGEN LEVELS ON UPTAKE OF MICRONUTRIENTS IN BASMATI RICE

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

ABSTRACT

A field experiment was conducted 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}) to evaluate the effect of methods of establishment and nitrogen levels on micronutrients uptake in basmati rice. The results showed that significantly higher grain yield was recorded with machine transplanted basmati rice after puddling which was statistically similar to direct seeded basmati rice with brown manuring. The effect of different methods of establishment and nitrogen levels on Zn, Mn and Fe content (%) in basmati rice grains and straw was non-significant. However, Zn, Mn and Fe uptake in grain and Mn uptake in straw was significantly higher in direct seeded basmati rice with brown manuring. Among nitrogen levels, 125% of recommended dose of nitrogen (51.14 kg N ha^{-1}) resulted in significantly higher grain yield. 125% of recommended dose of nitrogen recorded maximum Zn, Mn and Fe uptake in grain and straw. The interaction effects between nitrogen levels and establishment methods were non-significant.

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

INTRODUCTION

Conventional crop establishment practice in rice involves manual transplanting of rice in puddled soil. Puddling, a pre-requisite for rice transplanting, result not only in high-energy consumption but also in deterioration of soil structure, decreases the soil aggregates and pore size, thereby restricting germination and rooting of the succeeding crops (Ram *et al.,* 2006). Manual transplanting of rice, done usually by hired labour, shortage of labour during the peak period of transplanting, and escalating labour wages are the new challenges facing rice farmers in the state. Transplanting often gets delayed due to non availability of labour. The late planted crop has low productivity due to restricted vegetative growth (Chaudhary *et al*., 2011). Direct seeding and machine transplanting were examined as alternative methods for rice establishment. Optimization of applied nitrogen at critical growth stage,coinciding with the period of efficient utilization is essential (Pandey *et al*., 2002). The nitrogen requirement of direct seeded basmati rice for realizing optimum yield is lacking. Therefore, present study was conducted to evaluate the effect of different establishment methods and nitrogen levels on grain yield and micronutrient uptake in grain and straw of basmati 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 composition. 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 (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.

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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

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 with seed rate of @ 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 20 x 15 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 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) 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 yield were recorded. For estimating the micronutrients (Zn, Fe and Mn) content in grain and straw, the samples were collected from each plot at physiological maturity and dried in hot air oven at 60°C for 3 days. Dried samples were digested in a diacid mixture of nitric acid (HNO_3) and perchloric acid ($HClO_4$) in the ratio of 4:1 for the analysis of total Fe, Zn and Mn. The concentrations (ppm) of Fe, Zn and Mn were determined using an Atomic Absorption Spectrophotometry method given by Isaac and Kerber (1971). Fe, Zn and Mn uptake in grain, straw and total (Grains + Straw) was estimated by multiplying concentrations (ppm) of Fe, Zn and Mn to grain, straw and total (Grain + Straw) yield.

RESULTS AND DISCUSSION

Grain yield :

Machine transplanting of rice after puddling, being statistically at par with direct seeded basmati rice with brown manuring, yielded significantly more as compared to other methods of establishment. 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. Optimum utilization of resources and better yield attributes led to higher yield of basmati rice under machine transplanting of basmati rice after puddling (Table 2). Dixit *et al.* (2010) also reported 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}), direct seeded drill with adjustment of 15 kg ha^{-1} seed rate (7.20 t ha^{-1}) and drum seeded puddled transplanted rice with seed rate of 50 kg ha^{-1} (6.10 t ha^{-1}).

The highest grain yield (40.64 and 37.07 kg ha^{-1}) was obtained with 125% of RDN (51.14 kg N ha^{-1}). Higher values of growth parameters and yield attributing characters ultimately resulted in higher grain yield with 125% of RDN (51.14 kg N ha^{-1}). Singh and Walia (2010) also observed that application of 120 and 150 kg ha^{-1} gave similar grain yield in direct seeded and transplanted rice but significant superior to 90 kg N ha^{-1}.

Plant analysis :

Zinc (Zn), manganese (Mn) and iron (Fe) content of basmati grains and straw :

Statistically similar Zinc, manganese and iron content of basmati rice grain and straw was recorded with different crop establishment methods and nitrogen levels (Table 3, 4 and 5).

Zinc (Zn) uptake in grains and straw :

It is clearly seen from table 6 that direct seeded basmati rice with brown manuring recorded significantly more Zn uptake in grains [447.79 g ha^{-1} (2010), 393.75 g ha^{-1} (2011) and 420.77 g ha^{-1} (Pooled)] as compared to other methods of establishment. Direct seeded basmati rice without brown manuring and machine transplanted basmati rice in zero tilled plots with brown manuring were statistically at par with each other. Conventional transplanting of basmati rice and machine transplanting of basmati rice in zero tilled plots without brown manuring gave significantly lower Zn uptake and were statistically at par with each other.

Zn uptake by basmati rice straw in different methods of establishment were statistically at par. This might be attributed to statistically similar straw yield and Zn content in different establishment methods.

Total Zn uptake in grain and straw [1846.96 g ha^{-1} (2010), 1644.06 g ha^{-1} (2011) and 1745.51 g ha^{-1} (Pooled)] was significantly higher with direct seeded basmati rice with brown manuring. All methods of establishment differed significantly among themselves.

Nitrogen levels significantly influenced the uptake of Zn in grains and straw of basmati rice (Table 6). The significantly higher uptake of Zn in grains and straw was obtained with 125% of RDN (51.14 kg N ha^{-1}) which was statistically at par with Zn uptake in grains with 100% of RDN during both the years of study and was statistically at par with Zn uptake in straw with 100% of RDN during 2010. Total Zn uptake in grain and straw [2037.06 g ha^{-1} (2010), 1750.82 g ha^{-1} (2011) and 1893.94 g ha^{-1} (Pooled)] was significantly higher with 125% of RDN (51.14 kg N ha^{-1}) than all other nitrogen levels. Hosseiny and Maftoun, (2008) also reported that application of 400 mg N kg^{-1} soil increased Zn uptake and concentration compared to 50 and 100 mg N kg^{-1} and control treatments. The higher Zn uptake by basmati rice grain and straw in 125% of RDN (51.14 kg N ha^{-1}) nitrogen level might be attributed to higher grain and straw yield with this treatment.

Manganese (Mn) uptake in grains and straw :

Data from table 7 revealed that significantly more uptake of Mn in grains of basmati rice was observed with direct seeded basmati rice with brown manuring [105.06 g ha^{-1} (2010), 99.09 g ha^{-1} (2011) and 102.08 g ha^{-1} (Pooled)]. This might be due to higher Mn content in grains with this treatment. Significantly lowest uptake of Mn in grains of basmati rice was obtained with conventional transplanted rice.

Mn uptake in basmati rice straw was significantly more with direct seeded basmati rice with brown manuring [1637.18 g ha^{-1} (2010), 1515.37 g ha^{-1} (2011) and 1576.28 g ha^{-1} (Pooled)] as compared to other establishment methods and was statistically at par with machine transplanted basmati rice after puddling, direct seeded basmati rice without brown manuring and machine transplanted basmati rice in zero tilled plots with brown manuring. Higher Mn uptake by straw in these treatments might be due to higher Mn content and straw yield.

Significantly higher total Mn uptake in grain and straw [1742.24 g ha^{-1} (2010), 1614.46 g ha^{-1} (2011) and 1678.36 g ha^{-1} (Pooled)] in basmati rice was also obtained with direct seeded basmati rice with brown manuring and was statistically at par with machine transplanted basmati rice after puddling.

With respect to nitrogen levels (Table 7), Mn uptake in basmati rice grains and straw was significantly higher with 125% of RDN (51.14 kg N ha^{-1}) which was statistically at par with Mn uptake in grains with 100% of RDN (40.91 kg N ha^{-1}) during both the years of study and Mn uptake in basmati rice straw during 2010. 125% of RDN (51.14 kg N ha^{-1}) also gave significantly higher total Mn uptake in grain and straw [2022.50 g ha^{-1} (2010), 1781.98 g ha^{-1} (2011) and 1902.25 g ha^{-1} (Pooled)] in basmati rice. This might be due to higher grain and straw yield of basmati rice in this treatments as compared to other treatments.

Iron (Fe) uptake in grains and straw :

Data in table 8 showed that Fe uptake of basmati rice grains [269.88 g ha^{-1} (2010), 257.11 g ha^{-1} (2011) and 263.50 g ha^{-1} (Pooled)] increased significantly with direct seeded basmati rice with brown manuring. Direct seeded basmati rice without brown manuring and machine transplanted basmati rice in zero tilled plots with brown manuring recorded statistically similar Fe uptake in grains of basmati rice during 2010. Similarly, during 2011 direct seeded basmati rice without brown manuring and machine transplanted basmati rice after puddling were statistically at par with each other. Machine

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

Treatments	Grain yield (q ha^{-1})	
	2010	2011
Establishment methods		
DSBR	33.70	30.90
DSBR with brown manuring *Sesbania*	34.30	31.31
Machine transplanting in ZT with brown manuring	32.96	30.12
Machine transplanting in ZT without brown manuring	32.27	29.52
Machine transplanting after puddling	34.63	31.73
Conventional practice	33.10	30.34
SE±	0.14	0.18
CD (P=0.05)	0.47	0.52
Nitrogen levels (kg ha^{-1})		
Control	22.25	19.88
75% of RDN	32.49	30.17
100% of RDN	38.60	35.49
125% of RDN	40.64	37.07
SE±	0.25	0.46
CD (P=0.05)	0.73	1.37

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

Treatments	Zn (ppm)								
	2010			2011			Pooled		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
DSBR	126.69	158.19	284.88	118.83	153.83	272.66	122.76	156.01	278.77
DSBR with brown manuring *Sesbania*	130.50	159.94	290.44	125.91	156.58	282.49	128.21	158.26	286.47
Machine transplanting in ZT with brown manuring	127.88	159.31	287.19	120.58	155.92	276.50	124.23	157.62	281.85
Machine transplanting in ZT without brown manuring	122.38	156.16	278.54	112.42	151.42	263.84	117.40	153.79	271.19
Machine transplanting after puddling	126.55	157.50	284.05	115.92	152.92	268.84	121.24	155.21	276.45
Conventional practice	120.00	155.94	275.94	110.08	150.08	260.16	115.04	153.01	268.05
SE±	0.02	0.01	0.03	0.02	0.03	0.05	0.02	0.03	0.05
CD (P=0.05)	-	-	-	-	-	-	-	-	-
Nitrogen levels (kg ha^{-1})									
Control	132.63	162.61	295.24	118.28	154.39	272.67	125.46	158.50	283.96
75% of RDN	131.59	156.11	287.70	118.22	148.44	266.66	124.91	152.28	277.19
100% of RDN	125.97	152.23	278.20	116.78	146.94	263.72	121.38	149.59	270.97
125% of RDN	121.47	150.40	271.87	115.89	146.06	261.95	118.68	148.23	266.91
SE±	0.02	0.02	0.04	0.01	0.04	0.05	0.01	0.03	0.04
CD (P=0.05)	-	-	-	-	-	-	-	-	-

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

Treatments	Mn (ppm)								
	2010			2011			Pooled		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
DSBR	28.89	184.90	213.79	30.68	187.26	217.94	29.79	186.08	215.87
DSBR with brown manuring *Sesbania*	30.55	187.15	217.70	31.80	189.78	221.58	31.18	188.47	219.65
Machine transplanting in ZT with brown manuring	30.53	186.11	216.64	31.76	189.06	220.82	31.15	187.59	218.74
Machine transplanting in ZT without brown manuring	27.16	182.00	209.16	28.43	185.83	214.26	27.80	183.92	211.72
Machine transplanting after puddling	27.69	182.21	209.90	30.65	186.58	217.23	29.17	184.40	213.57
Conventional practice	25.24	181.49	206.73	26.63	183.30	209.93	25.94	182.40	208.34
SE±	0.01	0.01	0.02	0.01	0.02	0.03	0.01	0.02	0.03
CD (P=0.05)	-	-	-	-	-	-	-	-	-
Nitrogen levels (kg ha^{-1})									
Control	30.11	197.63	227.74	33.49	194.57	228.06	31.80	196.10	227.9
75% of RDN	24.91	190.26	215.17	30.77	187.97	218.74	27.84	189.12	216.96
100% of RDN	24.88	189.64	214.52	28.27	186.67	214.94	26.58	188.16	214.74
125% of RDN	23.47	187.77	211.24	27.44	185.66	213.1	25.46	186.72	212.18
SE±	0.01	0.02	0.03	0.03	0.02	0.05	0.02	0.02	0.04
CD (P=0.05)	-	-	-	-	-	-	-	-	-

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

Treatments	Fe (ppm)								
	2010			2011			Pooled		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
DSBR	76.75	248.01	324.76	80.33	253.76	334.09	78.54	250.89	329.43
DSBR with brown manuring *Sesbania*	78.63	249.88	328.51	82.27	254.99	337.26	80.45	252.44	332.89
Machine transplanting in ZT with brown manuring	78.50	249.13	327.63	81.10	254.33	335.43	79.80	251.73	331.53
Machine transplanting in ZT without brown manuring	75.69	244.81	320.5	77.48	251.93	329.41	76.59	248.37	324.96
Machine transplanting after puddling	76.69	246.50	323.19	78.48	252.83	331.31	77.59	249.67	327.26
Conventional practice	74.81	244.63	319.44	75.43	250.89	326.32	75.12	247.76	322.88
SE±	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.02
CD (P=0.05)	-	-	-	-	-	-	-	-	-
Nitrogen levels (kg ha^{-1})									
Control	83.50	288.42	371.92	89.57	287.04	376.61	86.54	287.73	374.27
75% of RDN	75.17	280.71	355.88	75.72	281.09	356.81	75.45	280.90	356.35
100% of RDN	74.50	278.88	353.38	75.79	280.58	356.37	75.15	279.73	354.88
125% of RDN	74.21	277.63	351.84	75.64	279.78	355.42	74.93	278.71	353.64
SE±	0.01	0.01	0.02	0.01	0.03	0.04	0.01	0.02	0.03
CD (P=0.05)	-	-	-	-	-	-	-	-	-

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

Treatments	Zn (g ha^{-1})								
	2010			2011			Pooled		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
DSBR	426.98	1359.52	1786.50	366.95	1211.90	1578.85	396.97	1285.71	1682.68
DSBR with brown manuring *Sesbania*	447.79	1399.17	1846.96	393.75	1250.31	1644.06	420.77	1324.74	1745.51
Machine transplanting in ZT with brown manuring	421.67	1340.93	1762.60	362.71	1197.32	1560.03	392.19	1269.13	1661.32
Machine transplanting in ZT without brown manuring	394.95	1286.48	1681.43	331.63	1139.92	1471.55	363.29	1213.20	1576.49
Machine transplanting after puddling	438.52	1389.79	1828.31	367.34	1237.47	1604.81	402.93	1313.63	1716.56
Conventional practice	397.33	1316.58	1713.91	333.39	1161.19	1494.58	365.36	1238.89	1604.25
SE±	2.30	0.21	2.51	1.90	0.29	2.19	2.10	0.25	2.35
CD (P=0.05)	6.85	-	6.85	5.66	-	5.66	6.26	-	6.26
Nitrogen levels (kg ha^{-1})									
Control	295.08	1032.59	1327.67	234.96	939.27	1174.23	265.02	985.93	1250.95
75% of RDN	427.75	1196.17	1623.92	356.26	1108.43	1464.69	392.01	1152.30	1544.31
100% of RDN	486.10	1507.09	1993.19	414.40	1112.77	1527.17	450.25	1309.93	1760.18
125% of RDN	493.56	1543.50	2037.06	429.50	1321.32	1750.82	461.53	1432.41	1893.94
SE±	3.24	34.12	37.36	5.16	28.25	33.41	4.20	31.19	35.39
CD (P=0.05)	9.71	101.94	111.65	15.44	84.42	99.86	12.58	93.18	105.76

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

Treatments	Mn (g ha^{-1})								
	2010			2011			Pooled		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
DSBR	97.39	1589.06	1686.45	94.57	1475.26	1569.83	95.98	1532.16	1628.14
DSBR with brown manuring *Sesbania*	105.06	1637.18	1742.24	99.09	1515.37	1614.46	102.08	1576.28	1678.36
Machine transplanting in ZT with brown manuring	100.91	1566.38	1667.29	95.18	1451.78	1546.96	98.05	1509.08	1607.13
Machine transplanting in ZT without brown manuring	87.67	1499.34	1587.01	83.70	1398.96	1482.66	85.69	1449.15	1534.84
Machine transplanting after puddling	96.16	1607.71	1703.87	96.78	1509.79	1606.57	96.47	1558.75	1655.22
Conventional practice	83.66	1532.26	1615.92	80.20	1418.32	1498.52	81.93	1475.29	1557.22
SE±	0.70	31.86	32.56	0.72	29.96	30.68	0.71	30.91	31.62
CD (P=0.05)	2.05	95.49	97.54	2.23	91.56	93.79	2.14	93.53	95.67
Nitrogen levels (kg ha^{-1})									
Control	67.12	1255.08	1322.2	66.25	1183.59	1249.84	66.69	1219.34	1286.03
75% of RDN	81.02	1457.67	1538.69	92.97	1403.59	1496.56	87.00	1430.63	1517.63
100% of RDN	96.18	1877.58	1973.76	99.61	1413.49	1513.1	97.90	1645.54	1743.44
125% of RDN	95.49	1927.01	2022.5	102.40	1679.58	1781.98	98.95	1803.30	1902.25
SE±	1.50	36.10	37.6	1.76	42.18	43.94	1.63	39.14	40.77
CD (P=0.05)	4.53	106.14	110.67	5.24	125.95	131.19	4.89	116.05	120.94

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

Treatments	Fe (g ha^{-1})								
	2010			2011			Pooled		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Establishment methods									
DSBR	258.68	2131.43	2390.11	247.99	1999.15	2247.14	253.34	2065.29	2318.63
DSBR with brown manuring *Sesbania*	269.88	2185.88	2455.76	257.11	2036.02	2293.13	263.50	2110.95	2374.45
Machine transplanting in ZT with brown manuring	258.91	2096.85	2355.76	243.80	1952.83	2196.63	251.36	2024.84	2276.20
Machine transplanting in ZT without brown manuring	244.28	2016.78	2261.06	228.49	1896.56	2125.05	236.39	1956.67	2193.06
Machine transplanting after puddling	265.77	2175.06	2440.83	248.54	2045.72	2294.26	257.16	2110.39	2367.55
Conventional practice	247.64	2065.18	2312.82	228.26	1941.26	2169.52	237.95	2003.22	2241.17
SE±	1.28	0.16	0.72	1.35	0.14	0.745	1.32	0.15	0.735
CD (P=0.05)	3.79	-	3.79	4.10	-	4.1	3.95	-	3.95
Nitrogen levels (kg ha^{-1})									
Control	185.91	1831.59	2017.50	178.26	1746.19	1924.45	182.09	1788.89	1970.98
75% of RDN	244.40	2150.70	2395.10	228.07	2098.71	2326.78	236.24	2124.71	2360.95
100% of RDN	287.71	2761.05	3048.76	268.54	2124.69	2393.23	278.13	2442.87	2721.00
125% of RDN	301.65	2849.10	3150.75	280.81	2531.00	2811.81	291.23	2690.05	2981.28
SE±	1.80	41.90	21.85	3.60	42.08	22.84	2.70	41.97	22.335
CD (P=0.05)	5.42	126.98	66.2	10.80	124.71	67.755	8.11	125.85	66.98

transplanted rice in zero tilled plots without brown manuring and conventional transplanted rice gave significantly lower Fe uptake in grains which were statistically at par with each other during both the years of study.

Different methods of establishment remained statistically at par in respect of Fe uptake by basmati rice straw. Similar results were obtained during both the years of study. The reason for similar Fe uptake might be attributed to statistically similar straw yield and Fe content of straw among different methods of establishment.

Direct seeded basmati rice with brown manuring recorded significantly higher total Fe uptake in grain and straw [2455.76 g ha^{-1} (2010), 2293.13 g ha^{-1} (2011) and 2374.45 g ha^{-1} (Pooled)] in basmati rice than other establishment methods but was statistically at par with machine transplanted basmati rice after puddling during 2011.

Fe uptake of basmati rice grains and straw increased significantly with nitrogen application upto125% of RDN (51.14 kg N ha^{-1}) as depicted in table 8. Maximum Fe uptake 291.23 g ha^{-1} in grains (Pooled) and 2690.05 g ha^{-1} in straw (Pooled) was found in 125% of RDN (51.14 kg N ha^{-1}) treatment. All levels of nitrogen differed significantly from each other in case of Fe uptake in grains of basmati rice but 125% of RDN (51.14 kg N ha^{-1}) was statistically at par with 100% of RDN (40.91 kg N ha^{-1}) during the study year 2010. Nitrogen level 125% of RDN (51.14 kg N ha^{-1}) also gave significantly higher total Fe uptake in grain and straw [3150.75 g ha^{-1} (2010), 2811.81 g ha^{-1} (2011) and 2981.28 g ha^{-1} (Pooled)] in basmati rice than other nitrogen levels. Higher Fe uptake in grains, straw and total (Grain + Straw) with higher level of nitrogen might be due to higher grain, straw and total yield.

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EFFECT OF ALTERING HOST PLANT NUTRITION SOURCES AGAINST EARLY BLIGHT *(Alternaria solani* ELL. and MART.) DISEASE SEVERITY AND YIELD OF TOMATO

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ABSTRACT

A field experiment was conducted for the two consecutive years 2007-08 and 2008-09 with an aim to explore the possibility of changing host nutrients through organic manures and inorganic fertilizers and their amalgamation to study their effect on early blight disease severity as well as yield of tomato. Alteration in nutrition sources showed difference in disease severity and their differences were statistically significant. All the treatment combinations had reduced the disease severity significantly as compared to untreated control. Disease severity was found to be minimum (AUDPC = 17.65) in only fertilizer treated plots i.e. N_{180}: P_{90}: K_{90} and maximum disease severity (AUDPC= 28.26) was noticed in the soil amended with N_{220}: P_{110}: K_{110} along with 3.2 ton FYM. Two years pooled results suggested maximum fruit yield (424.10 q ha^{-1}) from the plots treated with only N_{220}: P_{110}: K_{110} followed by the treatment combination of N_{220}: P_{110}: K_{110} along with 6.4 ton FYM and1.92 ton ha^{-1} vermicompost with 423.40 q ha^{-1}fruit yield of tomato. The experiment suggested that the application of N_{220}: P_{110}: K_{110} along with 6.4 ton FYM and 1.92 ton vermicompost ha^{-1} increased the fruit yield and reduced the disease severity of early blight of tomato.

(Key words: Tomato, early blight, organic manures, inorganic fertilizers, disease severity, AUDPC)

INTRODUCTION

Tomato *(Lycopersicon esculentum* Mill.*)* is one of the major vegetable crops grown throughout the world. Vegetables constitute the potential cash drops as region's climate and edaphic suitability supports their cultivation almost round the year (Dass *et al.*, 2002). Tomato is the most popular vegetable crop widely grown worldwide outdoor and indoor conditions and stands second to potato (Bose *et al.,* 2002). The production and productivity of the crop is declining every year due to different biotic and abiotic stresses. Among the biotic stress (diseases) early blight caused by the *Alternaria solani* Ell. and Mart. is the most destructive one and is the main fungus causing the economical losses (Tomescu and Negru, 2003) as well as major yield loss (Waals *et al.,* 2001). Yield losses upto 79% from early blight damage have been reported from India, Canada, United States and Nigeria. Saha and Das (2012) reported that losses in yield were 0.76 ton ha^{-1} for every 1% increase in disease severity.

Higher and imbalanced doses of fertilizers led to higher level of early blight incidence and severity, whereas reduction in disease index was observed with every increase in the level of P (Singh *et al.,* 2001). Huang- Shaomin *et al.* (1999) reported that application of K fertilizer increases the resistance of tomato plant to early blight pathogen and decreases disease incidence. Sawant *et al.* (1999) reported that comparatively higher tomato yield can be obtained at a spacing of 45 cm × 60 cm with fertilizer @ 125:100:75 N:P:K kg ha^{-1}. Under the given circumstances, management of early blight needs a new approach. In view of this, investigation was carried out continuously for two years i.e. during 2007-08 and 2008-09 to assess the effect of deployed host nutrient with the application of different doses of organic sources, inorganic fertilizers and their combination against early blight disease severity and yield of tomato as well as to develop a holistic approach module for sustainable and eco-friendly management of this disease.

MATERIALS AND METHODS

Studies were conducted at the University Research Farm of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The farm is situated at 22^{0}93′N (latitude) and 88^{0}33′E (longitude) and altitude 9.75 m above the sea level. The soil of the farm was sandy loam in texture with the pH 7.2. The relative status of the soil during the experimental period was as follows:

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Particulars		Status	Amount
a) Mechanical composition			
i)	Sand	Medium	52.74%
ii)	Silt	Low	19.60%
iii)	Clay	Low	25.66%
b) Chemical composition			
i)	pH	Towards alkalinity	7.2
ii)	Organic carbon	Medium	0.52(%)
iii)	Nitrogen	Low	206.43kg ha^{-1}
iv)	Phosphorus	Low	07.77 kg ha^{-1}
v)	Potassium	Medium	185.46 kg ha^{-1}

21 days old seedlings of tomato variety 'Patharkuchi' were planted in the main field at a spacing of 60 cm x 30 cm on the 28th October in each year to evaluate the efficiency of organic manures and inorganic fertilizers along with varying levels of N, P and K on tomato cultivation. The one third N ,P and K in the form of urea, single super phosphate and muriate of potash were applied as basal during land preparation and the rest amount were top dressed in equal proportion at 30 days and 60 days after sowing. Similarly, FYM and vermicompost were applied in the field at 21 days before planting of seedlings.

The experiment was laid out in randomized block design and replicated three times and plot size was 5×5 sq.m.

Treatment details:
Number of treatments: 12

T_1 = N_{150}:P_{60}: K_{60} (kg ha^{-1}) [810: 938: 251 (g $plot^{-1}$) in the form of Urea, SSP and MOP among them basal dose were 270: 313: 84 and the rest amount were top dressed in equal proportion at 30 days and 60 days after sowing.]

T_2 = N_{180}: P_{90}: K_{90} (kg ha^{-1}) [972: 1406: 376 (g $plot^{-1}$) in the form of Urea, SSP and MOP among them basal dose were 324: 469: 125 and the rest amount were top dressed in equal proportion at 30 days and 60 days after sowing.]

T_3 = N_{220}: P_{110}:K_{110} (kg ha^{-1}) [1188: 1719: 459 (g $plot^{-1}$) in the form of Urea, SSP and MOP among them basal dose were 396: 573: 153 and the rest amount were top dressed in equal proportion at 30 days and 60 days after sowing.]

T_4 = 12 ton ha^{-1} Farm Yard Manure

T_5 = 6 ton ha^{-1}FYM+2 ton ha^{-1} Vermicompost (VC)

T_6 = N_{150}:P_{60}:K_{60} Chemical fertilizers along with 3.2 ton ha^{-1} FYM.

T_7 = N_{180}:P_{90}:K_{90} Chemical fertilizers along with 3.2 ton ha^{-1} FYM.

T_8 = N_{220}:P_{110}:K_{110} Chemical fertilizers along with 3.2 ton ha^{-1} FYM.

T_9 = N_{150}:P_{60}:K_{60} Chemical fertilizers along with 6.4 ton FYM + 1.92 ton VC ha^{-1}.

T_{10} = N_{180}:P_{90}:K_{90} Chemical fertilizers along with 6.4 ton FYM + 1.92 ton VC ha^{-1}.

T_{11} = N_{220}:P_{110}:K_{110} Chemical fertilizers along with 6.4 ton FYM + 1.92 ton VC ha^{-1}.

T_{12} = Neither fertilizers nor any organics were applied (Control).

Here normal agronomic practices were adopted and natural epiphytotic development permitted. Five plants from each plot were selected randomly and observed for the presence of the disease. The disease severity was recorded using 0-9 scale (Mayee and Datar, 1986) and observations were recorded at 10 days interval after the initiation of the disease upto 15 days before last harvest.

The disease severity was averaged over the three replications and disease progress curves were plotted. For each replication the area under disease progress curve (AUDPC) was calculated as per Wilcoxon *et al.* (1975). The formula used as follows:

$$AUDPC = \sum_{i=1}^{N} [(Y_{i+1} + y_i)/2\,(X_{i+1} - X_i)]$$

Here, AUDPC = Area Under Disease Progress Curve Y_i = severity at 1st observation, X_i = Time (days) at first observation, N = Total number of observations.

The onset time was monitored as appearance of first spot and disease severity was recorded at every 10 days interval. Yield data were collected after each harvest of the crop and added up. Finally averaged and converted into yield in q ha^{-1}.

RESULTS AND DISCUSSION

In the year 2007-08, the minimum disease severity was recorded in the plots treated with N_{150}: P_{60}: K_{60} (17.12 AUDPC) followed by N_{180}: P_{90}: K_{90}, N_{220}: P_{110}: K_{110} (18.13 AUDPC) and N_{180}:P_{90}:K_{90} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (19.13 AUDPC) respectively and their differences were not statistically significant.

Maximum disease severity was observed in the soil amended with N_{220}:P_{110}:K_{110} along with 3.2 ton ha^{-1} FYM (27.15 AUDPC) followed by the application of 6 ton ha^{-1}FYM + 2 ton ha^{-1} VC (25.15 AUDPC) and N_{220}:P_{110}:K_{110} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (24.15 AUDPC) and there differences were statistically at par except N_{220}:P_{110}:K_{110} with 3.2 ton ha^{-1} FYM which differ significantly.

In the plots treated with N_{150}:P_{60}:K_{60} along with 3.2 ton ha^{-1} FYM , N_{180}:P_{90}:K_{90} chemical fertilizers along with 3.2 ton ha^{-1} FYM and N_{150}:P_{60}:K_{60} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} showed same AUDPC i.e.22.14 which means the treatments did not differ significantly among themselves in reducing the disease severity.

It was also observed that the disease severity was lower where only chemical fertilizers were applied in comparison to organic manures. Three doses of chemical fertilizer application showed no significant difference in reducing the disease severity. So also, two doses of organic manures application also showed no significant difference in disease severity. The three different doses of fertilizers and two doses of organic manures in combination showed difference in disease severity excluding N_{150}:P_{60}:K_{60} chemical fertilizers along with 3.2 ton ha^{-1} FYM, N_{180}:P_{90}:K_{90} chemical fertilizers along with 3.2 ton ha^{-1} FYM and N_{150}:P_{60}:K_{60} chemical fertilizers along with 6.4 ton FYM + 1.92 ton VC ha^{-1}.

Among the plots where both chemical fertilizers and organics were applied in combination there minimum disease severity was observed in N_{180}: P_{90}: K_{90} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (19.13 AUDPC) treated plot which differ significantly with the other treatments N_{150}:P_{60}:K_{60} along with 3.2 ton ha^{-1} FYM (22.14 AUDPC), N_{150}: P_{60}: K_{60} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (22.14 AUDPC) and N_{220}: P_{110}: K_{110} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (24.15 AUDPC) applications (Table1).The above findings support the report by Reddy and Reddy (2008) that though the organic manures had positive effects, but 100% organic manures could not meet the nutrient requirement of the plant because of the slow release or nutrients. So, combination of chemical fertilizers with any one of the organics is always beneficial.

In the year 2008-09, minimum disease severity was noticed in the soil ammended with N_{220} : P_{110} : K_{110} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (17.09 AUDPC) followed by the application of N_{180}: P_{90} : K_{90} (17.17 AUDPC) and N_{180}: P_{90}: K_{90} with 3.2 ton ha^{-1} FYM (18.19 AUDPC) and differences between them were not statistically significant.

Like the previous year, maximum disease severity was observed in the soil amended with N_{220} : P_{110} : K_{110} along with 3.2 ton ha^{-1} FYM (29.37 AUDPC) followed by the application of 6 ton ha^{-1}FYM + 2 ton ha^{-1} VC (26.35 AUDPC) and N_{150}:P_{60}:K_{60} along with 3.2 ton FYM (24.31 AUDPC) and they were statistically at par except N_{220} : P_{110} : K_{110} along with 3.2 ton ha^{-1} FYM which differ significantly.

Among the three fertilizer doses without organic manures N_{150}:P_{60}: K_{60} (19.20 AUDPC), N_{180}: P_{90}: K_{90} (17.17 AUDPC),N_{220} : P_{110} : K_{110} (23.30 AUDPC) and untreated control (32.31 AUDPC) also showed no significant difference among themselves in disease severity except the later two.Similarly, application of only organic manures at the rate 12 ton ha^{-1} FYM (21.27 AUDPC) and 6 ton ha^{-1}FYM + 2 ton ha^{-1} Vermicompost (26.35 AUDPC) showed significant difference in between them in disease severity (Table 1).

The two years pooled mean showed that three doses of fertilizers, two doses of organic manures and their different combinations reduced the early blight severity significantly as compared to untreated control. Amongst all the treatments N_{180}: P_{90}: K_{90}(17.65 AUDPC) showed minimum disease severity followed by N_{150}:P_{60}: K_{60}(18.16 AUDPC) and N_{180}:P_{90}:K_{90} chemical fertilizers along with 3.2 ton ha^{-1} FYM (20.17 AUDPC) and there differences were not significantly different between the first two treatments but differ significantly with N_{180}:P_{90}:K_{90} along with 6.4 ton FYM + 1.92 ton VC ha^{-1}. Bharadwaj *et al.* (2010) reported that application of vermicompost in the root zone resulted increase in availability and uptake of nutrients by the plant thus provide better growth to the plants.

The three fertilizers doses N_{220} : P_{110} : K_{110} (20.72 AUDPC) significantly differ in disease severity with N_{150}:P_{60}: K_{60}(18.16 AUDPC) and N_{180}: P_{90}: K_{90}(17.65 AUDPC) which was statistically at par. Among the two doses of organic manures maximum disease severity was observed in 6 ton ha^{-1} FYM + 2 ton ha^{-1} vermicompost (25.75 AUDPC) and minimum in the plot12 ton ha^{-1} FYM (22.21 AUDPC) and their difference was also statistically significant.

Different combinations of three doses of fertilizers and two doses of organic manures application in the field showed maximum disease severity in N_{220}:P_{110}:K_{110} along with 3.2 ton ha^{-1} FYM (28.26 AUDPC) followed by 6 ton ha^{-1} FYM + 2 ton ha^{-1} VC (25.75 AUDPC),N_{150}:P_{60}:K_{60} with 3.2 ton ha^{-1} FYM (23.23 AUDPC) and N_{150}:P_{60}:K_{60} chemical fertilizers along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (22.21 AUDPC) and their differences were statistically significant with the treatment N_{220}:P_{110}:K_{110} with 3.2 ton ha^{-1} FYM.

In case of fruit yield it was observed that reduction in disease severity had significant effect on the increase in the fruit yield of tomato. Here, two years data showed difference in fruit yield and their differences were statistically significant. In the year 2007-08, two doses of organic manures i.e. 12 ton ha^{-1} FYM and 6 ton ha^{-1} FYM + 2 ton ha^{-1} VC and untreated control showed no significant difference in producing the fruit yield of tomato. Three doses of fertilizers had showed no significant difference among themselves in the production of fruit yield. Similar results were found in the application of different combinations of three doses of fertilizers and two doses of organic manures which showed no significant difference among themselves in increase in the fruit yield. Maximum fruit yield was harvested in N_{220}:P_{110}:K_{110} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (468.13 q ha^{-1}) and minimum in 12 ton ha^{-1} FYM (297.47 q ha^{-1}) (Table 1).

In the year 2008-09, plot treated with 12 ton ha^{-1} FYM (217.73 q ha^{-1}) and without fertilizer applied control plots (200.67 q ha^{-1}) produced minimum fruit yield and their difference was not statistically significant. Among the other treatments maximum fruit yield was produced in N_{220}:P_{110}:K_{110} applied plots (381.27 q ha^{-1}) followed by N_{220}:P_{110}:K_{110} along with 6.4 ton FYM + 1.92 ton VC ha^{-1}(378.67 q ha^{-1}) but there differences were statistically at par.

Minimum fruit yield was observed in the plot treated with 12 ton ha^{-1} FYM (217.73q ha^{-1}) followed by 6 ton ha^{-1} FYM + 2 ton ha^{-1}VC (241.33 q ha^{-1}) and their difference was not statistically significant. Combinations with two doses of organic manures and three doses of fertilizers also increased the fruit yield of tomato and maximum was observed inN_{220}:P_{110}:K_{110} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (378.67 q ha^{-1}) and minimum in N_{150}:P_{60}:K_{60} along with 3.2 ton ha^{-1} FYM (341.06 q ha^{-1}) and their difference was statistically significant. Combination of sole fertilizer and organic manures showed no significant difference in increasing the fruit yield of tomato (Table 1). Fruit quality can be improved with the application of 50% NPK+50% FYM+biofertilizers reported by Chumyani *et al.* (2012).

The two years pooled mean also showed that two doses of sole organic manures and without fertilizer applied plots produced minimum fruit yield in the plot applied with 12 ton ha^{-1} FYM (257.60 q ha^{-1}) and 6 ton ha^{-1} FYM + 2 tonha^{-1} VC (278.93 q ha^{-1}) but their differences were not statistically significant. Maximum fruit yield was observed where only fertilizer N_{220}:P_{110}:K_{110} (424.10 q ha^{-1}) was applied followed by N_{220}:P_{110}:K_{110} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (423.40 q ha^{-1}) statistically at par with N_{180}:P_{90}:K_{90} along with 6.4 ton FYM + 1.92 ton VC ha^{-1} (406.90 q ha^{-1}) and N_{180}:P_{90}:K_{90} along with 3.2 ton ha^{-1} FYM. (391.47 q ha^{-1}). Combination of higher dose of fertilizer along with the organic manures showed no significant difference in between them in the production of fruit yield of tomato (Table 1).

These results are in conformity with the result of Singh *et al.* (2001) who reported that the lowest disease was recorded in the experiment where N was applied at more than 120 kg ha^{-1} along with FYM 3.0 ton ha^{-1}.

Table 1. Organic source, inorganic fertilizers and their combination on early blight disease severity and yield of tomato

Treatments	Disease severity (AUDPC)			Fruit yield (q ha^{-1})		
	2007-08	2008-09	Pooled Mean	2007-08	2008-09	Pooled Mean
T_1	17.12	19.20	18.16	412.67	331.73	372.20
T_2	18.13	17.17	17.65	436.40	348.33	392.37
T_3	18.13	23.30	20.72	466.93	381.27	424.10
T_4	23.14	21.27	22.21	297.47	217.73	257.60
T_5	25.15	26.35	25.75	316.53	241.33	278.93
T_6	22.14	24.31	23.23	423.20	341.06	382.13
T_7	22.14	18.19	20.17	421.73	361.20	391.47
T_8	27.15	29.37	28.26	396.13	370.93	383.53
T_9	22.14	22.27	22.21	412.00	351.67	381.83
T_{10}	19.13	21.26	20.20	452.53	361.27	406.90
T_{11}	24.15	17.09	20.62	468.13	378.67	423.40
T_{12}	30.23	32.31	31.27	259.87	200.67	230.27
SEm(±)	1.34	1.18	1.04	35.93	11.75	29.76
CD (P=0.05)	2.78	2.46	2.16	105.39	34.48	87.29

AUDPC= Area Under Disease Progress Curve, $T_1 = N_{150}:P_{60}: K_{60}$ (kg ha^{-1}), $T_2 = N_{180}: P_{90}: K_{90}$ (kg ha^{-1}), $T_3 = N_{220}: P_{110}:K_{110}$ (kg ha^{-1}) , T_4 = 12 ton ha^{-1} Farm Yard Manure, T_5 = 6 ton ha^{-1}FYM + 2 ton ha^{-1} Vermicompost, $T_6 = N_{150}:P_{60}:K_{60}$ along with 3.2 ton ha^{-1} FYM, $T_7 = N_{180}:P_{90}:K_{90}$ along with 3.2 ton ha^{-1} FYM, $T_8 = N_{220}:P_{110}:K_{110}$ along with 3.2 ton ha^{-1} FYM, $T_9 = N_{150}:P_{60}:K_{60}$ along with 6.4 ton FYM + 1.92 ton VC ha^{-1}, $T_{10} = N_{180}:P_{90}:K_{90}$ along with 6.4 ton FYM + 1.92 ton VC ha^{-1}, $T_{11} = N_{220}:P_{110}:K_{110}$ along with 6.4 ton FYM + 1.92 ton VC ha^{-1}, T_{12} = Control.

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BIOEFFICACY OF DIFFERENT NEWER INSECTICIDES AGAINST THE YELLOW STEM BORER (*Scirpophaga incertulas*) OF PADDY CROP

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ABSTRACT

Rice is an important cereals crop of the world which is known to be attacked by large number of insects pest during its different development stages. Out of these, yellow stem borer (*Scirpophaga incertulas*) is an important insect pest of rice. *Scirpophaga incertulas* Walker (Pyrelidae:Lapidoptera) is a serious pest of rice crop rendering damage to growing stems to pre harvest condition. The bioefficacy of newer insecticides with present one and new formulations of older molecules was thrust point of investigation. The present investigation was carried out at Department of Entomology, IGKV, Raipur during 2006-07. Incidence of yellow stem borer (*Scirpophaga incertulas*) was found in best reducing form due to the impact of treatment application. On the basis of overall impact of insecticidal application, Chloropyriphos 10 G @ 1250 g a.i. ha^{-1} was effective in reducing dead hearts. The application of Monocrotophos 36% @ 500 g a.i ha^{-1} and Neonicotinoid + Lamda cyhalothrin @ 33g a.i. ha^{-1} as sprays were found effective in reducing white ears and producing higher number of panicle bearing tillers, respectively.

(Key words- *Scirpophaga incertulas*, rice, newer insecticides, efficacy)

INTRODUCTION

Rice is the staple food of more than half of human population in the world and for more than 65 to 70 % of Indian population. It is grown over 44 million hectares in India under diverse ecologies, like upland, lowland, Irrigated, deep water etc. Indian population is increasing @1.5% and it would need over 100 million tons of rice by 2015 and 120 million tons by 2020 (Anonymous, 2007a). This additional production has to come from declining and degrading resources like land and water. Chhattisgarh popularly known as “rice bowl of India” occupies an area around 3.60 m ha with the production of 6.16 mt of paddy and was awarded Krishi Karman Award during 2010-11 (Anonymous, 2011). An average productivity of 1323 kg ha^{-1}, is very low as compared to the national average of 2236 kg ha^{-1} (Anonymous, 2007b). About 96% of total area under rice in the state is concentrated in low and very low productivity groups of the state (Sastri *et al.,*2006). Rice crop is infested with a large number of insect pests from sowing to harvesting stage of the crop (Gupta and Verma, 2001).

About 300 insect species have been reported to attack rice crop in India. About twenty species of insects have been found to be serious and causing more than 50% yield loss (Arora and Dhaliwal, 1996). Among the major insect pests attacking rice crop, yellow stem borer, *Scirpophaga incertulas* (Walker) is the number one pest, which attacks the crop both at vegetative and reproductive stage (Pasalu *et al*., 2002). This pest may cause 25-30% damage to the rice crop (Lal, 1996). To cope with ever challenging insects pest problems in Rice, the farmers needs to have the latest technological knowledge in pest management. Bioefficacy of new insecticides, along with present one and new formulations of older molecules is an important exercise of rice entomologists.The present investigation "Bioefficacy of different newer insecticides against the yellow stem borer (*Scirpophaga incertulas*) of paddy crop was carried out at Department of Entomology IGKV research farm, Raipur during *kharif* 2006-07, with an objective to find out most effective insecticides for the control of this pest.

MATERIALS AND METHODS

The present investigation entitled “Bioefficacy of newer insecticides against the yellow stem borer (*Scirpophaga incertulas*) of paddy crop” was carried out at IGKV research farm, Raipur under field condition during *kharif* 2006-07.

Site and Climate :

Raipur is an important rice growing tract of Chhattisgarh and comes under tropical region of India. It is situated at 21.16^{0}N latitude and 81.36^{0}E longitude and at an altitude of 299 metres above from mean sea level (MSL). The general climate condition of Raipur is sub-humid to semi-arid with annual rainfall of more than 1350 mm, of which 85% occurring during the month of June to September.

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Details of experiment conducted in field condition.

Crop	: Rice
Season	: *Kharif*
Situation	: Protective irrigation
Design	: R.B.D.
Plot Size	: 5 x 4 m
Number of treatments	: 14
Number of replications	: 04
Total number of plots	: 56
Spacing	: 20x15 cm (RxP)
No. of hills plot^{-1}	: 650 hills plot^{-1}
Variety	: Kranti
Date of nursery sowing	: 22-7-2006
Date of transplanting	: 17-08-2006
Date of treatment application	: 15/09/2006 06/10/2006
Volume of spray solution used	: @500 lit ha^{-1}
Type of spray applicator used	: Manually-operated Knapsack sprayer for spraying.
Granular application	: Broadcast in standing water.

Treatment details :

Treatments	Common name	Trade name	% a.i. in the Formulation	g a.i ha^{-1} dose	g or ml of formulation ha
T_1	Chlorpyriphos	Dursban 10G	10%	1000	10.0 Kg
T_2	Chlorpyriphos	Dursban 10G	10%	1250	12.5 Kg
T_3	Carbofuran (check)	Furadan 3G	3.0%	1000	33.0 Kg
T_4	Ethiprole 40% + Imidacloprid 40%	Confidor	80%	100	125 g
T_5	Neonicotinoid + Lamda cyhalothrin	ALIKA 247ZC	22%	33	150 ml
T_6	Neonicotinoid + Lamda cyhalothrin	ALIKA 247ZC	22%	44	200 ml
T_7	Deltamethrin	Decis 10%EC	10%	15	150 ml
T_8	Oxadiazin + Lamda cyhalothrin)	Ril-043	-	-	400 ml
T_9	Indoxacarb	Kingdoxa 15 SC	14.5%	30	200 ml
T_{10}	Spinosyn A 50% + Spinosyn D 50%	Spinosad 45%SC	45%	45	100 g
T_{11}	Spinosyn A 50% + Spinosyn D 50%	Spinosad 45%SC	45%	54	120 g
T_{12}	Monocrotophos (check)	Monocrown 36 WSC	36%	500	1390 ml
T_{13}	Phorate	Uthane (UPL) 10 G	10%	1250	12.5 Kg
T_{14}	Untreated control	-	-	-	-

Fertilizer application N: P: K 80:60:40 kg ha^{-1}:

The paddy crop grown for experimental purpose was given nutrition through the chemical fertilizer @ 80:60:40 NPK kg ha^{-1}.Full dose of P and K were applied at the time of planting and "N" was applied in three split doses. First dose was given at the time of planting and remaining two doses were applied at the tillering and panicle initiation stage of the crop.

Method of insecticidal treatment application :

The required quantity of insecticide for each plot was calculated on the basis of active ingredient and standard doses. The insecticidal treatments were applied to the crop homogeneously. Granules were broadcasted in standing water and foliar application was done with knapsack sprayer at the dose and time of application of insecticides as per treatments, on 30 and 50 DAT.

Time and method of recording observations:

Observations on stem borer incidence as dead hearts were recorded from ten randomly selected plants of each treatment plot replication^{-1}. Stem borer incidence was recorded one day prior and 10 days after insecticidal treatment. The dead hearts at tillering, white earheads at panicle stage and panicle bearing tillers at maturity were recorded from 10 plants from each plot and per cent dead hearts, and white earheads were calculated.

RESULTS AND DISCUSSION

Bio- efficacy under field condition :
First insecticidal treatment application (30 DAT)
Pre treatment observations :

In pre treatment observation on one day before treatment application (30 DAT), the dead hearts were not found in the field at the time of insecticidal application.

Post treatment observations :

The minimum dead hearts (1.5 %) was recorded with the treatment Chlorpyriphos 10 G @ 1250 g a.i. ha^{-1} followed by Carbofuran 3 G @ 1000 g a.i. ha^{-1} (4.0%). The highest dead hearts (20%) were recorded under untreated control.

Second insecticidal treatment application (50 DAT)

Pre-treatment observations :

Pre-treatment observations of stem borer incidence were recorded in the form of dead hearts varied from 4.25-5.25% in different plots. There were non significant differences between different treatment plots at one day before second treatment application (50 DAT). It may be stated that the stem borer incidence was homogenous during pre-treatment observation even at 49 DAT (19 days after first application of insecticides).

Tabel 1. Intensity of paddy stem borer infestation observed under different insecticidal treatments during *kharif* 2006

Treatments	Formulation g a.i. ha^{-1}	Mean percentage of dead heart				White ear heads	Panicle bearing tiller 10^{-1} hill
		1st application		2nd application			
		Pre-treatment one day before	Post-treatment 20 DAT	Pre-treatment One day before	Post-treatment 40 DAT		
T1 : Chlorpyriphos	1000	0.00	11.50 (2.91)	5.75 (2.49)	6.00 (2.55)	46.50	196.50
T2 : Chlorpyriphos	1250	0.00	1.50 (1.40)	5.00 (2.33)	5.00 (2.34)	43.50	195.50
T3 : Carbofuran (check)	1000	0.00	4.00 (2.12)	5.25 (2.39)	5.50 (2.44)	38.00	185.50
T4 : Ethiprole 40% + Imidacloprid 40%	100	0.00	7.00 (2.73)	5.00 (2.33)	5.25 (2.39)	40.00	191.00
T5 : Neonicotinoid + Lamda cyhalothrin	33	0.00	4.25 (2.18)	5.00 (2.30)	5.00 (2.34)	40.50	201.50
T6 : Neonicotinoid + Lamda cyhalothrin	44	0.00	5.00 (2.34)	4.25 (2.17)	5.50 (2.44)	34.00	193.00
T7 : Deltamethrin	15	0.00	7.35 (2.77)	5.00 (2.33)	7.00 (2.73)	36.50	196.50
T8 : Oxadiazin+ Lamda cyhalothrin	400	0.00	7.75 (2.87)	4.50 (2.22)	6.50 (2.64)	41.00	198.50
T9 : Indoxacarb	30	0.00	4.50 (2.23)	5.00 (2.34)	5.25 (2.39)	36.50	197.50
T10 : Spinosyn A 50% Spinosyn D 50%	45	0.00	6.00 (2.53)	5.25 (2.39)	5.50 (2.44)	38.00	187.00
T11 : Spinosyn A 50% Spinosyn D 50%	54	0.00	7.00 (2.73)	5.50 (2.44)	5.75 (2.49)	36.50	192.00
T12:Monocrotophos (check)	500	0.00	5.50 (2.44)	5.00 (2.34)	5.50 (2.45)	33.50	194.00
T13 : Phorate 10 G	1000	0.00	7.00 (2.73)	5.25 (2.39)	5.50 (2.45)	40.25	192.50
T14 : Untreated control	-	0.00	20.00 (4.52)	5.25 (2.38)	15.00 (3.93)	48.00	139.50
SE (m) +			0.11	0.13	0.10	2.58	3.62
CD(5%)			0.31	NS	0.29	7.38	10.35

Figures in parenthesis are square root transformed values

Post treatment observations :

Post treatment observations of stem borer incidence were recorded at ten days after second application of insecticides in the form of dead heart per cent. Significant impact of treatment application was observed in this study. The minimum dead hearts of 5.0% was recorded with the treatment Chlorpyriphos 10 G @ 1250 g a.i. ha^{-1} which was statistically at par with Neonicotinoid + Lamda cyhalothrin, 22% @ 22 g a.i. ha^{-1}, ethiprole + imidacloprid @ 100 g a.i. ha^{-1}, Carbofuran 3 G @ 1000 g a.i. ha^{-1} i.e. 5.0, 5.25, 2.50 per cent respectively and followed by Oxadiazin + Lamda cyhalothrin @ 400 g a.i. ha^{-1} (6.50%). The highest dead heart per cent (15.0) was recorded under the untreated control.

The observations on white earheads produced on crop were recorded at panicle stage to access the impact of treatment application. Minimum white earheads of 33.5% was recorded for Monocrotophos 36% @ 500 g a.i. ha^{-1} and followed by, Deltamethrin 10%@ 15 g a.i. ha^{-1} (36.5%) followed by Oxadiazin + Lamda cyhalothrin @ 400 g a.i. ha^{-1} and Cholorpyriphos 10% @ 1250 g a.i. ha^{-1} i.e. 41.00 and 43.5 per cent, respectively. The highest white earheads per cent of 48.00 was recorded under untreated control of this trial.

The maximum number of panicle bearing tillers (201.5) were recorded from Neonicotinoid + Lamda cyhalothrin 22% @ 33 g a.i. ha^{-1} treated plot which was statistically at par with Oxadiazin + Lamda cyhalothrin @ 400 g a.i. ha^{-1} (6.50%) and Indoxacarb-14.5% @ 45 g a.i. ha^{-1}. The minimum number of panicle bearing tillers (139.5) were recorded from the untreated control plots of this study.

On the basis of overall impact of insecticidal application, Chlorpyriphos 10% @ 1250 g a.i. ha^{-1} was effective in reducing dead head per cent. The application of Monocrotophos 35% @ 500 g a.i. ha^{-1} and Neonicotinoid + Lamda cyhalothrin 22% @ 33g a.i. ha^{-1} were found effective in reducing white ears and producing higher number of panicle bearing tillers, respectively.

Sharma and Kaushik (2010) reported application of Carbofuran, Quinalphos, Carbaryl, Fenvalerate, Monocrotophos and Fipronil as effective for controlling paddy stem borer.

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VARIATION IN SYMPTOMS EXPRESSION OF SHEATH ROT DISEASE OF RICE INCITED BY *Sarocladium oryzae* GAMES AND HAWK

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ABSTRACT

The study was carried out in the wet season of 2008 at IGKV, Raipur (CG). Besides the typical symptoms of sheath rot disease of rice, variation in symptoms of sheath rot was observed in field. Some spikelets turn into leafy structure. The leafy structures were greenish in colour. The brown spot was observed at the junction of sheath and stem (panicle). Infected panicles had discoloured (dark brown) and chaffy grains. Koch's postulates proved that the causal organism, a fungus associated with the various symptoms was identified as *Sarocladium oryzae* and confirmed by physico-cultural characteristics.

(Key words : Rice, Sheath rot, *Sarocladium oryzae*, Symptoms)

INTRODUCTION

Rice is a golden crop of paramount importance to Indian economy. The crop is used mainly as food, but could also be used as feed for livestock. Industrially, rice is processed into products like bread, cheese, wine, brewed beer and yoghurt. Sometimes husk of the grain are used to produce ceiling or strawboards.

Rice crop is known to suffer from many biotic and abiotic stresses. Rice in general and irrigated rice in particular, is the target of attack by over 100 species of insects and pathogenic organisms that are known to destabilize the yields (Ou, 1985). Total crop failure due to pests and diseases is regularly encountered in many parts of the country, though it may be in limited areas. Cultivation of semi dwarf, high nitrogen responsive varieties along with imbalanced use of inputs like fertilizers and pesticides, dense planting and crop canopy accelerated the pest-disease problem during the past high yielding varietal era.

Chhattisgarh state is most congenial for rice cultivation as well as for diseases also. Several diseases were reported on rice and among them blast, bacterial blight, sheath rot and sheath blight are most important for this state causing considerable economic yield losses (Salam, 2008).

Sheath rot, caused by *Sarocladium oryzae* (Sawada) Games and Hawksworth, has gained the status of a major disease in rice (Reddy and Gosh, 1985) and yield loss varies from 9.6 to 85%, depending on the weather conditions during the crop growth-period (Phookan and Hazarika, 1992). This disease was first reported in rice from Taiwan (Sawada, 1922) and was subsequently reported from different rice-growing ecosystems of the world (Shahajahan *et al*., 1977). Agnihothrudu (1973) recorded this disease in India for the first time and later several workers reported this disease from different parts of the country (Ghuffran *et al*., 1980).

Different types of sheath rot symptoms were oftenly seen in the rice fields at booting stage. The present study was, therefore, undertaken for characterization of the various sheath rot disease symptoms and to know the actual cause associated with them.

MATERIALS AND METHODS

The study was conducted during wet season of 2008 at IGKV, Raipur. The uppermost leaf sheath (flag leaf) of rice plants which encloses the emerging panicle, with the typical and other suspected sheath rot symptoms were collected. The paddy seeds from the infected panicles were also collected for the isolation of the pathogen. The isolated fungi were identified on the basis of the colony characters, mycelial characters and spore features of the fungus by confirming with the standard text (Ou, 1972; Games and Hawksworth, 1975; Mew and Mishra, 1994 and Manibhushan Rao, 1996).

The various types of symptoms observed were properly tagged, keenly observed for further development right from suspection, causal agent isolated and its pathogenicity was confirmed by following Koch's postulates.

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RESULTS AND DISCUSSION

A. Characterization of disease symptoms, causal organism and its pathogenicity test:

During the course of present investigation in the field condition, various types of sheath rot symptoms were observed, varied from the typical symptoms.

The typical symptoms of sheath rot were showed in plate II. Symptoms were most severe on the uppermost leaf sheaths (flag leaf) that enclose the emerging young panicle during the boot stage. Lesions were oblong or irregular oval spots (0.5 to 1.5 cm × 0.3 to 0.5 cm) with an undulated dark brown margin and gray or light brown centers or sometimes dark reddish brown, diffuse margin or lesions may form an irregular pattern. Grains from damaged panicles were discoloured, reddish brown to dark brown and may not be filled (chaffy grains).

Apart from the above symptoms, some variations in symptoms of sheath rot were also observed during investigation. Nearly nine different types of symptoms were recorded and described.

I. Big brown spots were present on sheath. The middle portion of spots look like sunken, grayish and spots were mostly in row. Water soaking was seen in infected area. The damaged panicles were unable to produced healthy grains, having mostly discoloured and chaffy grains (Plate II-1).

II. Some of the spikelets turn into leafy structure. The brown spots were observed at the junction of sheath and stem (panicle) and on sheath as well. Panicle had unfilled, discoloured and dark brown grains. The leafy structures were greenish in colour (Plate II-2 a, b, c).

III. The sheath surface showed severe spreading water soaked and brown spots. The spikelets had dark brown grains and some healthy grains as well (Plate II-3).

IV. Panicle does not emerge, encircled sheath severely damaged. Large water soaked area with browning and rotting of sheath was observed. All the grains inside were chaffy (Plate II-4 a, b).

V. Large dark brown area spread on sheath surface upward starting from junction with the stem node. All the grains observed were chaffy (Plate II-5).

VI. The brown coloured spreading lower portion of sheath with water soaked area were observed. Later infected sheath fell off. All the grains became chaffy (Plate II-6).

Some of the symptoms mentioned above were also described by researchers from different parts of the world.

Tasugi and Ikeda (1956) described the symptoms which were found most severe on the uppermost leaf sheaths that enclose the emerging young panicle during the boot stage. Lesions are oblong or irregular oval spots (0.5 to 1.5 cm long and 0.3 to 0.5 cm wide) with an undulated dark brown margin and gray or light-brown centers, sometimes a dark reddish-brown diffuse margin, or the lesions may form an irregular target pattern. The lesion is usually expressed as a reddish-brown discolouration of the flag-leaf sheath.

Ou (1985) described an irregular spots with brown margins and an abundant whitish powdery growth inside the affected sheaths and rotting of the young panicles. Under severe infection, the panicles showed large number of chaffy and/or discoloured grains (Amin *et al*., 1974 and Thrimurty *et al*., 1980).

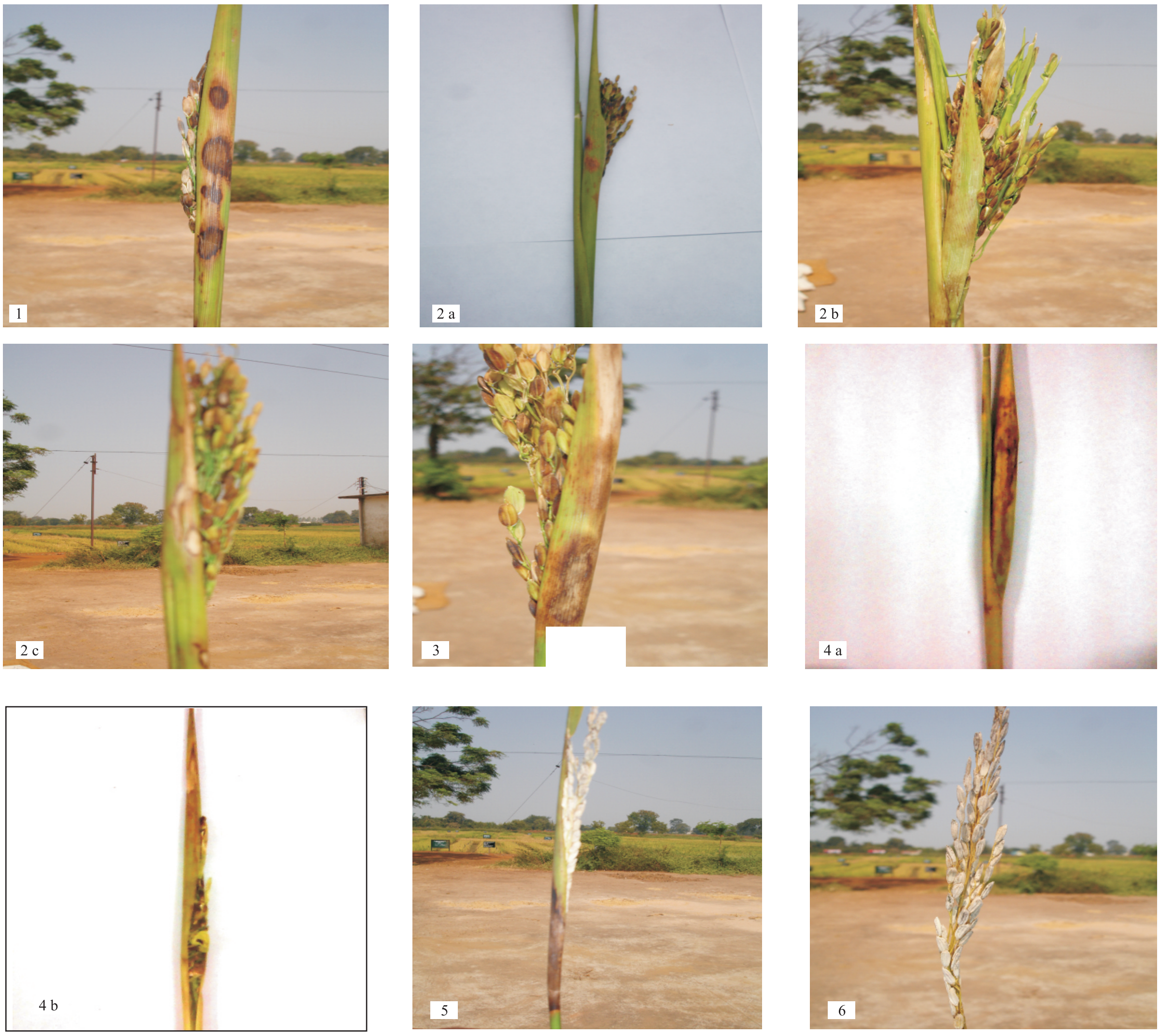
Zhuge *et al*. (1985) described that the symptoms included typical sheath rot lesions and purple sheath or purple sheath with yellow leaves.

Brady (1998) described that whitish mycelium may be seen in the centre of the lesions and occasionally inside the rotted sheaths. Severely affected panicles do not emerge, the effect being known as choking. The symptoms are evidently indistinguishable from those associated with *Sarocladium attenuatum.*

Lesions occur on the upper leaf sheaths, especially on the flag leaf sheath enlarge and coalesce as the disease progresses and may cover most of the leaf sheath, panicle formation may fail to complete. Brown or partially brown, unfilled or partially filled grain has also associated with infection of the panicle and a whitish powdery growth of fungus may be found inside affected sheaths (Naeimi *et al*., 2003).

PLATE 1. Typical symptoms of sheath rot

PLATE 2. Various types of sheath rot symptoms



Variation in symptom expression due to amount of toxin production by *Sarocladium oryzae* was attributed by Nandakumar *et al.* (2007).

B. Causal organism:

The causal organism, a fungus, thus isolated during the research work was identified on the basis of typical character of the mycelium, spore structure and other cultural characters described for *Sarocladium oryzae*. The characters are white, septate mycelium with sparsely branched conidiophores, slightly thicker than vegetative hyphae with terminal branches, phialides arising from conidiophores or directly from undifferentiated vegetative hyphae, 30-40 µm long and 1.5-2.0 µm wide at the base when formed at the apex of slender conidiophores, 6-20 µm long and 1.0-1.5 µm wide when arising in dense broom like fascicles, tips tapering to 0.6-1.0 µm in width, lacking any distinct collaret and conidia borne on tip. Conidia formed in slimy masses, cylindrical with rounded ends, sometimes becoming slightly curved, hyaline, thin walled, smooth, one celled with a 3.5-7.0 × 0.8-1.5 µm. Chlaymydospore absent, branches of conidiophores arises in whorls. All these characters were in accordance with the standard publications on *Sarocladium oryzae* by Games and Hawksworth (1975); Ou (1985); Mew and Mishra (1994) and Manibhushan Rao (1996). Thus, the causal organism responsible for causing sheath rot disease of rice.

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EFFECT OF INTEGRATED USE OF ORGANIC AND INORGANIC SOURCES OF PHOSPHORUS ON SOIL PHYSICO-CHEMICAL AND CHEMICAL PROPERTIES OF CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

A field experiment was conducted during 2009-10 on sandy loam Alfisol at College Farm, College of Agriculture, Rajendranagar, Hyderabad, A.P, India to study the response of phosphorus levels in combination with FYM @ 10 t ha^{-1} and phosphate solubilising bacteria (PSB) @ 2 kg ha^{-1} on various phisico-chemical properties of soil at flowering and at harvest of chickpea. The FYM application or PSB application to soil slightly reduced the soil pH towards neutral range due to rhizosphere acidification. Organic carbon and available N contents of soil at flowering significantly increased at P_{75} level over P_0 level but such increase was not observed at harvest. FYM application either alone or with PSB showed a significant increase in organic carbon content of soil at flowering. With the increase in the inorganic P levels and FYM application there was appreciable buildup in available P status. The treatments receiving FYM and FYM + PSB were at a par in increasing available P. Application of either graded levels of phosphorus or any component of P did not show any significant influence on available K status of soil at flowering. Increase in the level of P application was also not significant in increasing available K status of the soil at harvest. The available K status was significantly superior with FYM, with PSB and their combination when compared to inorganic P.Interaction effect was not significant both at flowering and at harvest.Available sulphur status of soil at flowering was significantly increased only at 75 kg P_2O_5 ha^{-1} and at harvest significantly increased upto P_{50} level and was on par with P_{75} treatment. Supplementing the crop with inorganic P along with FYM, PSB or FYM + PSB did not show significant variation in available S both at flowering and at harvest.The mean seed yield increased significantly by 44.0 per cent due to application of FYM along with PSB with graded levels of P. PSB inoculation at graded levels of P increased the seed yield by 28.9 per cent.

(Key words: organic and inorganic P sources, soil pH, EC, organic carbon, available nutrients, chickpea)

INTRODUCTION

Phosphorus is an important nutrient especially for pulses as a high phosphorus supply is needed for nodulation. It also influences N availability through N fixation. Phosphorus plays a pivotal role for the structure and regulatory functions in photosynthesis, root development, energy conservation and transformation, carbon metabolism, redox reactions, enzyme activation and inactivation, signaling and nucleic acid synthesis (Vance *et al*., 2003). But it is one of the highly immobile, inaccessible and unavailable nutrients present in the soil. Native available P in soil and applied P through fertilizer source become unavailable within a short period due to fixation in the soil (Meena *et al*., 2003). The high phosphatic fertilizer prices demand the need for recycling, mobilization and exploitation of fixed P to improve crop production. It could be made possible by developing strategies like integration of PSB, organic acids, arbuscularmycorrhizal fungi and rhizosphere manipulation through efficient P mobilizing genotypes along with inorganic P.

Application of farmyard manure is known not only to meet the nutrient requirement of crop, but also to improve the physical properties of soil (Venkateshwarlu, 2000). Activity of microbes gets enhanced in the presence of organic matter since organic matter (FYM) is the food for microbes. Soil inoculation with efficient strains of biofertilizer in association with mineral and organic manures have been known to enhance the efficiency of both these sources resulting in improved productivity of crop coupled with maintenance of soil fertility. With this view in mind a study was undertaken to ascertain the effect of organic and inorganic sources of P on soil physico-chemical properties under chickpea cultivation.

MATERIALS AND METHODS

Field experiment was conducted during post rainyseason of 2009-10 on Alfisol at College Farm of College of Agriculture, Rajendranagar, Acharya N.G. Ranga Agricultural University, Hyderabad. The soil was sandy loam with slightly alkaline pH of 8.12 and

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normal in EC (0.12 dSm^{-1}), low in organic carbon content (0.35 %)and available nitrogen (188 kg ha^{-1}), medium in available phosphorus (17.2 kg ha^{-1}), high in available potassium (368 kg ha^{-1}) and sufficient in available sulphur (33.6 kg ha^{-1}). The experiment was laid out in Randomised Block Design in factorial concept with three replications. Four levels of inorganic P (0, 25, 50 and 75 kg P_2O_5 ha^{-1} *viz.,* P_0, P_{25}, P_{50} and P_{75}), two levels of organic manure (0 and 10 t ha^{-1} of FYM) and two levels of PSB (without inoculation and with inoculation @ 2 kg ha^{-1}) were adopted, thus a total of 16 treatment combinations were imposed. Chickpea cv KAK - 2 was used for the study. All the cultural practices were followed as per the standard recommended practices. Composite soil sample was collected at flowering and at harvest from each experimental plot from 0 to 15 cm depth. The soil was mixed thoroughly and samples of about 0.5 kg were obtained by quartering technique and stored in neatly labelled polythene bags for soil analysis.Collected soils were sieved in a 2 mm mesh removing root hair as much as possible and assayed for pH, EC (Jackson, 1973), Organic Carbon (Walkley and Black, 1934), available nitrogen (Subbiah and Asija, 1956), phosphorus (Olsen *et al.,* 1954), potassium (Jackson, 1973) and sulphur (Chesnin and Yien, 1963).The harvested crop from each net plot was bundled separately and sun dried for 4 days and threshed. The threshed grains were cleaned and sun dried to a constant weight before recording final grain yield (kg ha^{-1}).

RESULTS AND DISCUSSION

Soil pH :

Neither the levels of P application nor the components of phosphorus management had significant effect on pH of the soil.Their interaction was also not significant at flowering stage of the crop (Table 1). Though not significant, the organic manuring or inoculation of soil with biofertilizers slightly reduced the soil pH towards neutral range. The pH of the soil at harvest was also not influenced by either P levels or components or both. The pH showed a slight decrease at harvest than at flowering. This might be due to the rhizosphere acidification as a result of organic acids released by FYM and PSB.

Soil EC :

The electrical conductivity of the soil both at flowering and harvest was not significantly influenced by either inorganic P application or by the components of phosphorus management (Table 2).

Organic carbon :

Organic carbon content of the soil at flowering increased significantly to 0.54 per cent (medium) due to application of inorganic P at 75 kg P_2O_5 ha^{-1} as against the low organic carbon content of 0.45 per cent in P_0. The organic carbon content was also low when either inorganic P alone or in combination with PSB was applied. When along with inorganic P, FYM or FYM + PSB were applied the organic carbon content increased significantly to 0.53 per cent. Interaction was not significant.This could be due to the reason that the effect of FYM excelled that of inorganic P at later stage. The inorganic P levels were not significant in increasing the organic carbon content of the soil at harvest. Among the components of phosphorus, FYM alone or with PSB were found to increase organic carbon significantly from 0.43 per cent with inorganic P to 0.58 and 0.60 per cent respectively. Interaction effects between inorganic P and FYM, inorganic P, FYM and PSB were significant. However, the highest organic carbon content of 0.73 per cent was recorded in the treatment receiving FYM and PSB without inorganic P (Table 3). This could be due to the release of organic acids and compounds into the soil as a result of FYM application.

Available nitrogen :

Available nitrogen content of soil at flowering was not influenced significantly by the application of inorganic P (Table 4). Application of FYM @ 10 t ha^{-1} either alone or in combination with PSB also increased significantly, the available N content of the soil to 191.7 and 193.1 kg ha^{-1} respectively when compared to 168.5 kg ha^{-1} observed with inorganic P alone. Inoculation with PSB alone did not show any influence on available N content of the soil. Significantly higher available N content of 214.1 kg ha^{-1} was obtained with the integrated application of inorganic P at 50 kg P_2O_5 ha^{-1} along with FYM and PSB over 156.8 kg ha^{-1} in the control.This might be due to increased availability of phosphorus (upto the level P_{75}), which through its effect on root nodulation fixes the atmospheric N by symbiosis, and the fixed N might be added to the soil through root exudates. Application of graded levels of P from 0 to 75 kg P_2O_5 ha^{-1} increased the available N status of the soil from 148.6 to 183.8 kg ha^{-1}. However, significant increase was observed upto 25 kg P_2O_5 ha^{-1} which was at par with the other two higher levels of P. Among the components of phosphorus management, FYM was significantly superior with 182.8 kg ha^{-1} of available N which was at par with the treatment in where, FYM was conjunctively applied with PSB with an available N content of 176.1 kg ha^{-1}. The highest value was obtained when inorganic P at 75 kg P_2O_5 ha^{-1} was combinely applied with FYM at 10 t ha^{-1}; the lowest was with control. This might be due to the additional amount of nitrogen supplemented through FYM. Tolanur and Badanur (2003) reported that the application of FYM along with recommended dose of fertilizer (25 kg N and P ha^{-1}) resulted in significant increase in the available nitrogen, phosphorus and potassium compared to application of recommended dose of fertilizer without FYM.

Available phosphorus :

Available phosphorus in the soil at flowering was influenced significantly due to the graded levels of P application and also by combinations of the three components (Table 5). The mean value increased significantly from 23.95 kg P ha^{-1} at control to 33.50 kg P ha^{-1} with the application of 50 kg P_2O_5 ha^{-1}, while P_{50} and P_{75} were at a par with regard to available P status of soil at harvest.When compared to inorganic P alone, the combinations of components were significant. The mean available P with inorganic P was 22.55 kg ha^{-1} which showed significant increase to 34.12, 28.35 and 37.17 kg ha^{-1} respectively due to the combination with FYM, PSB and both. The highest value of 41.22 kg P ha^{-1} was recorded due to application of P at 75 kg P_2O_5 ha^{-1} along with FYM and PSB. With the increase in the inorganic P levels, there was an increase in the available P. Appreciable buildup in available P status could be because of addition of phosphorus directly to the soil solution pool in the soil. Akbari *et al*. (2002) reported that the application of phosphorus @ 20 kg P_2O_5 ha^{-1} significantly increased the available phosphorus over control.Abdulla and Sharma (2003), who found the highest available P_2O_5 (48.47 kg ha^{-1}) with 40 kg DAP ha^{-1} over 20 kg DAP ha^{-1} (37.7 kg P_2O_5 ha^{-1}) and control (26.93 kg $P_2O_5ha^{-1}$).

The lowest available P status of 15.23 kg ha^{-1} was recorded in control. The interaction between the level of P application and combination of components was not significant. Available soil phosphorus status at harvest of chickpea increased significantly from a mean value of 21.99 to 34.69 kg P ha^{-1} due to application at 75 kg P_2O_5 ha^{-1}. Phosphorus when supplied only through inorganic source resulted in an available P status of 20.85 kg ha^{-1}, which showed a significant increase to 26.41, 31.72 and 34.52 kg ha^{-1} when integrated with PSB, FYM and PSB+ FYM. The highest available P of 38.52 kg ha^{-1} in the soil was recorded at harvest when 75 kg P_2O_5 $ha^{-1}$of inorganic P was supplied along with FYM and PSB. The lowest value was observed in the control. Above this, the organic anions compete with phosphates for chelation of metals like iron, Al and also Ca which form insoluble P compounds with applied P, causing effective solubilization of phosphates. This findings is in corroboration with the findings of Tanwar and Shaktawat (2004) who reported that application of 90 kg $P_2O_5ha^{-1}$ along with PSB and FYM @ 10 tonnes ha^{-1} resulted in a higher soil N and P after the harvest of soybean crop compared to application of 0, 30 and 60 kg P_2O_5 ha^{-1} along with PSB and FYM.

Available P content of the soil increased significantly due to PSB application over control, which might be due to production of organic and inorganic acids which convert the insoluble phosphates to available forms. The results obtained are in close agreement with those reported byAbdulla and Sharma (2003) who reported that available P increased significantly with PSB inoculation over no inoculation in chickpea. Gupta and Yadav (2009),reported that the soil available N and P with PSB inoculation (135.0 and 23.9 kg ha^{-1}) increased over control (132.7 and 19.0 kg ha^{-1}) in chickpea. However, the interaction effect was not significant.

Available potassium :

Application of either graded levels of phosphorus or any component of P did not show any significant influence on the available K status of soil at flowering stage of chickpea. The interaction of inorganic P and the components of phosphorus management were not significant.

Increase in the level of P application was not significant in increasing available K status of the soil. Among the four components of P, inorganic P was found inferior to other, available K status was significantly superior with FYM, PSB and their combination when compared to inorganic P (Table 6). Similar beneficial effects of integrated use of inorganic fertiliser and FYM on available K status of soil after harvest were earlier reported by Kumptawat, (2004).

Available sulphur :

Available sulphur status at flowering was significantly increased only due to the higher level of phosphorus application at 75 kg P_2O_5 ha^{-1} which resulted in increase of mean available sulphur status to 27.46 kg ha^{-1} as against 23.63 kg ha^{-1} in the treatment receiving 0 kg P_2O_5 ha^{-1}. Significant difference was not observed among the different components and their interaction with level of phosphorus application. Available sulphur at harvest significantly increased from 21.23 kg ha^{-1} at P_0 level to 23.58 kg ha^{-1} with the application of 50 kg P_2O_5 ha^{-1} which was at par with the treatment receiving 75 kg P_2O_5 ha^{-1}. Supplementing the crop with inorganic phosphorus alone resulted in available sulphur status of 20.64 kg ha^{-1} which increased significantly to 24.59 kg ha^{-1} and 25.15 kg ha^{-1} respectively when inorganic phosphorus was integrated with FYM or FYM+PSB. Interaction effect was not significant (Table 7). These results are in conformity with the findings of Akbari *et al*. (2002) who reported that application of FYM @ 10 t ha^{-1} significantly improved sulphur status of soil after harvesting of groundnut to the tune of 20.82 per cent as compared to the respective control.

Seed yield :

Application of inorganic P at 50 kg P_2O_5 ha^{-1} significantly increased the mean seed yield of chickpea to 10.57 q ha^{-1} over 8.20 q ha^{-1} in P_0 (Table. 8). The increased seed yield with P application might be due to increased availability of phosphorus through its effect on Rhizobium and proliferation of root system. The results corroborate the findings of Gupta *et al*.(2009) who reported that the grain yield of chickpea increased significantly over control and 20 kg P_2O_5 ha^{-1} with the application of 40 kg P_2O_5 ha^{-1} through DAP. Singh *et al.* (2008) reported that the seed yield of chickpea increased significantly due to the application of 40 kg P_2O_5 ha^{-1} over control and Chesti and Tahir (2008) also observed that application of 60 kg P_2O_5 ha^{-1} recorded maximum grain yield over 0 and 30 kg P_2O_5 ha^{-1} in chickpea.

Integrated application of inorganic P, FYM and PSB resulted in significantly higher yield of 11.18 q ha^{-1} which was at par with combined application of inorganic P and PSB (10.47 q ha^{-1}) against 8.61 q ha^{-1} when inorganic P alone was applied. The seed yield was the highest when FYM and PSB were combinedly applied with inorganic P at 75 kg P_2O_5 ha^{-1},the value being 14.45 q ha^{-1} which was significantly higher than the yield of 9.92 q ha^{-1} obtained at the same level of P application without FYM and PSB. The seed yield obtained with 25 kg P_2O_5 ha^{-1} in integration with FYM and PSB was slightly higher but at par with the yield obtained with 75 kg P_2O_5 ha^{-1} alone. At P_0 level, application of FYM along with PSB increased the seed yield significantly to 9.09 q ha^{-1} against the seed yield of 6.28 q.ha^{-1} in control (Table 8). This might be due to increased phosphorus availability by organic manure and PSB. These results are in conformity with Manjunath *et al.* (2006), who found that the green pod yield of frenchbean was significantly superior with the integrated application of rock phosphate, FYM and PSB producing a yield of 82.53 q ha^{-1} over the control yield of 68.16 q ha^{-1}. Tanwar *et al.* (2010) reported maximum seed yield with treatment of conjunctive use of 25.8 kg P ha^{-1}, FYM and PSB (2.96 t ha^{-1}) over the treatment of 12.9 kg P ha^{-1} + FYM + PSB (2.80 t ha^{-1}).

Table 1. Soil pH as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	8.13	8.14	8.12	8.07	8.11	6.47	7.90	7.86	6.44	7.16
FYM	8.12	8.09	7.95	8.07	8.05	6.58	6.52	6.43	7.77	6.83
PSB	7.61	8.07	8.08	8.14	7.97	7.88	6.57	7.78	6.51	7.18
FYM + PSB	8.04	8.10	8.02	8.01	8.03	6.50	7.87	6.52	6.47	6.83
Mean	8.00	8.10	8.04	8.06		6.86	7.21	7.15	6.80	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	0.02	0.07	P levels (F_1)	0.30	0.9
P components (F_2)	0.02	0.07	P components (F_2)	0.30	0.9
F_1x F_2	0.05	0.14	F_1x F_2	0.61	1.8

Table 2. Soil EC (d S m^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	0.16	0.12	0.17	0.14	0.15	0.27	0.20	0.21	0.25	0.23
FYM	0.09	0.15	0.18	0.15	0.14	0.16	0.21	0.16	0.25	0.19
PSB	0.13	0.10	0.14	0.11	0.12	0.21	0.19	0.21	0.30	0.23
FYM + PSB	0.14	0.12	0.09	0.15	0.12	0.31	0.18	0.14	0.24	0.22
Mean	0.13	0.12	0.14	0.14		0.24	0.19	0.18	0.26	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	0.01	NS	P levels (F_1)	0.01	NS
P components (F_2)	0.01	NS	P components (F_2)	0.01	NS
F_1x F_2	0.01	NS	F_1x F_2	0.02	NS

Table 3. Organic carbon (%) content of the soil as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	0.38	0.48	0.51	0.56	0.48	0.49	0.39	0.38	0.44	0.43
FYM	0.50	0.52	0.55	0.56	0.53	0.67	0.60	0.53	0.52	0.58
PSB	0.43	0.50	0.54	0.50	0.49	0.42	0.47	0.42	0.56	0.47
FYM + PSB	0.51	0.53	0.52	0.56	0.53	0.73	0.62	0.54	0.53	0.60
Mean	0.45	0.51	0.53	0.54		0.58	0.52	0.47	0.52	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	0.02	0.05	P levels (F_1)	0.02	0.07
P components (F_2)	0.02	0.05	P components (F_2)	0.02	0.07
F_1x F_2	0.03	0.10	F_1x F_2	0.05	0.15

Table 4.Available nitrogen (kg ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	156.8	169.2	170.9	177.2	168.5	125.6	163.0	144.3	169.3	150.7
FYM	200.7	185.0	201.8	179.2	191.7	175.6	154.1	194.4	207.0	182.8
PSB	169.3	181.9	135.7	143.7	157.6	130.2	198.3	158.1	163.1	162.4
FYM + PSB	181.77	175.0	214.1	201.2	193.1	163.1	163.1	182.4	195.7	176.1
Mean	177.1	177.8	180.6	175.3		148.6	169.6	169.8	183.8	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	7.52	22.6	P levels (F_1)	5.96	18.1
P components (F_2)	7.52	22.6	P components (F_2)	5.96	18.1
F_1x F_2	15.04	45.2	F_1x F_2	12.05	36.2

Table 5. Available phosphorus (kg ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	15.23	19.65	24.16	31.18	22.55	13.36	17.85	21.47	30.45	20.85
FYM	27.00	30.14	38.28	41.06	34.12	25.12	28.62	35.22	37.91	31.72
PSB	22.15	26.13	32.04	33.08	28.35	20.29	23.28	30.18	31.89	26.41
FYM + PSB	31.42	36.52	39.54	41.22	37.17	29.18	33.47	36.92	38.52	34.52
Mean	23.95	28.11	33.50	36.63		21.99	25.80	31.01	34.69	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	1.05	3.17	P levels (F_1)	1.13	3.41
P components (F_2)	1.05	3.17	P components (F_2)	1.13	3.41
F_1x F_2	2.10	NS	F_1x F_2	2.27	NS

Table 6.Available potassium (kg ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	342.4	345.0	342.9	347.5	344.4	382.4	354.5	334.7	386.2	364.5
FYM	337.6	338.6	357.0	366.1	349.8	373.4	383.2	428.6	433.3	404.6
PSB	344.8	334.2	342.6	344.6	341.6	391.6	405.6	413.9	357.1	392.0
FYM + PSB	362.6	355.8	352.2	365.4	359.0	436.3	370.3	419.2	393.4	404.8
Mean	346.9	343.4	348.1	355.9		395.9	378.4	399.2	392.5	

	S Em	CD @ 5 %		S Em	CD @ 5 %
P levels (F_1)	6.38	19.3	P levels (F_1)	8.03	24.5
P components (F_2)	6.38	19.3	P components (F_2)	8.03	24.5
F_1x F_2	12.85	38.6	F_1x F_2	16.10	48.1

Table 7. Available sulphur (kg ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	At flowering					At harvest				
	Phosphorus levels					Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	21.62	22.41	23.06	24.15	22.81	19.18	20.12	20.98	22.28	20.64
FYM	25.41	26.20	27.28	29.17	27.01	22.67	23.57	25.10	27.02	24.59
PSB	21.89	24.10	25.16	26.24	24.35	19.87	22.66	22.51	24.11	22.29
FYM + PSB	25.62	26.79	28.04	30.30	27.69	23.22	24.12	25.72	27.56	25.15
Mean	23.63	24.87	25.88	27.46		21.23	22.62	23.58	25.24	

	At flowering S Em	At flowering CD @ 5 %	At harvest S Em	At harvest CD @ 5 %
P levels (F_1)	1.04	3.17	0.73	2.21
P components (F_2)	1.04	NS	0.73	2.21
F_1x F_2	2.09	NS	0.89	2.68

Table 8: Seed yield (q ha^{-1}) as influenced by integrated phosphorus management in chickpea

Components of P	Phosphorus levels				
	P_0	P_{25}	P_{50}	P_{75}	Mean
Inorganic	6.28	8.42	9.82	9.92	8.61
FYM	8.44	9.41	10.38	11.08	9.83
PSB	8.97	9.82	11.29	11.78	10.47
FYM + PSB	9.09	10.38	10.80	14.45	11.18
Mean	8.20	9.51	10.57	11.81	

	S Em	CD @ 5 %
P levels (F_1)	0.44	1.34
P components (F_2)	0.44	1.34
F_1x F_2	0.89	2.68

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STATUS OF AVAILABLE MICRONUTRIENTS OF THE SAMPLED SOIL OF *INCEPTISOL* FROM JANJGIR DISTRICT OF CHHATTISGARH

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ABSTRACT

A detailed study of *Inceptisol* of Akaltara block, Janjgir district of Chhattisgarh was undertaken to assess the fertility status in the year 2010. After systematic survey, 1000 surface (0-15cm) soil samples were collected from 79 villages in Akaltara block covering 1000 sites (10000 ha) using the GPS such that one sample represents each grid of 10 ha based soil area represented. The soil available Fe, Mn and Cu were found in more than sufficient level, whereas 45% soil samples under *Inceptisol* of Akaltara block were delineated as deficient in available Zn content. The DTPA-extractable iron content ranged from 7.58 to 80.1 mg kg^{-1} with an average of 39.45 mg kg^{-1}. Manganese content ranged from 4.58 to 63.66 mg kg^{-1} with an average of 28.33 mg kg^{-1}, Copper content ranged from 0.34 to 7.68 mg kg^{-1} with an average of 2.95 mg kg^{-1} and zinc content ranged from 0.16 to 5.90 mg kg^{-1} with an average of 0.91 mg kg^{-1}. The samples of the study area were determined for pH and observed in the range of 4.8-6.70 with the mean value of 5.83, thus representing strongly acidic to neutral in reaction. The electrical conductivity of the soil water suspension ranged from 0.06 to 0.36 dS m^{-1} at 25^{o}C, with an average of 0.12 dS m^{-1} and was in safe limits. In the soil samples of Inceptisol collected from different villages of Akaltara block the organic carbon in all samples exhibited range of 0.23 to 0.66% with an average of 0.48%. Thus, the Inceptisol of Akaltara block are low to medium in organic carbon content. The significant and negative correlation was observed between soil pH and available Fe, Mn, Cu and Zn. Electrical conductivity of the soils exercised significant and negative relationship with available Mn and Cu. The available Fe, Mn, Cu and Zn showed significant and positive correlation with organic carbon.

(**Key words** : **Micronutrient status, *Inceptisol*, GPS based soil sampling**)

INTRODUCTION

Inceptisol is locally called *Matasi*. This soil is immature with weakly developed profile features. The soil is light textured with shallow to moderate depth. The soil is marginally suited for upland crops due to lack of structural stability, tendency to surface sealing and hard setting on drying, high susceptibility to erosion and limited water holding capacity. Under this order, the dominating sub-groups are Typic Haplustepts and Vertic Haplustepts which have clayey texture with clay content varying from 48.0 to 55.0 per cent. Typic Haplustepts is sandy clay loam to clay in texture with clay content ranging from 33.2 to 50.4 per cent. Clay content in the soil generally increased with depth indicating movement of clay from surface to sub surface layers. Very high profile water storage capacity was observed in Vertic Haplustepts and high profile water storage capacity was observed in Typic Haplustepts. The district Janjgir is situated in the centre of the Indian state of Chhattisgarh and so it is considered as the Heart of Chhattisgarh and is a major contributor of food grains in the state of Chhattisgarh. The Hasdeobango irrigation project has been considered as life supporting in the command area which accounts for 330524 ha area and irrigates 75% of the area of Janjgir district. At present time, micronutrient study is very important because most of the research done only on macronutrient like- N, P, K. So there is need of location specific research attention on delineation of micronutrient status of soils and their deficiency and toxicities affecting the crop growth. Such study is felt necessary now more than ever before. Hence, estimation of micronutrient status of Inceptisol of Akaltara tehsil of Janjgir district (C.G.) was undertaken. This system maintains soil fertility and plant nutrient supply from various sources through an integrated approach also. Such study on micro-nutrient status has not been done in Akaltara tehsil of Janjgir district which is also potential area for rice cultivation with facility of protective irrigation in majority area. Keeping this gap in mind, study was undertaken to determine the micro-nutrients status of inceptisol soils of Akaltara tehsil of Janjgir district (C.G.).

MATERIALS AND METHODS

The investigation to evaluate the soil fertility status of *Inceptisol* in different villages of Akaltara block of Janjgir district of C.G.was undertaken during the year 2010. Although four types of soils namely Entisol,Inceptisol,Alfisol and Vertisol are present,

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Inceptisol soils are more predominant and therefore this soil type was chosen in the study. Total 79 villages were included under the study. The villages were Chandaniya, Changori , Katnai, Ameri, Barbaspur, Latiya, Saraipali, Devarikhod, Suwarmal, Taga, Sonsari, Karumahu, Parsada (Leelagartir), Gadola, Akaltari, Sonadula, Pharada, Khisora, Jhiriya, Madhuva, Khaparidih, Amartal, Tarod, Lilawadih, Sondih, Darri, Mahuadih, Sajapali, Parsahi-Bana, Bana, Barpili, Karhidih, Buchihardi, Bhaistara-Damami, Padriya, Sankar, Murlidih, Dhanva, Kirari, Khod, Jhilmila, Amora, Kotgarh, Mahamadpur, Nariyara, Khatola, Arjuni, Rogda, Bamhani, Pondilalha, Pakriya, Pauna, Arasmeta, Banahil, Pachri-Khod, Parsahi-Podi, Katghari, Raseda, Mudpar, Pakriya, Amalipali, Barganwa, Kalyanpur, Birkoni, Piparda, Sondih, Parsada, Bhaistara-Malgujari, Tilai, Kotmi, Piparsatti, Kapan, Dalha-Damami, Nawapara, Akaltara and Hardi. The area to be mapped was divided into small systematic grids of whole agricultural land of each village. The village maps prepared by land revenue records were obtained from the concerned department. Once these maps were obtained in digital format, suitable soil sampling spots were precisely identified by overlaying systematic grids. The approach roads were overlaid on the map and the exact position of sampling spots (latitude, longitude) were obtained. Once the spots were fixed, they were navigated and the correct spot with the help of global positioning system (GPS) was finalised. The method of using these techniques for devising suitable soil sampling plan has been described by Polive and Aubert (1998). The application of soil sampling for spatial fertilizer recommendation is described recently by Grandzinski *et al.* (1998).

Table work :

Land System maps published by Chhattisgarh Infot tech and Biotech Promotion Society (CIBPS) and Indian Space Research Organisation (ISRO) in 2004-05 at the scale of 1:4000 have been used as the cadastral maps for conducting the field survey works. Prior to the actual fieldwork, tentative sampling sites were fixed on the cadastral maps. These sampling sites were set and distributed in such a way that all the agriculturally important land system units are proportionately represented.

Systematic sampling of soils :

Sampling points were pre-determined across a field for a soil type under study at fixed interval systematically across a grid from each of 10 ha area. Considering this unit of 10 ha as the ultimate unit, such 1000 sites were selected from 79 villages of Akaltara tehsil of Janjgir distrist. Within each of such sample unit, five samples were randomly taken for further analysis, to represent the 10 hectares area selected under the *Inceptisol* soil. Rice is main crop of the study area and it is being shallow rooted crop, soil samples upto the depth of 15 cm (0-15cm) were drawn from five spots, per sampling unit using soil auger. Then, these five samples of 200 g each were thoroughly mixed together and finally 1000 g soil samples per unit was collected and properly labelled and further used for analytical purpose. Thus, in all 1000 soil samples were analysed.

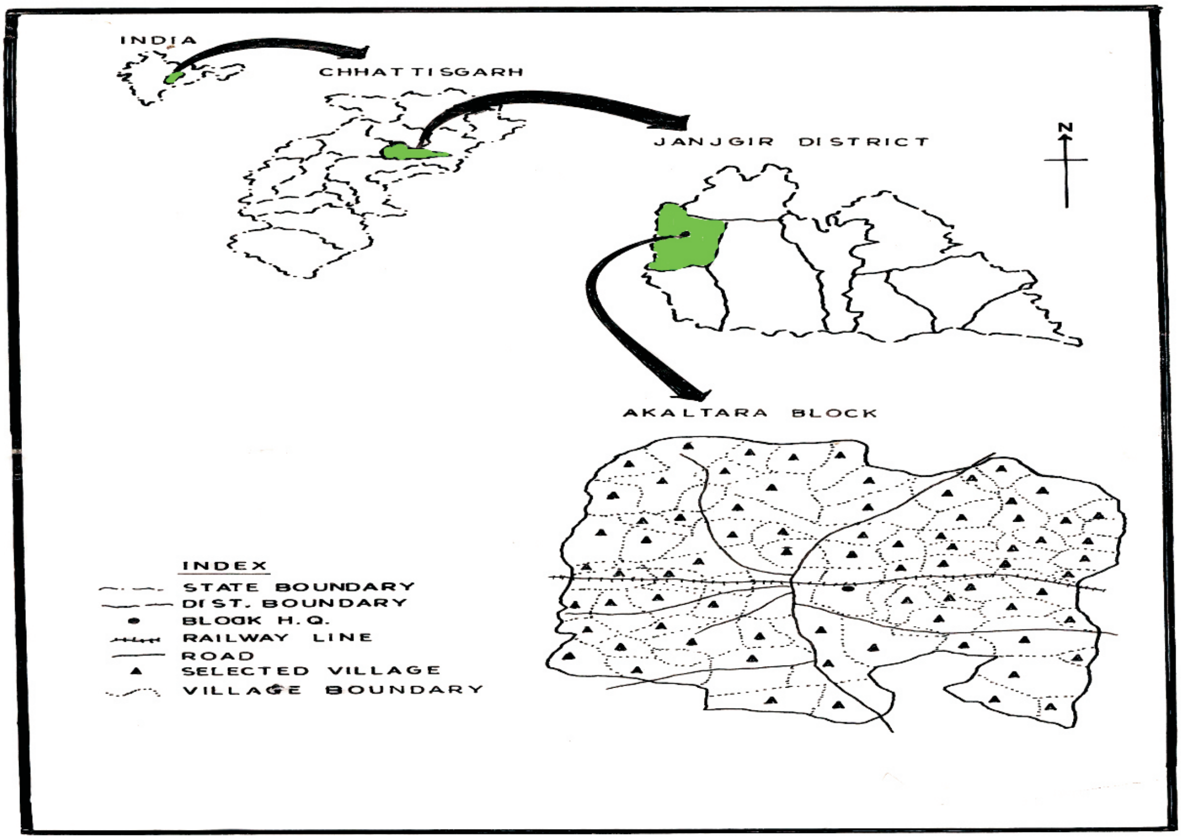
Laboratory work :

Soil samples collected from the study area were dried and crushed with the help of wooden rod and passed through 2 mm sieve and then used for the determination of soil pH, organic matter, macronutrients and micronutrients content by adopting standard laboratory methods as detailed below -

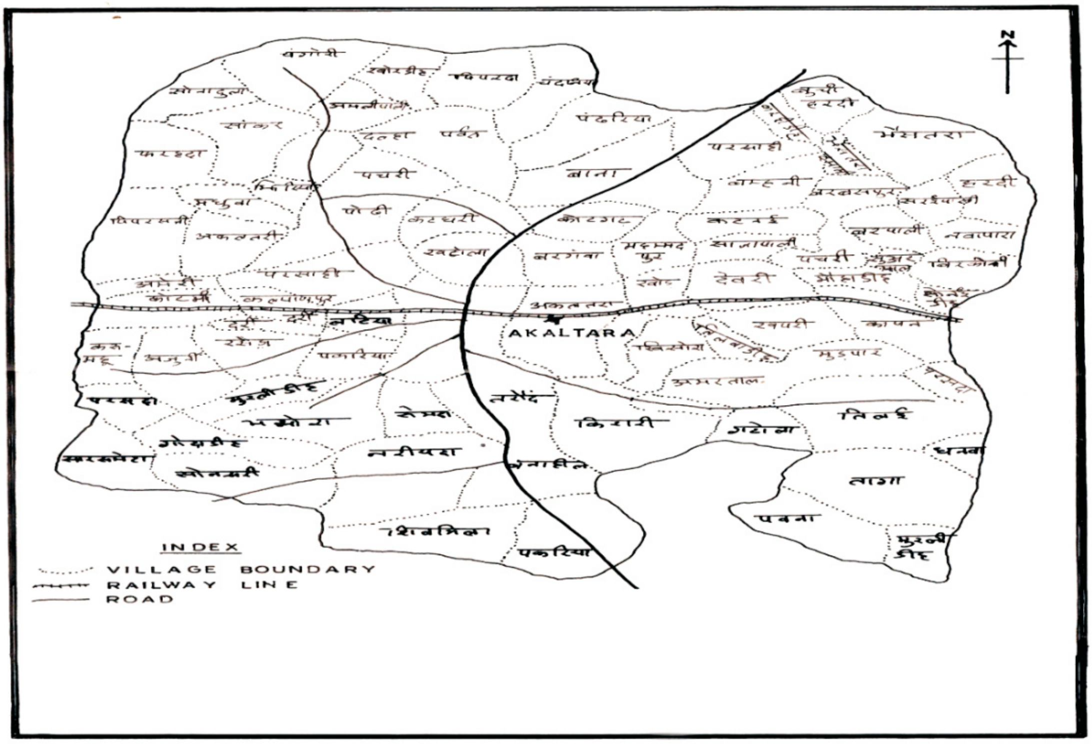
The micronutrients Zn, Cu, Fe and Mn were extracted by using 0.005M diethylene triamine penta acetic acid (DTPA), 0.01M calcium chloride dehydrate and 0.1M triethanol amine buffered at pH 7.3 (Lindsay and Norvell, 1978) and concentrations were analyzed by atomic absorption spectrophotometer 4129. Soil pH was determined by glass electrode pH meter in 1:2.5 soil water suspensions after stirring for 30 minutes as described by Piper (1967). The soil samples used for pH determination were allowed to settle down for 24 hours, and then the supernatant liquid was used to determine the electrical conductivity by Solu-bridge as described by Black (1965). Organic carbon was estimated by Walkley and Black's (1934) rapid titration method as described by Jackson (1967).

Statistical analysis :

A complete enumeration of all the sample points under the *Inceptisol* stratum was made for different soils variables stated above, and standard statistical procedure including correlation studies was adapted to analyze the data.



Location map of Akaltara block showing the study area



Location map of villages of study area

RESULTS AND DISCUSSION

Status of available micronutrients of soils :

Iron :

The data of available iron content of different soil samples of *Inceptisol* collected from different villages of Akaltara block are given in table1. The results showed that the available iron content ranged from 7.58 to 80.10 mg kg^{-1} with a mean value of 39.45 mg kg^{-1}. Considering the soil test rating for DTPA-extractable Fe (<4.5 mg kg^{-1} as deficient, 4.5-9.0 mg kg^{-1} as sufficient and >9.0 mg kg^{-1} as higher level), majority of the sampled area (99.10 %) fall under high (>9.0 mg kg^{-1}) and only 0.90% soil samples were categorized under sufficient (<4.5 mg kg^{-1}) status. Kumar *et al.* (2009) observed that an available Fe content of Dumka and Lachimpur series of Jharkhand, varied from 2.50 to 15.80 mg kg^{-1} with a mean of 7.66 mg kg^{-1} and 6.40 to 96.50 mg kg^{-1} with a mean of 19.41 mg kg^{-1} in soils of Santhal Paraganas region of Jharkhand. Dutta and Ram (1993) claimed that available iron varied from 4.3 to 61.8 mg kg^{-1} in soil series of Tripura. Verma (2012) reported that available Fe content ranged from 3.2 to 60.1 mg kg^{-1} in soils of Malkharauda block of Janjgir-Champa district of Chhattisgarh.

Manganese :

The data of available manganese content of different soil samples of *Inceptisol* collected from different villages of Akaltara block are given in table1. The results showed that it ranged from 4.58 to 63.66 mg kg^{-1} with an average of 28.33 mg kg^{-1}. Considering the soil test rating for DTPA-extractable Mn (<3.5 mg kg^{-1} as deficient, 3.5 to 7.0 mg kg^{-1} as sufficient and >7.0 mg kg^{-1} as higher level), majority of the sampled area (99.30 %) fall under higher level status (>7.0 mg kg^{-1}) and only 0.70% soil samples were categorized under sufficient (3.5 to 7.0 mg kg^{-1}) status in DTPA-extractable Mn content. Meena *et al.* (2006) found that the available manganese content varied from 6.85 to 45.25 mg kg^{-1} with a mean value of 21.56 mg kg^{-1} in soils of Tonk district of Rajasthan. Sharma and Chaudhary (2007) reported that available Mn in the studied profiles varied from 2.7 to 56.7 mg kg^{-1}, respectively in lower Shiwaliks of Solan district in North–West Himalayas.

Copper :

The data of available copper in different soil samples of *Inceptisol* collected from different villages of Akaltara block are given in table 1. The results showed that it ranged from 0.34 to 7.68 mg kg^{-1} with an average of 2.95 mg kg^{-1}. Considering the soil test rating for DTPA-extractable Cu (<0.2 mg kg^{-1} as deficient, 0.2-0.4 mg kg^{-1} as sufficient and > 0.4 mg kg^{-1} as higher level), majority of the sampled area (99.50 %) fall under higher status (>0.4 mg kg^{-1}) and only 0.50% soil samples were categorized under sufficient (0.2-0.4 mg kg^{-1}) DTPA-extractable Cu status. Singh *et al.* (2006) reported that the DTPA extractable Cu varied from 0.79 to 6.44 mg kg^{-1} in soils of Nainital and Almora district of Kumaon hills of Uttaranchal.

Zinc :

A study of available zinc content of different soil samples of *Inceptisol* collected from different villages of Akaltara block are given in table 1. The results showed that it ranged from 0.16 to 5.90 mg kg^{-1} with an average of 0.91 mg kg^{-1}. Considering the soil test rating for DTPA-extractable Zn (<0.6 mg kg^{-1} as deficient, 0.6-1.2 mg kg^{-1} as sufficient and >1.2 mg kg^{-1} as higher level), majority of the sampled area (45.10 %) fall under deficient (<0.6 mg kg^{-1}) and required Zn application for optimum production and to get full benefit from NPK fertilizers. Only 35.10% soil samples had sufficient (0.6-1.2 mg kg^{-1}) and 19.80% soil samples exhibited higher status (>1.2 mg kg^{-1}) of DTPA-extractable Zn content. Minakshi *et al.* (2005) reported that DTPA-Zn content varied from 0.14 to 4.9 mg kg^{-1} soil with a mean value of 1.45 mg kg^{-1} soil in Patiala district of Punjab. Dwivedi *et al.* (2005) found the DTPA extractable Zn in the range from 0.06 to 16.3 mg kg^{-1} in soils of Leh district and 0.14 to 5.17 mg kg^{-1} in soils of Kargil district of Ladakh region of Jammu and Kashmir. Thus, deficiency of Zn appears to be prevalent in other areas also.

Soil reaction (pH) :

The samples of the study area were determined for pH (Table 2) and were observed in the range of 4.8-6.70 with the mean value of 5.83. The pH estimated from total 1000 soil samples of Akaltara block covering about 79 villages showed that nearly

42.90 % samples fall under moderately acidic (pH 5.5-6.0), 29.80 % under slightly acidic (pH 6.0-6.5), 26.30 % under (pH <5.5) strongly acidic (Table 2) and only 1.00 % samples (pH 6.5-7.5) were categorized under neutral soil reaction. The relative low pH of the soils is due to low base saturation and light textured soil. Kumar *et al.* (2009) characterized the soils of Santhal Paraganas region of Jharkhand, and they reported that Dumaka soil series were found in low pH range (from 3.80 to 6.40) and Lachimpur series showed wide variation in pH (4.60 to 7.70).

Electrical conductivity (E.C.) :

Data regarding electrical conductivity of different soil samples of Inceptisol collected from different villages of Akaltara block are given in table 2. The results showed that the EC of the soil water suspension ranged from 0.06 to 0.36 dS m^{-1} at 25°C, with an average of 0.12 dS m^{-1}. The results showed that the soluble salt content is under (<1.0 dS m^{-1}) normal range (Table 2) and there is no deleterious effect on crop. The normal soil EC may be ascribed to leaching of salts to lower horizons and its light textured nature. Sharma and Chaudhary (2007) reported that available EC status in the soil profiles of different soil series ranged from 0.09 to 0.40 dS m^{-1} in lower Shiwaliks of Solan district in North–West Himalayas.

Organic carbon :

The organic carbon in all samples exhibited range of 0.23 to 0.66% with an average of 0.48%. (Table 2). Thus, the Inceptisol of Akaltara block are low in organic carbon content. Distribution of soil samples with respect to organic carbon content also indicates (Table 2) that about 61% samples have low (<0.50 %) and 39 % medium (0.50-0.75%) organic carbon. Use of almost nil to very low amount of organics like farm yard manure and chemical fertilizers in imbalanced manner are the main reasons for poor organic carbon and low productivity of the region.

Correlation studies of micronutrients :

Iron :

The available Fe was negative and significantly correlated (r = -0.079*) with pH (Table 4). This confirms the basic chemistry of Fe availability in various pH levels of the soil. Shukla (2011) reported that the available iron was negative and significantiy correlated with pH (r = -0.095**) in inceptisols of Pamgarh block at Janjgir district of Chhattisgarh. Minakshi *et al.* (2005) reported that the DTPA Fe was negatively but significantly correlated with pH in soils of Patiala district of Punjab. Negative significant correlation was observed between available Fe and electrical conductivity (r = -0.067*) in *Inceptisol* of Akaltara block (Table 3). Sharma *et al.* (2006) reported that the electrical conductivity was negatively correlated with iron in soils of Leh district of cold arid region of Ladakh. A significant positive correlation (r = 0.094**) was found between organic carbon and available Fe content (Table 3). Yadav and Meena (2009) reported that available Fe was positively correlated (r = 0.872**) with organic carbon content in Degana soil series of Rajasthan. Thus, the results of present studies conform the previous revelations.

Manganese :

Soil pH was negatively correlated with available Mn (r = -0.122**) content (Table 3) with significance. The possible reason behind this may be the formation of insoluble higher valent oxides of Mn at high pH. Kumar *et al.* (2009) showed the negative significant correlation of available Mn (r = -0.374**) with pH in Lachimpur series, whereas no such relationship was found in Dumka series in soils of Santhal Paraganas region of Jharkhand. No significant but negative correlation was found between available Mn (r = -0.052) content and electrical conductivity (Table 3). Sharma *et al.* (2006) reported the non significant negative correlation between available manganese and electrical conductivity in soils of Leh district of cold arid region of Ladakh. Available Mn was positive and significantly correlated (r = 0.071*) with organic carbon (Table 3). Since organic carbon shows the level of organic matter present in a soil, this micronutrient is present in appreciable amount and hence there is positive relation of organic carbon with the micronutrient. Sharma *et al.* (2006) reported that the available Manganese was positively correlated (r=0.029) with organic carbon in soils of Leh district of cold arid region of Ladakh.

Table 1. Mean and standard deviation of available iron, manganese, copper and zinc of Akaltara block

Soil characteristics	Range	Mean	S.D.
Available Fe (mg kg^{-1})	7.58-80.1	39.45	$\pm$14.16
Available Mn (mg kg^{-1})	4.58-63.66	28.33	$\pm$10.56
Available Cu (mg kg^{-1})	0.34-7.68	2.95	$\pm$1.48
Available Zn (mg kg^{-1})	0.16-5.90	0.91	+0.67

Number and per cent soil samples under ratings

Available iron			Available manganese			Available copper			Available zinc		
Iron (kg ha^{-1})	**No. of samples analyzed**	**Per cent (%) of samples**	**Manganese (kg ha^{-1})**	**No. of samples analyzed**	**Per cent (%) of samples**	**Copper (kg ha^{-1})**	**No. of samples analyzed**	**Per cent (%) of samples**	**Zinc (kg ha^{-1})**	**No. of samples analyzed**	**Per cent (%) of samples**
Deficient (<4.5)	0	0	Deficient (<3.5)	0	0	Deficient (<0.2)	0	0	Deficient (<0.6)	451	45.10%
Sufficient (4.5-9.0)	9	0.90%	Sufficient (3.5-7.0)	7	0.70%	Sufficient (0.2-0.4)	5	0.50%	Sufficient (0.6-1.2)	351	35.10%
Higher level (>9.0)	991	99.10%	Higher level (>7.0)	993	99.30%	Higher level (>0.4)	995	99.50%	Higher level (>1.2)	198	19.80%
Total	1000	100%	**Total**	1000	100%	**Total**	1000	100%	**Total**	1000	100%

Table 2. Mean and standard deviation of Soil pH, EC and Organic carbon of Akaltara block

Soil characteristics	Range	Mean	S.D.
pH (1:2.5, Soil water)	4.8-6.70	5.83	± 0.38
E.C. (dS m^{-1})	0.06-0.36	0.12	± 0.04
O.C. (%)	0.23-0.66	0.48	+0.06

Number and per cent soil samples under ratings

Soil pH			EC			OC		
Soil Reaction	**No. of samples analyzed**	**% of samples**	**E.C. (dS m^{-1})**	**No. of samples analyzed**	**% of samples**	**Organic carbon (%)**	**No. of samples analyzed**	**% of samples**
<5.5 (strongly)	263	26.30%	No deleterious effect on crop (<1)	1000	100.00%	Low (<0.50)	606	60.60%
5.5-6 (moderately)	429	42.90%	Critical for germination (1-2)	0	0%	Medium (0.50-0.75)	394	39.40%
6-6.5 (slightly)	298	29.80%	Critical for salt sensitive crop (2-3)	0	0%	High (>0.75)	0	0%
6.5-7.5 (neutral)	10	1.00%	Injurious to most crops (>3)	0	0%			
Total	1000	100%	**Total**	1000	100%	**Total**	1000	100%

Table 3. Correlation coefficient (r) for physico-chemial properties and DTPA-extractable Fe, Mn, Cu and Zn of inceptisol of Akaltara block.

Soil properties	Fe	Mn	Cu	Zn
p H	- 0.079*	- 0.122**	- 0.174**	- 0.063*
E C	- 0.067*	- 0.052	- 0.093**	- 0.54
OC	0.094**	0.071*	0.116**	0.1**

*Significant at 5% level (0.062) **Significant at 1% level (0.081)

Copper :

A significant negative correlation (r = -0.174 **) was found between soil pH and available copper (Table 3). The availability of Cu content showed higher values at low pH due to their solubility effects. Meena *et al.* (2006) reported that a significant negative correlation (r = -0.195**) was observed between soil pH and available copper in soils of Tonk district of Rajasthan. Negative significant correlation was also observed between available copper and electrical conductivity (r = -0.093**) in *Inceptisol* of Akaltara block (Table 3). Sharma *et al.* (2006) reported that the electrical conductivity was negatively correlated with Copper in soils of Leh district of cold arid region of Ladakh. A significant positive relationship (r = 0.116**) was observed between organic carbon and available copper (Table 3). The availability of metal ion (Cu) increases with increase in organic matter which may supply chelating agents. Minakshi *et al.* (2005) reported that the DTPA-extractable Cu was significantly and positively correlated (r = 0.566) with soil organic carbon content in soils of Patiala district of Punjab. Thus, present results are in general agreement with these results.

Zinc :

A significant and negative relationship of Zn (r = -0.063*) was observed with pH (Table 3), thereby indicating that availability of Zn decreases with increase in soil pH. This negative relationship might be attributed to the increased availability of Zn under low pH condition which increased solubility of oxides and hydroxides of this micronutrient. Thakur and Bhandari (1986) reported a negative correlation between available zinc and soil pH in Saproon valley of Himanchal Pradesh (r = -0.2). Non significant negative correlation was found between available Zn (r = -0.54) content and electrical conductivity (Table 3). Available Zn was positive and significantly correlated (r = 0.1**) with organic carbon (Table 3), since organic carbon shows the level of organic matter present in a soil. Minakshi *et al.* (2005) reported that the DTPA-Zn content of soils exhibited a positive and significant correlation with organic carbon (r = 0.284), in soils of Patiala district of Punjab.

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PRODUCTIVITY AND ECONONICS OF LENTIL (*Lens culinaris,*MEDIKUS) AS AFFECTED BY DIFFERENT WEED MANAGEMENT PRACTICES

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ABSTRACT

The present investigation deals with the productivity and econonics of lentil *(Lens culinaris* Medikus) as affected by different weed management practices.The study was carried out during *rabi* (winter) season of 2010-11 at the Research Farm, Indira Gandhi Krishi Vishwavidyala, Raipur. The experiment was laid out in randomized block design with three replications and 12 treatments of weed management which included quizalofop-p-ethyl, imazethapyr, pendimethalin,chlorimuron ethyl alone or in combination. In addition to these weedicidal treatments, stale seed bed, lentil+linseed and lentil+mustard were also included in the treatments.In experimental field, *Chenopodium album, Euphorbia hirta, Melilotus alba, Anagallis arvensis, Xanthium strumarium* and *Cyperus rotundus* were the dominant weeds and were found throughout the crop growth period.

Results revealed that maximum seed yield and stover yield were obtained under hand weeding twice at 20 and 40 DAS, followed by pendimethalin applied as PE @ 1.0 kg a.i. ha^{-1} + imazethapyr as PoE @ 37.5 g a.i. ha^{-1} . Intercropping of lentil + linseed (1:1 additive series) and lentil + mustard (1:1 additive series) had produced at par lentil equivalent yield. The minimum values of above character were observed under control plot. The highest gross income (Rs. 49574.66) was obtained under hand weeding twice at 20 and 40 DAS, whereas highest net income (Rs. 34502.19) and B:C ratio (2.33) were recorded under intercropping of lentil + mustard followed by pendimethalin applied as PE @1.0 kg a.i. ha^{-1} + imazethapyr as PoE @ 37.5 g a.i. ha^{-1} .

(Key words*:* Weed management practices, productivity and economics of lentil)

INTRODUCTION

The lentil *(Lens culinaris* Medikus) is a lens-shaped grain legume well known as a nutritious food. It grows as an annual bushy leguminous plant typically 20-45 cm tall, which produces many small purse- shaped pods containing one to two seeds each. Lentil is an integral part of diet of Indian and middle Eastern people. But it also features in many French and Italian regional dishes, where they are often cooked with salted fish or meat – a legacy of peasant food. Lentil is an important food legume, among more than a dozen pulse crops grown in India. It is not only a rich source of improved nutrition for people but also provides nutritious straw for cattle. Lentil contains about 11 per cent water, 25 per cent protein and 60 per cent carbohydrate. It is also rich in calcium, iron and niacin and high lysine and tryptophane content. The important lentil growing countries of the world are India, Turkey, Syria, Pakistan, Spain and Bangladesh. India ranks first in the world in respect of production as well as area followed by Turkey. India's position in average productivity of lentil is 23rd in world. The total area under lentil crop in our country is 1.38 million ha. The production of this crop is 0.95 million tonnes with the productivity of 693 kg ha^{-1} (Anonymous, 2009). Lentil *(Lens culinaris* Medikus) is an important winter season pulse crop in India. Its productivity is adversely affected by the presence of weeds. The prominent weed species infesting lentil crop are *Cynodon dactylon, Chenopodium album, Euphorbia hirta, Melilotus alba, Anagallis arvensis* and *Xanthium strumarium*.etc. The concept that high input provided for higher yield, also pose high risk, if weeds are not controlled. A weed free crop environment is, therefore, important both for increasing yield and income for the security of crop. During recent past, it has been progressively realized that for a more permanent agriculture, one must develop concept of "Weed management" in variance with the more popularly known weed control. Lentil is generally cultivated in Chhattisgarh as monoculture crop in paddy / soybean - lentil cropping system. There are two types of sowing systems *i.e.* after harvest of paddy / soybean as cultivated crop and in standing paddy crop as *utera* crop. In lowland areas with excessive moisture, lentil is a more assured crop than chickpea. It occupies an area of 23.24 thousand ha with production and productivity of 9.61 thousand tonnes and 441 kg ha^{-1}, respectively (Anonymous, 2010).There are number of reasons for low production and productivity of lentil out, of which weeds, being serious negative factors in crop production are responsible for reduction in the yield of lentil to a tune of 84 per cent (Mohamed *et al*., 1997). To control weeds generally hand weeding is in

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practice but it is now costly as well as difficult because of non-availability of labour in peak period. With the advancement of agro techniques, chemical weed control has become an effective and affordable alternative to control weeds. With this view, the study was undertaken to evaluate the influence of various weed management practices including chemical weedicides on productivity and economics of lentil crop.

MATERIALS AND METHODS

The field experiment was conducted in the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *rabi* (winter) season of 2010 – 11. Raipur is situated in central part of Chhattisgarh and lies at 21^0 16' N latitude and 81^0 36' E, longitude with an altitude of 298 meter above mean sea level. The climatic condition of Raipur is sub-humid to semi-arid. The average annual rainfall is 1326 mm, out of which 85% rainfall is received during rainy season (June to September) and the rest during winter and summer season (October to May). May is the hottest and December is the coolest month of the year. The pattern of rainfall particularly during June to September months has great variation from year to year. The maximum temperature is as high as 46°C during summer. The relative humidity is high from June to October and wind velocity is high from May to August with its peak in June-July months.

Experimental details:

The experiment was laid out in Randomized Block Design with 12 treatments replicated thrice. The treatments were allotted to different plots by using random method. The details of the treatments are presented below:

Treatment details	Other Details	
T_1: Quizalofop -p-ethyl @ 50.0 g a.i.ha^{-1} (PoE)	Variety	: JL-3
T_2: Imazethapyr @ 37.5 g a.i. ha^{-1} (PoE)	Design	:Randomised Block Design
T_3: Chlorimuron ethyl @ 4.0 g a.i. ha^{-1} (PPI)	Treatments	:12 (Twelve)
T_4: Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE)	Replication	: 03 (Three)
T_5: Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) +	Gross plot size	: 5.00 X 4.00 m = 20.00 m^2
Quizalofop -ethyl @ 50.0 g a.i. ha^{-1} (PoE)	Net plot size	: 4.00 X 3.00 m = 12.00 m^2
T_6: Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) +	Total Experimental	: 909.50 m^2
Imazethapyr @ 37.5 g a.i.ha^{-1} (PoE)	area Spacing	: 25 X 5 cm
T_7: Hand weeding twice (20 & 40 DAS)	Date of sowing	: 05th December, 2010
T_8: Weedy check	Date of harvesting	: 08th March, 2011
T_9: Chlorimuron ethyl @ 4.0 g a.i. ha^{-1} (PoE)		
T_{10}: Stale seed bed		
T_{11}: Lentil+ Linseed [1:1 additive series]		
T_{12}: Lentil + Mustard [1:1 additive series]		

'JL-3' cultivar's of lentil was taken as test crop. It is a medium duration bold seeded variety and matures in 100-110 days. Its potential yield is 12-15 q ha^{-1}. This variety is resistant to wilt disease.

A recommended seed rate of 30 kg ha^{-1} was used. The seeds were treated with Bavistin and *rhizobium* @ 2.5 g and 5 g kg^{-1} of seed, respectively. Seed was drilled in row, maintaining the row to row and plant to plant spacing of 25 and 5 cm, respectively. The gap filling was done 7 days after sowing and plant population within row was maintain at 5 cm. by thinning at 20 DAS.

Basal dose of N: P: K: S @ 20: 17:16:20 kg ha^{-1} was applied uniformly to each plot. Nitrogen was applied through urea (0.56 kg plot^{-1}), phosphorus and nitrogen through diammonium phosphate (0.73 kg plot^{-1}), potash through muriate of potash (0.56 kg plot^{-1}) and sulphur through gypsum (0.21 kg plot^{-1}). The required amount of different fertilizers was weighed for individual plots and drilled at the time of sowing. For protection against insect pests, monocrotophos @ 2 ml litre^{-1} of water was sprayed two times at 35 and 65 DAS.

Application of herbicides:

The dose of different herbicides was determined as per treatments according to their active ingredient present in the commercial products. The measured dose of herbicides and water (500 l ha^{-1}) for each plot was mixed thoroughly before spraying. Hand compression sprayer with flat fan nozzle was used. Fresh solution for individual plot was prepared each time separately. After completing the spray of one herbicidal treatment in all the replications, the sprayer was washed thoroughly with detergent powder and finally rinsed with fresh water before using other herbicidal treatment. The herbicides were applied as PPI (1 day before sowing), pre-emergence (PE, 2 DAS) and post-emergence (PoE, 20 and 35 DAS), as per treatments.

Yield of seed and stover (kg ha^{-1}) :

Seed yield and stover yield were recorded on net plot basis after harvesting and threshing of the crop. Then net plot^{-1} values of these yields were converted into ha^{-1} basis.

Economics :

The cost of cultivation of lentil crop was calculated on the basis of prevailing prices for different fixed inputs. The cost of application of weed management practices was added to this fixed input cost and thus total cost of cultivation treatment^{-1} was determined the production of lentil crop (both seed and stover) was converted into gross returns (Rs. ha^{-1}) on the basis of prevailing prices of market. Net returns were worked out by subtracting treatment-wise total cost of cultivation from the gross returns. This value gave the actual profit obtained by the farmer under different treatments. Further, economics of lentil crop production pertaining to each of the treatments was worked out in terms of Benefit:cost ratio by dividing net return with cost of cultivation for each treatment.

RESULTS AND DISCUSSION

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

The data pertaining to seed yield (kg ha^{-1}) are presented in table 1. It is evident from the table that significantly maximum seed yield was produced under hand weeding twice at 20 and 40 DAS which was at par with yield obtained from the plot treated with pendimethalin as PE @ 1.0 kg a.i. ha^{-1} + imazethapyr as PoE @ 37.5 g a.i. ha^{-1}, and lentil equivalent yield of intercropping with mustard. The yield recorded under the best treatment was 986.17 kg ha^{-1}, 983.87 kg ha^{-1} and 983.03 kg ha^{-1} higher, than the later treatments respectively. Minimum seed yield was recorded under weedy check plot. These results are in agreement with the findings of Singh and Choudhary (1970) who reported that one and two hand weeding produced significantly higher yield of lentil (2361 kg ha^{-1} and 2807 kg ha^{-1}) over control. Dawood (1994) also reported performance of one, two or three hand weedings in lentil which increased seed yield by 142.42 per cent, 208.79 and 182.79 per cent, respectively as compared to the weedy check.

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

Data on stover yield (kg ha^{-1}) are presented in table 1. It is quite clear from the table that among all weed management practices, hand weeding twice at 20 and 40 DAS produced maximum stover yield which was significantly superior to rest of the treatments except pendimethalin applied as PE @ 1.0 kg a.i. ha^{-1} + imazethapyr as PoE @ 37.5 g a.i. ha^{-1}and intercropping of lentil + linseed and lentil + mustard. The lowest yield was recorded under weedy check. Singh and Choudhary (1987) reported that Hand weeding twice gave comparatively higher grain and straw yield of lentil (2.54 t ha^{-1} and 3.87 t ha^{-1}, respectively) than chemical treatments. It might be due to effective control of weeds by hand weeding twice at 20 and 40 DAS , pendimethalin as PE @ 1.0 kg a.i. ha^{-1} + imazethapyr as PoE @ 37.5 g a.i. ha^{-1} and intercropping of lentil + linseed which provided opportunity to grow crop plant in better way.

Economics :

Data regarding fixed cost of cultivation excluding cost incurred in weed management treatments are presented in table 2 and data regarding total cost of cultivation for each weed management treatment, including cost of each treatment applied, gross returns, net returns and benefit:cost ratio are presented in table 3. It was observed that the maximum total cost of cultivation (Rs.16489.00 ha^{-1}) was computed under hand weeding twice at 20 and 40 DAS and minimum (RS.12739.00 ha^{-1}) was under weedy check. The highest gross returns (Rs 49574.66 ha^{-1}) was noted under hand weeding twice at 20 and 40 DAS which was found comparable to gross returns received from application of pendimethalin as PE @ 1.0 kg a.i. ha^{-1} + imazethapyr as PoE @ 37.5 g a.i. ha^{-1} treated plot and intercropping of lentil + mustard . Whereas the highest net returns (Rs 34502.19) was obtained from intercropping of lentil + mustard followed by application of pendimethalin as PE @ 1.0 kg a.i. ha^{-1} + imazethapyr as PoE @ 37.5 g a.i. ha^{-1}. The highest benefit: cost ratio (2.33) was noted under intercropping of lentil + mustard (T_{12}) which was at par with plot treated with pendimethalin as PE @ 1.0 kg a.i. ha^{-1} + imazethapyr @ 37.5 g a.i. ha^{-1}. Although more gross returns were obtained under hand weeding treatment, the total cost of cultivation was also the highest and therefor it gave lower benefit cost ratio. Vaishya *et al.* (2004) reported that integration of pendimethalin as PE @ 1.0 kg a.i. ha^{-1} and hand weeding at 30 DAS had registered the highest gross return, net profit and cost benefit ratio (1:4.33) followed by hand weeding twice at 20 and 40 DAS (1:4.20).

Table 1. Seed yield, stover yield, harvest index and weed index of lentil as affected by different weed management practices

Weed management practices	**Seed yield (kg ha^{-1})**	**Stover yield (kg ha^{-1})**
T_1 : Quizalofop-p-ethyl @ 50.0 g a.i.ha^{-1}(PoE)	682.53	1474.33
T_2 : Imazethapyr @ 37.5 g a.i. ha^{-1} (PoE)	701.00	1531.00
T_3 : Chlorimuron-ethyl @ 4.0 g a.i. ha^{-1} (PPI)	661.27	1430.67
T_4 : Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE)	695.43	1520.33
T_5 : Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop-ethyl @ 50.0 g a.i. ha^{-1} (PoE)	831.00	1580.00
T_6 : Pendimethalin @ 1.0 kg a.i.ha^{-1} (PE) + Imazethapyr @ 37.5 g a.i. ha^{-1} (PoE)	983.87	1813.00
T_7 : Hand weeding twice (20 & 40 DAS)	986.17	1814.67
T_8 : Weedy check	582.63	1425.33
T_9 : Chlorimuron-ethyl @ 4.0 g a.i.ha^{-1} (PoE)	612.17	1428.00
T_{10} : Stale seed bed	681.83	1441.67
T_{11} : Lentil + Linseed (1:1 additive series)	965.09	1810.33
T_{12} : Lentil + Mustard (1:1 additive series)	983.03	1812.67
SEm $\pm$	**2.99**	**35.69**
CD (P = 0.05)	**8.78**	**104.7**

Table 2. Calculation of fixed cost of cultivation (Rs ha^{-1}) of lentil

S. No.	Particulars		Input	Lentil Price (Rs)	Total cost (Rs ha^{-1})
1.	**Land preparation**				
	i	Deep ploughing	1 tractor (2 hrs) ha^{-1}	350 Rs hr^{-1}	700.00
	ii	Harrowing	1 tractor (2 hrs) ha^{-1}	350 Rs hr^{-1}	700.00
	iii	Planking	1 tractor (1 hr) ha^{-1}	350 Rs hr^{-1}	350.00
2.	**Sowing**				
	i	Cost of seed	30 kg ha^{-1}	49.35 Rs kg^{-1}	1480.5
	ii	Bavistin	2 g kg^{-1} seed	550 Rs kg^{-1}	33.00
	iii	*Rhizobium* culture	1 Packet	45 Rs $Packet^{-1}$	45.00
	iv	Seed sowing	15 man days	125 Rs man day^{-1}	1875.00
3.	**Fertilizer**				
	i	N	20 kg ha^{-1}	11.9 Rs kg^{-1}	238.00
	ii	P_2O_5	17 kg ha^{-1}	20.62 Rs kg^{-1}	350.54
	iii	K_2O	16 kg ha^{-1}	8.00 Rs kg^{-1}	128.00
	iv	S	20 kg ha^{-1}	24.00 Rs kg^{-1}	480.00
	v	Fertilizer application cost	5 man days	125 Rs man day^{-1}	625.00
4.		Irrigation	One irrigation	Rs 450	450.00
		Application cost	One man days	125 Rs man day^{-1}	125.00
5.	**Thinning**		2 man day	125 Rs man day^{-1}	250.00
6.	**Plant protection**		1.5 lit ha^{-1}	250 Rs lit^{-1}	375
7.	**Harvesting**		15 man days	125 Rs man day^{-1}	1875
8.	**Threshing and winnowing**		12 man days	125 Rs man day^{-1}	1500
	A	**Common cost**			11580.04
	B	**Miscellaneous**	10 % of common cost		1158.004
	Grand Total (A+B)				**12738.044**

Rs = Rupees, ha^{-1} = hectare, hrs^{-1}= per hour, g = gram, kg^{-1} per kilogram, % = per cent, N = Nitrogen, P = Phosphorus, K = Potash, S = Sulphur

Table 3.Economics of lentil as affected by different weed management practices

Treatments	Cost of cultivation (Rs ha^{-1})			Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit : cost ratio
	Fixed cost	Treatment cost	Total cost			
T_1 : Quizalofop-p-ethyl @ 50.0 g a.i. ha^{-1} (PoE)	12739	1770.0	14509.00	34420.19	19912.19	1.37
T_2 : Imazethapyr @ 37.5 g a.i. ha^{-1} (PoE)	12739	917.50	13656.50	35359.85	21703.35	1.58
T_3 : Chlorimuron-ethyl @ 4.0 g a.i. ha^{-1} (PPI)	12739	452.56	13191.56	30831.26	17639.70	1.33
T_4 : Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE)	12739	1648.6	14387.60	35076.97	20689.37	1.43
T_5 : Pendimethalin @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop-p-ethyl @ 50.0 g ha^{-1} (PoE)	12739	3168.6	15907.60	41799.85	25892.25	1.62
T_6 : Pendimethalin @ 1.0 kg ha^{-1} + Imazethapyr @ 37.5 g a.i. ha^{-1} (PoE)	12739	2316.1	15055.10	49460.15	34405.05	2.28
T_7 : Hand weeding twice (20 & 40 DAS)	12739	3750	16489.00	49574.66	33085.66	2.00
T_8 : Weedy check	12739	-	12739.00	29145.28	16406.28	1.28
T_9 : Chlorimuron-ethyl @ 4.0 g a.i. ha^{-1}(PoE)	12739	452.56	13191.56	33121.18	19929.62	1.50
T_{10} : Stale seed bed	12739	1500.00	14239.00	34295.97	20056.97	1.40
T_{11} : Lentil + Linseed (1:1 additive series)	12739	2835.00	15574.00	48995.44	33421.44	2.14
T_{12} : Lentil + Mustard (1:1 additive series)	12739	2075.00	14814.00	49316.19	34502.19	2.33
SEm ±				**167.80**	**167.79**	**0.01**
CD (P = 0.05)				**492.15**	**492.13**	**0.03**

Singh *et al.* (1994) stated that lentil cv. L 12 was intercropped with Indian mustard. Lentil yield was highest in the monocrop, followed by intercropping with Indian mustard. However, net returns and benefit: cost ratio were the highest with intercropping with Indian mustard. Ram-pyare *et al.* (2008) also studied the suitability of pure crop, inter and mixed cropping systems of lentil and mustard. Results indicated that intercropping of mustard with lentil was found the best in respect of total productivity, lentil equivalent yield, land equivalent ratio and economics. This system could bring all the above parameters higher than the growing sole crops and mixed cropping systems. On an average, the highest grain yield of lentil (17.25 q ha^{-1}) and mustard (26.27 q ha^{-1}) was obtained in pure cropping but the highest gross return of Rs. 52640/-, net profit of Rs. 38744/-, lentil equivalent yield of 31.89 q ha^{-1} and land equivalent ratio of 1.44 were recorded in intercropping of mustard with lentil.

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NUTRIENT INDEXING OF MAJOR SOYBEAN GROWING SOILS OF LATUR DISTRICT

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ABSTRACT

Nutrient indexing of the important plant nutrients of major soybean growing soils of seven tehsils (Latur, Renapur, Nilanga, Ausa, Udgir, Chakur and Ahmedpur) of Latur district were carried out in the year 2009-10. For this purpose, 140 representative soil samples (0-15 cm depth) were collected from seven tehsils (20 villages from each tehsil) of Latur district and analyzed for available P, S and some micronutrients (Fe, Mn, Zn and Cu) following standard procedures. The available phosphorus in these soils varied from 0.20 to 21.15 kg ha^{-1} with an average value of 7.42 kg ha^{-1}, out of 140 soil samples 66.43 per cent were low (< 10 kg ha^{-1}) and 33.57 per cent samples were found medium (10 To 25 kg ha^{-1}) in available P content. Available sulphur ranged from 3.62 to 53.52 mg kg^{-1} with a mean value of 21.47 mg kg^{-1}, about 12.14 per cent samples were low (<5mg kg^{-1}), 32.14 per cent medium (5 to 10 mg kg^{-1}) and 55.72 per cent high (> 10 mg kg^{-1}) in sulphur content. In case of micronutrients, available Zn ranged from 0.12 to 2.96 mg kg^{-1}, the available Fe varied from 0.48 to 17.1 mg kg^{-1}, available Mn content were 0.16 to 21.12 mg kg^{-1}, Cu was very high varying from 0.25 to 12.19 mg kg^{-1}. Renapur and Chakur tehsils found highly deficit in available P, all tehsils were depleted in case of Zn, available Fe, Mn, Cu and S were adequate in all tehsils. Soil Nutrient Index values of the soybean growing soils of Latur district were high in S, Fe, Mn and Cu, whereas low in available P and Zn. All the seven tehsils were found under high category for available Mn and Cu, while all the tehsils were low in category for available Zn. In case of available Fe, Renapur tehsil was found under medium category while remaining six tehsils were in high category. The soybean growing soils of Latur district were found depleted with respect to available phosphorus, whereas they were adequate for available sulphur.

(Key words: Soybean growing soils, nutrient indexing, available P, S and micronutrients)

INTRODUCTION

Soil nutrient indexing is an efficient tool in predicting the soil potential and actual suitability for growing various crops. Soybean is one of leading oilseed crop of Latur district of Maharashtra which is famous among the farmers, because of its ability to survive in the aberrant weather conditions or drought. In order to improve and sustain the performance of soybean (*Glycine max* L.) crop, adequate supply of phosphorus, sulphur and micronutrients are to be insured. Maharashtra is one of the leading soybean growing state occupying about 26.52 lakh ha with an annual production of 32.37 lakh million metric tons. During the year 2010-2011 area under soybean crop in Latur District was 1.945 lakh ha with an annual production of 4318 MT and productivity of 2220 kg ha^{-1} (Anonymous, 2012).

Soybean being oilseed legume, phosphorus plays a very important role in its nutrition. In order to improve and sustain performance of the soybean crop adequate supply of phosphorus and sulphur is to be insured. Phosphorus is the structural component of plant cell and required for early root development and growth. It helps in flowering and fruiting. An adequate supply of P_2O_5 in the early stages helps in initiating its reproductive parts. Further, excess of phosphorus may cause in some cases trace element deficiency, particularly zinc and iron (Pattanayak *et al.,* 2009). Besides phosphorus, sulphur is an essential secondary plant nutrient which plays a vital role in biosynthesis of primary metabolism for improving yield and quality of oilseed crop. Sulphur deficiency has been recorded in India with the expansion of area under oilseed (Khamaria *et al.,* 2009), increased use of sulphur free fertilizers and inadequate use of organic manures in intensive cropped area and this problem is likely to aggravate in the near future.

Besides phosphorus and sulphur some of the micronutrients like Fe, Mn, Zn and Cu are required to improve and sustain performance of the soybean crop (Mali and Ismail, 2002). Zinc promotes growth hormones, starch formation, seed maturation and production, whereas, iron helps in the absorption of other nutrients. It also plays an important role in chlorophyll formation along with Mn. Copper has some indirect effect on nodule formation. However, there is a large decline in yield levels of the crop in recent years and farmers are shifting to another cropping pattern. Low soil fertility and inadequate manuring may be the major causes for the low yield of the soybean crop (Malewar, 1995). In addition to this intensive cultivation of oilseed crops remove

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substantial amount of micronutrient from the soil, especially zinc, causing yield reductions (Takkar, 1996 and Mali and Raut, 2001).

However, a very little or no information is available on the nutrient indexing in soybean growing soils of latur district. Accordingly, the present study was undertaken with a view to assessing the phosphorus, sulphur and micronutrient status in soybean growing soils of Latur district.

MATERIALS AND METHODS

In order to analyze the nutrient index of Latur district with respect to phosphorus, sulphur and micronutrients (Fe, Mn, Zn and Cu), one hundred and forty soil samples were collected from seven tehsils (Latur, Renapur, Nilanga, Ausa, Udgir, Chakur and Ahmedpur) of Latur district. Randomly twenty villages representing all the characteristics of the soil were selected from each tehsil keeping in view the physiographic characteristics in different cross sections of the area where soybean crop is being grown since last 3-4 years as a component of dominant cropping system in the district. Twenty soil samples (0-15 cm depth) one each from each from each village were collected from each tehsil.

The available phosphorus was determined by extracting the soil with 0.5 M sodium bicarbonate as an extracting reagent and determined using double beam UV-VIS spectrophotometer with Olsen's method as described by Olsen *et al.* (1954) and available sulphur was determined by turbidity method using spectrophotometer (Williams and Steinberg, 1959). Micronutrient cations *viz*., Fe, Mn, Zn and Cu in soil were determined as per the procedure described by Lindsay and Norvell (1978). Nutrient index was calculated as per the formula suggested by Ramamoorthy and Bajaj (1969) and the values for low, medium and high were taken as <1.67, 1.67-2.33, >2.33, respectively.

$$NIV = \frac{\text{No. of samples “Low” x 1 + No. of samples “Medium” x 2 + No. of samples “High” x 3}}{\text{Total number of samples}}$$

The data so collected from twenty villages per tehsil were compiled tehsilwise and are presented in the following tables.

RESULTS AND DISCUSSION

Status of available phosphorus and sulphur :

The data presented in table 1 showed that the available phosphorus content ranged from 0.2 to 21.15 kg ha^{-1} with an average value of 7.42 kg ha^{-1}. Among seven tahsils of Latur district, the lower range of available P content was 0.2 to 12.35 kg ha^{-1} with an average value of 4.05 kg ha^{-1} in Chakur tehsil. Whereas, the higher range of available P was 6.59 to 18.3 kg ha^{-1} with an average value of 12.77 kg ha^{-1} in Ausa tehsil followed by Nilanga tehsil (4.21 to 21.15 kg ha^{-1} with an mean value of 10.65 kg ha^{-1}). Out of 140 soil samples 66.43 per cent were low (< 10 kg ha^{-1}) and 33.57 per cent samples were medium (10 To 25 kg ha^{-1}) in available P content. More *et al*. (2005) studied the oilseed dominated area of Parbhani and reported that available P ranged from 0.5 to 14.28 kg ha^{-1}. Low available phosphorus content of these soils could be attributed to their high P fixing capacity, which prevents readily available form in the soil solution (Hundal *et al.*, 2006). Beside this the continuous growing of high P requiring crop like soybean with inadequate P fertilizers might have depleted the available P balance.

The available sulphur ranged from 3.62 to 53.52 mg kg^{-1} with an average value of 21.47 mg kg^{-1}. Among seven tehsils the lower range of sulphur content was 3.62 to 41.72 mg kg^{-1} with an average value of 15.11mg kg^{-1} in Chakur tehsil. While, higher range of 4.5 to 49.47 mg kg^{-1} with an average value of 28.50 mg kg^{-1} was observed in Nilanga tehsil. It was followed by Ausa tehsil (4.32 to 52.3 mg kg^{-1} with mean value of 25.99 mg kg^{-1}). Out of 140 samples 12.14, 32.14 and 55.72 per cent samples were categorized as low (< 5 mg kg^{-1}), medium (5 to 10 mg kg^{-1}) and high (> 10 mg kg^{-1}) respectively, in sulphur content. From the above results, it was inferred that soils of Latur district were sufficient in sulphur content. The high amount of sulphur content in soils could be attributed to high amount of clay content which can absorb varying amounts of sulphur (Mali and Raut, 2001). Singh *et al.* (2006) reported that the available sulphur content in valley hill soils of Manipur ranged from 10.0 to 7.00 mg kg^{-1} with an average value of 26.6 mg kg^{-1}. Chauhan *et al.* (2012) reported that the available sulphur ranged from 0.9 to 50.2 mg kg^{-1} with an average value of 13.9 mg kg^{-1}.

Status of available micronutrients :

The data presented in table 2 revealed that the available Zn content ranged from 0.12 to 2.96 mg kg^{-1} with an average value of 0.59 mg kg^{-1} in soybean growing soils of Latur district. Among all samples 67.14 % samples were low and 25.71 % samples were medium in available Zn content. This might be due to the fact that in well drained, aerated, calcareous soils, Zinc exits in oxidized state and their availability becomes very low (Malewar, 1995). It was also observed that Vertisol and Alfisol in Maharashtra region and some arid soils of Rajasthan also showed the available content of Zn in the similar range (Pharande *et al.,* 1996 and Mahesh Kumar *et al.,* 2011). The available Fe content in data under study ranged from 0.48 to 17.1 mg kg^{-1} with an average value of 6.10 mg kg^{-1} in Latur district. This high Fe content (65.72 %) in soil was due to the presence of minerals like feldspar, magnetite, hematite and limonite which together constitute bulk of trap rock in these soils. The available Fe in Vertisol of Maharashtra was in the range from 3.52 to 19.44 mg kg^{-1} (Verma *et al.*, 2008) and Chauhan *et al.* (2012) showed that available Fe ranged from 4.5 to 22.5 mg kg^{-1}. The present results are more or less in accordance with the above findings.

The available Mn content in these soils varied from 0.16 to 21.12 mg kg^{-1} with an average value of 5.32 mg kg^{-1}. Among 140 samples 40 % samples were medium and 49.29 % samples were high in available Zn content. This status of Mn might be due to the fact that lower oxidation (reduced) states of Mn was more soluble than higher oxidation state at normal pH range of soils and oxidation of divalent Mn^{++} to trivalent Mn^{+++} by certain fungi and bacteria. Certain organic compounds synthesized by microorganisms or released by the plants as root exudates. Dwivedi *et al.* (2005) reported that the available Mn ranged from 2.23 to 49.1 mg kg^{-1} and Chauhan *et al.* (2012) showed that available Mn ranged from 1.70 to 25.70 mg kg^{-1}. The soybean growing soils of Latur district were high in Cu content (0.25 to 12.19 mg kg^{-1}) with an average value of 3.03 mg kg^{-1}. Out of 140 samples 99.29 per cent of soil samples were high in available Cu content. Most of soil samples from Latur district were high in available Cu. This Cu content could be attributed to the difference in geology, physiography and degree of weathering in these soils. Ghosh *et al.* (2010) showed the content of available Cu ranged from 0.5 to 4.0 mg kg^{-1} and Chauhan *et al.* (2012) showed the content of available Cu ranged from 0.24 to 5.90 mg kg^{-1}.

Nutrient Index Value :

Tehsilwise soil nutrient index for phosphorus, sulphur and micronutrients :

The data regarding soil nutrient indices for phosphorus and sulphur are presented in table 4. Among seven tehsils Renapur, Latur, Nilanga, Chakur, Ahmedpur and Udgir were found under category low for phosphorus except Ausa which came under category medium for phosphorus. The values worked out for Renapur, Latur, Nilanga, Chakur, Ahmedpur, Udgir and Ausa were 1.1, 1.15, 1.55, 1.1, 1.15, 1.5 and 1.8 respectively. While all the tehsils categorized as high in sulphur content except Chakur which was found in medium category. The values worked out for tehsils Ausa, Renapur, Latur, Nilanga, Ahmedpur, Udgir and Chakur were 2.4, 2.35, 2.55, 2.65, 2.35, 2.5 and 2.25, respectively.

The Nutrient Index Value (NIV) for micronutrients (Zn, Fe, Mn and Cu) content in soils are given in table 3. The NIV for available Zinc was found under category Low in all the seven tehsils. The values worked out for Nutrient Index of Zinc were 1.45 (Ausa), 1.35 (Renapur), 1.55 (Latur), 1.5 (Nilanga), 1.25 (Chakur), 1.45 (Ahmedpur) and 1.25 (Udgir). Ausa, Latur, Nilanga, Chakur, Ahmedpur and Udgir were found under category high for available Iron (Fe) and Renapur was categorized as Medium in Fe content. The values worked out for Nutrient Index of Fe were 2.55 (Ausa), 2.5 (Latur), 2.9 (Nilanga), 2.65 (Chakur), 2.65 (Ahmedpur), 2.6 (Udgir) and 2.15 (Renapur). All the seven tehsils were found high for both Manganese and Copper and the values worked out for Nutrient Index of Manganese were 2.6, 1.9, 2.45, 2.9, 2.9, 2.75 and 2.6 for Ausa, Renapur, Latur, Nilanga, Chakur, Ahmedpur and Udgir, respectively. For copper, nutrient index values were 3 for Ausa, Renapur, Latur, Nilanga, Ahmedpur, Udgir and 2.9 for Chakur.

Soil nutrient Index of Latur district :

The nutrient index values for phosphorus, sulphur, Zn, Fe, Mn, and Cu content in soybean growing soils of Latur district are given in table 4.

Table 1. Characterization of available phosphorus and sulphur in soybean growing soils of Latur district

Tehsil	Phosphorus ($kg\ ha^{-1}$)				Sulphur ($mg\ kg^{-1}$)			
	Range (Mean)	< 10 Low	10 to 25 Medium	> 25 High	Range (Mean)	< 5 Low	5 to 10 Medium	> 10 High
Ausa	6.59-18.3 (12.77)	4	16	-	4.32-52.3 (25.99)	4	4	12
Renapur	1.02-15.93 (5.86)	18	2	-	3.68-32.08 (16.98)	3	7	10
Latur	0.23-12.48 (4.06)	17	3	-	6.95-53.28 (20.43)	-	9	11
Nilanga	4.21-21.15 (10.65)	9	11	-	4.5-49.47 (28.50)	2	3	15
Chakur	0.2-12.35 (4.05)	18	2	-	3.62-41.72 (15.11)	4	7	9
Ahmedpur	0.5-13.12 (4.63)	17	3	-	3.92-53.52 (21.53)	4	5	11
Udgir	2.42-17.18 (9.90)	10	10	-	5.85-51.03 (21.77)	-	10	10
Total		93	47	-		17	45	78
Percentage		66.43	33.57	-		12.14	32.14	55.72

Figures in parenthesis indicates mean of twenty samples

Fig 1. Nutrient index value of soybean growing soils of Latur distirct

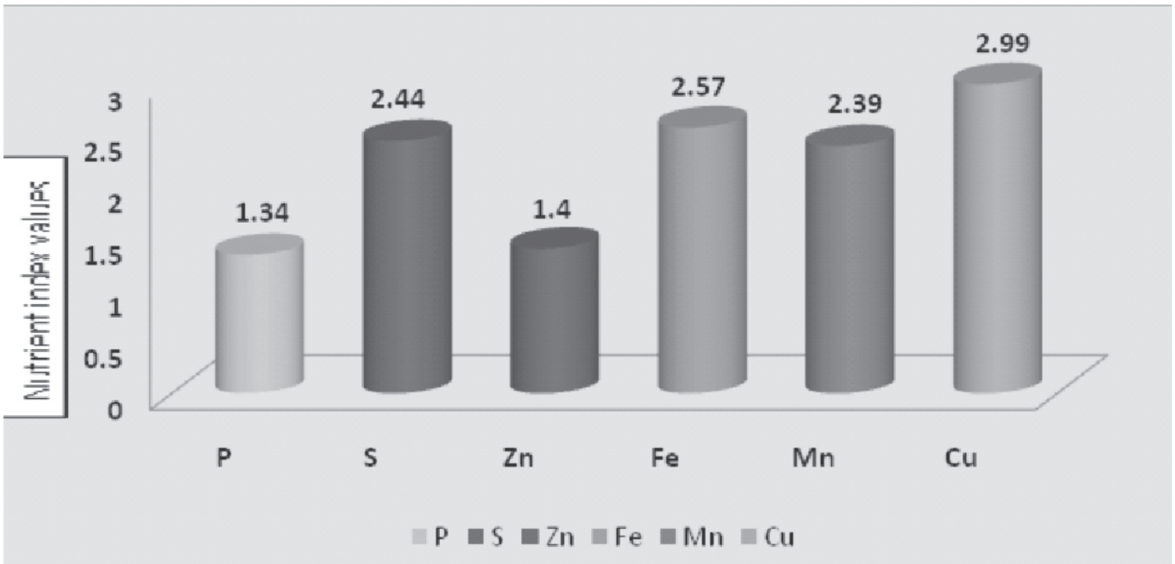

Table 2. Characterization of micronutrients (Zn, Fe, Mn and Cu) of soybean growing soils of Latur district

Tehsil	Zn ($mg\ kg^{-1}$)				Fe ($mg\ kg^{-1}$)				Mn ($mg\ kg^{-1}$)				Cu ($mg\ kg^{-1}$)			
	Range (Mean)	< 0.6 L.	0.6 to 1.2 M.	> 1.2 H.	Range (Mean)	< 2.5 L.	2.5 to 4.5 M.	> 4.5 H.	Range (Mean)	< 2.0 L.	2.0 to 5.0 M.	> 5.0 H.	Range (Mean)	< 0.3 L.	0.3 to 0.5 M.	> 0.5 H.
Ausa	0.27-1.74 (0.62)	13	5	2	2.65-9.4 (5.59)	-	9	11	1.25-13.48 (6.62)	1	5	14	1.44-12.19 (3.44)	-	-	20
Renapur	0.22-2.84 (0.66)	16	1	3	0.48-12.12 (4.62)	6	5	9	1.16-11.38 (4.43)	2	11	7	0.98-6.1 (2.41)	-	-	20
Latur	0.18-2.96 (0.69)	11	7	2	0.98-10.41 (5.93)	3	4	13	0.6-11.3 (5.29)	2	7	11	0.82-8.74 (2.65)	-	-	20
Nilanga	0.29-1.86 (0.64)	11	8	1	3.76-17.1 (6.92)	-	2	18	2.35-14.28 (6.94)	-	7	13	1.08-7.12 (2.85)	-	-	20
Chakur	0.12-0.95 (0.44)	15	5	-	1.98-10.43 (6.06)	1	5	14	0.68-4.88 (2.44)	6	13	1	0.25-5.5 (2.35)	1	-	19
Ahmedpur	0.23-1.75 (0.60)	12	7	1	2.66-11.32 (6.66)	-	7	13	1.18-9.15 (4.72)	2	8	10	1.38-6.5 (4.01)	-	-	20
Udgir	0.2-1.24 (0.49)	16	3	1	1.18-12.86 (6.94)	2	4	14	0.16-21.12 (6.78)	2	5	13	0.98-7.65 (3.52)	-	-	20
Total		94	36	10		12	36	92		15	56	69		1	-	139
Percentage		67.14	25.71	7.14		8.57	25.71	65.72		10.71	40	49.29		0.71	-	99.29

Figures in parenthesis indicates mean of twenty samples

L. – Low M. – Medium H. High

Table 3. Nutrient index value for phosphorus and sulphur content in soybean growing soils of Latur district

Sr. No.	Tehsil	Phosphorus		Sulphur	
		NIV	Category	NIV	Category
1	**Ausa**	1.8	Medium	2.4	High
2	**Renapur**	1.1	Low	.35	High
3	**Latur**	1.15	Low	2.55	High
4	**Nilanga**	1.55	Low	2.65	High
5	**Chakur**	1.1	Low	2.25	Medium
6	**Ahmedpur**	1.15	Low	2.35	High
7	**Udgir**	1.5	Low	2.5	High
	Latur district	1.34	Low	2.44	High

Table 4. Nutrient index value for Zn, Fe, Mn and Cu content in soybean growing soils of Latur district

Sr. No.	Tehasil	Zn		Fe		Mn		Cu	
		NIV	Category	NIV	Category	NIV	Category	NIV	Category
1	**Ausa**	1.45	Low	2.55	High	2.60	High	3	High
2	**Renapur**	1.35	Low	2.15	Medium	1.95	High	3	High
3	**Latur**	1.55	Low	2.50	High	2.45	High	3	High
4	**Nilanga**	1.50	Low	2.90	High	2.90	High	3	High
5	**Chakur**	1.25	Low	2.65	High	2.90	High	2.9	High
6	**Ahmedpur**	1.45	Low	2.65	High	2.75	High	3	High
7	**Udgir**	1.25	Low	2.60	High	2.60	High	3	High
	Latur district	1.40	Low	2.57	High	2.39	High	2.99	High

Considering Soil Nutrient Index of Latur district, it was found under category high for sulphur, Fe, Mn and Cu while low for phosphorus and Zn. The value worked out for sulphur, Fe, Mn, Cu, phosphorus and Zn were 2.44, 2.57, 2.39, 2.99, 1.34 and 1.4, respectively.

From the analysis of nutrient index of Latur district with respect to phosphorus, sulphur and micronutrients like Zn, Fe, Mn and Cu, it is observed that the soybean growing soils of the district were depleted with respect to available phosphorus and zinc, whereas adequate with respect to available sulphur and other micronutrients.

In view of relatively higher sulphur requirement of soybean crop, though available sulphur status in soil of Latur district was adequate, application of single super phosphate should be preferred over sulphur free DAP or other complex fertilizers as a source of phosphorus to prevent sulphur depletion. Among the micronutrients, available Zn became a limiting factor and therefore, application of $ZnSO_4$ (25 kg $ZnSO_4$ ha^{-1}) could help to sustain soybean yield.

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EFFECT OF DIFFERENT LEVELS OF SULPHUR AND ZINC ON FERTILITY STATUS AND MICROBIAL ECOLOGY UNDER SOYBEAN GROWN ON VERTISOLS

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ABSTRACT

The experiment was conducted during 2008-09 to study the effect of different levels of sulphur and zinc on fertility status and microbial population in soil under soybean grown on Vertisols at Dr. P. D. K. V., Akola. The experiment was laid in FRBD with 16 treatment combinations comprising four levels of sulphur (0, 15, 30 and 45 kg ha^{-1}) and four levels of zinc (0, 1, 2 and 3 kg ha^{-1}). The nutrient status of soil after harvest of soybean was significantly influenced with increasing levels of sulphur and zinc. However, significantly highest available N (226.74 kg ha^{-1}), K (335.88 kg ha^{-1}) and S (12.18 kg ha^{-1}) were recorded with the application of 45 kg S ha^{-1}. The available phosphorus and zinc due to different levels of sulphur was found to be non significant. The application of Zn @ 3 kg ha^{-1} significantly increased the status of available N (214.64 kg ha^{-1}). The application of sulphur @ 15 kg ha^{-1} significantly increased bacterial population viz., 8.05 x 10^7 and 9.07 x 10^7 cfu g^{-1} soil respectively on 30 and 45 DAS. Similarly, the fungi and actinomycetes were significantly influenced with the application of 15 kg S ha^{-1}. The fungi and actinomycetes were recorded to the extent of 6.70 x 10^4 and 5.97 x 10^6 g^{-1} soil respectively, at 45 DAS. The grain yield was increased significantly with the application of sulphur @ 30 kg ha^{-1}. The interaction effect (S x Zn) was found non –significant.

(Key words: Nutrient status, microbial population, cfu, Vertisols)

INTRODUCTION

Soybean is a triple beneficial crop. It fixes atmospheric nitrogen in soil at the rate of 65-100 kg ha^{-1} (Quayam *et al*., 1985). Inadequate use of fertilizer is one of the most important reasons for low productivity. Soybean contains 40% protein, 20 % oil and 20-30 % carbohydrates, vitamins and essential amino acids. Oilseed crops in general have high sulphur requirement because of oil strength organs are quite rich in proteins (Kanwar, 1984). Now a days, based on latest research results, soil in over 250 districts of India are reported to suffer from varying degrees of sulphur deficiency (Tandon and Messick, 2007). Use of higher dose of synthetic fertilizers for higher yields creates physiological nutrient imbalance due to lower availability of micronutrients, which leads to harmful effect on crop growth. The full benefit of application of NPK fertilizers and secondary nutrients is obtained only in presence of adequate quantities of available micronutrients in soil. Along with major plant nutrients, the micronutrients are also removed proportionately from the soil. However, while adding major plant nutrients to soil, no attention has been paid in applying micronutrients to soil. With the adoption of intensive multiple cropping, continuous use of sulphur free fertilizers, high yielding crop varieties and high sulphur requiring crops, leading to more widespread and more intense S deficiencies in Indian soil (Jat and Yadav,2006). Taking into consideration the importance of sulphur and zinc nutrition in soybean cultivation, the present investigation was undertaken with the objective to study the effect of different levels of sulphur and zinc on nutrient status and microbial ecology under soybean grown on vertisols.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* 2008 at Dr. P.D.K.V., Akola. The experiment was laid in FRBD with 16 treatment combinations comprising four levels of sulphur (0, 15, 30 and 45 kg ha^{-1}) and four levels of zinc (0, 1, 2 and 3 kg ha^{-1}) replicated thrice. The soil of experimental site is clay in texture, moderately alkaline in reaction (pH -7.9), low in organic carbon (3.34 g kg^{-1}) and available nitrogen (187 kg ha^{-1}), medium in available phosphorus (17.6 kg ha^{-1}), high in available potassium (385 kg ha^{-1}) and marginal in available sulphur (11.24 ppm) and zinc (0.58 ppm). The soybean variety TAMS-38 was sown at 45 x 5 cm spacing with seed rate of 75 kg ha^{-1}. The recommended dose of fertilizer (30:75:00 kg N, P_2O_5 and K_2O kg ha^{-1}) and FYM @ 5 t ha^{-1} were applied to all treatments. The seed treatment

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of *Rhizobium japonicum* and PSB was done for all treatments. The S and Zn were applied through zinc oxide and gypsum respectively as basal dose at the time of sowing.

Soil samples (0-20 cm depth) were collected initially and after harvest of soybean. Available nitrogen was determined by alkaline permanganate method using micro-processor based automatic distillation system (Subbiah and Asija, 1956), available phosphorus by Olsen's method using 0.5 M sodium bi-carbonate as an extractant using UV based double beam spectrophotometer (Watanabe and Olsen, 1965), available potassium was determined by neutral normal ammonium acetate method using flame photometer (Knudsen and Peterson, 1982), available sulphur by turbidimetric method (Chesnin and Yien,1951) and DTPA- Zn by extracting soil with DTPA using atomic absorption spectrophotometer (Lindsay and Norvell, 1978). Soil microbial count was determined by serial dilution plate technique (Dhingra and Sinclair, 1993). In this technique one gram of soil sample was taken under aseptic condition in 10 ml sterile test tube and 9 ml distilled water was added and shaked thoroughly. Then, 1 ml suspension was transferred in a test tube and 9 ml distilled water was added to it. The test tube was well shaken and diluted 10 times by distilled water to get desired level of 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} dilution. After dilution 1 ml of suspension was transferred in petridish in particular media for specific growth of microorganism.Nutrient Agar, Potato Dextrose Agar (PDA) and Kenknight Agar media were used for growth of bacteria, fungi and actinomycetes respectively.

RESULTS AND DISCUSSION

Available nutrients:

Effect of sulphur on available N, P, K, S and Zn:

The application of 45 kg S ha^{-1} significantly increased available nitrogen (226.74 kg ha^{-1}) after harvest of soybean. However, the status of available nitrogen with the application of sulphur @ 45 kg ha^{-1} was found at par with 30 kg S ha^{-1} (218.96 kg N ha^{-1}). Application of sulphur did not influence significantly the available phosphorus in the soil but it tended to increase with increasing level of sulphur. Chandra Deo and Khandelwal (2009) reported that different sulphur levels influenced significantly the status of available S. The application of sulphur significantly increased the availability of potassium after harvest of soybean (335.88 kg ha^{-1}) with the application of 45 kg S ha^{-1} followed by 30 kg S ha^{-1} which was 334.76 kg K_2O ha^{-1}. The available sulphur increased significantly (12.18 mg kg^{-1}) with the application of 45 kg S ha^{-1}. The application of different levels of sulphur significantly increased the available S content in soil and the increase was 19 per cent with the application of sulphur @ 30 kg ha^{-1} over control.

Effect of zinc on available N, P, K, S and Zn:

Among different levels of zinc, Zn @ 3 kg ha^{-1} recorded significantly highest available nitrogen (214.62 kg ha^{-1}) followed by Zn @ 2 kg ha^{-1} (200.92 kg N ha^{-1}). The role of zinc in nodulation and fixing atmospheric nitrogen might be reason for higher availability of nitrogen in soil. This indicates the role of zinc in nodulation and nitrogen fixation. Abadi *et al.* (1995) reported that number of root nodules and nodules dry weight per plant increased with the application of zinc. The available P, K and S were found non-significant due to different levels of Zn. The application of zinc significantly increased available zinc after harvest. The highest available zinc (0.69 mg kg^{-1}) was recorded with the application of 3 kg Zn ha^{-1}. Jha and Chandel (1987) reported that availability of zinc increased significantly with the increasing levels of zinc.

Interaction effect on available N, P, K, S and Zn:

The interaction effect on available N, P, K, S and Zn was found non-significant.

Organic Carbon:

Effect of sulphur on organic carbon:

Application of sulphur @ 45 kg ha^{-1} significantly increased the organic carbon (4.02 g kg^{-1}) followed by sulphur @ 30 kg ha^{-1}, where the organic carbon content was recorded to the extent of 3.61 g kg^{-1}.

Effect of zinc on organic carbon:

Similarly, the application of Zn @ 3 kg ha^{-1} was found beneficial in maintaining significantly highest organic carbon (4.0 g kg^{-1}). The increase in organic carbon content due to increased levels of sulphur and zinc can be attributed to the higher yield resulted due to greater root biomass, crop residues and stubbles. The increase in organic carbon under soybean grown on Vertisols was due to increased contribution from the biomass. Contribution from root stubble could also be expected to improve organic carbon status of soil (Thakur *et al*., 2011).

Interaction effect on organic carbon:

The interaction effect of sulphur and zinc was found non-significant.

Effect of sulphur on microbial population (bacteria, fungi and actinomycetes):

The bacterial population increased with the crop growth period as well as with increased levels of sulphur and zinc. Application of sulphur increased significantly the bacterial population at 30 and 45 DAS. However, the bacterial population at 30 DAS (6.92×10^{-4} cfu g^{-1} soil) and 45 DAS (8.12×10^{-4} cfu g^{-1} soil) was the highest with the application of sulphur @ 30 kg ha^{-1}. As the crop growth period increased, the population become more proliferate. It might be due to more amount of leaf biomass, which provided more amount of organic forms of carbon for food and energy of microorganism. Further increase in sulphur level resulted decrease in the bacterial population. It indicates that, sulphur @ 15 kg ha^{-1} was the optimum level for the growth of bacteria.

The population of fungi increased as the crop growth period increased. However, decreased with the increase in level of sulphur. The fungal population was higher at 30 DAS (6.42×10^{-6} cfu g^{-1} soil) and 45 DAS (7.13×10^{-6}cfu g^{-1} soil) where sulphur was not applied.

The decreasing tendency of fungal population of rhizosphere soil with increasing levels of sulphur are also reported by Patil and Varade, (1998). Their findings revealed that the decrease in fungal population through sulphur application might be due to fungicidal nature of sulphur.

The actinomycetes populations were also reported in decreasing trend with increase in the levels of sulphur. As the crop growth period advanced, the actinomycetes population increased. The diminishing trend of actinomycetes population due to sulphur application has also been reported by Patil and Varade, (1998). It can be opined that probably actinomycetes are not compatible with sulphur oxidizing microorganisms, which build up in soil due to increase in sulphur content.

Effect of zinc on microbial population (bacteria, fungi and actinomycetes):

The effect of different levels of Zn on bacterial and fungal population was found non - significant. However, actinomycetes population was increased with the levels of applied Zn. Significantly higher actinomycetes population were recorded with the application of Zn @ 3 kg ha^{-1} (5.13 cfu x 10^{7} g^{-1} soil) and (6.14 cfu x 10^{7} g^{-1} soil) respectively at 30 and 45 days of crop growth period.

Interaction effect on microbial population (bacteria, fungi and actinomycetes):

The interaction effect on microbial population was found non –significant.

Yield:

Effect of sulphur on grain yield of soybean:

The highest grain yield (19.64 q ha^{-1}) was recorded with the application of 30 kg S ha^{-1},which was at par with S @ 45 kg ha^{-1} (18.20 q ha^{-1}).The results are in close agreement with the Pasricha and Randhawa *et al.* (1973). They reported that soybean is quite responsive to sulphur application and it has a high sulphur requirement due to higher quantities of proteins and sulphur containing amino acids, which helped in higher grain yield in soybean.

Effect of zinc on grain yield of soybean:

Application of 3 kg Zn ha^{-1} recorded significantly highest grain yield of soybean (20.38 q ha^{-1}). This response in grain yield of soybean due to increasing levels of zinc attributed to the role of zinc in regulating growth hormones such as auxin which promote starch formation and seed maturation. The results are in conformity with the finding of Bolusamy *et al.* (1996). They reported increase in the yield with the application of Zn @ 10 kg ha^{-1} alongwith FYM @ 10 t ha^{-1}.

Interaction effect on grain yield of soybean:

Interaction effect on grain yield of soybean was found non –significant.

Table 1. Effect of sulphur and zinc on available nutrient status after harvest of soybean

Treatments	Available Nutrient Status of Soil				
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg^{-1})	Zn (mg kg^{-1})
Sulphur Levels					
S_0 - 0 kg ha^{-1}	167	17.8	309	8.85	0.58
S_1- 15 kg ha^{-1}	184	16.6	320	9.54	0.61
S_2 - 30 kg ha^{-1}	219	18.9	335	10.94	0.65
S_3 - 45 kg ha^{-1}	227	18.1	336	12.18	0.67
SE (m) ±	3.55	0.56	3.38	0.22	0.33
CD at 5%	10.25	-	9.75	0.66	-
Zinc Levels					
Zn_0 - 0 kg ha^{-1}	188	16.8	320	9.99	0.62
Zn_1- 1 kg ha^{-1}	194	17.7	326	10.22	0.63
Zn_2 - 2 kg ha^{-1}	201	18.4	331	10.53	0.63
Zn_3 - 3 kg ha^{-1}	215	18.5	326	10.78	0.69
SE (m) ±	3.55	0.56	3.38	0.22	0.33
CD at 5%	10.25	--	--	--	0.49
Interaction (S x Zn)					
SE (m) ±	7.11	1.12	6.76	0.45	0.66
CD at 5%	-	-	-	-	-

Table 2. Effect of sulphur and zinc application on organic carbon at harvest of soybean

Sulphur levels	Organic carbon (g kg^{-1})	Zinc levels	Organic carbon (g kg^{-1})
S_0 - 0 kg S ha^{-1}	3.32	Zn_0 - 0 kg Zn ha^{-1}	3.30
S_1- 15 kg S ha^{-1}	3.49	Zn_1 - 1.0 kg Zn ha^{-1}	3.41
S_2 - 30 kg S ha^{-1}	3.61	Zn_2 - 2.0 kg Zn ha^{-1}	3.56
S_3 - 45 kg S ha^{-1}	4.02	Zn_3 - 3.0 kg Zn ha^{-1}	4.00
SE (m) ±	0.03	SE (m) ±	0.03
CD at 5%	0.10	CD at 5%	0.10
		Interaction (S x Zn)	
SE (m) ±	0.12	0.24	0.29
CD at 5%	-	-	-
CV	2.85	4.02	4.08

Table 3. Effect of sulphur and zinc on microbial population of rhizosphere

Sulphur Levels	Microbial Population					
	Bacteria x10^4 cfu g^{-1} soil		Fungi x10^6 cfu g^{-1} soil		Actinomycetes x 10^7 cfu g^{-1} soil	
	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
Sulphur Levels						
S_0 - 0 kg ha^{-1}	7.48	8.42	6.42	7.13	5.49	6.53
S_1- 15 kg ha^{-1}	8.05	9.07	6.03	6.70	4.92	5.97
S_2 - 30 kg ha^{-1}	6.92	8.12	5.36	5.96	4.44	5.49
S_3 - 45 kg ha^{-1}	6.87	7.74	5.35	5.94	3.79	4.83
SE (m) ±	0.24	0.23	0.21	0.18	0.23	0.34
CD at 5%	0.72	0.69	0.61	0.54	0.69	1.02
Zinc Levels						
Zn_0 - 0 kg ha^{-1}	6.86	8.27	5.30	5.90	3.79	4.83
Zn_1- 1 kg ha^{-1}	7.30	8.06	5.93	6.60	4.83	5.88
Zn_2 - 2 kg ha^{-1}	7.56	8.42	5.91	6.57	4.90	5.94
Zn_3 - 3 kg ha^{-1}	7.70	8.61	6.01	6.68	5.13	6.17
SE (m) ±	0.24	0.23	0.21	0.18	0.23	0.34
CD at 5%	-	-	-	-	-	-
Interaction (S x Zn)						
SE (m) ±	0.5	0.45	0.32	0.36	0.46	0.69
CD at 5%	-	-	-	-	-	-

Table 4. Effect of different levels of sulphur and zinc on grain yield of soybean

Sulphur Levels	Grain Yield (q ha^{-1})	Zinc Levels	Grain Yield (q ha^{-1})
S_0 - 0 kg ha^{-1}	15.97	Zn_0 - 0 kg ha^{-1}	15.82
S_1- 15 kg ha^{-1}	17.67	Zn_1- 1 kg ha^{-1}	17.73
S_2 - 30 kg ha^{-1}	19.64	Zn_2 - 2 kg ha^{-1}	18.97
S_3 - 45 kg ha^{-1}	18.20	Zn_3 - 3 kg ha^{-1}	20.38
SE (m) ±	0.48	SE (m) ±	0.48
CD at 5%	1.40	CD at 5%	1.40
Interaction			
SE (m) ±		0.96	
CD at 5%		--	

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CHARACTERIZATION, CLASSIFICATION AND SOIL SITE SUITABILITY FOR GROWING CITRUS Sp. AT TELANGKHEDI GARDEN, NAGPUR (M. S.)

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ABSTRACT

Based on variation in physiography, five pedons of Telangkhedi garden, Centre of Excellence for Citrus under Indo-Israel work plan, College of Agriculture, Nagpur were dugged and characterized for their physical and chemical properties of soil during the year 2011. The soil of study area is shallow to medium deep with colour ranging from very dark grey brown (10YR 3/2) to very pale brown (10YR 7/3). The dominant structure is moderate, medium and subangular blocky type, but angular blocky structure is a common feature in slickensides zone of Vertisols. Soils of this area are clay loam to clayey with more than 40 per cent clay, which increased gradually with depth. The silt and sand content ranges from10.8 to 33.6 per cent and 10.4 to 25.7 per cent respectively. Bulk density of these soils varied from 1.42 to 1.56 mg m^{-3}. Relatively higher content of smectite clay resulted in higher moisture content at 33 and 1500 kPa suctions (i.e. at 33 kPa ranging from 20.7 to 44.9 per cent and 1500 kPa from 15.2 to 26.8 per cent). Soil was slightly alkaline to moderately alkaline in reaction and non - saline as indicated by electrical conductivity. The CEC of soil varied from 43.7 to 51.9 cmol (p+) kg^{-1}. Majority surface and subsurface soil had relatively higher organic carbon content (3.8 to13.3 g kg^{-1}). The calcium carbonate content found to be decreased with fineness of the soil aggregates of this soil which ranged from 1.5 to 6.13 per cent. The exchangeable cations were in order of Ca > Mg > Na > K. The available N, P, K and S varied from 188.16 to 238.33 kg ha^{-1}, 15.38 to 34.35 kg ha^{-1}, 168.0 to 616.0 kg ha^{-1} and 9.2 to 17.8 mg kg^{-1}, respectively. The micronutrients DTPA-Zn, Fe, Cu and Mn in the soil varied from 0.32 to 1.66, 10.2 to 24.90, 0.33 to 3.95 and 4.80 to 16.3 mg kg^{-1}, respectively. The soil is deficient in available Zn. These soil are classified as fine smectite (calcareous) Typic Haplustepts (P_1, P_4 and P_5) and fine smectite (calcareous) Vertic Haplusterts (P_2 and P_3).

(Key words: Soil taxonomy, soil fertility, citrus suitability)

INTRODUCTION

Citrus consists of a group of fruits belonging to the family Rutaceae. In India, citrus is grown in an area of 8.46 lakh ha with the production of 74.64 lakh tones and productivity is 8.8 MT ha^{-1} (Anonymous, 2011). Among the state Maharashtra ranked first in production followed by Andhra Pradesh and Madhya Pradesh in national pool, accounting about 48 per cent of total orange production in country (Anonymous, 2011). As citrus is an important crop of Maharashtra, it is essential to study the distribution of the crop in the states and to find out the areas of suitability for citrus cultivation. Environmental suitability is an important aspect which has a direct impact on the productivity of the crop. Climatic variability is the principal drivers of geographic distribution. Soil is the major factor for determining the success or failure of citrus plantation. The cultivation of citrus depends on several factors like presence of free lime, excessive salt, defective drainage, and presence of hard pan in the sub-surface, soil texture, mineralogy of soil, cation exchange capacity and soil fertility etc (Srivastava, 2009). Different parent material gives rise to different soils and their properties in a similar pedo-climate; provide an opportunity to relate parent material. The highest global citrus production comes from the soils represented by the order Alfisol, Uitisol, Entisol and Insceptisol (Srivastava and Singh, 2002). The present investigation site was Centre of Excellence for Citrus under Indo-Israel work plan, College of Agriculture, Nagpur, where the plantation of citrus species have to be undertaken and this site have not yet been characterized and classified for suitability of citrus species. It is therefore, the present study was under taken to characterize, classify and evaluate the fertility status of soils for sustainable management and development of agro-technology for its effective transfer to other areas having comparable soil characteristics.

MATERIALS AND MEHODS

The present investigation site was Centre of Excellence for Citrus under Indo-Israel work plan, Telangkhedi garden, College of Agriculture, Nagpur. It was the place where the plantation of citrus species was undertaken. Nagpur is characterized by hot and dry summer and fairly cold winter. The total area of study was 7.08 ha, the five representative soil profiles were selected by free survey and differences were

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seen by visual observations likely topography, variation in colour, texture etc. The different horizons were observed on the basis of change in morphological characteristics in the layer of pedon as per the procedures laid out in the Soil Survey Manual (Anonymous, 1998). About 1.5 kg representative soil sample from each horizons of various depth were collected in cloth bag for laboratory characterization (Table 1). The bulk soil samples were allowed to air dry in shade and then weighed soil aggregates were passed through 5 mm, 2 mm, and 0.5 mm sieve and used for laboratory analysis. Particle size distribution was determined as per the international pipette method after oxidizing organic matter by using 2 mm sample. The bulk density of soil was determined by dry clod coating method (Black *et al.,* 1965). Soil pH and electrical conductivity was determined in soil suspension (1: 2.5 soil: water) by a glass electrode pH meter and conductivity bridge (Jackson, 1967). Organic carbon was determined by the Walkley and Black rapid titration procedure by using 0.5 mm sample (Jackson, 1967). The calcium carbonate was estimated by rapid titration method from different size aggregate (Piper, 1966). Ammonium acetate method was used to determine cation exchange capacity of soil (Jackson, 1967). Exchangeable calcium and magnesium were determined by using 1 N KCl triethanolamine buffer solution (pH 8.2) and titrating the leachate with standard EDTA solution using mureoxide and EBT as an indicator (Richard, 1954). Exchangeable sodium and potassium were determined by leaching the soil with 1 N ammonium acetate (pH 7) solution. Na+ and K+ from the leachate was estimated using flame photometer (Jackson, 1967). The available N was determined by alkaline permanganate method as described by Subbiah and Asija (1956). The soil was extracted with Olsen's reagent 0.5 M $NaHCO_3$ of pH 8.5 and in the extract, available P was estimated colorimetrically (Olsen, *et al.,*1954). The available potassium was determined by flame photometer method using neutral ammonium acetate as extractant (Jackson, 1967). The sulphur was estimated by extracting soil with Morgan's solution and the resultant turbidity was measured colorimetrically using blue filter (Chesnin and Yien, 1950). The DTPA (Diethylene triamine penta-acetic acid) (0.005 M) extractable (1:2, Soil: DTPA) Fe, Mn, Zn and Cu were determined as per the procedure outlined by Lindsay and Norvell, (1978) using Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Morphological properties of soil :

The data regarding landscape characteristics of the pedons are given in table 1. The surface horizons of the soil had dark grey colour (Pedon 1), greyish brown colour (Pedon 2) and brown colour (Pedon 3, 4 and 5). The soil of subsurface horizons of pedon 1, 2, 3 and 4 had pale brown to very dark greyish brown colour and had very pale brown in pedon 5 which may be attributed to their development on basalt *in situ* (Pedon 2 and 3) and basaltic alluvium (Pedon 1 and 5) associated with clay texture, smectite mineralogy, organic carbon and drainage condition. However, the subsurface horizon of pedon 4 and 5 soils had very pale brown to light grey colour (rubbed) due to presence of powdery lime resulting in variegated colour. The structure of the soil was dominated by sub angular blocky with the exception in pedon 2 and 3 in Ck horizon. The soil of pedon 2 and 3 showed most of the characteristics of Vertisols such as slickensides and cracks below 60 cm. These soils had well developed slickenside in Bssk and Ck horizon in the subsoil and classified as Vertisols in order of taxonomy. The dominant structure is moderate, medium and subangular blocky type, but angular blocky structure is a common feature in slickensides zone of vertisols in Ahmednagar district of Maharashtra (Ashokkumar and Prasad, 2010). The soil structure of Vertisols is generally sub angular blocky or blocky.

Physical characteristics of soil :

The particle size distribution showed inflection in sand, silt and clay content in depth distribution (Table 2). The sand content ranged from 10.4 to 25.7 per cent. The pedon 1 and 5 showed considerable amount of sand. The higher values of sand were observed in Bk horizon of pedon 5 (25.7 per cent) and lower value was observed in Ap horizon of pedon 3 (10.4 per cent). The silt content was higher in Bk horizon of pedon 5 (33.6 per cent) and lower content of silt was 10.8 per cent in Ck horizon of pedon 3. In trend silt content showed irregular trend in all the pedons. All the soils irrespective of depth and other properties had clay ranging from 40.7 per cent (Pedon 5) to 70.8 per cent (Pedon 3). More than 35 per cent clay in pedon 1 and 5 qualified for the particle size at family level as clayey, while pedon 2 and 3 was fine. Kadu *et al.* (2009) reported that clay content increases with the increase in depth in black soil. Bulk density values ranged from 1.42 to 1.56 Mg m^{-3} (Table 2). The highest value of bulk density 1.56 Mg m^{-3} was observed in Ap horizon of pedon 5 and lowest value 1.42 Mg m^{-3} in Bk horizon of pedon 1. The bulk density of soil increased with the depth of soil. Singh and Agrawal (2005) also recorded increase in bulk density with the depth which was attributed to lower organic matter, more compaction and less aggregation in soils of Eastern region of Varanasi. The soil of pedon 2 and 3 showed higher water retention as it contained more amount of clay. Soil of pedon 4 and 5 revealed low content of water at field capacity due to considerable amount of sand content in it.

Chemical properties of soil :

As shown in table 3, the pH of studied soils (1:2.5 soil: water suspension) ranged between 7.70 to 8.40 which indicates that the soil of study area was slightly to moderately alkaline in soil reaction. The electrical conductivity of soil ranged from 0.159 to 0.548 dSm^{-1}. The surface layers had relatively higher organic carbon than underlying horizons. The calcium carbonate in general increased with the depth and it ranged from 1.85 to 24.6 per cent in different size soil aggregates. The cation exchange capacity (CEC) of soils varied from 41.2 to 50.3 cmol (p+) kg^{-1}. The maximum and minimum values of CEC were recorded in pedon 4 and 1 respectively. The cation exchange capacity (CEC) of soils varied from 41.2 to 50.3 cmol (p+) kg^{-1}. Likhar and Prasad, (2011) studied the variation in soil and productivity of orange in Nagpur district of Maharashtra and recorded the CEC varied from 18.3 to 59.3 cmol (p^{+}) kg^{1}.

The N, P, K and S ranged from 188.16 to 238.33, 15.38 to 34.35, 168.0 to 616.0 kg ha^{-1} and 9.2 to 17.8 respectively. The DTPA-Zn, Cu, Fe and Mn in the soil varied from 0.32 to 1.66, 0.33 to 3.95, 12.5 to 24.90 and 4.80 to 16.3 mg kg^{-1} respectively. The soil is deficient in available Zn.

Taxonomy :

Geologically the area consisted of Deccan trap and alluvial soils. Pedon 1, 4 and 5 have development of pressure faces in subsoil horizon and slight increase in clay content, therefore classified in Inceptisols order. This area belongs to subtropical climate so these soils have Ustic moisture regime therefore grouped in Ustepts suborder. These soils did not classify other great group so grouped in a Haplustepts. These soils have depth more than 50 cm therefore classified in a Typic subgroup. This soil showed high calcium carbonate in subsurface horizon and therefore grouped as calcic soil and having fine texture. The black soil is form due to dominance of smectite minerals. The pedon have more than 30 % of clay in the earth fraction and hence these pedons are classified under fine particle size class with smectite mineralogy.

Pedon 2 and 3 were deep and are clayey in texture showing the development of slickensides in subsurface soil therefore grouped as Vertisols order and due to Ustic soil moisture regime grouped as Usterts. This soil also had Ustic soil moisture regime. These soils do not qualify the other great group, therefore classified as Haplusterts. These pedons have more than 30 % of clay in the earth fraction and hence these pedons are classified under fine particle size class with smectite mineralogy. The study area soil pedon 2 and 3 at site is taxonomically Fine smectite (calcareous) Vertic Haplusterts.

Suitability assessment to citrus species :

As per Anonymous, 1994 the ideal soils for citrus are deep (above 150 cm), well drained and well structured silty clay to clayey with lots of organic matter. The physicochemical characteristics of soil influenced the yield and quality parameters of citrus, which are pH, EC, texture, structure, bulk density, content of organic matter and water retention capacity. Citrus grows and fruits well in pH range of 6.5–7.5, however lower limit is 4 and upper limit is 8.5. The electrical conductivity of soil should be below 1 dS m^{-1} and calcium carbonate content below 10 per cent.

As per above criteria pedon 1 and 5 of these site were not suitable owing to very severe limitation of calcium carbonate, while pedon 2, 3 and 4 were marginally suitable for plantation of citrus. As per climatic charcterstics, the study area was moderatly suitable under total rainfall condition, highly suitable in length of growing period i.e 240-265 days and marginally suitable under mean temperature in growing season for citrus. As per soil site

Table 1. Morphological characteristics of soil

Depth (cm)	Horizon	Munsell colour		Texture	Structure	Consistence			Effervescence (10% dilute HCl)	Other Features
		Dry	moist			Dry	Moist	Wet		
1	2	3	4	5	6	7	8	9	10	11
Pedon1:Clayey, Fine , Smectite (calcareous), Typic Haplustept										
0-20	Ap	10YR 4/2	10YR 3/3	Clay	Sbk	sh	fl	s	violent	
20-35	Bk	10YR 6/3	10YR 5/4	Clay	Sbk	sh	f	ss	violent	----------
35-90	Bwk	10YR 5/4	10YR 4/3	Clay	Sbk	sh	vfl	ss	violent	
Pedon 2:Clayey, Fine , Smectite (calcareous), Vertic Haplustert										
0-22	Ap	10YR 5/2	10YR 3/3	Clay	sbk	sh	f	ss	strong	
22-45	B	10YR 4/3	10YR 3/3	Clay	sbk	sh	f	s	strong	
45-60	Bwk	10YR 4/2	10YR 3/2	Clay	sbk	sh	f	s	violent	Slikenslides were
60-80	Bssk	10YR 6/4	10YR 4/3	Clay	sbk	sh	f	ns	violent	seen below 60 cm.
80-90	Ck	10YR 5/3	10YR 4/3	Clay	abk	sh	f	ns	violent	
Pedon 3:Clayey, Fine , Smectite (calcareous), Vertic Haplustert										
0-25	Ap	10YR 5/3	10YR 3/2	Clay	sbk	sh	f	p	slight	
25-45	Bw	10YR 4/2	10YR 3/2	Clay	sbk	sh	f	p	strong	Slikenslides were
45-70	Bssk	10YR 4/2	10YR 3/2	Clay	sbk	sh	efl	vp	strong	seen below 70 cm.
70-100	Ck	10YR 5/1	10YR 4/2	Clay	abk	sh	efl	vp	violent	
Pedon 4:Clayey, Fine , Smectite (calcareous), Typic Haplustept										
0-25	Ap	10YR 5/3	10YR 3/2	Clay	sbk	sh	f	s	strong	
25-50	Bw_1k	10YR 7/2	10YR 5/4	Clay	sbk	sh	f	ss	strong	---------
50-100	Bw_2k	10YR 6/3	10YR 5/3	Clay	sbk	sh	f	ns	violent	
Pedon 5:Clayey, Fine , Smectite (calcareous), Typic Haplustept										
0-40	Ap	10YR 5/3	10YR 5/4	Clay	sbk	sh	fl	ss	violent	$CaCO_3$ layer below 40 cm depth.
40-80	Bk	10YR 7/3	10YR 6/6	Clay loam	sbk	sh	f	ns	violent	

Note: Symbols used are according to Soil Survey Manual notations (Soil Survey Division staff, 1998)

Table 2. Physical characteristics of soil

Depth	Horizon	Size class and particle diameter: Sand (2.0 - 0.05)	Silt (0.05 - 0.002)	Clay (<0.002)	Bulk Density (Mg m^{-3})	Water retention at 33 kPa (%)	Water retention at 1500 kPa (%)	AWC (%)
		% of less than 2 mm						
Pedon1:Clayey, Fine , Smectite (calcareous), Typic Haplustept								
0-20	Ap	23.8	17.8	58.4	1.45	40.0	22.1	17.9
20-35	Bk	15.6	22.2	62.2	1.42	41.3	24.3	17.0
35-90	Bwk	16.8	21.2	62.0	1.43	43.5	25.9	17.6
Pedon 2:Clayey, Fine , Smectite (calcareous), Vertic Haplustert								
0-22	Ap	14.8	24.9	60.3	1.43	38.3	26.0	12.3
22-45	B	15.7	21.7	62.6	1.44	42.4	25.8	16.6
45-60	Bwk	16.2	22.4	61.4	1.43	44.9	25.4	19.5
60-80	Bssk	17.2	22.2	60.6	1.48	42.3	25.0	17.3
80-90	Ck	20.9	22.4	56.7	1.49	44.5	26.8	17.7
Pedon 3:Clayey, Fine , Smectite (calcareous), Vertic Haplustert								
0-25	Ap	10.4	26.2	63.4	1.46	38.9	22.8	16.1
25-45	Bw	14.8	16.8	68.4	1.50	36.0	22.4	17.8
45-70	Bssk	15.2	23.5	61.3	1.49	32.8	20.0	13.6
70-100	Ck	18.4	10.8	70.8	1.49	40.4	20.1	20.3
Pedon 4:Clayey, Fine , Smectite (calcareous), Typic Haplustept								
0-25	Ap	14.6	15.6	69.8	1.49	30.1	17.2	12.9
25-50	Bw_1k	18.6	26.6	54.8	1.49	29.8	17.0	10.8
50-100	Bw_2k	22.8	28.3	48.9	-----	24.7	15.8	8.9
Pedon 5:Clayey, Fine , Smectite (calcareous), Typic Haplustept								
0-40	Ap	23.6	28.6	47.8	1.56	20.7	15.2	5.5
40-80	Bk	25.7	33.6	40.7	------	25.3	15.9	9.4

Table 3. Chemical characteristics of soil

Depth (cm)	Horizon	pH (1:2.5 H_2O)	EC (dS m^{-1})	Organic Carbon (g kg^{-1})
Pedon1:Clayey, Fine , Smectite (calcareous), Typic Haplustept				
0-20	Ap	8.08	0.241	9.6
20-35	Bk	8.12	0.167	5.6
35-90	Bwk	8.13	0.184	3.8
Pedon 2:Clayey, Fine , Smectite (calcareous), Vertic Haplustert				
0-22	Ap	7.76	0.548	8.7
22-45	B	7.86	0.499	7.3
45-60	Bwk	7.97	0.498	7.0
60-80	Bssk	8.12	0.234	5.9
80-90	Ck	8.15	0.318	5.3
Pedon 3:Clayey, Fine , Smectite (calcareous), Vertic Haplustert				
0-25	Ap	7.70	0.350	10.1
25-45	Bw	8.37	0.304	9.9
45-70	Bssk	7.99	0.257	9.0
70-100	Ck	8.04	0.334	7.9
Pedon 4:Clayey, Fine , Smectite (calcareous), Typic Haplustept				
0-25	Ap	7.74	0.172	13.3
25-50	Bw_1k	8.07	0.193	6.7
50-100	Bw_2k	7.99	0.159	4.4
Pedon 5:Clayey, Fine , Smectite (calcareous), Typic Haplustept				
0-40	Ap	8.40	0.244	9.7
40-80	Bk	8.33	0.531	9.3

Table 4. Distribution of $CaCO_3$ according to soil aggregates size (%)

Depth	Horizon	>5mm	5mm-2mm	2mm-0.5mm	<0.5mm
Pedon1:Clayey, Fine , Smectite (calcareous), Typic Haplustept					
0-20	Ap	23.08	23.92	23.75	12.74
20-35	Bk	23.75	23.92	23.92	13.59
35-90	Bwk	24.09	24.26	24.26	14.09
Pedon 2:Clayey, Fine , Smectite (calcareous), Vertic Haplustert					
0-22	Ap	7.58	10.78	8.59	9.09
22-45	B	9.60	10.44	6.90	6.40
45-60	Bwk	10.11	14.99	11.12	10.11
60-80	Bssk	14.65	19.71	17.52	11.79
80-90	Ck	24.26	24.43	23.75	12.41
Pedon 3:Clayey, Fine , Smectite (calcareous), Vertic Haplustert					
0-25	Ap	1.85	4.21	3.37	2.52
25-45	Bw	3.37	8.25	4.38	6.23
45-70	Bssk	5.56	8.25	6.40	7.07
70-100	Ck	8.42	11.45	14.40	11.79
Pedon 4:Clayey, Fine , Smectite (calcareous), Typic Haplustept					
0-25	Ap	15.16	17.18	14.49	8.00
25-50	Bw_1k	16.34	17.52	16.68	8.42
50-100	Bw_2k	24.93	24.60	24.26	12.46
Pedon 5:Clayey, Fine , Smectite (calcareous), Typic Haplustept					
0-40	Ap	23.08	22.57	23.25	18.25
40-80	Bk	24.60	24.43	24.76	19.26

Table 5. Exchangeable characteristics of soil

Depth (cm)	Horizon	Exchangeable Cations						BS
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Sum	C.E.C	
		<----------------cmol (p^{+}) kg^{-1}---------------------->						(%)
Pedon1:Clayey, Fine , Smectite (calcareous), Typic Haplustept								
0-20	Ap	32.5	6.6	0.55	0.48	40.13	43.7	91.8
20-35	Bk	33.1	8.7	0.44	0.46	42.70	47.3	90.2
35-90	Bwk	33.2	5.0	0.43	0.35	38.98	44.9	86.6
Pedon 2:Clayey, Fine , Smectite (calcareous), Vertic Haplustert								
0-22	Ap	38.5	6.4	0.48	0.50	45.88	50.1	91.6
22-45	B	38.7	7.3	0.46	0.44	46.94	51.0	92.0
45-60	Bwk	38.5	7.1	0.39	0.33	46.47	49.8	93.3
60-80	Bssk	37.9	7.0	0.39	0.30	45.73	47.5	96.2
80-90	Ck	34.1	6.0	0.58	0.40	41.08	43.7	94.0
Pedon 3:Clayey, Fine , Smectite (calcareous), Vertic Haplustert								
0-25	Ap	36.4	7.6	0.50	0.45	45.01	49.8	90.3
25-45	Bw	36.8	7.9	0.50	0.48	45.68	51.9	88.0
45-70	Bssk	35.1	7.7	0.48	0.46	43.74	46.7	93.6
70-100	Ck	35.4	7.2	0.31	0.46	43.37	50.3	86.2
Pedon 4:Clayey, Fine , Smectite (calcareous), Typic Haplustept								
0-25	Ap	32.3	7.3	0.58	0.45	46.63	49.5	94.2
25-50	Bw_1k	33.0	7.5	0.54	0.45	40.49	45.1	90.6
50-100	Bw_2k	34.5	6.4	0.52	0.45	41.93	47.2	88.8
Pedon 5:Clayey, Fine , Smectite (calcareous), Typic Haplustept								
0-40	Ap	38.8	6.0	0.56	0.49	42.85	46.2	92.6
40-80	Bk	34.4	6.9	0.35	0.34	42.11	44.2	95.2

Table 6. Fertility status of soil

Depth (cm)	Avail. N (kg ha^{-1})	Avail. P_2O_5 (kg ha^{-1})	Avail. K_2O (kg ha^{-1})	Avail. S (mg kg^{-1})
Pedon1:Clayey, Fine , Smectite (calcareous), Typic Haplustept				
0-20	231.24	31.29	545.0	11.5
21-35	200.70	31.28	434.0	12.5
35-90	188.16	22.05	321.4	9.2
Pedon 2:Clayey, Fine , Smectite (calcareous), Vertic Haplustert				
0-22	225.79	33.85	434.0	16.5
23-45	213.24	31.80	350.0	13.1
45-60	213.24	25.64	252.0	12.6
60-80	200.70	24.10	181.2	12.6
80-90	188.16	20.51	195.0	10.5
Pedon 3:Clayey, Fine , Smectite (calcareous), Vertic Haplustert				
0-25	238.33	25.64	616.0	14.5
26-45	213.24	21.03	588.0	13.4
45-70	225.79	19.49	476.0	12.5
70-100	200.70	15.38	420.0	9.5
Pedon 4:Clayey, Fine , Smectite (calcareous), Typic Haplustept				
0-25	225.79	34.35	364.2	17.8
26-50	213.24	28.72	280.0	14.5
50-100	200.70	20.51	168.0	11.5
Pedon 5:Clayey, Fine , Smectite (calcareous), Typic Haplustept				
0-40	200.70	32.82	392.0	12.7
40-80	188.16	25.64	307.0	11.5

Table 7. Micronutrient status of soil

Depth (cm)	Zn mg kg^{-1}	Cu mg kg^{-1}	Fe mg kg^{-1}	Mn mg kg^{-1}
Pedon1:Clayey, Fine , Smectite (calcareous), Typic Haplustept				
0-20	0.39	0.59	15.3	8.55
21-35	0.37	0.40	15.5	8.90
35-90	0.33	0.34	12.2	7.50
Pedon 2:Clayey, Fine , Smectite (calcareous), Vertic Haplustert				
0-22	0.99	2.01	24.9	16.3
23-45	0.55	1.53	21.0	16.2
45-60	0.43	1.26	19.2	15.2
60-80	0.30	1.55	18.7	12.3
80-90	0.32	1.52	17.3	10.4
Pedon 3:Clayey, Fine , Smectite (calcareous), Vertic Haplustert				
0-25	1.66	3.95	24.4	15.2
26-45	0.91	2.55	22.1	12.3
45-70	0.82	2.19	15.1	10.4
70-100	0.77	2.29	12.5	10.2
Pedon 4:Clayey, Fine , Smectite (calcareous), Typic Haplustept				
0-25	0.33	2.67	18.0	8.78
26-50	0.38	1.73	20.4	5.44
50-100	0.32	1.66	19.0	4.80
Pedon 5:Clayey, Fine , Smectite (calcareous), Typic Haplustept				
0-40	0.37	0.49	12.5	8.21
40-80	0.29	0.33	10.2	7.33

Table 8. Degree and limitation of soil suitablity for Citrus species

Character / Pedon	Total rainfall (mm)	Length of growing period (days)	Mean temp. in growing season (^0C)	Slope (%)	Drainage	Texture (%)	Soil depth (cm)	$CaCO_3$ (%)	pH (H_2O)	EC (dS m^{-1})	Suitability class
Pedon 1	S_2	S_1	S_3	S_1	S_2	S_1	S_3	S_4	S_2	S_2	S_4 Not suitable
Pedon 2	S_2	S_1	S_3	S_1	S_2	S_1	S_3	S_3	S_2	S_2	S_3 Marginally suitable
Pedon 3	S_2	S_1	S_3	S_1	S_2	S_1	S_3	S_3	S_2	S_2	S_3 Marginally suitable
Pedon 4	S_2	S_1	S_3	S_1	S_2	S_1	S_3	S_3	S_2	S_2	S_3 Marginally suitable
Pedon 5	S_2	S_1	S_3	S_1	S_2	S_1	S_3	S_4	S_2	S_2	S_4 Not suitable

characterstics, the slope of the study area was ideal for citrus cultivation i.e. 1 to 3 %, while drainage of study area was moderatly well and shows moderate limitation. As per the soil texture, all pedons were suitable for plantation of citrus. According to soil depth, all pedons were in severe limitation for citrus plantation and these pedons were marginally suitable for citrus plantation. Inspite of severe limitation and nonsuitablity of pedon 1 and 5 and marginally suitable pedon 2, 3 and 4 for citrus cultivation due to maximum content of calcium carbonate which directly or indirectly affect the availablity of nitrogen, phosphorus, pottasium, magnesium, iron, managnese and zinc. Such areas can bring under use for development of nursury, poly house etc. Also this area can bring under cultivation of citrus by following certain land configurartion practicess like planting trees on broad based ridges, application of water and fertilizers through drip irrigation, addition of organic manure and development of drainage facilities.

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SIMPLIFIED TRIPLE TEST CROSS ANALYSIS FOR YIELD, YIELD CONTRIBUTING AND FIBRE TRAITS IN COTTON (*Gossypium hirsutum* L.)

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ABSTRACT

An experiment to study the additive, dominance and epistasis components of genetic variation was conducted during *kharif* 2007-08 at Botany Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Two genotypes with extreme phenotypic selections viz., AKH-84635 (L_1) and AKH-023B (L_2) were used as female parents (testers) and were crossed to each of ten genotypes viz., AKH-081, AKH-053B, AKH-9312, AKH-976, AKH-9913, BBP-9, AKH-1174 , LRK-516, 8660B, AKH-8828 used as male lines and obtained 20 F_1's. Observations were recorded on days to 50 % flowering, plant height (cm), chlorophyll content (mg g^{-1}), number of bolls plant^{-1}, seed cotton yield plant^{-1}, lint yield plant^{-1} (g), ginning out turn (%), 2.5% span length (mm), Micronaire value (mg inch^{-1}), Fibre strength (g tex^{-1}), uniformity ratio (%), maturity co-efficient and oil content (%). The test of epistasis indicated its presence for all characters. The maximum epistatic variation was contributed by the parents viz., AKH-053B, AKH-1174, 8660B, AKH-9913, AKH-976 and LRK-516. The mean squares due to sums and differences were significant for all the characters studied. Both additive and dominance component were observed for all the characters, any how the additive component were predominant for all the characters under study. Maximum dominance genetic variation were contributed by the parents BBP-9, AKH-9312, LRK-516, AKH-1174, 8660B, AKH-081 and AKH-8828 for different economically important characters.

(Key words: Simplified triple test cross, epistasis, *Gossypium hirsutum* L.)

INTRODUCTION

Progress in the genetic improvement of yield in any crop depends upon the genetic information available on inheritance of quantitative traits i.e. yield and yield component characters. Therefore, knowledge of magnitude and type of genetic variance has a great importance for cotton breeders dealing with simultaneous improvement of fibre quality and lint yield. Various biometrical methods have been used in the past for estimating various types of gene actions. In most of the mating designs, it is assumed that non-allelic interactions are absent where as the fact is often contrary to this assumption. The triple test cross analysis and the simplified triple test cross are considered as significant methods to estimate non allelic intraction from the plant breeders view point. The appropriate analysis of triple test cross and simplified triple test cross yields information on epistasis as well as additive and dominance components. Hence, an attempt was made in this study to adopt simplified triple test analysis method to estimate the epistasis, additive and dominance type of genetic component.

MATERIALS AND METHODS

Two genotypes with extreme phenotypic selections viz., AKH-84635 (Rajat) (L_1) and AKH-023B (L_2) were used as female parents and as testers which were crossed to each of ten genotypes viz., AKH-081,AKH-053B, AKH-9312, AKH-976, AKH-9913,BBP-9,AKH-1174,LRK-516,8660B and AKH-8828 used as male lines and obtained 20 F_1's. The crosses along with their respective parents were sown in randomized complete block design replicated thrice at the Farm of Department of Agricultural Botany, PGI, Dr.P.D.K.V., Akola during *kharif*, 2006 and 2007. Data were recorded on days to 50 % flowering, plant height (cm), chlorophyll content (mg g^{-1}), number of bolls plant^{-1}, seed cotton yield plant^{-1}, lint yield plant^{-1} (g), ginning out turn (%), 2.5% span length (mm), micronaire value (mg inch^{-1}), fibre strength (g tex^{-1}), uniformity ratio (%), maturity co-efficient and oil content (%). Oil content in seeds was estimated by Soxhlet method as suggested by Sankaran (1966), and the total chlorophyll content of leaves was estimated by DMSO method as suggested by Arnon (1949).

The statistical analysis were performed for simplified triple test cross as per the methodology suggested by Jinks *et al.* (1969).

RESULTS AND DISCUSSION

The data regarding test of epistasis for different characters are presented in table 1 indicating the presence of epistasis for all characters. Epistasis

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($L_1i + L_2i - Pi$) is an important component in the inheritance of quantitative traits in cotton for all traits under study. Epistasis for yield and its components were also reported in cotton by Mehetre *et al*. (2003) and Singh *et al*. (2009).

Estimates of individual line contribution to the epistasis comparison ($L_1i + L_2i - Pi$) are given in table 2. The parent AKH-9312 contributed maximum epistatic variation for days to 50% flowering and oil content. The parent AKH-053B showed maximum epistatic variation for plant height and chlorophyll content. AKH-1174 recorded maximum epistatic variation for number of bolls plant^{-1}, ginning out turn, seed cotton yield and lint yield. For micronaire value 8660B showed maximum epistatic variation. AKH-9913 exhibited maximum epistatic variation for 2.5% span length and uniformity ratio. The parent AKH-976 recorded maximum epistatic variation for fibre strength and uniformity ratio. LRK-516 showed maximum epistatic interaction for maturity co-efficient. Cockerham (1961) stated that the relative merits of the current method of selection with regards to epistatic gene actions are not known. However, the presence of epistasis for economic traits could have important implications in plant breeding programme. It is difficult to determine the most efficient breeding procedures when epistasis is operative. Standard hybridization and selection procedures should take the advantage of epistasis if it is of the additive and additive x additive types of epistasis. Other types of epistasis (additive x dominance, dominance x dominance etc.) are not fixable by selection under self fertilization and therefore, would not be favourable for developing pure line cultivators. However, they must be useful in the development of hybrid varieties.

The data regarding analysis of variance for sum ($L_1i + L_2i$) and differences ($L_1i - L_2i$) are presented in table 3 and 4 respectively. The mean squares due to sums ($L_1i + L_2i$) and due to difference ($L_1i - L_2i$) were significant for all the character studied. The additive (D) and dominance (H) components were estimated for different characters under epistatic model and data of the same are presented in table 5. The additive (D) components were predominant for all the thirteen characters studied. The predominance of additive component for different economic characters were also reported by Basal and Turgut (2005) and Singh *et al*. (2009).

The data regarding estimates of individual line contribution to the additive and dominance components are presented in table 6 and 7 respectively. The maximum additive genetic variance was contributed by the parent BBP-9 for days to 50% flowering, seed cotton yield and lint yield and dominance genetic variance for 2.5% span length, fibre strength and oil content. AKH-9312 showed additive genetic variation for plant height, 2.5% span length, maturity co-efficient and oil content and showed dominance genetic variation for uniformity ratio. LRK-516 exhibited additive genetic variation for number of bolls plant^{-1} and maturity co-efficient, which also exhibited dominance genetic variation for seed cotton yield and lint yield. The parent AKH-1174 showed maximum additive genetic variation for ginning out turn and dominance genetic variation for days to 50% flowering, ginning out turn and chlorophyll content. The parent 8660B recorded maximum additive genetic variation for micronaire value and maturity co-efficient and the same parent also recorded dominance genetic component for plant height. The parent AKH-9913 exhibited maximum additive genetic variation for fibre strength and uniformity ratio and AKH-053B for chlorophyll content. Similarly AKH-081 showed maximum dominance genetic component for maturity co-efficient and AKH-8828 for micronaire value. The parents with high additive genetic variation may be utilized in cotton breeding programme on the basis of general combining ability effects, and the parents with dominance genetic variation may be utilized in cotton hybrid breeding programme on the basis of specific combining ability and heterosis.

Chahal and Singh (1974) reported that simplified triple test cross yields comparatively unbiased estimates of degree of dominance in the presence of epistasis. The magnitude of additive and dominance components is affected by the presence of epistasis for all characters under extreme phenotypic selection. If L_1 and L_2 testers do not differ at all loci it may be wrongly concluded that epistasis is present when it is not and may underestimate or overestimate the additive component and underestimate the dominance component (Virk and Jinks, 1977). In the present study, it was not possible to test the adequacy of the testers. The choice of appropriate tester for simplified triple test cross is therefore crucial.

Table 1. Test of epistasis for different characters

Sources	d. f.	Mean squares												
		Plant height (cm)	No. of bolls $plant^{-1}$	Seed cotton yield $plant^{-1}$ (g)	Lint yield $plant^{-1}$ (g)	Chloro phyll content ($mg\ g^{-1}$)	Days to 50% flowering	Ginning out turn (%)	2.5% span length (mm)	Micron aire value ($\mu g\ inch^{-1}$)	Fibre strength ($g\ tex^{-1}$)	Uniformity ratio (%)	Maturity co-efficient	Oil content (%)
Epistasis $\overline{L_{1i}} + \overline{L_{2i}} - \overline{P_i}$	9	26.40*	9.58**	35.59*	22.28**	0.30**	7.6**	20.85**	4.70**	0.56**	4.03**	10.09**	0.0004**	0.60**
Error	18	10.38	2.48	13.32	1.68	0.0003	0.21	0.90	0.46	0.004	0.05	0.61	0.00002	0.03

Note : *Significant at 5% ** Significant at 1%

Table 2. Estimation of individual line (P_i) contribution to the epistatsis comparison $L_{1i} + L_{2i} - P_i$

Sr. No.	Parents	Plant height (cm)	No. of bolls $plant^{-1}$	Seed cotton yield $plant^{-1}$ (g)	Lint yield $plant^{-1}$ (g)	Chlorophyll content ($mg\ g^{-1}$)	Days to 50% flowering	Ginning out turn (%)	2.5% span length (mm)	Micronaire value ($\mu g\ inch^{-1}$)	Fibre strength ($g\ tex^{-1}$)	Uniformity ratio (%)	Maturity co-efficient	Oil content (%)
1.	AKH - 081	98.00	20.67	51.82	18.87	1.94	59.33	37.63	24.90	2.77	19.47	43.00	0.83	22.47
2.	AKH - 053B	109.00	16.67	44.02	17.03	2.98	58.33	42.05	27.53	3.50	19.77	44.67	0.84	22.36
3.	AKH - 9312	107.33	17.67	43.44	11.53	2.70	66.33	38.83	31.07	3.60	21.80	45.00	0.85	23.27
4.	AKH - 976	95.00	20.00	57.81	22.54	2.22	64.33	40.99	30.50	3.63	26.37	51.33	0.85	21.77
5.	AKH - 9913	104.67	16.67	55.56	23.41	2.73	62.00	42.75	31.27	1.90	23.27	51.33	0.81	22.69
6.	BBP - 9	102.00	20.67	50.45	22.58	2.11	63.33	38.10	26.73	4.10	21.80	50.00	0.83	22.64
7.	AKH - 1174	104.00	24.33	60.25	28.03	2.38	60.00	46.23	30.40	4.27	22.60	44.67	0.82	20.38
8.	LRK - 516	96.00	22.33	51.51	23.72	2.04	58.00	42.36	30.90	2.93	22.67	48.33	0.87	22.65
9.	8660B	99.00	21.00	55.15	26.00	1.48	59.33	43.10	28.93	4.33	21.23	47.67	0.86	22.58
10.	AKH - 8828	108.33	14.00	44.28	20.77	1.26	61.67	29.48	28.03	3.50	20.33	43.67	0.83	22.49

Table 3. Analysis of variance for the sums ($L_{1i} + L_{2i}$) for different characters

Sources	d. f.	Mean squares					
		Plant height (cm)	No. of bolls plant^{-1}	Seed cotton yield plant^{-1} (g)	Lint yield plant^{-1} (g)	Chlorophyll content (mg g^{-1})	Days to 50% flowering
Sum (M_s) $\overline{L_{1i}} + \overline{L_{2i}}$	9	544769.4**	16759.29**	108255**	19357.3**	290.57**	244302.1**
Error (M_w)	18	27.74	24.57	122.42	50.73	0.001	5.46

Sources	d. f.	Mean squares						
		Ginning out turn (%)	2.5% span length (mm)	Micronaire value (µg inch^{-1})	Fibre strength (g tex^{-1})	Uniformity ratio (%)	Maturity co-efficient	Oil content (%)
Sum (M_s) $\overline{L_{1i}} + \overline{L_{2i}}$	9	97036.7**	51138.81**	826.81**	31388.9**	150007.2**	45.61**	31163.98**
Error (M_w)	18	0.62	0.56	0.007	0.20	2.54	0.0001	0.02

Note : *Significant at 5% ** Significant at 1%

Table 4. Analysis of variance for the difference ($L_{1i} - L_{2i}$) for different characters

Sources	d. f.	Mean squares					
		Plant height (cm)	No. of bolls plant^{-1}	Seed cotton yield plant^{-1} (g)	Lint yield plant^{-1} (g)	Chlorophyll content (mg g^{-1})	Days to 50% flowering
Difference (M_d) $\overline{L_{1i}} - \overline{L_{2i}}$	9	38.57**	6.56**	12.63	11.21**	0.23**	12.38**
Error (M_w)	18	7.07	2.50	5.10	1.75	0.0003	0.28

Sources	d. f.	Mean squares						
		Ginning out turn (%)	2.5% span length (mm)	Micronaire value (µg inch^{-1})	Fibre strength (g tex^{-1})	Uniformity ratio (%)	Maturity coefficient	Oil content (%)
Sum (M_d) $\overline{L_{1i}} - \overline{L_{2i}}$	9	11.77**	6.66**	0.31**	1.34**	5.62**	0.0002**	0.54**
Error (M_w)	18	0.10	0.37	0.005	0.04	0.62	0.00001	0.006

Note : *Significant at 5% ** Significant at 1%

Table 5. Components of genetic variation

Sources of variation	Plant height (cm)	No. of bolls plant^{-1}	Seed cotton yield plant^{-1} (g)	Lint yield plant^{-1} (g)	Chlorophyll content (mg g^{-1})	Days to 50% flowering
D	363161.11	11156.48	72088.39	12871.05	193.71	162864.43
H_1	21	2.71	0.29	6.31	0.153	8.07
$\sqrt{H_1/D}$	0.0076	0.016	0.002	0.022	0.028	0.007

Sources of variation	Ginning out turn (%)	2.5% span length (mm)	Micronaire value (µg inch^{-1})	Fibre strength (g tex^{-1})	Uniformity ratio (%)	Maturity coefficient	Oil content (%)
D	64690.72	34092.17	551.20	20925.8	100003.11	30.41	20775.97
H_1	7.78	4.19	0.20	0.87	3.33	0.00013	0.356
$\sqrt{H_1/D}$	0.011	0.011	0.019	0.0064	0.0058	0.0021	0.0041

Table 6. Estimation of individual line (Pi) contribution to the additive comparison $\overline{L}_{1i} + \overline{L}_{2i}$ for different characters

Sr. No.	Parents	Plant height (cm)	No. of bolls plant^{-1}	Seed cotton yield plant^{-1} (g)	Lint yield plant^{-1} (g)	Chlorophyll content (mg g^{-1})	Days to 50% flowering
1.	AKH - 081	164.33	31.67	78.87	28.73	3.84	120.00
2.	AKH - 053B	182.00	29.67	75.67	28.90	5.10	118.00
3.	AKH - 9312	193.00	28.33	71.21	25.07	4.72	123.33
4.	AKH - 976	182.00	28.00	76.53	30.85	4.01	124.67
5.	AKH - 9913	186.67	30.00	84.72	36.77	4.55	122.00
6.	BBP - 9	185.67	35.00	86.13	39.28	4.22	127.33
7.	AKH - 1174	165.67	34.00	85.54	36.77	4.42	117.00
8.	LRK - 516	170.33	35.67	82.46	37.42	3.95	118.00
9.	8660B	187.67	33.33	85.44	39.27	3.38	119.00
10.	AKH - 8828	190.33	31.33	79.20	37.40	3.54	121.33

Sr. No.	Parents	Ginning out turn (%)	2.5% span length (mm)	Micronaire value (µg inch^{-1})	Fibre strength (g tex^{-1})	Uniformity ratio (%)	Maturity coefficient	Oil content (%)
1.	AKH - 081	75.08	53.33	6.57	41.17	92.67	1.64	42.74
2.	AKH - 053B	76.70	55.03	7.10	42.60	93.00	1.64	41.89
3.	AKH - 9312	69.95	60.53	6.67	43.73	91.00	1.68	45.06
4.	AKH - 976	77.27	58.90	6.37	44.17	96.00	1.66	43.22
5.	AKH - 9913	79.97	57.37	6.43	44.73	100.33	1.62	43.85
6.	BBP - 9	72.06	53.67	7.23	42.93	97.33	1.67	44.06
7.	AKH - 1174	81.07	52.87	8.27	43.83	92.67	1.61	39.48
8.	LRK - 516	79.74	55.43	6.53	44.17	97.67	1.68	44.19
9.	8660B	77.43	53.23	8.33	42.83	94.33	1.68	44.33
10.	AKH - 8828	73.69	53.50	6.90	42.80	93.67	1.66	43.57

Table 7. Estimation of individual line (Pi) contribution to the dominance comparison $\overline{L}_{1i}$ - $\overline{L}_{2i}$ for different characters

Sr. No.	Parents	Plant height (cm)	No. of bolls plant^{-1}	Seed cotton yield plant^{-1} (g)	Lint yield plant^{-1} (g)	Chlorophyll content (mg g^{-1})	Days to 50% flowering
1.	AKH - 081	-2.33	-1.00	3.03	-0.20	-0.50	-0.67
2.	AKH - 053B	12.67	-0.33	3.02	0.70	0.29	0.67
3.	AKH - 9312	5.00	-0.33	0.84	2.93	0.47	-4.00
4.	AKH - 976	6.00	-4.00	-3.60	-2.32	0.42	-4.00
5.	AKH - 9913	2.00	-4.00	3.19	2.17	0.22	-6.67
6.	BBP - 9	1.67	1.00	1.97	3.48	0.59	0.00
7.	AKH - 1174	5.67	-2.67	1.95	1.63	0.99	1.67
8.	LRK - 516	9.00	1.00	7.23	6.18	0.29	1.33
9.	8660B	13.00	2.00	5.00	5.93	0.16	-2.33
10.	AKH - 8828	11.00	0.00	5.00	5.00	0.00	-4.67

Sr. No.	Parents	Ginning out turn (%)	2.5% span length (mm)	Micronaire value (µg inch^{-1})	Fibre strength (g tex^{-1})	Uniformity ratio (%)	Maturity coefficient	Oil content (%)
1.	AKH - 081	1.66	-0.87	0.30	0.63	-2.00	0.01	-0.58
2.	AKH - 053B	5.59	-2.37	-0.17	-0.40	0.33	-0.02	-0.27
3.	AKH - 9312	3.99	-6.00	0.40	0.00	1.67	0.00	-0.03
4.	AKH - 976	0.45	-4.57	0.70	0.30	-2.67	-0.01	0.41
5.	AKH - 9913	2.06	-6.43	0.83	-0.73	-1.00	-0.02	-1.02
6.	BBP - 9	2.88	0.07	0.23	1.13	0.67	0.00	0.50
7.	AKH - 1174	8.67	-2.73	0.13	-0.37	-4.00	-0.01	0.34
8.	LRK - 516	2.38	-1.97	0.80	-0.30	-3.67	-0.02	-0.61
9.	8660B	-0.92	-3.90	-0.13	-2.30	-0.33	0.00	-0.70
10.	AKH - 8828	5.53	-4.10	1.23	-1.00	0.33	0.00	-1.50

The limitation, however, lies in the difficulty of finding a pair which fulfills the condition of simplified triple test cross for all characters. The testers, which are suitable for one character might fail to detect interaction between genes for other characters.

In the present study, both additive (D) and dominance (H) component of genetic variation played an important role in the inheritance of characters under study. Therefore, it is suggested that both additive and dominance genetic variation can be exploited. For capitalizing the additive genetic variation, selective intermitting in F_2 generation should be followed and further segregating material should be carried by single seed descent method to obtain superior recombinant lines. The parents with maximum additive genetic variation will be useful for improvement of economic traits and may be utilized in hybridization programme. Similarly, the maximum dominance genetic variation were contributed by the parents BBP-9, AKH-9312, LRK-516, AKH-1174, 8660B, AKH-081 and AKH-8828 will be exploited for heterosis breeding programme.

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INFLUENCE OF SULPHUR OXIDIZING FUNGI ON GROWTH AND YIELD OF SOYBEAN

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ABSTRACT

Efficacy of two sulphur oxidizing fungal cultures viz., *Trichoderma harzianum* and *Aspergillus niger* individually and in combination with sulphur was evaluated in soybean crop in field trial at research farm of Plant Pathology Section, College of Agriculture, Nagpur during *kharif,* 2012. The yield parameters viz., number of pods plant^{-1}, grain yield and 1000 grains weight increased significantly due to inoculation of cultures under study with or without sulphur fertilizer. The treatment of *T. harzianum* and recommended dose of fertilizer (30:75:30 NPK kg ha^{-1}) with sulphur (15 kg ha^{-1}) had given maximum response in respect of number of pods plant^{-1}, grain yield and 1000 grains weight. The number of pods plant^{-1}, grain yield and 1000 grains weight were increased from 47.30 to 68.34, 823.00 to 1590.00 kg ha^{-1} and 111.21 to 127.43 g by this treatment respectively over uninoculated control. The inoculation of *T. harzianum* + Sulphur (15 kg ha^{-1}) + RDF could increase available sulphur content in soil from 13.36 kg ha^{-1} in control to a maximum of 19.60 kg ha^{-1} and sulphur uptake ranging from 250.00 to 322.33 mg 100 g^{-1} plant dry weight when compared with control.

(Key words: Sulphur oxidizing fungi, yield, sulphur uptake, soybean)

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is well known oilseed as well as pulse crop which is grown in various countries. Pulses and oilseeds are important constituents of Indian diet and supply a major part of the protein requirement. Soybean supplies 20 per cent oil and 40 per cent protein.

Sulphur is one of the seventeen essential nutrients and it is a structural component of amino acids, proteins, vitamins and enzymes and is essential to produce chlorophyll. Sulfur ranked equal to nitrogen for optimizing crop yield and quality. It enhances the efficiency of nitrogen for protein manufacture (Tucker, 1999). The major reservoir of sulphur in soil is an unavailable elemental and reduced form of sulphur. Plants generally utilize the oxidised state of sulphate (SO_4^{-2}) and therefore, it must first be oxidized before it can be used by crops. Most agricultural soils contain some micro organisms that are able to oxidize sulphur. The micro organisms are mainly responsible to make available sulphate from elemental or reduced forms of sulphur through its oxidation process with the intermediate formation of thiosulphate ($S_2O_3^{2-}$) and tetrathionate ($S_4O_6^{2-}$) in soils (Anandham and Sridar, 2004). Sulphur oxidizing fungi appear particularly useful for oxidation purpose since their spores or mycelia can be produced economically in large quantities and have good survival characteristics, both in the inoculants and in soil. Reports showed that combined inoculation of *Thiobacillus thioxidans* and *Aspergillus niger*, *Trichoderma harzianum*, *Myrothecium cinctum*, *Aspergillus terreus* with sulphur improved soybean grain yield and protein content (Shinde *et al*., 2004). Therefore, the study was undertaken to determine performance of sulphur oxidizing fungi on yield parameters of soybean, available sulphur in soil and on sulphur uptake.

MATERIALS AND METHODS

The sulphur oxidizing fungi were isolated from soil samples collected from selected spots of different oilseed crops i.e. sesame, mustard, linseed and soybean fields of Agronomy Section, College of Agriculture, Nagpur. These isolates were further purified and screened for sulphur oxidizing ability in potato dextrose agar medium and czapek dox medium respectively. From these, two isolates i.e. *Aspergillus niger* and *Trichoderma harzianum* were selected for further experiment. A field experiment was conducted in randomized block design with three replications during *kharif,* 2012. There were nine treatments comprising of two fungal cultures and two sulphur levels (Table 1). The recommended dose of NPK (30:75:30 kg ha^{-1}) was applied in the form of DAP and MOP, sulphur in the form of elemental sulphur powder. The cultures were multiplied in modified sulphur medium (Wainwright, 1978) and when they attained 10^{-7} cfu ml^{-1} strength, each one was mixed in 1:2 (v/w) carrier. Then each of the cultures @ 250 g 10 kg^{-1} of JS-335 seed of soybean were treated. The yield parameters of soybean viz., number of pods plant^{-1},

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grain yield and 1000 grains weight were studied. Five plants from each net plot were uprooted at harvest and all the developed pods were plucked and counted to estimate number of pods plant^{-1}. The available sulphur content in soil and sulphur uptake by plant was analyzed by turbidimetric method (Chopra and Kanwar, 1980).

RESULTS AND DISCUSSION

The influence of sulphur oxiding fungal cultures with and without sulphur on the growth and yield of soybean plant was found to be significant. Particularly, inoculation of *Trichoderma harzianum* culture along with sulphur (15 kg ha^{-1}) showed significantly superior performance over all other treatments under study.

It is revealed from the data that number of pods plant^{-1} were increased due to the cultures under study with and without sulphur over control. The maximum number of pods (68.34 plant^{-1}) were recorded in the treatment *Trichoderma harzianum* culture and recommended dose of fertilizer along with sulphur (15 kg ha^{-1}) and it was significantly superior over rest of the treatments and control. Next to this treatment application of *Aspergillus niger* culture and recommended dose of fertilizer along with sulphur (15 kg ha^{-1}) significantly better than the remaining treatments except *Trichoderma harzianum* + recommended dose of fertilizer + Sulphur (10 kg ha^{-1}). The remaining less effective treatments were viz., *Aspergillus niger* + recommended dose of fertilizer + Sulphur (10 kg ha^{-1}), Sulphur (20 kg ha^{-1}) + recommended dose of fertilizer, *Trichoderma harzianum* + recommended dose of fertilizer, *Aspergillus niger* + recommended dose of fertilizer, recommended dose of fertilizer in a descending manner. The minimum number of pods (47.30 plant^{-1}) was recorded in uninoculated control. Similar trend of results was noticed in respect of grain yield. The maximum grain yield (1590 kg ha^{-1}) was obtained in *Trichoderma harzianum* culture and recommended dose of fertilizer along with sulphur (15 kg ha^{-1}) treatment and minimum Weight of 1000 grains per treatment was also noticed to be the maximum (127.43 g) with the treatment of *Trichoderma harzianum* culture and recommended dose of fertilizer along with sulphur (15 kg ha^{-1}). Shinde *et al.* (2004) in soybean reported that the number of pods, grain yield and 1000 grains weight were significantly increased due to combined inoculation of *Thiobacillus thioxidans* and *Aspergillus niger*, *Trichoderma harzianum*, *Myrothecium cinctum*, *Aspergillus terreus* with sulphur. These results were conformed during the present studies so far as *T. harzianum* and *A. niger* are concerned. Shinde *et al.* (2010) in cotton reported that the number of picked bolls and seed yield were significantly increased due to combined inoculation of *Scolecobasidium constrictum, Myrothecium cinctum, Aspergillus terreus, Thiobacillus thioparus* and *T. thiooxidans.*

The available sulphur content in soil increased due to inoculation of sulphur oxidizing fungi in conjunction with sulphur application. The maximum available sulphur (19.60 kg ha^{-1}) was observed in the treatment of *Trichoderma harzianum* culture and recommended dose of fertilizer along with sulphur (15 kg ha^{-1}) and it was at par with *Aspergillus niger* culture and recommended dose of fertilizer along with sulphur (15 kg ha^{-1}) treatment. Next to these treatment applicaton of *Trichoderma harzianum* + recommended dose of fertilizer + Sulphur (10 kg ha^{-1}) and *Aspergillus niger* + recommended dose of fertilizer + Sulphur (10 kg ha^{-1}). The sulphur treatment alone also helped in increasing available sulphur level in soil from 13.36 kg ha^{-1} to 17.40 kg ha^{-1}. The less effective treatments were viz., *Trichoderma harzianum* + recommended dose of fertilizer and *Aspergillus niger* + recommended dose of fertilizer. The minimum available sulphur (13.36 kg ha^{-1}) was recorded in uninoculated control. Kadam *et al*. (2004) and Shinde *et al*. (2010) in soybean found increased available sulphur content in soil due to combined inoculation of *Thiobacillus thioxidans* and *Aspergillus niger*, *Trichoderma harzianum*, *Myrothecium cinctum*, *Aspergillus terreus* with sulphur.

The data on sulphur uptake by soybean crop revealed that two fungal cultures with or without sulphur treatment increased sulphur uptake ranging from 250.00 to 322.33 mg 100^{-1} g dry weight of plant and maximum was recorded in *Trichoderma harzianum* culture and recommended dose of fertilizer along with sulphur (15 kg ha^{-1}) and it was significantly superior over rest of the treatments. Next to this treatment application of *Aspergillus niger* culture and recommended dose of fertilizer along

Table 1: Effect of sulphur oxidizing fungi on yield parameters, available sulphur content in soil and sulphur uptake after harvesting of soybean crop

Sr. No	Treatments	No. of pods plant^{-1}	Grain yield (kg ha^{-1})	1000 grains weight (g)	Available sulphur content in soil (kg ha^{-1})	Sulphur uptake (mg 100g^{-1})
T_1	*Aspergillus niger* + RDF	53.00	1105.00	118.33	15.86	255.33
T_2	*Trichoderma harzianum* + RDF	54.80	1180.00	119.51	16.06	258.66
T_3	*A. niger* + Sulphur (10 kg ha^{-1}) + RDF	57.08	1272.33	121.21	17.89	283.66
T_4	*T. harzianum* + Sulphur (10 kg ha^{-1}) + RDF	59.81	1374.66	123.01	18.42	289.33
T_5	*A. niger* + Sulphur (15 kg ha^{-1}) + RDF	62.03	1440.33	126.67	19.00	318.00
T_6	*T. harzianum* + Sulphur (15 kg ha^{-1}) + RDF	68.34	1590.00	127.43	19.60	322.33
T_7	Sulphur (20 kg ha^{-1}) + RDF	55.33	1216.00	120.61	17.40	262.00
T_8	RDF (30:75:30 NPK kg ha^{-1})	51.97	1045.00	115.16	15.06	253.33
T_9	Control	47.30	823.00	111.21	13.36	250.00
	SE $\pm$ (m)	1.51	32.54	0.70	1.14	3.39
	CD (P=0.05)	4.53	97.57	2.09	3.44	10.18

(Initial available sulphur content in soil is 13.03 kg ha^{-1})

with sulphur (15 kg ha^{-1}), *Trichoderma harzianum* + recommended dose of fertilizer + Sulphur (10 kg ha^{-1}) and *Aspergillus niger* + recommended dose of fertilizer + Sulphur (10 kg ha^{-1}). The sulphur uptake also increased due to sulphur application alone from 250.00 to 262.00 mg 100^{-1} g dry weight of plant. The less effective treatments were viz., *Trichoderma harzianum* + recommended dose of fertilizer and *Aspergillus niger* + recommended dose of fertilizer. The minimum sulphur uptake (250.00 mg 100^{-1} g) was recorded in uninoculated control. Shinde *et al.* (2004) reported increase in sulphur uptake in soybean due to combined inoculation of *Thiobacillus thioxidans* and *Aspergillus niger*, *Trichoderma harzianum*, *Myrothecium cinctum*, *Aspergillus terreus* with sulphur. Earlier, Shinde *et al.* (2000) recorded similar results in groundnut and cotton crops.

The significant effect of different cultures on the performance of soybean may be attributed to the increased rate of microbial oxidation of elemental sulphur to sulphate (SO_4) sulphur in soil which in turn might have increased the sulphur uptake and thereby the yield.

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EFFECT OF SPACING ON GROWTH, FLOWER YIELD AND QUALITY OF CALENDULA UNDER VIDARBHA (M.S.) CONDITIONS

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ABSTRACT

An experiment entitled "Effect of spacing on growth, flower yield and quality of calendula" was carried out at Horticulture Section, College of Agriculture, Nagpur (M.S.), India during the year 2011-12 with seven treatments of spacing *viz.,* 30x30 cm, 30x20 cm, 30x10 cm, 20x20 cm, 20x10 cm, 15x15 cm and 15x10 cm in randomized block design. The results revealed that, the wider spacing of 30x30 cm recorded significantly maximum branches plant^{-1}, leaf area, flowering span, cut flower yield plant^{-1} and thickness of flower stalk, whereas, closer spacing 15x10 cm recorded maximum height of plant, stalk length of flower and minimum days to first flower bud initiation and flower opening from bud initiation.

(Key words: Calendula, flower yield, growth, quality, spacing)

INTRODUCTION

Calendula is the one of the commonly cultivated seasonal flower crops. It is also known as pot marigold. Calendula flowers has good scope in cut flower industries particularly for flower arrangement. The calendula flower has certain medicinal properties. The alcohol extract from the leaves and flowers of calendula have anti microbial activity and are used for the treatment of patients affected by varicose ulcer and skin lesions. It is effective in wound healing and also possesses anti helminthic properties. They serve the purpose of useful fillers in the flower bouquets and arrangement. The plants are very popular for growing in beds as well as pot plants and also grown in window boxes.

Now a days, calendula is gaining importance as a cut flower and grown on large scale for cut flower production. The flower of calendula has a good scope in cut flower industry, particularly for flower bouquets and arrangements. As a cut flower, calendula is very useful for flower arrangement in flat bowls. Due to flatness of the flowers, they are not easily mixed with any other flowers. In cut flower industry, the most important aspects are maximum production of better quality cut flowers in order to fetch more market price. For obtaining better vegetative growth and thereby, increasing the yield of better quality flowers, plant density plays an important role. Very few research work has been carried out in calendula under Vidarbha conditions and hence sufficient information on different agro-techniques followed in this crop as a cut flower is not available. Therefore, the present investigation was carried out to find out the suitable spacing for maximum production of better quality cut flower of calendula under Vidarbha conditions.

MATERIALS AND METHODS

A field experiment was carried out at Farm No.16, Horticulture Section, College of Agriculture, Nagpur during *rabi* season of the year 2011-2012 to study the effect of spacing on growth, flower yield and quality of calendula cut flower with the seven treatments and three replications laid out in Randomized Block Design. The treatments comprised of various spacing *viz.,* T_1-30x30 cm, T_2-30x20 cm, T_3-30x10 cm, T_4-20x20 cm, T_5-20x10 cm, T_6-15x15 cm and T_7-15x10 cm. The experimental plot was brought to fine tilth by ploughing, clod crushing and harrowing. At the time of land preparation, well rotted FYM @ 15 t ha^{-1} was mixed uniformly in the soil before last harrowing. The fertilizer dose of 50 kg ha^{-1} nitrogen, phosphorus 20 kg ha^{-1} and potassium 25 kg ha^{-1} was applied in the form of urea, single super phosphate and muriate of potash, respectively. Half dose of nitrogen and full dose of phosphorus and potash were applied at the time of planting, while, the remaining half dose of nitrogen was applied 30 days after transplanting of seedlings. The field was laid out with flat beds of the dimension 1.2x2.1m. Various observations growth and flowering parameters v*iz.,* height of plant (cm), no. of branches plant^{-1}, leaf area plant^{-1}(cm^2), days to first flower bud initiation, days to opening of flower from bud emergence, flowering span (days), no of flowers plant^{-1}, thickness of flower stalk (cm) and stalk length of flower (cm) were recorded and the data was statistically analyzed by Panse and Sukhatme (1967).

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RESULTS AND DISCUSSION

Growth parameters :

The data presented in table 1 revealed that, different spacing treatments had significant effect on growth parameters *viz.,* plant height and leaf area.

Plant height of calendula was noted significantly the highest with the spacing of 15x10 cm (58.23 cm) which was statistically at par with the spacing of 15x15 cm (57.28 cm), whereas, lowest height of plant (51.69 cm) was recorded with the spacing of 30x30 cm and it was found at par with the spacing of 30x20 cm (52.73 cm). An increase in plant height in calendula was observed with the closer spacing of 15x10 cm, might be due to insufficient space available for spreading of plant and active competition between the plants for light and aeration under closer spacing treatment resulting into more vertical growth. Similar results are also obtained by Kumar and Singh (2011) who reported that, the maximum plant height (25.94 cm) obtained with the closer spacing of 30x10 cm as compared to other spacing *viz.,* 30x20 cm and 30x30 cm in calendula.

The wider spacing of 30x30 cm had recorded significantly maximum branches plant^{-1} in calendula (26.13) and it was followed by the spacing of 30x20 cm (24.20), however, minimum number of branches plant^{-1} were counted with the closer spacing of 15x10 cm (17.07) which was statistically at par with the spacing of 15x15 cm (17.40). The number of branches plant^{-1} of calendula were increased with the increase in plant spacing and the highest number of branches were found with the treatment of wider spacing 30x30 cm. This might be due to sufficient amount of nutrients available for widely spaced plants for producing vigorous growth of plant with maximum number of branches. Kumar and Singh (2011) registered that the maximum number of primary branches (20.21) were recorded with the wider spacing of 30x30 cm in calendula.

Similarly, significantly maximum leaf area was recorded with the wider spacing of 30x30 cm (68.21 cm^2) which was found statistically at par with the spacing of 30x20 cm (67.29 cm^2) and minimum leaf area was noted with the closer spacing of 15x10 cm (56.25 cm^2) which was found at par with the spacing 15x15 cm (56.57 cm^2). Significantly the maximum leaf area recorded under the wider plant spacing i.e. 30x30 cm as compared to other treatments of closer spacing, which might be due to availability of more space and sunlight for growth and development of plants which might have increased nutrient uptake by the plant. Mitra and Pal (2008) also recorded the highest leaf area (49.23 cm) with the minimum plant density (12 plant/m^2) i.e., 12x50 cm in chrysanthemum.

Flowering parameters :

Significant effect on flowering parameters *viz.,* days to first flower bud initiation, days to opening of flower from bud emergence and flowering span was found due to different spacing treatments in calendula (Table 1).

The closer spacing of 15x10 cm took significantly minimum days for first flower bud initiation (27.07 days) and opening of flower from bud emergence (11.42 days) and it was found statistically at par with the closer spacing of 15x15 cm (27.77 and 11.63 days respectively), whereas, maximum days were required under the wider spacing of 30x30 cm for first flower bud initiation and opening of flower from bud emergence (31.53 and 14.70 days, respectively) in calendula.

Delay in flowering was observed under wider spacing of 30x30 cm which might may be due to increased vigour and enhanced vegetative growth of widely spaced calendula plants as results of maximum uptake of nutrients by individual plant and this ultimately might have resulted into late flowering. However, an early bud initiation and flowering in calendula with closer spacing might be due to early physiological maturity of shoots as a results of minimum vegetative growth of plant in respect of leaf area and branches plant^{-1} in closer spacing as compared to wider spacing. Awchar (2008) noted that, the earliest bud initiation (45.33 days) was noted with the closer spacing of 45x30 cm in gaillardia and Kour (2009) also reported the earliest flower bud initiation with the closer spacing of 20x20 cm in chrysanthemum as compared to wider spacing.

Significantly maximum flowering span (73.48 days) was recorded under the wider spacing of 30x30 cm which was statistically at par with the

Table1. Effect of spacing on growth, flower yield and quality of calendula

Treatments	Plant height (cm)	Branches plant^{-1}	Leaf area (cm^{-2})	Days to first flower bud initiation	Days to opening of flower from bud emergence	Flowering span (days)	Yield plant^{-1}		Thickness of flower stalk (cm)	Stalk length of cut flower (cm)
							Cut	Loose		
T_1 30x30 cm	51.69	26.13	68.21	31.53	14.70	73.48	6.33	54.33	0.67	42.40
T_2 30x20 cm	52.73	24.20	67.29	30.60	14.52	73.35	5.67	51.33	0.63	42.57
T_3 30x10 cm	53.72	22.03	65.41	30.07	13.04	71.20	4.70	47.67	0.61	43.74
T_4 20x20 cm	54.69	21.43	62.45	28.67	12.66	70.01	3.80	43.00	0.59	45.49
T_5 20x10 cm	55.90	19.47	58.89	28.40	12.78	68.9	2.93	37.33	0.52	47.48
T_6 15x15 cm	57.28	17.40	56.57	27.77	11.63	69.68	2.67	27.67	0.51	50.08
T_7 15x10 cm	58.23	17.07	56.25	27.07	11.42	68.29	2.33	21.00	0.47	51.13
SE m(±)	0.35	0.38	0.67	0.23	0.26	0.44	0.27	0.94	0.02	0.40
CD at 5 %	1.05	1.13	1.99	0.70	0.78	1.30	0.82	2.80	0.06	1.21

spacing of 30x20 cm (73.35 days), whereas, total flowering span was noticed to be minimum (68.29 days) with the closer spacing of 15x10 cm and it was found at par with the spacing of 15x10 cm (69.29 days). The results are congruent with those of Kumar and Singh (2011) who reported the maximum flowering span (76.54 days) with the wider spacing of 30x30 cm in calendula.

Flower yield and quality parameters :

The number of cut and loose flowers plant^{-1}, thickness of flower stalk and length of cut flower of calendula were significantly influenced by different spacings. Significantly maximum cut and loose flowers plant^{-1} were noticed under the wider spacing of 30x30 cm (6.33 and 54.33, respectively) which was at par with the spacing of 30x20 cm (5.67) in respect of number of cut flower, however, the spacing of 15x10 cm had recorded least (2.33 and 21.00) number of cut and loose flowers plant^{-1} of calendula, respectively. The wider spacing resulted into the production of more number of cut as well as loose flowers plant^{-1} of calendula. This might be attributed to more vegetative growth of the plants due to availability of maximum nutrients, sunlight, and soil moisture in widely spaced plants. Kumar and Singh (2011) also recorded that, maximum flower yield plant^{-1} (137.26) recorded with the wider spacing 30x30 cm in calendula.

Similarly, significantly maximum thickness of flower stalk of calendula cut flower was registered with the wider spacing of 30x30 cm (0.67 cm) and it was statistically at par with the spacing of 30x20 cm (0.63 cm), however, thickness of flower stalk recorded minimum with the closer spacing of 15x10 cm (0.47 cm). However, significantly maximum stalk length of calendula cut flower was recorded with the closer spacing of 15x10 cm (51.13 cm) which was statistically at par with the spacing of 15x15 cm (50.08 cm), whereas, minimum stalk length of cut flower was recorded with the spacing of 30x30 cm (42.40 cm).

The thickness of calendula cut flower stalk was found to be decreasing and stalk length of cut flower was found to be increased with the decrease in spacing. The decrease in flower stalk thickness might be due to higher plant population pressure leading to increase in competition for nutrients among the plants, whereas, increase in flower stalk thickness might be due to lesser availability of space and solar radiation in closely spaced calendula plants. Mane *et al.* (2007) also recorded maximum thickness of flower stalk (1.67 cm) and minimum stalk length of flower (42.40 cm) with the wider spacing of 20x25 cm as compared to other spacing in tuberose and Malam *et al.* (2010) recorded maximum spike length (89.64) obtained with closer spacing 30x15 cm in tuberose.

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CHEMICAL COMPOSITION AND SPONGINESS OF GULABJAMUN PREPARED FROM DIFFERENT READY MIX

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ABSTRACT

Among the Indian sweets, gulabjamun is the most important milk product throughout the country. Traditionally gulabjamun is prepared from the mixture of khoa, wheat flour (Maida) and baking powder, A few readymade gulabjamuns mix powder are sold in the market to make gulabjamuns at home. The present study was conducted during 2009-10 at Animal Husbandry and Dairying Section, College of Agriculture, Nagpur, to find out the chemical composition and sugar syrup absorption rate of gulabjamuns prepared from different ready mixes in comparison to fresh pure khoa based gulabjamuns. The results showed that, gulabjamuns prepared from fresh unadulterated khoa (standard) contained significantly ($P < 0.05$) more total solid, fat, protein and ash as compared to gulabjamuns made from four ready mix treatments (RM-1, RM-2, RM-3 and RM-4)studied. The chemical compositions of gulabjamuns prepared from different ready mixes were nearly in the same range. The sugar syrup plays a key role in volume expansion, weight increase, change in mouth feel quality and sponginess of gulabjamuns. The sugar syrup absorption rate of gulabjamuns prepared from ready mix RM-2 was significantly higher as compared to standard gulabjamuns made from unadulterated fresh khoa and other ready mix treatments.

(Key words: Gulabjamuns, ready mix, khoa, sugar syrup absorption)

INTRODUCTION

India is land of many splendored celebrations of fairs, feast and festivals. They are marked by a lavish variety of food delicacies, adorned with dazzling colours, aromas and flavours. In this rich diversity gulabjamuns occupies a place of pride.

Gulabjamun is the nationally popular khoa based sweet, originates from an Arabic desserts “Luqmat – Al – Qadi” that becomes popular in the Indian subcontinent during the Mughal era (Anonymous 2009). The term gulabjamuns comes from two different languages “Gulab” from Persian referring to the rose water and Jamun from Hindustani language which refers a South Asian fruit “*Syzygium jambolanum*” with similar shape and size (Annonymous,2009). Traditionally gulabjamun is prepared from a mixture of fresh khoa, wheat flour (Maida) and baking powder. The gourmet version of gulabjamuns has centre cored honey with pistachio and cardamom seeds and is prepared in kesar (saffron) syrup. Gulabjamuns is characterized by brown colour, smooth and spherical shape, soft and slightly spongy body free from both lumps and hard centre core, uniform granular texture, mildly cooked and oily flavour, free from doughy feel and fully succulent with sugar syrup (Sharma, 2006).

Gulabjamuns has been traditionally prepared on small scale by Halwais, but recently has aroused interest in the organized dairy industry for large scale mechanized production (Patel *et al*., 1992). Because of the changes in traditional families' structure and hurried life style, which has changed the eating pattern and food choice of modern societies, ready mixes of variety of traditional products have become popular. Gulabjamuns mix powder (GMP) is one such products. It is commercially available under quite a few brand names. N.D.R.I. has also developed gulabjamuns mix powder with roller dried skim milk powder (SMP) as base (Rao *et al*., 2002).

Since there is an increasing trend in the consumption of gulabjamuns in our country, the development of ready mix formulations could be of interest because of its advantages such as easy for preparation and product diversification.

It was, therefore, planned to compare the gulabjamuns made from different ready mix formulations of gulabjamuns with traditionally prepared Gulabjamuns i.e. gulabjamuns prepared from fresh unadulterated khoa with standard mixing with maida and baking powder for variation in their chemical composition and sponginess.

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MATERIALS AND METHODS

The experiment was planned to compare gulabjamuns prepared from four ready mixes in comparison to standard traditional home made gulabjamuns from fresh pure khoa. The study was undertaken during 2009-10 at Animal Husbandry and Dairying Section, College of Agriculture, Nagpur, Four different ready mixes collected from local market of Nagpur and each of them was allotted a code name so as to avoid their identity viz., RM-1, RM-2, RM-3 and RM-4 and one standard check treatment i.e. gulabjamuns prepared from fresh khoa. During the entire study fresh, clean, whole cow milk was obtained from Animal Husbandry and Dairying Section, College of Agriculture, Nagpur for preparing fresh khoa. Ingredients like ready mixes, sugar, maida, vegetable oil and baking powder were purchased from local market of Nagpur.

Fresh standardized cow milk (4.0% fat) was used for fresh pure khoa preparation. Khoa was prepared by standard procedure given by Rangi *et al*. (1985). The sugar syrup was prepared by dissolving cane sugar in 1:1 proportion and was boiled for 10 to 15 minutes. The syrup was ready when it attains the first signs of stickiness. A few milliliters of milk were added to remove the scum in the sugar syrup. The syrup was then filtered through a clean muslin cloth. The traditional gulabjamuns were prepared as per standard procedure of Prajapati *et al*. (1991).The dough was prepared by mixing khoa, maida (33%) and baking powder(0.5%)(control).The dough then hand rolled into small balls and then deep fried in vegetable oil till balls acquire golden brown colour and put into sugar syrup(50%) and allowed to soak. Similar procedure of dough and ball making and ultimately frying was adopted for gulabjamuns ready mixes and then put into same syrup.

Product Analyses:

After deep frying gulabjamuns were soaked in sugar syrup for 4.00 hours at room temperature (28^0-30^0C) and then they were removed from syrup, allowed to drain on wire mesh for 10 minutes and then used for analyses for fat using Gerber method described by Chaudhari (1959), total solid as per SP: 18 Part – XI of BIS (Anonymous, 1981), protein by using Micro-Kjeldahl method as per IS: 1479, Part - II (Anonymous, 1961), ash as per AOAC (Anonymous, 2002) and sugar syrup absorption rate for sponginess as per Prajapati *et al.* (1992) The data were subjected to statistical analysis (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

Chemical composition:

Composition of gulabjamuns obtained from fresh pure khoa (standard check) and from four different ready mixes i.e. RM-1, RM-2, RM-3 and RM-4 for different parameters varied significantly (Table-1) in their chemical composition and sponginess. The average values for total solids for gulabjamuns prepared from fresh khoa, RM-1, RM-2, RM-3 and RM-4 were 68.36, 65.89, 61.11, 66.46 and 65.40 per cent respectively with a significant difference ($P< 0.05$). Bandopadhyay *et al*. (2006) recorded that the total solids content of gulabjamuns was 67.89 per cent made from fresh khoa.Thus the present finding is in agreement with them.

The average reported values of fat were 15.37, 12.91, 12.98, 12.13 and 13.20 per cent for the respective treatments prepared from khoa(control), RM-1, RM-2, RM-3 and RM-4 and they differed significantly ($P <0.05$). Result obtained by Bandopadhyay *et al*. (2006) showed that the fat content was 14.79 per cent in gulabjamuns made from fresh khoa.

The average protein content in gulabjamuns prepared from khoa(control), RM-1, RM-2, RM-3 and RM-4 were 8.36, 7.48, 6.94, 7.11 and 6.96 per cent respectively. The findings of the present experiment corroborate well with the findings of Prajapati *et al*. (1991), who reported that the protein content of gulabjamuns was 8.9 per cent prepared under standard condition, while Bandopadhyay *et al*. (2006) reported 6.22 per cent protein content .

The average ash content in gulabjamuns prepared from pure khoa(control), RM-1, RM-2, RM-3 and RM-4 were 1.12, 0.95, 0.82, 0.91 and 0.82 per cent respectively with a significant difference ($P <0.05$). Prajapati *et al.* (1994) recorded ash content of gulabjamuns at 1.2 per cent when prepared under standard condition, while Bandopadhyay *et al*. (2006) reported 0.72 per cent ash content .

Table 1. Average total solid, fat, protein, ash and sugar absorption(per cent) by gulabjamuns under different treatments

Treatments	Chemical composition				Sugar absorption
	Total solids	Fat	Protein	Ash	
Control	68.36	15.37	8.36	1.12	70.85
RM-1	65.89	12.91	7.48	0.95	81.11
RM-2	66.11	12.98	6.94	0.82	83.78
RM-3	66.46	12.13	7.11	0.91	75.19
RM-4	65.40	13.20	6.96	0.82	74.76
S E m ±	0.264	0.294	0.132	0.034	3.542
CD at 5 %	0.796	0.885	0.339	0.104	10.675

Sugar absorption:

Sugar absorption expressed in terms of per cent increase in weight of gulabjamuns over the initial weight before soaking. The sugar absorption(Table-1) was found more in gulabjamuns prepared from ready mix RM-2 (83.78 per cent) as compared to gulabjamuns prepared from khoa(control) (70.98 per cent) over a period of 4 hours, was significant (P <0.05). The gulabjamuns prepared from pure khoa showed significant reduction in sugar syrup absorption as compared to gulabjamuns prepared from different ready mixes i.e. RM-1 (81.11 per cent), RM-3 (75.19 per cent) and RM-4 (74.76 per cent). The difference in sugar absorption between control and ready mix treatments was significant after 4 hours soaking. This was true, spongier products holds greater amount of sugar than does a less spongy one (Patel *et al*. 1992). The lowest sugar absorption was noticed in control treatment i.e. gulabjamuns prepared from khoa. i.e., it was less spongy, may be due to comparatively less content of baking powder than marketed ready mixes.

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RESPONSE OF NITROGEN AND POTASSIUM LEVELS ON GROWTH, FLOWERING AND SEED YIELD OF AFRICAN MARIGOLD

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ABSTRACT

An experiment was conducted to study the effect of nitrogen and potassium on growth, flowering and seed yield of african marigold during the *kharif* season 2012-13 at Horticulture Section, College of Agriculture , Nagpur. The experiment was laid out in Factorial Randomized Block Design with two main factors with four levels of Nitrogen (0 kg N ha^{-1}, 100 kg N ha^{-1}, 150 kg N ha^{-1} and 200 kg N ha^{-1}) and four levels of potassium (0 kg K_2O ha^{-1}, 50 kg K_2O ha^{-1}, 75 kg K_2O ha^{-1}, 100 kg K_2O ha^{-1}). Results of the investigation showed that, the maximum height of plant, stem diameter, earliness for the flower bud initiation and days to harvesting of flower for seed, number of dry flowers, number of seeds flower^{-1} and seed yield plant^{-1} were recorded under the treatments of 200 kg N and 100 kg K_2O ha^{-1}. Interactions were found significant in two parameters viz., number of dry flowers and seed yield plant^{-1} and it was found significantly maximum in treatment combination of 200 kg N and 100 kg K_2O ha^{-1}.

(Key words: African marigold, flowering, growth, fertilizers, seed yield)

INTRODUCTION

Marigold is one of the commercially exploited flower crops that belongs to the family Asteraceae and genus *Tagetes*. African marigold (*Tagetes erecta* L.*)* is annual flower. Marigold is easily adaptable to various conditions of growing and has fairly good keeping quality. The flowers of these species are generally large in size with bright shades, ranging from yellow to orange and are the best for combination in any flower arrangement. Because of its size, shape, and colour, the African marigold are popular amongst people. Marigold seedlings can be planted as intercrop to minimise the population of nematodes.

In marigold, the fertilizer has great importance for manipulating plant growth, flowering behaviour and seed yield. Therefore, balanced supply of nutrients are important for obtaining higher seed yield. Nitrogen plays an important role in growth and flower yield, the response of nitrogen is remunerative, but it is imperative to find out the optimum dose for the growth and quality seed yield. Potassium is neccessory to maintain the turgidity in plant ,along with this is also improve the quality of flower and seed which is important for the quality seed production.Therefore, the present investigation was undertaken to study the response of nitrogen and potassium levels on growth, flowering and seed yield of African marigold.

MATERIALS AND METHODS

An field experiment on respose of nitrogen and potassium levels on growth, flowering and seed yield of African marigold was carried out at the experimental field of Horticulture section, College of Agriculture, Nagpur during the *kharif* season of the year 2012-2013. The experiment was laid out in Factorial Randomized Block Design (FRBD) with sixteen treatment combinations comprising four levels of nitrogen (0 kg N ha^{-1}, 100 kg N ha^{-1}, 150 kg N ha^{-1} and 200 kg N ha^{-1}) and four levels of potassium (0 kg K_2O ha^{-1}, 50 kg K_2O ha^{-1}, 75 kg K_2O ha^{-1}, 100 kg K_2O ha^{-1}) with three replications in ridges and furrows. Uniform and healthy seedlings were transplanted in each plot at the distance of 45 cm x 30 cm. Full dose of K_2O and half dose of nitrogen according to the treatment was applied at the time of transplanting and remaining half nitrogen was given one month after transplanting. The common dose of P_2O_5 (50 kg ha^{-1}) was applied at the time of transplanting. Fertilizer was applied by making circular band around the seedlings by ring method.

All the intercultural operations were followed as and when required. The various observations on growth, flowering and seed yield characters *viz*., plant height and stem diameter at 90 DAT, days to 1st flower bud initiation, days to harvesting of flowers for seed, number of dry flowers plant^{-1}, number of seeds flower^{-1}, seed yield plant^{-1} of African marigold were recorded and the data were statistically analyzed as per method suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

The data presented in table 1 revealed that, different levels of nitrogen and potassium had

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significant effect on all parameters in respect of growth, flowering, yield of African marigold under study.

Growth :

Significant increase in the plant height observed with the increasing levels of nitrogen at 90 DAT. Treatment N_4 (200 kg N ha^{-1}) was significantly superior over all other treatments in case of plant height (105.48 cm) which was followed by the treatment N_3 (150 kg N ha^{-1})(102.75 cm). However, minimum plant height (95.67 cm) was recorded in treatment N_1 (0 kg N ha^{-1}). At the stage of 90 DAT, significantly maximum stem diameter (1.23 cm) was recorded in treatment N_4 (200 kg N ha^{-1}) which was at par with the treatment N_3 (150 kg N ha^{-1}) (1.20 cm) and treatment N_2 (100 kg N ha^{-1}) (1.19 cm).This might be due to general improvement in growth and development of plant by nitrogenous fertilizer as the nitrogen is an essential part of nucleic acid involved in various metabolic processes of plants promoting plant growth. The results obtained during the investigation are in close accordance with the findings of Sharma *et al.* (2006) in African marigold. They reported maximum plant height (75.05) with 200 kg N ha^{-1}. At the stage of 90 DAT, significantly maximum plant height (103.44 cm) was recorded with the application of 100 kg potassium which was found to be at par with the application of 75 kg and 50 kg potassium (101.62 cm and 101.54 cm respectively). Similarly every increase in the level of potassium fertilizer significantly increased the stem diameter. The maximum stem diameter (1.23 cm) was recorded with the application of 100 kg K_2O which was found to be at par with 75 kg K_2O (1.19 cm) and 50 kg K_2O (1.17 cm). Potassium increases protein synthesis which might have been responsible for the significant increase in height and stem diameter of the plant at all the growth stages with the increasing levels of potassium. The similar results were also obtained by Das and Mishra (2005). They reported that the maximum plant height and superior vegetative growth were obtained with 100 kg K_2O ha^{-1} in African marigold.

Flowering :

Significantly, an early flower bud initiation was recorded (39.43 days) in treatment N_4 (200 kg N ha^{-1}), which was found to be at par with the treatment N_3 (150 kg N ha^{-1}) (39.99 days) and N_2 (100 kg N ha^{-1}) (40.29 days). Whereas, the treatment control (N_1) had take maximum 41.30 days for flower bud initiation. The reduction of days required for bud initiation in N_4 and N_3 might be due to the application of nitrogen attributed to acceleration in development of growth and reproductive phages. Higher nitrogen content might have accelerated protein synthesis, thus promoting early floral primordial development. The results are in confirmation with the results of Tiwari *et al*. (2010) in African marigold. They observed that, minimum days taken for first flower bud initiation (22.50) were recorded with 200 kg N ha^{-1}.

The treatment K_4 (100 kg K_2O ha^{-1}) had recorded significantly minimum days (39.54 days) for the flower bud initiation which was found to be at par with the treatment K_3 75 kg K_2O ha^{-1} (40.04 days). However, the maximum days (41.2 days) were taken by the treatment K_1 (0 kg K_2O ha^{-1}).The reduction of days required for bud initiation in K_4 and K_3 might be due to the higher level of K_2O application which increases the rate of photosynthesis and mobilization of sucrose to the shoots which have positive influence in flower initiation. Above findings can be correlated with the findings of Patil and Dhuduk (2009). They observed that,100% inorganic fertilizers (NPK @ 100:40:40 kg ha^{-1}) showed the constant decrease in number of days required to first flowering in African marigold cv. 'Pusa Narangi Gainda'.

Significantly minimum days (90.49 days) for harvesting of flower for seed from transplanting was recorded in the treatment N_4 (200 kg N ha^{-1}) when compared with control and rest of the treatments under study. Whereas, the treatment N_1 had take maximum days (94.05 days) for harvesting of flower for seed from transplanting. Increase in nitrogen levels favoured the proper development of plants which ultimately might have taken less number of days required for harvesting of flower for seed from transplanting. Moreover higher content of nitrogen might have accelerated protein synthesis, thus promoting earlier floral primordial development . These results obtained during this investigation are in agreement with the findings of Sharma *et al*. (2006) in African marigold. They revealed that, minimum days (73.10 days) to picking of flowers were recorded with 150 kg N ha^{-1}.

Significantly minimum days (89.93 days) to harvesting of flower for seed from transplanting was recorded in treatment K_4 (100 kg K_2O ha^{-1}). Whereas, the treatment K_1 (0 kg K_2O ha^{-1}) had take maximum days (95.00 days) for harvesting of flower for seed from transplanting. Days required to harvesting of flower for seed from transplanting were significantly reduced with the increase in potassium level, this might be due to supply of potassium increases the rate of photosynthesis and mobilization of sucrose to the shoots which have positive influence in flowering and seed developement. Above findings can be correlated with the findings of Beniwal *et al.* (2005) in chrysanthemum. They reported that, the application of nitrogen and potassium at 20 g m^{-2} significantly improved flowering, days to first flower bud initiation, days to first harvesting and yield parameters.

Seed yield :

Significantly maximum number of dry flowers $plant^{-1}$ (27.87) were recorded in treatment N_4 (200 kg N ha^{-1}). Whereas, the treatment N_1(0 kg N ha^{-1}) had minimum (16.08) number of dry flowers $plant^{-1}$. The more number of dry flowers $plant^{-1}$ produced with increased levels of nitrogen might be due to vigorous growth and better photosynthesis which was favourable for development of flowers. Similar results were reported by Yadav *et al*. (2004). They studied the effect of N rate on the performance of *Tagetes erecta* L. Nitrogen @ 180 kg ha^{-1} recorded the maximum number of flowers (25.37).

Significantly maximum number of dry flowers $plant^{-1}$ (25.52) were recorded in treatment K_4 (100 kg K_2O ha^{-1}) which was found to be at par with treatment K_3 (75 kg K_2O ha^{-1}) (24.59). Whereas, the treatment K_1 (0 kg K_2O ha^{-1}) had minimum number of dry flowers $plant^{-1}$ (19.40). Potassium is a constituent of many energy rich compounds in plants and also involved in active root growth and helps in uptake of other nutrients resulted in increase in number of dry flowers. Above findings are close in conformity with the findings of Natrajan and Vijaykumar (2002). They found higher number of flowers $plant^{-1}$, number of seeds $flower^{-1}$, seed yield $plant^{-1}$ with N:P:K at 125:125:50 kg ha^{-1} in African marigold.

The interaction effect due to nitrogen and potassium on number of dry flowers $plant^{-1}$ was found to be significant .The maximum number of dry flowers $plant^{-1}$ (29.47) was recorded with the treatment combination of N_4K_4 (200 kg N ha^{-1} and 100 kg K_2O ha^{-1}) which was found to be at par with the treatment combination of N_4K_3 (200 kg N ha^{-1} and 75 kg K_2O ha^{-1}) (29.07) and N_3K_4 (150 kg N ha^{-1} and 100 kg K_2O ha^{-1}) (29.20). This might be due to the fact that higher dose of potassium was linked with the production of cytokinin and promotion of flower morphogenesis by cytokinin. Higher doses of potassium along with higher doses of nitrogen resulted in production of more number of flowers. This finding is in conformity with the findings of Kokate (2010). They observed that application of 100 kg N and 100 kg K_2O ha^{-1} increased number of flower stalks $plot^{-1}$ in golden rod (197.01).

Significantly maximum number (319.05) of seeds $flower^{-1}$ was recorded in treatment N_4 (200 kg N ha-1). Next to this treatment, treatments were N_3 (150 kg N ha^{-1}) and N_2 (100 kg N ha^{-1}). Whereas, the treatment N_1 (0 kg N ha^{-1}) had minimum number of seeds $flower^{-1}$ (291.31). The maximum number of seeds $flower^{-1}$ was recorded under the higher dose of nitrogen whereas, the lowest levels of nitrogen produced minimum number of seeds $flower^{-1}$. The similar results were recorded by Natrajan and Vijaykumar (2002). They studied the effect of N:P:K levels in marigold (*Tagetes erecta* cv. African gaint) and observed higher number of flowers $plant^{-1}$, number of seeds $flower^{-1}$, seed yield $plant^{-1}$ with N:P:K at 125:125:50 kg ha^{-1}.

Significantly maximum number (316.30) of seeds $flower^{-1}$ were recorded with the application of 100 kg K_2O which was found to be at par with the application of potassium 75 kg K_2O ha^{-1} (314.35). Whereas, the treatment K_1 (0 kg K_2O ha^{-1}) had minimum number of seeds $flower^{-1}$ (294.13). Potassium is a constituent of many energy rich compounds in plants and also involved in active root growth and helps in uptake of other nutrients resulted in increased number of seeds $flower^{-1}$. The above findings are close in conformity with the findings of Natrajan and Vijaykumar (2002). They studied the effect of N:P:K levels in marigold (*Tagetes erecta* cv. African gaint) and observed higher number of flowers $plant^{-1}$, number of seeds $flower^{-1}$, seed yield $plant^{-1}$ with N:P:K at 125:125:50 kg ha^{-1}.

Table 1. Response of nitrogen and potassium levels on growth, flowering and seed yield of African marigold

Treatments	Plant height (90 DAT) (cm)	Stem diameter (90 DAT) (cm)	Days to 1st flower bud initiation	Days to harvesting of flowers for seed	Number of seeds $flower^{-1}$
Nitrogen levels					
N_1 (0 kg N ha^{-1})	95.67	1.12	41.30	94.05	291.31
N_2 (100 kg N ha^{-1})	100.01	1.19	40.29	93.33	307.51
N_3 (150 kg N ha^{-1})	102.75	1.20	39.99	92.13	313.52
N_4 (200 kg N ha^{-1})	105.48	1.23	39.43	90.49	319.05
SE(m) ±	1.039	0.016	0.287	0.435	1.910
CD at 5%	2.999	0.046	0.830	1.256	5.511
Potassium levels					
K_1 (0 kg K_2O ha^{-1})	97.29	1.13	41.2	95.00	294.13
K_2 (50 kg K_2O ha^{-1})	101.54	1.17	40.23	93.01	306.58
K_3 (75 kg K_2O ha^{-1})	101.62	1.19	40.04	92.03	314.35
K_4 (100 kg K_2O ha^{-1})	103.44	1.23	39.54	89.93	316.30
SE (m) ±	1.039	0.016	0.287	0.435	1.910
CD at 5%	2.999	0.046	0.830	1.256	5.511
Interaction effect (NxK)					
SE (m) ±	2.079	0.032	0.575	0.871	3.820
CD at 5%	--	--	--	--	--

Table 2. **Response of nitrogen and potassium levels on number of dry flowers and seed yield plant^{-1} in African marigold**

Treatments	**Number of dry flowers plant^{-1} Potassium levels**				
Nitrogen levels	K_1(0 kg K_2O ha^{-1})	K_2(50 kg K_2O ha^{-1})	K_3(75 kg K_2O ha^{-1})	K_4(100 kg K_2O ha^{-1})	Mean
N_1 (0 kg N ha^{-1})	14.07	15.60	16.93	17.73	16.08
N_2 (100 kg N ha^{-1})	17.27	18.87	23.57	25.70	21.35
N_3 (150 kg N ha^{-1})	21.07	23.33	28.80	29.20	25.60
N_4 (200 kg N ha^{-1})	25.20	27.73	29.07	29.47	27.87
Mean	19.40	21.38	24.59	25.52	
	Factor A N		Factor B K		Interaction N x K
SE (m) ±	0.322		0.322		0.645
CD at 5%	0.931		0.931		1.862

Treatments	**Seed yield plant^{-1}(g) Potassium levels**				
Nitrogen levels	K_1(0 kg K_2O ha^{-1})	K_2(50 kg K_2O ha^{-1})	K_3(75 kg K_2O ha^{-1})	K_4(100 kg K_2O ha^{-1})	Mean
N_1 (0 kg N ha^{-1})	11.97	15.19	16.98	18.03	15.54
N_2 (100 kg N ha^{-1})	17.11	19.05	24.73	28.50	22.35
N_3 (150 kg N ha^{-1})	20.85	24.82	31.83	32.71	27.55
N_4 (200 kg N ha^{-1})	26.71	30.14	32.64	34.65	31.03
Mean	19.16	22.30	26.54	28.47	
	Factor A N		Factor B K		Interaction N x K
SE (m) ±	0.390		0.390		0.780
CD at 5%	1.125		1.125		2.251

Significantly maximum seed yield plant^{-1} (31.03 g) was recorded in treatment N_4 (200 kg N ha^{-1}). Whereas, the treatment N_1 (0 kg N ha^{-1}) had minimum seed yield plant^{-1} (15.54 g). The maximum seed yield plant^{-1} was recorded under the higher dose of nitrogen whereas, the lowest levels of nitrogen produced minimum seed yield plant^{-1}. The increased in seed yield due to nitrogen application is attributed to its effect on vegetative attributes as nitrogen is main constituent of chlorophyll and is involved in important physiological processes like photosynthesis (Mengel and Kirkby, 1987). The similar results were recorded by Khan *et al.* (2004) in petunia. They reported that application of 30 g N m^{-2} alone gave the maximum seed yield (26.81 g m^{-2}).

Significantly maximum seed yield plant^{-1} were recorded with the application of 100 kg K_2O ha^{-1} (28.47 g) which was followed by the application of 75 kg K_2O ha^{-1} (26.54 g). Whereas, the treatment K_1 (0 kg K_2O ha^{-1}) had minimum seed yield plant^{-1} (19.16 g). Potassium is a constituent of many energy rich compounds in plants and also involved in active root growth and helps in uptake of other nutrients resulted in increase in seed yield plant^{-1}. Above findings are close conformity with the findings of Agrawal *et al.* (2002). They reported that maximum seed yield plant^{-1} (11.9 g plant^{-1}) obtained with the application of 100 kg K_2O ha^{-1}.

The interaction effect due to nitrogen and potassium on seed yield plant^{-1} was found to be significant. The maximum seed yield plant^{-1} (34.65 g) was recorded with the treatment combination of N_4K_4 (200 kg N ha^{-1} and 100 kg K_2O ha^{-1}) which was found to be at par with treatment combination N_4K_3 (200 kg N ha^{-1} and 75 kg K_2O ha^{-1}) (32.64 g) and N_3K_4 (150 kg N ha^{-1} and 100 kg K_2O ha^{-1}) (32.71 g). This might be due to the fact that higher dose of potassium was linked with the production of cytokinin and promotion of flower morphogenesis by cytokinin. Higher doses of potassium along with higher doses of nitrogen resulted in increase in seed yield plant^{-1}. The similar results were reported by Agrawal *et al.* (2002). They reported that application of nitrogen 300 kg ha^{-1} and potassium 200 kg ha^{-1} gave more number of flowers (85.50 and 84.20, respectively) plant^{-1} and seed yield (15.90 and 16.20 q ha^{-1}, respectively) when compared with control (58.40 and 56.30 and 9.30 and 9.40 q/ha, respectively) in African marigold.

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ECONOMIC ANALYSIS OF PRODUCTION OF WHEAT IN AMRAVATI DIVISION

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ABSTRACT

The study on economic analysis of production of wheat in Amravati division was conducted during the year 2009-10. The per hectare cost of cultivation i.e. cost 'C' at overall level, for Akola district was Rs. 18802.39 ha^{-1}, for Amravati district it was Rs. 20132.07 ha^{-1}, for Buldhana district it was Rs. 18638.70, for Washim district it was Rs. 19286.15 ha^{-1}, for Yavatmal it was Rs. 21226.30 ha^{-1} and for Amravati division it was Rs. 19617.12 ha^{-1}. The gross returns and net returns of wheat were high in Yavatmal district and less in Akola district i.e. for Yavatmal district gross returns was Rs. 27048.29 ha^{-1} and net returns at cost 'C' was Rs. 5821.98 ha^{-1}. For Akola district gross returns was Rs. 21962.65 ha^{-1} and net returns at cost 'C' was Rs. 3160.26 ha^{-1}. The output-input ratio was greater than unity which indicated that the wheat is profitable crop in Amravati division.

(Key words : Wheat, cost of cultivation, gross returns, net profit)

INTRODUCTION

Agriculture sector is an important component of the Indian economy and also it is the biggest business of the world. Wheat is the major food grain crop of India and occupies great economic importance. Wheat (*Triticum aestivum* L.) is the world's widely cultivated crop, because it produces a good yield per unit area, grows well in a temperate climate even with a moderately short growing season. Wheat is a staple food and also an important component of daily diet. It is very nutritious.

Currently, India is the second largest producer of wheat in the world after China with about 12 per cent share in the world. The cost of production is a changing phenomenon and changes with the cost components (Sidhu and Byertee,1991). The main purpose of the present study was to study the economic analysis of wheat production in Amravati division.

MATERIALS AND METHODS

The study was restricted to only five districts viz., Akola, Amravati, Buldhana, Washim, Yavatmal districts of Western Vidarbha region which constitute Amravati division in Maharashtra. The sixty farmers from each district were randomly selected. The primary data were collected representing almost all representative areas upto village level in each district for the year 2009-10.

The primary data on input utilization, cost of cultivation and returns were collected from the selected growers and other relevant information was collected through a survey method with the help of pretested schedules. The village wise data so collected for cost of cultivation and returns were compiled for the entire district as a whole. For studying the economics of production of wheat the standard cost concept i.e. Cost ' A', Cost 'B' and Cost 'C' were used. The analytical part of research work was mainly confined to:

1) Estimation of hectare^{-1} Cost 'A', Cost 'B' and Cost 'C'.
2) Per hectare net returns at cost 'A', Cost 'B' and Cost 'C'.
3)

$$\text{Output-input ratio} = \frac{\text{Gross returns}}{\text{Cost}}$$

RESULTS AND DISCUSSION

Data on hectare^{-1} cost of cultivation of wheat in Akola, Amravati, Buldhana, Washim and Yavatmal districts of Amravati division are presented in table 1. The cost 'A' was the highest (Rs.13372.32) in Yavatmal district followed by Amravati district (Rs.12306.25), Washim district (Rs.11957.53), Akola district (Rs.11848.05) and Buldhana district Rs. 11440.68. Also the cost 'B' in Yavatmal district was the highest Rs. 19346.43 followed by Amravati district (Rs.18019.33), Buldhana district (Rs.17851.02), Washim district (Rs.17531.45) and Akola district (Rs.17366.88). Overall cost of cultivation of wheat i.e. cost 'C' was maximum in Yavatmal district (Rs.21226.30) followed by Amravati district (Rs.20132.07), Buldhana district (Rs.19637.00), Washim district (Rs.19286.15) and Akola district(Rs.18802.39). In Amravati divisition,

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Table 1a. Per hectare cost of cultivation of wheat in Amravati division at cost 'A'level (Rs. ha^{-1})

Sr .No.	Particulars	Districts					Amravati division
		Akola	Amravati	Buldhana	Washim	Yavatmal	
1	Hired labour						
	Male	529.58 (2.82)	950.23 (4.72)	760.63 (4.08)	700.16 (3.63)	767.49 (3.62)	741.62 (3.73)
	Female	1047.17 (5.57)	1117.15 (5.56)	1181.68 (6.34)	1211.16 (6.28)	1053.66 (4.96)	1122.16 (5.68)
	Total	1576.75 (8.39)	2067.38 (10.28)	1942.31 (10.42)	1911.32 (9.90)	1821.15 (8.58)	1863.78 (9.41)
2	Bullock labour	602.48 (3.20)	1260.07 (6.26)	851.36 (4.57)	936.25 (4.85)	1180.53 (5.56)	966.14 (4.84)
3	Machine charges	2321.91 (12.35)	2114.95 (10.51)	1828.14 (9.81)	2337.29 (12.12)	2453.43 (11.56)	2211.14 (11.14)
4	Seed	2147.72 (11.42)	1871.19 (9.29)	1761.55 (9.45)	2047.06 (10.61)	2089.48 (9.84)	1983.40 (10.03)
5	Fertilizers						
	N	1059.30 (5.63)	943.09 (4.68)	936.47 (5.02)	1047.67 (5.43)	1150.56 (5.42)	1027.42 (5.19)
	P	685.12 (3.64)	746.75 (3.71)	719.63 (3.86)	806.50 (4.18)	851.86 (4.01)	761.97 (3.84)
	K	28.61 (0.15)	38.68 (0.19)	47.64 (0.26)	33.41 (0.17)	47.52 (0.22)	39.17 (0.19)
6	Irrigation	1736.95 (9.23)	1741.98 (8.65)	1621.06 (8.70)	1296.55 (6.72)	1920.78 (9.05)	1663.46 (8.38)
7	Plant protection	107.26 (0.57)	76.69 (0.38)	68.61 (0.37)	60.12 (0.31)	80.97 (0.38)	81.06 (0.41)
8	Repairing charges	195.85 (1.04)	137.08 (0.68)	200.51 (1.08)	201.61 (1.06)	183.99 (0.87)	181.47 (0.92)
9	Incidental charges	379.29 (2.02)	322.46 (1.60)	281.66 (1.50)	300.71 (1.56)	354.05 (1.67)	327.63 (1.66)
10	Land revenue	14.19 (0.08)	14.17 (0.07)	13.78 (0.07)	13.81 (0.06)	13.78 (0.07)	13.95 (0.07)
11	Depreciation	667.38 (3.55)	632.15 (3.14)	860.18 (4.62)	635.88 (3.31)	860.18 (4.05)	731.15 (3.69)
12	Interest on working capital @ 6%	325.24 (1.74)	339.61 (1.69)	307.77 (1.65)	329.35 (1.71)	364.03 (1.71)	333.20 (1.68)
	Cost ‘A’	11848.05 (63.01)	12306.25 (61.13)	11440.68 (61.38)	11957.53 (62.00)	13372.32 (62.99)	12184.97 (61.48)

Table 1b. Per hectare cost of cultivation of wheat in Amravati division at cost 'B'and cost 'C'level and gross income (Rs. ha^{-1})

Sr. No.	Particulars	Districts					Amravati division
		Akola	Amravati	Buldhana	Washim	Yavatmal	
13	Rental value of land(1/6 of gross produce)	3365.09 (17.90)	3825.74 (19.01)	3498.18 (18.77)	3732.47 (19.35)	3852.67 (18.16)	3681.50 (18.58)
14	Interest on fixed capital @ 10%	2153.73 (11.45)	1887.35 (9.37)	1927.24 (10.34)	1841.453 (9.55)	2121.43 (9.99)	2156.56 (10.90)
	Cost 'B'	17366.88 (92.36)	18019.33 (89.51)	16866.10 (90.49)	17531.45 (90.90)	19346.43 (91.14)	18023.02 (90.96)
15	Family labour						
	Male	1251.75 (6.66)	1764.44 (8.76)	1507.45 (8.09)	1458.34 (7.56)	1627.56 (7.67)	1521.91 (7.67)
	Female	183.77 (0.98)	348.30 (1.73)	265.15 (1.42)	296.35 (1.54)	252.31 (1.19)	271.85 (1.37)
	Total family labour	1435.52 (7.64)	2112.73 (10.49)	1772.60 (9.51)	1754.69 (9.10)	1879.87 (8.86)	1793.76 (9.04)
	Cost 'C'	18802.39 (100.00)	20132.07 (100.00)	18638.70 (100.00)	19286.15 (100.00)	21226.30 (100.00)	19816.78 (100.00)
	Main produce	21289.47	23770.40	21690.87	23641.77	26120.03	21410.67
	By produce	693.18	871.60	882.67	902.75	928.25	564.39
	Gross income	21962.65	24642.00	22573.54	24544.52	27048.29	21975.07

Table 2.Economics of production of wheat (Rs. ha^{-1})

Sr. No.	Particular	Districts					Amravati division
		Akola	Amravati	Buldhana	Washim	Yavatmal	
1	Gross returns	21962.65	24642.00	22573.54	24544.52	27048.29	24154.20
2	Cost						
	Cost 'A'	11848.05	12306.25	11440.68	11957.53	13372.32	12184.97
	Cost 'B'	17366.88	18019.33	16867.11	17531.45	19346.43	17826.24
	Cost 'C'	18802.39	20132.07	18638.71	19286.15	21226.30	19617.12
3	Net returns at						
	Cost 'A'	10114.60	12335.75	11132.86	12586.98	13675.96	11969.23
	Cost 'B'	4597.44	6622.67	5706.43	7013.06	7701.86	6328.29
	Cost 'C'	3160.26	4509.93	3934.83	5258.37	5821.98	4537.07
4	Output-Input ratio at						
	Cost 'A'	1.85	1.99	1.97	2.05	2.02	1.98
	Cost 'B'	1.26	1.36	1.34	1.39	1.40	1.35
	Cost 'C'	1.16	1.22	1.21	1.27	1.28	1.23

overall cost 'A' was Rs. 12184.97, cost 'B' was Rs. 18023.02 and total cost of cultivation of wheat i.e. cost 'C' was Rs. 19816.78. Ansari *et al.* (2009) reported that hectare^{-1} returns and net profit, were Rs. 15443.13 and Rs. 5635.40, respectively. Kumar *et al*.(2003) reported that the average net income was Rs. 10273.66 hectare^{-1} and farm business income came to Rs. 19009.14 hectare^{-1}.

The hectare^{-1} cost, returns and output-input ratio of the sample farms are presented in the table 2. The highest gross returns was obtained in Yavatmal district and it was Rs. 27048.29 ha^{-1} and the lowest in Akola district (Rs.21962.65 ha^{-1}). Gross returns for Amravati division was Rs. 24154.20 ha^{-1}. The cost of cultivation of wheat at cost 'C' was the highest in Yavatmal district (Rs.21226.30 ha^{-1}) and the lowest in Buldhana district (Rs.18638.71ha^{-1}). For Amravati division it was Rs. 19617.12 ha^{-1}. Net returns at cost 'C' in Amravati division was Rs. 4537.07 ha^{-1}. The output-input ratio at cost 'C' was the highest (1.28) for for Yavatmal district and it was the lowest (1.16) for Akola district. Output-input ratios of Amravati division at cost 'A', cost 'B' and cost 'C' were 1:98, 1:35, and 1:1.23, respecctively. Patel *et al*.(2011) reported the cost returns and output input ratio of production of wheat (unirrigated) in Bhal region of Ahmedabad district (Gujrat). Results of the study indicated that average cost of cultivation per hectare^{-1} was Rs. 11,968.38. The average net profit hectare^{-1} was Rs. 4228.33 per hectare and the overall input-output ratio was 1.38.Similar results were also reported by Singh *et al.* (1991).

From the present investigation, it could be inferred that, the cost of cultivation, gross returns and net returns of wheat were the highest in Yavatmal district and the lowest in Akola district. The output-input ratio was greater than unity which indicates that wheat is profitable crop in Amravati division.

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EFFECT OF GROWTH REGULATORS AND METHODS OF APPLICATION ON GROWTH, YIELD AND QUALITY OF GLADIOLUS

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ABSTRACT

An experiment entitled, "Effect of growth regulators and methods of application on growth, yield and quality of gladiolus" was carried out at Satpuda Botanic Garden, College of Agriculture, Nagpur (M.S.), India during 2011-2012 with fifteen treatment combinations in factorial randomized block design. The treatments comprised of different growth regulators (GA_3 100 and 200 ppm, Benzyl adenine 50 and 100 ppm and control) with three methods of application (soaking, spraying and soaking + spraying). The results revealed that, application of GA_3 200 ppm significantly recorded maximum sprouting of corms, plant height, leaf area, spikes hectare^{-1}, diameter of spike, florets spike^{-1}, vase life of spike and minimum days to 50 per cent flowering, whereas, maximum weight of corm plant^{-1} and cormels plant^{-1} and diameter of corms were recorded with the application of BA 100 ppm soaking of corms. Among different methods of application of growth regulators, soaking treatment noted maximum sprouting of corms and the earliest 50 per cent flowering in gladiolus. Interaction effect due to growth regulators and methods of application was found to be significant with 50 per cent flowering only.

(Key words : Gladiolus, growth, yield, quality, growth regulators, methods of application)

INTRODUCTION

Gladiolus is the leading cut flower grown worldwide for flower trade and garden display owing to it's magnificent inflorescence and attractive colour. It ranks second best cut flower in Netherlands. In India gladiolus is one of the most important commercial cut flowers of export potential. Commonly gladiolus is also known as "Sword Lily".

Various research workers have reported that, the application of growth regulators and chemicals helps to increase the yield of good quality spikes and corms in gladiolus. Gibberellic acid has been reported to increase the plant height, leaves and shoots plant^{-1} and improve the spike quality (Kirad *et al*., 2001), stimulate flowering and increased the yield of gladiolus spikes (Sharma *et al*., 2004). Gibberellic acid plays a vital role in improvement of vegetative growth characters of the plant as it enhances the cell elongation and cell division by promoting DNA synthesis in the cell. Similarly, benzyl adenine is a growth regulator reported to be useful for enhancing sprouting, increasing sprouts plant^{-1} and yield of better quality corms and cormels in gladiolus.

In cut flower industry, the most important aspects are maximum production of better quality cut flowers in order to fetch more market prices. In spite of number of benefits of plant growth regulators in crop production, their utilization in gladiolus production under Vidharbha conditions has not been carried out on large scale. The present investigation was therefore, proposed on "Effect of growth regulators and methods of application on growth, yield and quality of gladiolus" with the following objectives.

i. To study the effect of growth regulators on growth, yield and quality of gladiolus.

ii. To study the effect of methods of application of growth regulators on growth, yield and quality of gladiolus.

iii. To find out the suitable combination of growth regulators and methods of application for better growth, yield and quality of gladiolus spikes and corms.

MATERIALS AND METHODS

The present investigation was carried out at Horticulture section, College of Agriculture, Nagpur during *rabi* season of the year 2011-2012 to study the effect of growth regulators and methods of application on growth, yield and quality of gladiolus with fifteen treatment combinations in Factorial Randomized Block Design with three replications. The treatment comprised of different growth regulators *viz*., GA_3 100 and 200 ppm, BA 50 and 100 ppm and control and three methods of application *viz*., Soaking, spraying and Soaking + Spraying.

All the cultural practices such as ploughing, harrowing and clod crushing were carried out to

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prepared the field. At the time of land preparation, well rotted FYM @ 20 t ha^{-1} was mixed uniformly in the soil before last harrowing. After preparing the land, the field was laid out with the beds of 45 cm spaced ridges and furrows and the beds were prepared of the dimension of 2.25 m x 1.40 m.

The rested, cold stored, best quality, de-husked and uniform sized corms of gladiolus variety American Beauty were treated with aqueous solution of GA_3 @100 and 200 ppm and BA @ 50 and 100 ppm for 24 hours as per the treatment. Then all the corms were treated with copper fungicide solution for 20 minutes as a preventive measure for *Fusarium wilt* disease before planting. The treated corms were then planted at a spacing of 45 x 20 cm on the ridges at a depth of 5-6 cm. Light irrigation was given immediately after planting. Foliar sprays of GA_3 and BA in the prescribed concentration of the treatments were undertaken twice at 30^{th} and 45^{th} day after planting. Observations on various vegetative characters *viz*., sprouting of corms (%), height of plant (cm) and leaf area (cm^2), flowering character *viz*., days to 50 % flowering (days), quality characters *viz.*, diameter of spike (cm), florets $spike^{-1}$, vase life of flower and diameter of corm and yield characters *viz.*, spike $hectare^{-1}$ (lakh), weight of corms $plant^{-1}$ (g) and weight of cormels $plant^{-1}$ (g) were recorded and analyzed statistically.

RESULTS AND DISCUSSION

The data presented in table 1 revealed that, different growth regulators had significant effect on all growth, flowering and yield parameters of gladiolus.

Effect of growth regulators :

Significantly the maximum sprouting of corms (95.03 %), plant height (54.99 cm) and leaf area (134.41 cm^2) were recorded with the treatment of GA_3 200 ppm which was found to be at par with GA_3 100 ppm (90.18 %, 54.33 cm and 133.64 cm^2, respectively), whereas, control treatment had produced minimum sprouting of corms (84.79 %), plant height (45.09 cm) and leaf area (114.01 cm^2). This might be due to the promotory action of gibberellic acid on vegetative growth of plant and maximum plant height and leaf area cuased due to higher concentrations of GA_3 which induced plasticity in cell wall, active cell division in apical meristem and elongation of individual cell by DNA synthesis. This results are close conformity with the findings of Maurya and Nagda (2002) who concluded that, treatment with GA_3 at 50 ppm and 100 ppm had shown maximum sprouting of corms (90.0 % and 91.7 %, respectively) and Kirad *et al*. (2001) who recorded maximum plant height (146.53 cm) and leaf area (209.76 cm^2) at GA_3 100 ppm.

Significantly the earliest 50 per cent flowering in gladiolus was found with the application of GA_3 200 and 100 ppm (60.22 days both) which was followed by the treatments of BA 50 ppm and 100 ppm (67.33 and 68.33 days, respectively), whereas, control treatment took maximum days to 50 per cent flowering (75.45 days). This might be due to application of GA_3 terminates the juvenile phase in shoot apical meristem, instead of producing leaves and branches starts producing flower and these findings are close to findings of Baskaran and Misra (2007) who observed, decrease in days required for blooming (53.87 days) with the increase in concentration of GA_3 500 ppm.

The quality parameters such as spike diameter, florets $spike^{-1}$, vase life of flower and diameter of corm in gladiolus were found to be significant with the application of growth regulators. Significantly maximum diameter of spike, number of florets $spike^{-1}$ and vase life of flower (0.89 cm, 9.76 and 10.31 days, respectively) were recorded in the treatment of GA_3 200 ppm and it was found to be at par with the treatment of GA_3 100 ppm (0.87 cm, 9.40 and 10.07 days, respectively). However, minimum diameter of spike, number of florets $spike^{-1}$ and vase life of flower were recorded with control treatment (0.66 cm, 6.96 and 7.24 days, respectively) which was at par with the treatment of BA 100 ppm (0.68 cm, 7.15 and 8.07 days, respectively). GA_3 might have increased diameter of spike, due to more production of photosynthates which might have been utilized for the production of better quality spikes. The results obtained in this investigation are in close agreement with the findings of Kumar *et al*. (2010) in gladiolus who noted maximum diameter of spike (0.79 cm) with GA_3 200 ppm and Kumar and Singh (2005) reported that, pre-planting treatment of corms with GA_3 exhibited more vase life of spike (10.76 days) with sand and florets $spike^{-1}$ (15.56) without sand media in gladiolus.

GA_3 increases photosynthesis and metabolic activities causing more transport and utilization of photosynthetic products which might have resulted into an improvement in the quality of gladiolus spikes due to which an uptake of water would have been increased and the turgidity of spikes was maintained due to which the vase life of flowers might have been increased. The similar results were also found by Sharma *et al*. (2006) who registered maximum florets spike^{-1} (18.01) and vase life of spike (14.33 days) with GA_3 200 ppm in gladiolus.

Significantly maximum diameter of gladiolus corm (5.07 cm) was recorded with the treatment of BA 50 ppm which was at par with the treatment BA 100 ppm (5.06 cm), however, minimum diameter of corm was noticed with the control treatment (3.62 cm) and it was at par with the treatment of GA_3 100 ppm (3.85 cm). An application of BA might have increased the size of gladiolus corm due to maximum accumulation of food material in the corm as a result of stunted vegetative growth of plant. Similar results were obtained by Baskaran *et al*. (2009) in gladiolus who noted that, treatment of corm soaking in BA 50 ppm and 100 ppm resulted in big sized corms (4.10 cm and 3.59 cm, respectively).

The differences in yield parameters such as spikes hectare^{-1}, weight of corms and cormels plant^{-1} were found to be significant due to application of growth regulators. The application of GA_3 200 ppm had noticed significantly maximum number of spikes hectare^{-1} (2.88 lakh) and it was found to be at par with the treatment of GA_3 100 ppm (2.69 lakh), whereas, minimum number of spikes hectare^{-1}were recorded in the control treatment (1.60 lakh) which was at par with the treatment of BA 100 ppm (1.69 lakh). Application of GA_3 recorded maximum yield of gladiolus spikes which might be due to the fact that, gibberellic acid promotes vegetative growth and then accumulates enough photosynthates required for reproductive phase which might have been resulted into more spikes yield in gladiolus. These results are in close conformity with the results of Kumar and Singh (2005) in gladiolus who found maximum spikes plant^{-1} (1.90) with GA_3 50 ppm. Significantly maximum weight of corms plant^{-1} (76.11 g) and cormels plant^{-1} (8.17 g) were recorded with the treatment of BA 100 ppm and it was found to be at par with the treatment BA 50 ppm (74.70 g and 7.95 g, respectively). However, minimum weight of corms and cormels plant^{-1} were noticed under control treatment (61.19 g and 5.91 g, respectively) and it was found to be at par with the treatments of GA_3 200 ppm (65.41 g and 7.60 g, respectively) and 100 ppm (62.99 g and 6.75 g, respectively). The results might be due to application of Benzyl adenine which promotes cell division and anabolism which might have resulted into an increase of number of good sized daughter corms which resulted into maximum weight of corms and cormels plant^{-1}. An increase in weight of corms plant^{-1} and cormels plant^{-1} (36.5 g and 7.3 g, respectively at BA 100 mg L^{-1}) with increase in concentration of BA were resulted by Rajaram *et al*. (2002) in gladiolus.

Effect of methods of application :

Among the methods of application of growth regulators, soaking treatment of corms had significantly recorded the maximum sprouting of gladiolus corms (91.49 %) which was found to be at par with soaking + spraying treatment (90.04 %). However, significantly the minimum sprouting (86.18 %) was found with spraying treatment. Significantly minimum days (61.93 days) to 50 per cent flowering was recorded under soaking treatment of gladiolus corm, however, maximum days (68.20 days) to 50 per cent flowering was required due to the treatment of spraying which was found to be at par with the treatment of soaking + spraying (66.73 days). Similar findings were recorded by Attia (2001) in gladiolus. He reported that, soaking of corms in the plant growth regulators was more effective than foliar spraying. These might have been caused due to the absorption of chemicals by gladiolus corms through soaking treatment, which might have been further utilized for physiological processes which resulted into early sprouting and bud emergence.

The data furnished in table 1 regarding plant height, leaf area, spike diameter, florets spike^{-1}, vase life of flower, diameter of corm, number of spikes hectare^{-1} and weight of corms and cormels plant^{-1} as influenced by methods of application had shown non-significant differences.

Interaction effect :

The data furnished in the table 1 revealed that, interaction effect due to growth regulators and

Table 1. Effect of growth regulators and methods of application on growth , yield and quality of gladiolus

Treatments	Sprouting of corms (%)	Height of plant (cm)	Leaf area (cm^2)	Days to 50 % flowering (days)	Spikes $hectare^{-1}$ (lakh)	Diameter of spike (cm)	Florets $spike^{-1}$	Vase life of flower (days)	Diameter of corm (cm)	Weight of corms $plant^{-1}$ (g)	Weight of cormels $plant^{-1}$ (g)
Growth Regulators											
GA_3 100 ppm	90.18	54.33	133.64	60.22	2.69	0.87	9.40	10.07	3.85	62.99	6.75
GA_3 200 ppm	95.03	54.99	134.41	60.22	2.88	0.89	9.67	1.31	4.53	65.41	7.60
BA 50 ppm	88.88	53.23	118.44	67.33	2.28	0.78	8.24	8.11	5.07	74.70	7.95
BA 100 ppm	87.30	51.55	116.29	68.33	1.69	0.68	7.15	8.07	5.07	76.11	8.17
Control	84.79	45.09	114.09	72.45	1.60	0.66	6.96	7.24	3.62	61.19	5.91
SE (m)±	1.89	1.71	3.03	0.71	0.18	0.02	0.38	0.37	0.18	2.75	0.53
CD @ 5 %	5.49	4.95	8.77	2.05	0.52	0.05	1.09	1.07	0.52	7.99	1.54
Methods of application											
Soaking	91.49	54.34	124.13	61.93	2.47	0.79	8.85	9.33	4.69	70.14	7.93
Spraying	86.18	51.60	121.98	68.20	2.08	0.76	7.89	8.45	4.28	64.20	6.57
Soaking + Spraying	90.04	49.58	123.95	66.73	2.13	0.78	8.11	8.49	4.30	69.90	7.33
SE (m)±	1.46	1.32	2.35	0.55	0.14	0.01	0.29	0.29	0.14	2.13	0.14
CD @ 5 %	4.25	--	--	1.59	--	--	--	--	--	--	--
Interaction											
SE (m)±	3.28	2.96	5.26	1.23	0.31	0.03	0.65	0.64	0.32	4.78	0.92
CD @ 5 %	--	--	--	3.56	--	--	--	--	--	--	--

methods of application on days to 50 per cent flowering was found to be significant. The treatment combination of GA_3 200 ppm and soaking methods of application significantly recorded minimum days (59.00 days) and the treatment combination of control and spraying method of application noted maximum days for 50 per cent flowering (80.67 days) in gladiolus, whereas, interaction effect due to growth regulators and methods of application had showed non significant differences in respect of other characters in gladiolus.

Thus, it can be inferred from the investigation that, application of GA_3 200 ppm and corm soaking treatment of growth regulators was found to be better for obtaining higher yield of better quality gladiolus spikes, whereas, application of BA 100 ppm and corm soaking treatment was found to be better for obtaining higher yield and better quality corms in gladiolus.

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IMPACT OF NITROGEN FIXING, PHOSPHORUS SOLUBILISING AND POTASSIUM MOBILISING BACTERIA ON GROWTH AND YIELD OF BRINJAL

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ABSTRACT

Pot culture experiment was conducted in Department of Plant Pathology, College of Agriculture, Nagpur in *rabi*, 2012-2013 to evaluate the impact of nitrogen fixing bacteria (*Azotobacter chroococcum*), phosphorus solubilising bacteria (*Pseudomonas striata)* and potash mobilising bacteria (*Frateuria aurantia*) inoculated to seedling roots before transplanting brinjal. Plant height and more number of leaves were recorded in the treatment *Azotobacter* + *P. striata* + *F. aurantia* + RDF (60:50:50) and the values were 18.03 cm, 40.89 cm and 59.47 cm at 30 and 60 and 90 DAT for plant height and 13.92, 41.00, 72.01 leaves at 30 and 60 and 90 DAT when compared with control and rest of the treatments. Among various treatments *Azotobacter* + *P. striata* + *F. aurantia* + 50 % RDF recorded a significantly higher root length, yield (31.53 cm and 2.60 kg plant^{-1} respectively) when compared with control and rest of the treatments which clearly indicated that the fertilizer dose can be reduced by applying biofertilizers with similar growth and yield of brinjal.

(Key words: *Azotobacter chroococcum, Pseudomonas striata, Frateuria aurantia,* Brinjal)

INTRODUCTION

India ranks second in world in production of brinjal (egg plant). Brinjal accounts for 10.4 per cent of India's annual production and contributes close to Rs.9,600 crore to the national economy.

Brinjal is produced in 5.50 lakh hectares and its annual production is 8.45 metric tones. Brinjal cultivation has grown by 15 per cent in the last 10 years but the production has barely increased by 9.0 per cent (Anonymous, 2004).

Azotobacter chroococcum synthesize some biologically active substances, including some phytohormones such as auxin (Ahmad *et al.,* 2005) there by stimulating plant growth (Oblisami *et al.,* 2007). *Pseudomonas striata* (PSB) are a group of beneficial bacteria capable of hydrolysing organic and inorganic phosphorus from insoluble compounds (Chen *et al.,* 2006). *Frateuria aurantia* is capable of solubilizing the fixed form of potash into easily absorbable simpler form and mobilizing the solubilized potash into the plants (Chandra *et al*., 2005). In the light of the above facts, an experiment involving, nitrogen fixing bacteria *A.chroococcum,* phosphorus solubilising bacteria (PSB) *P. striata* and potash solubilising bacteria (KSB) *F. aurantia* and combination of these bacteria was conducted on brinjal crop to see the effect of combined inoculation of nitrogen fixing bacteria, potassium solubilising bacteria and phosphorus solubilising bacteria on growth and yield in brinjal plant.

MATERIALS AND METHODS

The experiment was conducted in completely randomized design with three replications during *rabi*, 2012-2013. There were eight treatments comprising of three cultures and two fertilizer doses (Table 1). The recommended dose of NPK (60:50:50 kg ha^{-1}) was applied. Culture of *A. chroococcum*, *P. striata* and *F. aurantia* were procured from Plant Pathology Laboratory, College of Agriculture, Nagpur. *A. chroococcum, P. striata* and *F. aurantia* were multiplied on Jensen's medium, Pikovasky medium and potash solubulising medium respectively (Hu *et al.*, 2006).

As per the treatment details, biofertilizers were used for root inoculation of brinjal seedlings (root dipping). For the preparation of biofertilizers solution 250 ml biofertilizer solution was dissolved in 3 litres of water. Immediately after uprooting 30 days old seedlings from the nursery bed, the roots of the required seedlings were dipped in each of the solution separately for 10 minutes. Then the seedlings after thoroughly washing were used for transplanting in 25 cm diameter pots. Three pots were taken for each treatment. Plant height and number of leaves were recorded at 30, 60 and 90 DAT, root length was recorded after harvest and harvesting was done at two pickings after 90 DAT for yield estimation.

RESULTS AND DISCUSSION

The data about the influence of treatments on height of plant and number of leaves are presented in

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Table 1. Effect of biofertilizers on plant height, number of leaves, root length and yield of brinjal

Sr. No	Treatments	Plant height (cm)	No. of leaves	Root length (cm)	Yield (kg plant^{-1})
T_1	*Azotobacter* + 50 % N + Full dose of P and K	58.02	67.16	22.30	1.03
T_2	*P. striata* + 50 % P + Full dose of N and K	53.12	57.33	26.33	1.90
T_3	*F. aurantia* + 50 % K + Full dose of N and P	52.87	56.26	24.06	1.63
T_4	*Azotobacter* + P. *striata* + *F. aurantia*	50.04	55.86	21.56	0.93
T_5	*Azotobacter* + P. *striata* + *F. aurantia* + RDF	59.47	72.01	29.16	2.30
T_6	*Azotobacter* + P. *striata* + *F. aurantia* + 50 % RDF	55.82	59.76	31.53	2.60
T_7	RDF (60:50:50 kg NPK ha^{-1})	56.24	63.22	25.66	2.13
T_8	Control	47.03	55.07	21.06	0.73
	SE + (m)	0.05	0.19	0.13	0.08
	CD (P=0.05)	0.17	0.57	0.40	0.25

table 1. All the treatments were found effective in increasing the plant growth over control. Increased plant height and more number of leaves were recorded in *Azotobacter* + *P. striata* + *F. aurantia* + RDF (60:50:50). The values for plant height were 18.03 cm, 40.89 cm and 59.47 cm at 30 and 60 and 90 DAT respectively whereas 13.92, 41.00, 72.01 leaves plant^{-1} were recorded at 30, 60 and 90 DAT respectively. The rest of treatments *Azotobacter* + 50 % N + Full dose of P and K, RDF, *Azotobacter* + *P. striata* + *F. aurantia* + 50 % RDF, *P. striata* + 50 % P + Full dose of N and K, *F. aurantia* + 50 % K + Full dose of N and P, *Azotobacter* + *P. striata* + *F. aurantia* were superior over control. The increase in growth attributes may be due to addition of biofertilizers which improved the physical, chemical and biological properties of soil and increasing nutrient availability for improving the plant growth.

Ramarethinam and Chandra (2005) found that the height of the plant was influenced by the application of biofertilizers along with the chemical fertilizers which recorded that the increase was 81 cm. Kiran *et al.* (2010) observed that there was an increase in number of leaves due to application of fertilizers along with the *Azotobacter* and PSB i.e 89.38 leaves. Anburani and Manivannan (2002) recorded the increase in the plant height (108 cm) by applying FYM + press mud along with the application of biofertilizers which was significantly higher than the control. Kiran (2006) indicated that significantly higher growth components such as plant height, number of leaves plant^{-1} and higher yield components like number of fruits plant^{-1} (16.72) were recorded at 100:50 kg NPK ha^{-1} + *Azospirillum* and PSB (root dipping) treatment. Thus, the present results are in conformity with the findings of these authors.

Effect on root length and yield :

Treatment *Azotobacter* + *P. striata* + *F. aurantia* + 50 % RDF, caused significantly increased length of root after harvesting (31.53 cm) and yield (2.60 kg plant^{-1}). When compared with treatments T_5 (*Azotobacter* + P. *striata* + *F. aurantia* + RDF), T_7 (RDF), T_2 (*P. striata* + 50 % P + Full dose of N and K), T_3 (*F. aurantia* + 50 % K + Full dose of N and P), T_4 (*Azotobacter* + P. *striata* + *F. aurantia*) and control. Patel *et al.* (2011) observed in brinjal the increase in yield with the application of 100 % RDF + *Azospirillum* + *Azotobacter* + PSB. Premsekhar and Rajashree (2009) reported that the increase in yield of brinjal was noted by application of *Azotobacter* + 75 % N +100 % P and K and it was 27.1 number of fruits plant^{-1}.

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EFFECT OF FOLIAR SPRAYS OF HUMIC ACID THROUGH VERMICOMPOST WASH AND NAA ON MORPHO-PHYSIOLOGICAL PARAMETERS, YIELD AND YIELD CONTRIBUTING PARAMETERS OF CHICKPEA

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ABSTRACT

The present investigation was undertaken during year *rabi* 2012-13 to study the effect of foliar sprays of humic acid through vermicompost wash and NAA on growth, yield contributing parameters of chickpea.The experiment was laid out in RBD with three replications comprising of different doses of humic acid through vermicompost wash and NAA. Spraying of humic acid and NAA was done at 25 and 40 DAS.The different treatments tested were 25 and 50 ppm NAA and 300 ppm, 400 and 500 ppm HA through VCW alone or in combination. One control (water spray) treatment was also taken during experimentation. Foliar sprays of 50 ppm NAA+400 ppm HA through VCW followed by 50 ppm NAA+300 ppm HA through VCW significantly enhanced the plant height, number of branches, leaf area, total dry matter production plant^{-1}, RGR,NAR, number of pods plant^{-1}, 100 seed weight (g) and seed yield ha^{-1}.

(Key words: Chickpea, vermicompost wash, NAA, morpho-physiological and growth parameters)

INTRODUCTION

Chickpea is important pulse crop in the world and it ranks third position. The important gram growing countries in the world are India, Turkey, Pakistan, Iran, Canada, Russia and Morocco. India ranks first in the world in respect of production as well as acreage followed by Pakistan. The largest gram producing states in India with respect to area are Madhya Pradesh, Uttar Pradesh, Andhra Pradesh, Rajasthan, Haryana and Karnataka. In Maharashtra chickpea ranks second next to pigeonpea in the production and productivity.

In India area under chickpea crop during 2011-12 was 83.20 million hectares with the production of 75.80 million tonnes having productivity of yield was 912 kg ha^{-1} (Anonymous a, 2012). In Maharashtra total area under chickpea cultivation during the year 2011-12 was 10.51 million hectares with the production of 8.14 million tonnes having average productivity of 775 kg ha^{-1} (Anonymous b, 2012). In Maharashtra Vidharbha region contributes major share in area as well as production of chickpea. In Vidharbha total area under chickpea was 3.98 million hectares with a total production of about 3.10 million tonnes having productivity of 775 kg ha^{-1} during the year 2011-12 (Anonymous c, 2012).

Humic acid (HA) when externally supplied was observed to increase crop growth and ultimately the yield. It improves the nutritional status of soil and plant system. Humic acid (HA) application had definite input on protein synthesis and nucleic acid synthesis.

The high cation exchange capacity of humic acid prevents nutrients from leaching. It absorbs the nutrients from chemical fertilizers and these exchanged nutrients are slowly released to the plant. Humic acid is the product of breakdown of organic matter. Humic acid proved many binding sites for nutrient such as calcium, iron, potassium and phosphorus. These nutrients are stored in humic acid molecule in a form readily available to plant and are released when the plants require them, humic acid increases the absorption and translocation of nutrients in plant and ultimately influences yield. Humic acid supply polyphenols that catalyze plant respiration and increases plant growth.

Vermicompost wash is useful as foliar spray. It is transparent pale yellow biofertilizer. It is a mixture of excretory products and mucous secretion of earth worm (*Lampito mautrii* and *Eisenia fetida*) and organic micronutrients of soil, which may be promoted as “potent fertilizer” for better yield and growth (Shweta *et al*., 2005). Vermicompost wash is having approximately 1300 ppm humic acid, 116 ppm dissolve oxygen, 50 ppm inorganic phosphate, 168 ppm potassium and 121 ppm sodium (Haripriya and Pookodi, 2005). Vermicompost wash is having N-0.29%, P-0.042%, K-0.143%, Ca-0.186%, Mg-0.11%, S-0.058%, Fe 0. 466 ppm, Mn 0.406 ppm, Zn 0.11 ppm, Cu 0.18 ppm. (Anonymous, 2007).

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NAA (Naphthalene Acetic Acid) is the synthetic auxin with the identical properties to that naturally occuring auxin. It prevents formation of abscission layer and thereby flower drop. It was observed that the growth regulators are involved in the direct transport of assimilates from source to sink (Sharma *et al.,* 1989). Considering the above facts present investigation was undertaken to see the effect of foliar sprays of humic acid through vermicompost wash and NAA on growth, yield and yield contributing parameters of chickpea.

MATERIALS AND METHODS

The present investigation on the effect of foliar sprays of humic acid through vermicompost wash and NAA on growth, yield contributing parameters of chickpea was conducted in field trial of experimental farm of Agril. Botany Section, College of Agriculture, Nagpur during 2012-13. The treatments of 25 and 50 ppm NAA and 300 ppm, 400 and 500 ppm HA through VCW alone or in combination like T_2 (25 ppm NAA), T_3 (50 ppm NAA), T_4(300 ppm HA through VCW), T_5 (400 ppm HA through VCW)), T_6(500 ppm HA through VCW), T_7 (25 ppm NAA+300 ppm HA through VCW), T_8 (25 ppm NAA+400 ppm HA through VCW), T_9 (25 ppm NAA+500 ppm HA through VCW), T_{10} (50 ppm NAA+300 ppm HA through VCW), T_{11} (50 ppm NAA+400 ppm HA through VCW) and T_{12} (50 ppm NAA+500 ppm HA through VCW) were tested with control (T_1). Chickpea seed variety Jaki-9218 was used for experiment *rabi* 2012-13. Observations on growth, yield contributing parameters of chickpea were also recorded. Plant height (cm), number of branches plant^{-1}, leaf area and total dry matter production plant^{-1} were recorded at 45, 65 and 85 DAS. Similarly RGR and NAR were calculated at 45-65 and 65-85 DAS. Observations on number of pods plant^{-1},100 seed weight and seed yield ha^{-1} were also recorded.

RESULTS AND DISCUSSION

Morpho – physiological parameters :
Plant height (cm) :

Data regarding plant height were recorded at three observational stages viz., 45, 65, and 85 DAS and are presented in table 1. At 45 DAS significantly highest plant height was recorded in treatment T_{11} (50 ppm NAA+400 ppm HA through VCW) followed by treatments T_{10}(50 ppm NAA + 300 ppm HA through VCW), T_8 (25 ppm NAA+400 ppm HA through VCW), T_7 (25 ppm NAA+300 ppm HA through VCW), T_5 (400 ppm HA through VCM),T_4 (300 pm HA through VCW), T_3 (50 ppm NAA), T_{12} (50 ppm NAA+500 ppm HA through VCW), T_9 (25 ppm NAA + 500 ppm HA through VCW) and T_6 (500 ppm HA through VCW). All the treatments were significantly superior over treatments T_1 (control) and T_2 (25 ppm NAA).

At 65 DAS plant height was significantly influenced by different treatments. At this stage treatment T_{11} (50 ppm NAA+400 ppm HA through VCW) showed significantly maximum plant height followed by treatments T_{10} (50 ppm NAA+300 ppm HA through VCW), T_8 (25 ppm NAA + 400 ppm HA through VCW), T_5 (400 ppm HA through VCW), T_7 (25 ppm NAA+300 ppm HA through VCW) and T_4(300 ppm HA through VCW). Treatments T_3 (50ppm NAA), T_{12} (50 ppm NAA + 500 ppm HA through VCW), T_9 (25 ppm NAA + 500 ppm HA through VCW), T_6 (500 ppm HA through VCW) and T_2 (25 ppm NAA) not influenced plant height at this stage and remained at par with T_1 (control).

The data recorded about plant height was statistically significant at 85 DAS. Significantly highest plant height was recorded in treatment T_{11} (50 ppm NAA + 400 ppm HA through VCW), followed by treatments T_{10} (50 NAA + 300 ppm HA through VCW), T_8 (25 ppm NAA + 400 ppm HA through VCW), T_7 (25 ppm NAA + 300 ppm HA through VCW), T_5 (400 ppm HA through VCW), T_4 (300 ppm HA through VCW),T_3 (50 ppm NAA), T_{12} (50 ppm NAA + 500 ppm HA through VCW) and T_9 (25 ppm NAA + 500 ppm HA through VCW) in a descending manner when compared with control and remaining treatments. Treatments T_6 (500 ppm HA through VCW) and T_2 (25 ppm NAA) were not influenced plant height and found at par with control (T_1).

The application of growth promotive substances increased the plant height and such effect was due to increased photosynthetic activity, enhancement in the mobilization of photosynthates and change in the membrane permeability (Shukla *et al*., 1997). Foliar application enhances the absorption and transport of nutrients and growth regulators. Hence, it facilitates availability of nutrients and growth of the plant. The data revealed that plant height was increased with the age till its maturity. Gaikwad *et al.* (2012) observed that two foliar sprays of 400 ppm HA through VCW increased plant height in maize.

Leaf area of plant :

Data regarding leaf area were recorded at three growth stages i.e. 45, 65 and 85 DAS. The data are given in table 1. At 45 DAS significantly maximum leaf area noticed in treatment T_{11} (50 ppm NAA + 400 ppm HA through VCW) followed by treatments T_{10} (50 ppm NAA + 300 ppm HA through VCW), T_8 (25 ppm NAA + 400 ppm HA through VCW),T_7 (25 ppm NAA + 300 ppm HA through VCW),T_5 (40 ppm HA through VCW), T_4 (300 ppm HA through VCW), T_3 (500 ppm NAA) and T_{12} (50 ppm NAA + 500 ppm HA through VCW) when compared with treatment T_1 (control) and rest of the treatments under study. The treatment T_9 (25 ppm NAA + 500 ppm HA through VCW), T_6 (500 ppm HA through VCW), T_2 (25 ppm NAA) could not achieved more leaf area at this stage and these treatments were found at par with treatment T_1 (control).

At 65 and 85 DAS leaf area plant^{-1} was significantly influenced by different treatments. At this stage treatments T_{11} (50 ppm NAA + 400 ppm HA through VCW),T_{10} (50 ppm NAA + 300 ppm HA through VCW),T_8 (25 ppm NAA + 400 ppm HA through VCW), T_7 (25 ppm NAA + 300 ppm HA through VCW), T_5 (400 ppm HA through VCW), T_4 (300 ppm HA through VCW), T_3 (50 ppm NAA) and T_{12} (50 ppm NAA + 500 ppm HA through VCW) recorded significantly maximum leaf area in a descending manner. Treatments T_9 (25 ppm NAA + 500 ppm HA through VCW), T_6 (500 ppm HA through VCW) and T_2 (25 ppm NAA) unable to show their superiority over treatment T_1 (Control).

Gaikwad *et al.* (2012) suggests that foliar sprays of 400 ppm followed by 350 ppm HA increased leaf area plant^{-1} over control in maize. Deotale *et al.* (2011) investigated the effect of two foliar sprays of different concentrations of NAA (50 ppm) and cow urine (2, 4, and 6%) at 25 and 40 DAS on soybean cultivar JS 335.Considering the concentrations 6% cow urine spray and 50 ppm NAA alone and in combinations were found more effective in enhancing the leaf area, when compared with control.

Total dry matter production plant^{-1} :

Data pertaining to the dry matter plant^{-1} recorded at different stages are presented in table 1. Significantly maximum dry matter was noticed in treatment T_{11} (50 ppm NAA + 400 ppm HA through VCW) followed by treatments T_{10} (50 ppm NAA + 300 ppm HA through VCW) and T_8 (25 ppm NAA + 400 ppm HA through VCW) when compared with control and rest of the treatments under observations. Similarly treatmentsT_7 (25 ppm NAA + 300 ppm HA through VCW), T_5 (400 ppm HA through VCW), T_4 (300 ppm HA through VCW), and T_3 (500 ppm NAA) also gave significantly more dry matter in a descending manner when compare with treatment T_1 (control) and other remaining treatments. Treatments T_{12} (50 ppm NAA + 500 ppm HA through VCW), T_9 (25 ppm NAA + 500 ppm HA through VCW), T_6 (500 ppm HA trough VCW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control).

The data recorded about the dry matter production were statistically significant at 65 and 85 DAS. Significantly highest dry matter was recorded in treatment T_{11} (50 ppm NAA + 400 ppm HA through VCW), treatments T_{10} (50 ppm NAA + 300 ppm HA through VCW) and T_8 (25 ppm NAA + 400 ppm HA through VCW) also recorded more dry matter when compared with control and rest of the treatments under study. Treatments T_7 (25 ppm NAA + 300 ppm HA through VCW), T_5 (400 ppm HA through VCW), T_4 (500 ppm HA through VCW), T_3 (50 ppm NAA), T_{12} (50 ppm NAA + 500 ppm HA through VCW) also recorded more dry matter production when compared with control and rest of the treatments under observations. Similarly treatments T_6 (25 ppm NAA + 500 ppm HA through VCW) and T_2 (25 ppm NAA) also gave significantly more dry matter when compared with treatment T_1 (control). One of the reasons for low productivity in pulses is due to poor source-sink relationship. In an attempt to see the foliar sprays of HA through VCW and NAA in the present study it was found that there was a significant increase in the dry matter production and its distribution in different plant parts viz., leaf, stem and reproductive parts due to the application of humic acid through vermicompost wash and NAA in combination or alone on chickpea. Celk *et al.* (2011) studied the effect of foliar application of humic acid on dry matter accumulation of maize grown under calcareous soil condition. Three foliar application doses of humic acid (0, 0.1 and 0.2%) sprayed at 20 and 35 days after emergence. Foliar application of humic acid had a statistically significant and positive effect on dry weight of maize. Deotale *et al.* (2010) reported the effectivity of foliar sprays of 2-6% cow urine and 50 ppm NAA on morpho-physiological parameters of black gram. Data revealed that foliar application of 6% cow urine +50 ppm NAA significantly increased total dry matter of black gram.

Growth analysis :

Growth analysis is one of the measures for accessing the seed yield of 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 photosynthate into economic and non-economic sink.

Relative growth rate :

The highest rate of RGR indicates the ability of maximum dry matter for development. The increment in RGR might be associated with maximum leaf area expansion and growth of stem and root. Data regarding RGR are given in table 2. At 45 – 65 DAS all the treatments gave significant variation in respect of RGR when compared with control. Significantly maximum RGR was observed in treatment T_{11} (50 ppm NAA + 400 ppm HA through VCW) followed by treatments T_{10} (50 ppm NAA + 300 ppm HA through VCW), T_8 (25 ppm NAA + 400 ppm HA through VCW) and T_7 (25 ppm NAA + 300 ppm HA through VCW) when compared with other treatments under observations. Similarly treatments T_5 (400 ppm HA through VCW), T_4 (300 ppm HA through VCW), T_3 (50 ppm NAA) and T_{12} (50 ppm NAA + 500 ppm HA through VCW) recorded moderate RGR in a descending manner. Treatments T_9 (25 ppm NAA + 500 ppm HA through VCW), T_2 (25 ppm NAA) and T_6 (500 ppm HA through VCW) were found at par with the T_1 (control). At 65 – 85 DAS all the treatments gave significant variation in respect of RGR when compared with control. Significantly more RGR was noticed in treatment T_{11} (50 ppm NAA + 400 ppm HA through VCW) followed by treatments T_{10} (50 ppm NAA + 300 ppm HA through VCW), T_7 (25 ppm NAA + 300 ppm HA through VCW), T_8 (50 ppm NAA + 300 ppm HA through VCW), T_5 (400 ppm HA through VCW), and T_9 (25 ppm NAA + 500 ppm HA) in a descending manner when compared with treatment control and rest of the treatments. Treatments T_3 (50 ppm NAA), T_4 (300 ppm HA through VCW), T_2 (25 ppm NAA), T_6 (500 ppm HA through VCW), and T_{12} (50 ppm NAA + 500 ppm HA through VCW) were found at par with treatment T_1 (control).

Gaikwad *et al.* (2012) carried out an experiment in randomized block design with three replications comprising of different doses of humic acid through vermicompost wash. Spraying of humic acid was done at 20 and 40 DAS. The different treatments tested were control, 100, 150, 200, 250, 300, 400, 450, 500 ppm humic acid. Foliar sprays of humic acid showed their significance over control. Foliar sprays of 400 ppm followed by 350 ppm humic acid increased RGR.

Net assimilation rate :

NAR is closely connected with photosynthetic efficiency of leaves, but it is not a pure measure of photosynthesis. Increment in NAR is related with the increase in total dry weight of plant unit^{-1} of leaf area. NAR depends upon the excess dry matter gained, over the loss in respiration. It is increase in plant dry weight unit^{-1} area of assimilatory tissues unit^{-1} time. Data regarding NAR are given in table 2.

At 45 – 65 DAS NAR was significantly maximum in treatment T_{11} (50 ppm NAA + 400 ppm HA through VCW) followed by treatment T_{10} (50 ppm NAA + 300 ppm HA through VCW). Similarly treatments T_8 (25 ppm NAA + 400 ppm HA through VCW) and T_7 (25 ppm NAA + 300 ppm HA through VCW) also recorded more NAR as compared to treatment T_1 (control) and rest of the treatments under observations. Treatments T_5 (400 ppm HA through VCW), T_4 (300 ppm HA through VCW), T_3 (50 ppm

NAA), T_{12} (50 ppm NAA + 500 ppm HA through VCW) and T_9 (25 ppm NAA + 500 ppm HA through VCW) recorded moderate NAR in a descending manner. But treatments T_6 (500 pm HA through VCW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control). At 65 – 85 DAS NAR was significantly maximum in treatment T_{11} (50 ppm NAA + 400 ppm HA through VCW) followed by treatment T_{10} (50 ppm NAA + 300 ppm HA through VCW) compared to treatment T_1 (control) and rest of the treatments under observations. Treatments T_8 (25 ppm NAA + 400 ppm HA through VCW), T_7 (25 ppm NAA + 300 ppm HA through VCW) and T_5 (400 ppm HA through VCW) also recorded more NAR as compared to treatment T_1 (control) and rest of the treatments under observations. Similarly treatments T_4 (300 ppm HA through VCW), T_3 (50 ppm NAA), T_{12} (50 ppm NAA + 500 ppm HA through), T_9 (25 ppm NAA + 500 ppm HA through VCW) and T_2 (25 ppm NAA) recorded moderate NAR in a descending manner. Treatment T_6 (500 pm HA through VCW) was also found at par with treatment T_1 (control).

Ingle (2007) tried foliar application of 50 ppm NAA and 2, 4 and 6% cow urine on black gram and found that 6% cow urine + 500 ppm NAA increased NAR over control. Hiradeve (2010) carried out a field experiment to study the physiological response of groundnut to foliar sprays of different concentrations of vermicompost leachate. HA applied with different concentrations at 20 and 35 DAS significantly enhanced NAR.

Yield and yield contributing parameters :

Yield is complex character determined by several traits internal plant processes and environmental factors. In present study data on effect of humic acid sources i.e. VCW and NAA on number of pods plant^{-1}, 100 seed weight and seed yield ha^{-1} are presented in table 2.

Number of pods plant^{-1}, 100 seed weight and seed yield ha^{-1}:

Significantly maximum number of pods plant^{-1}, 100 seed weight and seed yield ha^{-1} were recorded in treatment T_{11} (50 ppm NAA + 400 ppm HA through VCW) followed by treatments T_{10} (50 ppm NAA + 300 ppm HA through VCW), T_8 (25 ppm NAA + 400 ppm HA through VCW), T_7 (25 ppm NAA + 300 ppm HA through VCW), T_5 (400 ppm HA through VCW), T_4 (300 ppm HA through VCW), T_3 (50 ppm NAA) and T_{12} (50 ppm NAA + 500 ppm HA through VCW) in a descending manner when compared with control and rest of the treatments. While, treatments, T_9 (25 ppm NAA + 500 ppm HA through VCW), T_6 (500 ppm HA through VCW) and T_2 (25 ppm NAA) were found at par with T_1 (control).

Hu and Wang (2001) studied the effect of Komix, humic acid containing organic fertilizer on spring soybean, Komix significantly increased yield, seeds plant^{-1}, pods seed weight plant^{-1} and 100 seed weight of spring soybean. Gaikwad *et al.* (2012) observed that the foliar sprays of 400 ppm followed by 350 ppm humic acid increased the 100 grain weight (g) in maize.

Table 1. Effect of humic acid through vermicompost wash and NAA on morpho - physiological parameters of chickpea

Treatments	Plant height (cm)			Number of branches $plant^{-1}$			Leaf area $plant^{-1}$ (dm^2)			Total dry matter production $plant^{-1}$ (g)		
	45 DAS	65 DAS	85 DAS	45 DAS	65 DAS	85 DAS	45 DAS	65 DAS	85 DAS	45 DAS	65 DAS	85 DAS
T_1 (Control)	29.88	43.20	49.38	2.40	3.60	3.63	1.03	1.30	1.40	0.75	1.42	2.00
T_2 (25 ppm NAA)	30.28	44.20	50.20	2.45	3.67	3.69	1.05	1.34	1.48	0.75	1.48	2.10
T_3 (50 ppm NAA)	37.70	46.60	51.90	2.67	3.95	3.97	1.27	1.58	1.80	0.94	2.26	3.23
T_4 (300 ppm HA)	31.81	47.40	52.03	2.70	4.00	4.02	1.29	1.59	1.85	0.96	2.35	3.35
T_5 (400 ppm HA)	32.20	49.50	53.91	2.73	4.17	4.21	1.32	1.63	1.88	1.01	2.68	3.85
T_6 (500 ppm HA)	31.41	44.73	50.23	2.47	3.81	3.90	1.12	1.40	1.56	0.82	1.58	2.20
T_7 (25 ppm NAA+ 300 ppm HA)	32.50	49.04	54.22	2.76	4.20	4.26	1.35	1.66	1.90	1.03	2.95	4.24
T_8 (25 ppm NAA+ 400 ppm HA)	32.67	50.50	54.60	2.80	4.24	4.29	1.37	1.69	1.93	1.11	3.20	4.60
T_9 (25 ppm NAA+ 500 ppm HA)	31.44	45.30	50.51	2.50	3.89	3.93	1.17	1.45	1.64	0.86	1.78	2.50
T_{10} (50 ppm NAA+ 300 ppm HA)	32.71	50.80	54.90	2.85	4.31	4.36	1.38	1.71	1.94	1.11	3.36	4.86
T_{11} (50 ppm NAA+ 400 ppm HA)	32.82	50.91	55.22	2.93	4.60	4.65	1.41	1.75	1.99	1.20	3.78	5.48
T_{12} (50 ppm NAA+ 500 ppm HA)	31.60	46.00	51.70	2.53	3.93	3.97	1.24	1.52	1.72	0.91	2.05	2.90
SE (m)±	0.589	1.370	1.318	0.09	0.14	0.12	0.077	0.08	0.110	0.038	0.112	0.174
CD at 5%	1.728	4.018	3.867	0.26	0.42	0.35	0.226	0.25	0.324	0.112	0.330	0.511

(Note : Source of HA through vermicompost wash)

Table 2. Effect of humic acid through vermicompost wash and NAA on PGR, NAR and yield and yield contributing parameters of chickpea

Treatments	RGP g g^{-1} day		NAR g dm^2 day^{-1}		Yield contributing parameters		
	45-65 DAS	65-85 DAS	45-65 DAS	65-85 DAS	Number of pods $plant^{-1}$	100 seed weight (g)	Seed yield ha^{-1} (q)
T_1 (Control)	0.0319	0.01701	0.01258	0.00921	39.69	22.00	17.22
T_2 (25 ppm NAA)	0.0338	0.01749	0.01329	0.00982	39.74	22.10	18.16
T_3 (50 ppm NAA)	0.0437	0.01760	0.02018	0.01230	43.59	23.12	20.66
T_4 (300 ppm HA)	0.0449	0.01749	0.02113	0.01244	44.50	23.48	21.09
T_5 (400 ppm HA)	0.0480	0.01779	0.02449	0.01468	45.63	24.00	21.63
T_6 (500 ppm HA)	0.0328	0.01728	0.01332	0.00929	40.10	22.32	18.19
T_7 (25 ppm NAA+ 300 ppm HA)	0.0526	0.01808	0.02799	0.01581	46.40	24.65	21.99
T_8 (25 ppm NAA+ 400 ppm HA)	0.0530	0.01800	0.02983	0.01670	46.75	24.80	22.16
T_9 (25 ppm NAA+ 500 ppm HA)	0.0362	0.01779	0.01531	0.01048	40.77	22.55	19.33
T_{10}(50 ppm NAA+ 300 ppm HA)	0.0556	0.01839	0.03204	0.01792	47.31	25.00	22.43
T_{11}(50 ppm NAA+ 400 ppm HA)	0.0576	0.01854	0.03623	0.02027	47.72	25.80	22.59
T_{12}(50 ppm NAA+ 500 ppm HA)	0.0404	0.01718	0.01785	0.01164	41.90	22.80	19.86
SE (m)±	0.0028	0.00029	0.00151	0.00088	1.649	0.810	0.678
CD at 5%	0.0084	0.00087	0.00443	0.00260	4.836	2.376	1.990

(Note : Source of HA through vermicompost wash)

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GROWTH, FLOWERING AND SEED YIELD OF AFRICAN MARIGOLD AS INFLUENCED BY GROWTH REGULATORS

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ABSTRACT

A field experiment was conducted at College of Agriculture, Nagpur (M.S.) during summer season of the year 2012-2013 to study the effect of growth regulators *viz.*, GA_3 100 ppm, GA_3 200 ppm, GA_3 300 ppm, GA_3 400 ppm, NAA 100 ppm, NAA 200 ppm, NAA 300 ppm, NAA 400 ppm and control on growth, flowering and seed yield of African marigold. The results revealed that, significantly maximum seeds flower^{-1}, seed yield plant^{-1}, test weight of seed were recorded with the treatment GA_3 300 ppm and it was found at par with all the other concentrations of GA_3 and NAA 100 ppm. However, minimum days to opening of flower from bud emergence as well as days to harvesting of flowers for seed were recorded with the treatment of GA_3 300 ppm. The treatment of NAA 400 ppm followed by NAA 300 ppm had recorded significantly maximum stem diameter, spread of plant and flowers plant^{-1}.

(Key words: African marigold, flowering, growth, growth regulators, seed yield)

INTRODUCTION

Among the flowers grown by farmers, marigold (*Tagetes erecta* L.) has its own importance. It has gained popularity among flower growers because of its easy cultivation and wide adaptability. The growers are attracted towards marigold flower as it has a habit of free flowering, short duration to produce marketable flowers of attractive colours and good keeping quality. Marigold flower has more demand during festival period especially on Diwali and Dashehara. There is a constant demand for flowers throughout the year for various functions, festivals and floral decorations. For maximization of seed yield of African marigold some advanced techniques like use of growth regulators are required to be followed besides usual cultural and management practices. Various research workers have reported that, the application of GA_3 and NAA help to increase the yield of better quality seed of African marigold. (Swaroop *et al.,* 2007 and Sunitha *et al.*, 2007). The present investigation was therefore carried out to study the effect of GA_3 and NAA of different concentrations on growth, flowering and seed yield of African marigold.

MATERIALS AND METHODS

A field experiment was carried out during Summer season of the year 2012-2013 at Horticulture Section, College of Agriculture, Nagpur (M. S.). Nagpur city comes under Vidarbha region of Maharashtra state. The experiment was laid out with nine treatments in randomized block design with three replications. The treatments comprised of T_1-Control, T_2-GA_3 100 ppm, T_3-GA_3 200 ppm, T_4-GA_3 300 ppm, T_5-GA_3 400 ppm, T_6-NAA 100 ppm, T_7-NAA 200 ppm, T_8-NAA 300 ppm and T_9-NAA 400 ppm. After preparing the land, the field was laid out in flat beds. Uniform and healthy seedlings were transplanted in each plot at the distance of 45 cm x 30 cm. While, application of growth regulators solutions of GA_3 (100, 200, 300 and 400 ppm) and NAA (100, 200, 300 and 400 ppm) were prepared by taking the required quantity of chemicals and dissolving them initially in a small quantity of absolute alcohol and thereafter diluted with water as per the treatment concentration. The Gibberellic acid and naphthalene acetic acid of the respective concentrations were sprayed twice, first at 20 days after transplanting and second at 30 days after transplanting as per the treatments.

All the intercultural operations were followed as and when required. The various observations on growth, flowering and seed yield characters *viz*., stem diameter, spread of plant, days to opening of flower from bud emergence, days to harvesting of flowers for seed, flowers plant^{-1}, seeds flower^{-1}, seed yield plant^{-1}, test weight of African marigold seed etc. were recorded and the data was statistically analyzed as per method suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

The data presented in table 1 revealed that, different levels of GA_3 and NAA had significant effect on all parameters in respect of growth, flowering, yield and quality of African marigold under study.

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Growth :

Plant height of African marigold was found significantly maximum (81.90 cm) with the treatment of GA_3 300 ppm and it was found statistically at par with the treatment of GA_3 400 ppm (79.76 cm) and GA_3 200 ppm (79.37 cm), whereas, minimum plant height was noted under the control treatment (68.80 cm). This might be due to the fact that, an application of gibberellic acid at different concentrations and NAA at lower concentration i.e. 100 ppm might have enhanced the plant height by increasing the internodal length as a result of increased cell elongation and faster cell division. The results are in conformity with the findings of Ramdevputra *et al*. (2009) in African marigold. They reported that, maximum plant height was highly influenced by GA_3 300 ppm. However, the reduction in plant height due to application of NAA at higher concentration might have caused ethylene formation which is correlated with an inhibition of plant growth instead of promoting the cell division. Similar inhibition of linear growth of carnation plant with higher concentration of NAA was also noticed by Mukhopadhyay (1990).

The treatment NAA 400 ppm recorded significantly maximum diameter of stem (1.39 cm) and it was found to be statistically at par with the treatment NAA 300 ppm (1.35 cm). However, minimum stem diameter was recorded in the control treatment i.e. T_1 (0.93 cm). Increased stem diameter of plant was observed with an increase in concentration of NAA, however, minimum stem diameter was recorded with no application of growth regulator i.e. control.

Similarly, in respect of spread of African marigold plant, the treatment NAA 400 ppm (34.90 cm) was found significantly superior over all other treatments except NAA 300 ppm (32.38 cm) which was statistically found at par with the superior treatment. While, minimum spread of plant was noticed with the control i.e. treatment T_1 (23.70). Increased stem diameter and spread of plant was observed with increase in concentration of NAA which might be due to reduction in plant height as a result of application of higher concentration of NAA which might have caused the utilization of food material for development of stem and the production of more number of branches plant^{-1} and thus increased the spread of plant. Gautam *et al*. (2006) and Ghadge *et al*. (2010) also reported increase in stem diameter and branches plant^{-1} in chrysanthemum and gaillardia, respectively due to application of NAA at 200 ppm.

Flowering :

The treatment of GA_3 300 ppm took significantly minimum period for opening of flower and days to harvesting of flowers for seed as compared to other treatments, except, the treatments GA_3 400 ppm, GA_3 200 ppm and GA_3 100 ppm. Earlier flower opening from bud initiation and harvesting of flowers for seed were recorded when the plants were treated with gibberellic acid. Foliar treatment of gibberellic acid enhanced vegetative growth in terms of plant height and also gibberellins is quite effective in reducing the juvenile period of the plant which would have associated with an early opening of flower from bud emergence and harvesting of flowers for seed in African marigold. The results obtained in the present investigation are in close agreement with the findings of Naliniprabhakar and Patil (2002) in China aster. They reported that spraying with 300 ppm gibberellic acid 30 days after transplanting resulted in higher seed yield as compared to the other treatments.

The number of flowers plant^{-1} were noticed significantly maximum (22.80) with the treatment (T_9) NAA 400 ppm which was found to be at par with the treatments (T_8) NAA 300 ppm (22.40), (T_7) NAA 200 ppm (22.20). While, significantly minimum numbers of flowers plant^{-1} (18.60) were noted with the control treatment i.e. T_1.

An increase in number of flowers plant^{-1} in African marigold with the application of NAA might be due to reduction in plant height which might have produced more number of branches plant^{-1}. This might be one of the reason for increase in number of the flowers plant^{-1} in the present investigation. The findings are in line with the results obtained by Tyagi and Kumar (2006) in African marigold. They recorded that, GA_3 at 200 ppm gave maximum number of flowers plant^{-1} in African marigold.

Seed yield :

Among the different treatments of growth regulators, GA_3 300 ppm noted significantly

Table 1. Growth, flowering and seed yield parameters of African marigold as influenced by growth regulators

Treatments	Plant height (cm)	Stem diameter (cm)	Spread of plant (cm)	Days to opening of flower from bud emergence	Days to harvesting of flowers for seed	Flowers plant^{-1}	Seeds flower^{-1}	Seed yield plant^{-1} (g)	Test weight of seed (g)
T_1 – Control (Water spray)	68.80	0.93	23.70	9.00	91.53	18.60	235.07	16.51	3.37
T_2 – GA_3 100 ppm	72.20	1.19	27.56	7.47	89.87	21.00	280.73	25.43	3.83
T_3 – GA_3 200 ppm	79.37	1.17	26.07	7.33	89.40	20.80	292.47	27.77	3.97
T_4 – GA_3 300 ppm	81.90	1.16	24.73	6.70	85.67	20.47	299.93	27.86	4.00
T_5 – GA_3 400 ppm	79.76	1.15	24.19	6.94	86.40	20.07	275.73	25.03	3.80
T_6 – NAA 100 ppm	74.00	1.18	27.37	7.53	90.33	20.93	290.40	27.32	3.93
T_7 – NAA 200 ppm	70.90	1.21	32.31	7.60	90.73	22.20	267.27	22.32	3.57
T_8 – NAA 300 ppm	70.00	1.35	32.38	7.80	90.87	22.40	252.73	20.92	3.47
T_9 – NAA 400 ppm	69.20	1.39	34.90	7.93	91.00	22.80	236.80	20.02	3.40
SE (m) ±	1.06	0.04	0.85	0.26	0.73	0.59	8.22	1.72	0.10
CD at 5%	3.08	0.13	2.55	0.77	2.19	1.77	24.67	5.15	0.33

maximum number of seeds flower^{-1} (299.93) and it was found to be at par with the treatments GA_3 200 ppm (292.47), NAA 100 ppm (290.40), GA_3 100 ppm (280.73) and GA_3 400 ppm (275.73), however, significantly minimum seeds were counted (235.06) in the control treatment. An increase in number of seeds flower^{-1} in African marigold was observed from the plants which were treated with GA_3. This might be due to better growth and increased photosynthesis of plants due to which better quality flowers might have been produced and thus, the number of seeds flower^{-1} might have been increased. The findings are in line with the results obtained by Swaroop *et al.* (2007) in African marigold. They registered that, GA_3 at 300 ppm recorded maximum number of seeds flower^{-1} in African marigold.

Similarly, maximum seed yield plant $^{-1}$ were recorded with the treatment of GA_3 300 ppm and it was found statistically at par with the treatments GA_3 200 ppm, NAA 100 ppm, GA_3 100 ppm and GA_3 400 ppm. However, significantly minimum seed yield plant $^{-1}$ was noticed with the control treatment. An increase in the seed yield plant^{-1} of African marigold might be due to the fact that, gibbrellic acid treated plants enhanced vegetative growth in terms of plant height. This might have resulted into the production and accumulation of more photosynthates which would have diverted to the sink resulting into the more seed yield in African marigold. These results are congruent with the results of Sunitha *et. al*. (2007) in African marigold and Sainath Uppar and Meena (2012) in chrysanthemum. They reported that, spraying of GA_3 200 ppm recorded maximum seed yield plant^{-1} in African marigold as well as in annual chrysanthemum.

The treatment of GA_3 300 ppm had produced significantly the maximum test weight of seed (4.00 g) and it was found to be at par with the treatments GA_3 200 ppm (3.97 g), NAA 100 (3.93 g), GA_3 100 ppm (3.83 g) and GA_3 400 ppm (3.80 g). Whereas, significantly minimum test weight of seed (3.37 g) was recorded with the control treatment. This might have been due to the fact that, GA_3 enhanced photosynthesis and other metabolic activities and thus it might have produced better quality flowers with bolder seeds due to which higher test weight of seed was obtained with the treatment of gibberellic acid. The results obtained in this investigation are in close agreement with the findings of Singh (2004) in French marigold and Sainath Uppar and Meena (2012) in chrysanthemum. They reported that, the test weight of seeds was recorded significantly higher with the treatment of GA_3 200 ppm in French marigold as well as in annual chrysanthemum.

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INFLUENCE OF FOLIAR SPRAYS OF HUMIC ACID THROUGH COWDUNG WASH AND NAA ON MORPHO-PHYSIOLOGICAL PARAMETERS, GROWTH AND YIELD OF MUSTARD

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ABSTRACT

The present study examined the effectiveness of foliar sprays of humic acid (HA) through CDW and NAA as a source for enhancing morpho-physiological growth and yield of mustard (*Brassica juncea*). A field experiment was conducted at an experimental farm of Botany section, College of Agriculture, Nagpur by growing mustard during the *rabi* season in the crop area spanning from October 2012 – February 2013, using randomized block design. The effectiveness of foliar sprays of HA and NAA was studied as control (water spray) with 11 different levels of HA through CDW (300,400 and 500 ppm) and NAA (25 and 50 ppm) alone and in combinations. Mustard plants were sprayed two times at 15 days interval at 30 and 45 DAS with different concentrations of humic acid and NAA. Recorded data showed that all morpho-physiological parameters including plant height, number of primary branches, leaf area, dry matter production plant^{-1}, RGR, NAR as well as yield ha^{-1} of mustard plants showed significant responses with the foliar application of 50 ppm NAA + 300 ppm HA through CDW followed by 25 ppm NAA + 300 ppm HA through CDW, 50 ppm NAA + 400 ppm HA through CDW and 25 ppm NAA + 400 ppm HA through CDW when compared with control.

(Key words: Cowdung wash, humic acid, NAA, mustard)

INTRODUCTION

Indian mustard (*Brassica juncea*) is the second important oilseed crop in India after groundnut. Mustard growing countries of the world are India, China, Canada, France, Poland and Pakistan. Major states producing mustard are Rajasthan, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, West Bengal and Gujarat. Mustard is well adopted in cool moist growing condition. In India area under mustard crop during 2011-12 was 6.69 million hectares with the production of 6.60 million t ha^{-1} having potential of yield was 1145 kg ha^{-1} (Anonymous a, 2011). In Maharashtra total area under mustard cultivation during 2011-12 was 12000 hectares with the production of 4000 t ha^{-1} having average productivity of 308 kg ha^{-1} (Anonymous a, 2011). In Maharashtra Vidarbha region contributes major share in area as well as production of mustard. In Vidarbha total area under mustard was 865 hectares with a total production of about 330 t ha^{-1} having productivity of 380 kg ha^{-1} during the year 2011-12 (Anonymous b, 2011).

Humic acid (HA) is important component of soil organic matter, which could improve the soil properties and crop nutrition. Humic acids are intermediates in complexity between humins and fulvic acids persist in soil for a larger period, so that to be useful to the crops. Humic acid with high molecular weight are not known to be assimilate while, these with low molecular weight are said to be assimilate by the plant (Chandrashekharan, 1992). Between three humic substances, humic acid have received the most attention and has been extensively studied to find out its effect on several crop plants.

Cow dung wash is excellent liquid manure. It is good source of humic acid (approximately 1100 ppm), macronutrients (1.5%N, 1%P and 1%K) and also good amount of micronutrients. Farmer who used biogas slurry reports to have obtained higher yield of many crops (Thomas and Ramesh, 2004).

NAA is synthetic auxin with identical properties to that of naturally occurring auxin i.e., IAA in plant. Auxin in low concentration promotes cell elongation i.e., growth, but in higher concentration it inhibits the growth.

Inorganic fertilizers are costly and cause pollution. There is huge gap between requirement and availability of fertilizers. Now a day's people have recognized the importance of organic fertilizers. The demand for organically produced food is high and it is fetching good price.

Hence, an attempt has been made in the present investigation to asses the influence of foliar sprays of humic acid through CDW and NAA alone and in combinations on morpho-physiological parameters and yield of mustard.

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MATERIALS AND METHODS

A field experiment on mustard was conducted at an experimental farm of Botany section, College of Agriculture, Nagpur. The present investigation was undertaken during the *rabi* season of 2012-2013. The field experiment was laid out in Randomized block Design (RBD) with three replications consisting of twelve treatments comprising of different doses of cowdung wash and NAA. Spraying of cowdung wash and NAA was done two times at 30 and 45 DAS with hand sprayer. Observations were recorded at different stages i.e. at 35, 50, 65 and 80 DAS. Data was analysed by statistical method suggested by Panse and Sukhatme (1954). Observations on Plant height plant^{-1}, number of primary branches plant^{-1}, leaf area plant^{-1}, dry matter production plant^{-1}, were recorded at 35, 50, 65 and 80 DAS and RGR and NAR were recorded at 35-50, 50-65 and 60-85. Seed yield was also recorded.

RESULTS AND DISCUSSION

Plant height plant^{-1}(cm) :

At 35 DAS significantly maximum plant height was recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW) and T_3 (50 ppm NAA) in a descending manner when compared with T_1 (control) and remaining treatments under study. Foliar application of 500 ppm humic acid through CDW (T_6), 50 ppm NAA + 500 ppm humic acid through CDW (T_{12}) and 25 ppm NAA (T_2) were found at par with control (T_1). But treatment T_9 (25 ppm NAA + 500 ppm humic acid through CDW) showed their significance over control (T_1).

At 50 DAS significantly maximum plant height was recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW) and T_4 (300 ppm humic acid through CDW) in a descending manner when compared with T_1 (control) and remaining treatments under study. But treatments T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were not found effective and remained at par with treatment T_1 (control).

At 65 DAS significantly maximum plant height was recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW) and T_3 (50 ppm NAA) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control).

At 80 DAS significantly maximum plant height was recorded by treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW) and T_3 (50 ppm NAA) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control) in respect of plant height at this stage of observation.

Deotale *et al.* (2011) reported that two foliar sprays of different concentrations of NAA (50 ppm) and cow urine (2%, 4%, 6%) increased plant height in soybean.

Mithua Setua *et al.* (2008) found that foliar spraying of NAA-based plant growth regulator increased plant height in mulberry.

Number of primary branches plant^{-1} :

At 35 DAS significantly maximum number of primary branches were recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) and T_7 (25 ppm NAA + 300 ppm humic acid through CDW). Treatments T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW) and T_5 (400 ppm humic acid through CDW) recorded moderate number of primary branches plant^{-1}. Minimum number of primary branches plant^{-1} recorded by treatments T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW), T_2 (25 ppm NAA) and T_1 (control) and were found at par with each other.

At 50 DAS significantly maximum number of primary branches were recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW) and T_4 (300 ppm humic acid through CDW) in a descending manner when compared with T_1 (control) and remaining treatments under study. Treatments T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA) and T_9 (25 ppm NAA + 500 ppm humic acid through CDW) were also found significantly superior over treatments T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW), T_2 (25 ppm NAA) and T_1 (control) in respect of number of primary branches plant^{-1}.

At 65 DAS significantly maximum number of primary branches were noticed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW) in a descending manner when compared with T_1 (control) and remaining treatments under study. Treatments T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW) and T_6 (500 ppm humic acid through CDW) also gave significantly more number of primary branches over T_1 (control). But treatments T_{12} (50 ppm NAA + 500 ppm humic acid through CDW), T_2 (25 ppm NAA) and T_1 (control) were found at par with each other.

At 80 DAS significantly more number of primary branches were noted in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) and T_7 (25 ppm NAA + 300 ppm humic acid through CDW) when compared with treatment T_1 (control) and remaining treatments. Next to these treatments, treatments T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW) and T_5 (400 ppm humic acid through CDW) also produced significantly more number of primary branches over treatment T_1 (control) and remaining treatments under study. Treatments T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control).

Das and Prasad (2003) reported that two sprays of NAA at 20 and 40 ppm, one at 30 DAS and second at flowering on green gram significantly increased number of branches plant^{-1}.

Venkataramana *et al.* (2010) studied the effect of foliar application of nutrients on mulberry, they reported that 100, 150 and 200 ppm vermiwash and cowdung wash increased the number of branches plant^{-1}.

Favourable effect of two foliar sprays of growth hormones on plant height and number of branches plant^{-1} might be due to moderate and constant supply of carbohydrates within the plant as a result of increased vegetative growth. Increased vegetative growth might be due to increased uptake of N, P, K and all other essential nutrients. Similarly foliar application of humic acid through cowdung wash was the most important factor affecting mustard growth. It has been reported that humic acid increase the number of roots thereby stimulating nutrient uptake of plant development. (Alvarez and Grigera, 2005). These might be the reasons in increased plant height and number of branches plant^{-1} in the present investigation.

Leaf area :

At 35 DAS significantly maximum leaf area was noticed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW) and T_4 (300 ppm humic acid through CDW) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. Also treatments T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW) and T_6 (500 ppm humic acid through CDW) showed their significance over treatment T_1 (control). Treatments T_{12} (50 ppm NAA + 500 ppm humic acid through CDW), T_2 (25 ppm NAA) and T_1 (control) were found at par with each other. The per cent increase in leaf area by treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) over T_1 (control) was 35.86.

At 50 DAS significantly maximum leaf area was recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW) and T_8 (25 ppm NAA + 400 ppm humic acid through CDW) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. Tretments T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA) and T_9 (25 ppm NAA + 500 ppm humic acid through CDW) also showed their significance over treatment T_1 (control). Treatments T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW), T_2 (25 ppm NAA) and T_1 (control) were found at par with each other. The per cent increase in leaf area by treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) over treatment T_1 (control) was 45.01.

At 65 DAS significantly maximum leaf area was recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW) and T_3 (50 ppm NAA) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW), T_2 (25 ppm NAA) and T_1 (control) were found at par with each other.

At the 80 DAS significantly maximum leaf area was recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA) and T_9 (25 ppm NAA + 500 ppm humic acid through CDW) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW), T_2 (25 ppm NAA) and T_1 (control) were found at par with each other. The per cent increase in leaf area by treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) over T_1 (control) was 33.18.

Similar results were also obtained by Ingle (2007). He tried foliar sprays of 2, 4 and 6% cow urine and 50 ppm NAA alone and in combination on black gram and found increase in leaf area.

Ghadge (2008) reported that foliar application of humic acid through cowdung wash and vermicompost wash significantly increased leaf area in green gram.

Dry matter production plant^{-1} (g) :

At 35 DAS significantly maximum dry matter was noticed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW) and T_6 (500 ppm humic acid through CDW) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control).

At 50 DAS significantly more dry matter was observed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW) and T_3 (50 ppm NAA) in a descending manner. These above mentioned treatments were significantly superior over rest of the treatments and T_1 (control). Treatments T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with T_1 (control).

At 65 DAS significantly maximum dry matter was recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW) and T_5 (400 ppm humic acid through CDW). But treatments T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control).

At 80 DAS significantly maximum dry matter was noticed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW) and T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study.

Deogirkar (2010) reported that foliar spray of cow urine and NAA alone and in combination significantly increased dry matter production of chickpea.

Khalid and Fawy (2011) also noticed highest dry weight with the foliar application of 0.5% humic acid in corn.

Relative Growth Rate (g g^{-1} day^{-1}) :

At 35-50 DAS significantly maximum RGR was observed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA) and T_9 (25 ppm NAA + 500 ppm humic acid through CDW). Treatments T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) in a descending manner also recorded more RGR as compared to treatment T_1 (control).

At 50-65 DAS significantly maximum RGR was observed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatment T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA) and T_9 (25 ppm NAA + 500 ppm humic acid through CDW) in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with T_1 (control).

At 65-80 DAS significantly highest RGR was observed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) and T_7 (25 ppm NAA + 300 ppm humic acid through CDW). Treatments T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA) and T_9 (25 ppm NAA + 500 ppm humic acid through CDW) recorded significantly moderate RGR in a descending manner when compared with treatment T_1 (control) and remaining treatments under study. But lowest RGR was recorded in treatment T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW), T_2 (25 ppm NAA) and these treatments were found at par with treatment T_1 (control).

Net assimilation rate (g dm^{-2}day^{-1}) :

At 35-50 DAS significantly maximum NAR was observed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW) and T_3 (50 ppm NAA) when compared with treatment T_1 (control) and rest of the treatments under study. Treatments T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control).

At 50-65 DAS significantly maximum NAR was observed in treatments T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) and T_7 (25 ppm NAA + 300 ppm humic acid through CDW). Next to these treatments, treatments T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW) and T_6 (500 ppm humic acid through CDW) showed maximum RGR when compared with treatment T_1 (control) and rest of the treatments under study. Treatments T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control).

At 65-80 DAS significantly maximum NAR was observed in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW). Next to this treatment, treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid through CDW), T_8 (25 ppm NAA + 400 ppm humic acid through CDW), T_4 (300 ppm humic acid through CDW) and T_5 (400 ppm humic acid through CDW) also gave maximum NAR when compared with other treatments and control (T_1) also. Treatments T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control).

Ghadge (2008) reported that foliar sprays of humic acid through vermicompost wash and cowdung wash significantly increased RGR and NAR in green gram.

Deotale *et al.* (2011) reported that two foliar sprays of different concentrations of NAA (50 ppm) and cow urine (2%, 4%, 6%) increased RGR and NAR in soybean.

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

Significantly maximum seed yield was recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) followed by the treatments T_7 (25 ppm NAA + 300 ppm humic acid through CDW), T_{11} (50 ppm NAA + 400 ppm humic acid

Table 1. Effect of humic acid through cowdung wash and NAA on morpho – physiological parameters and yield of mustard

Treatments	Plant height (cm)				Number of primary branches plant^{-1}				Leaf area plant^{-1} (dm^2)				dry matter production plant^{-1} (g)				Seed yield ha^{-1}
	35 DAS	45 DAS	65 DAS	85 DAS	35 DAS	45 DAS	65 DAS	85 DAS	35 DAS	45 DAS	65 DAS	85 DAS	35 DAS	45 DAS	65 DAS	85 DAS	
T_1 (control)	38.15	120.86	131.09	132.22	1.91	4.97	4.48	4.59	1.45	2.51	7.18	4.46	1.69	3.64	24.09	49.01	7.73
T_2(25 ppm NAA)	42.50	121.48	132.38	133.47	1.92	5.09	4.61	4.73	1.48	2.62	7.22	4.81	1.74	3.72	25.28	49.08	7.89
T_3(50 ppm NAA)	49.71	126.47	141.40	142.93	1.99	5.69	5.10	5.32	1.71	2.97	7.47	5.24	2.03	4.37	28.29	50.46	8.92
T_4 (300 ppm HA)	52.20	134.53	147.68	151.42	2.16	6.42	5.41	5.63	1.80	3.14	7.54	5.39	2.09	4.61	30.83	50.59	9.13
T_5 (400 ppm HA)	51.83	131.68	145.87	148.70	2.08	5.88	5.38	5.59	1.73	3.04	7.54	5.37	2.06	4.55	30.37	50.50	9.00
T_6 (500 ppm HA)	45.12	123.89	137.13	138.67	1.97	5.22	4.86	5.02	1.60	2.68	7.27	4.91	1.92	4.05	27.73	50.03	8.26
T_7 (25 ppm NAA+300 ppm HA)	56.97	138.85	152.17	155.29	3.00	6.89	5.98	6.30	1.94	3.57	7.89	5.82	2.21	5.05	32.78	51.58	10.11
T_8 (25 ppm NAA+400 ppm HA)	54.63	137.54	151.02	153.53	2.30	6.51	5.78	5.75	1.84	3.34	7.65	5.46	2.12	4.78	31.43	50.75	9.50
T_9 (25 ppm NAA+500 ppm HA)	48.52	124.73	139.43	141.81	1.98	5.55	5.09	5.19	1.62	2.89	7.36	5.13	1.97	4.25	28.05	50.37	8.65
T_{10} (50 ppm NAA+300 ppm HA)	58.12	143.23	155.87	159.08	3.12	6.96	6.24	6.55	1.97	3.64	7.90	5.94	2.26	5.18	33.09	51.82	10.40
T_{11} (50 ppm NAA+400 ppm HA)	56.43	138.85	151.02	154.61	2.36	6.73	5.78	5.93	1.85	3.46	7.77	5.51	2.14	4.93	32.44	51.12	9.78
T_{12} (50 ppm NAA+500ppm HA)	42.94	122.97	135.52	137.13	1.96	5.14	4.69	4.91	1.48	2.63	7.24	4.81	1.75	3.95	27.50	49.59	8.10
SE (m) ±	3.203	3.847	5.429	5.84	0.109	0.266	0.191	0.101	0.075	0.154	0.159	0.274	0.118	0.288	1.887	0.816	0.575
CD at 5%	9.395	11.284	15.923	17.15	0.320	0.781	0.561	0.296	0.219	0.451	0.468	0.804	0.345	0.844	5.535	2.392	1.688

(Note: Source of HA through cowdung wash)

Table 2. Effect of humic acid through cowdung wash and NAA on relative growth rate (RGR) and net assimilation rate (NAR) in mustard

Treatments	RGR (g g^{-1} day^{-1})			NAR (g dm^2 day^{-1})		
	35-50 DAS	**50-65 DAS**	**65-80 DAS**	**35-50 DAS**	**50-65 DAS**	**65-80 DAS**
T_1 (control)	0.0482	0.1210	0.0299	0.0254	0.1330	0.0725
T_2 (25 ppm NAA)	0.0503	0.1237	0.0302	0.0274	0.1334	0.0732
T_3 (50 ppm NAA)	0.0529	0.1257	0.0338	0.0310	0.1471	0.0859
T_4 (300 ppm HA through CDW)	0.0542	0.1276	0.0388	0.0321	0.1492	0.0919
T_5 (400 ppm HA through CDW)	0.0530	0.1260	0.0381	0.0311	0.1475	0.0918
T_6 (500 ppm HA through CDW)	0.0512	0.1251	0.0319	0.0293	0.1409	0.0793
T_7 (25 ppm NAA + 300 ppm HA CDW)	0.0553	0.1293	0.0455	0.0343	0.1608	0.1086
T_8 (25 ppm NAA + 400 ppm HA CDW)	0.0547	0.1278	0.0390	0.0324	0.1497	0.0966
T_9 (25 ppm NAA + 500 ppm HA through CDW)	0.0528	0.1256	0.0329	0.0296	0.1466	0.0848
T_{10} (50 ppm NAA + 300 ppm HA through CDW)	0.0556	0.1295	0.0474	0.0352	0.1664	0.1267
T_{11} (50 ppm NAA + 400 ppm HA through CDW)	0.0553	0.1291	0.0393	0.0325	0.1520	0.0979
T_{12} (50 ppm NAA + 500 ppm HA through CDW)	0.0512	0.1247	0.0303	0.0277	0.1362	0.0786
SE(m)±	0.00146	0.00133	0.00231	0.00187	0.00474	0.00582
CD at 5%	0.00428	0.00390	0.00679	0.00550	0.0139	0.0170

through CDW) and T_8 (25 ppm NAA + 400 ppm humic acid through CDW) when compared with treatment T_1 (control) and remaining treatments under study. Treatments T_4 (300 ppm humic acid through CDW), T_5 (400 ppm humic acid through CDW), T_3 (50 ppm NAA), T_9 (25 ppm NAA + 500 ppm humic acid through CDW), T_6 (500 ppm humic acid through CDW), T_{12} (50 ppm NAA + 500 ppm humic acid through CDW) and T_2 (25 ppm NAA) were found at par with treatment T_1 (control). The maximum seed yield ha^{-1} was recorded in treatment T_{10} (50 ppm NAA + 300 ppm humic acid through CDW) i.e., 10.40 q and minimum in T_1 (control) i.e., 7.73 q respectively..

In another study Chris *et al.* (2005) reported that both the foliar and soil application of humic acid significantly improved seed yield of mustard. .

Similarly Thakare *et al*. (2006) reported that foliar sprays of 6% cow urine + 2% DAP of urea with 50 ppm NAA or IAA significantly increased the seed yield plant$^{-1,}$ plot^{-1} and hectare^{-1} in soybean.

The above data gives clear view that the combination effect of cow dung wash and NAA assured significantly better results. As these treatments were given through foliar sprays, the observed superiority might be due to foliar feeding of major nutrients like N, P, K to the plants through cow dung wash and altered metabolic acitivities due to hormone NAA. When nutrients required by plants are applied through foliage, there is enhancement in uptake, translocation and synthesis of photosynthetic assimilates which results into increase in various plant growth characters such as plant height, leaf area, total dry matter which ultimately results into increase in seed yield. These might be the reasons responsible for spectacular increase in overall seed yield of mustard in the present investigation.

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EFFICACY OF ENTOMOPATHOGENIC FUNGAL PESTICIDES UNDER LABORATORY CONDITION AGAINST SOYBEAN SEMILOOPER

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ABSTRACT

The present investigation was conducted in Insectary premises of Entomology Section, College of Agriculture, Nagpur, during year 2010 (*kharif*). To work out the efficacy of two promising entomopathogenic fungi *viz*., *Beauveria bassiana* and *Metarrhizium anisopliae,* LC_{50}, LC_{90} as well as LT_{50}, LT_{90} were determined against 2nd /3rd larvae of soybean semilooper, *Plusia signata* under laboratory condition at different concentrations along with the untreated control.

The results revealed that, LC_{50} of *Beauveria bassiana* was 6.0 x 10^4 spores ml^{-1} and LC_{90} was 7.6x10^8 while LC_{50} of Metarrhizium anisopliae was 7.0 x 10^4 spores ml^{-1} and LC_{90} was 2.5x10^{11}. On the other hand LT_{50} was 4.14 days in case of *Beauveria bassiana* as against 4.72 days in case of *Metarrhizium anisopliae* at the concentration of 1 x 10^{10} spores ml^{-1}. From the above data, it is clear that, *B. bassiana* appeared more effective than *Metarrhizium anisopliae* to manage soybean semilooper population.

(**Key Words:** *Plusia signata*, Entomopathogenic Fungi, *Beauveria bassiana, Metarrhizium anisopliae,* LC_{50}, LC_{90}, LT_{50}, LT_{90})

INTRODUCTION

In India, soybean (*Glycine max* L. Merrill) crop is mainly grown in *kharif* season, in different agro - climatic regions. In last few years, area under soybean cultivation has increased tremendously, because of its various benefits, but there are many problems in the cultivation of soybean in India, as all stages of this crop are prone to heavy infestation by insect pest complex (Gangrade, 1976).

Soybean crop was attacked by American bollworm, *Helicoverpa armigera*; tobacco caterpillar, *Spodoptera litura*; semilooper, *Plusia signata*; hairy caterpillar, *Spilosoma oblique* and girdle beetle, *Oberea (Obereopsis) brevis*. Out of all these insect pests, attack of semilooper was severe in Yavatmal followed by Wasim, Amaravati and Akola. It devastated the crop in June - July by feeding on leaves and caused severe damage (Sohi, 2010).

Because of easy availability, high efficacy and rapid action, chemical insecticides are preferred in insect pest control, but indiscriminate use of these chemicals resulted in numbers of problems *viz.,* the development of insect resistance to insecticides, induced resurgence of other insect pests, environmental pollution and toxicity to non-target animals (Dodia *et al.,* 2008).

An attractive alternative method to chemical pesticides is the microbial biocontrol (MBCAs) agents. They are the natural enemies devastating the pest population with no hazardous effects on human health and the environment. Entomopathogenic fungi occupy important position among all the biocontrol agents, because of their route of pathogenicity, broad host range and ability to control both sap sucking as well as insect pest with chewing mouthparts (Khan *et al.,* 2012).

In 2001, the entomopathogenic fungus *Nomuraea rileyi* was observed in population of soybean green semilooper, *Chrysodeixis acuta* in the humid southeastern plain zone of Rajasthan, India. The fungus caused 100% mortality of the larvae of *C.acuta* (Gupta, 2003).

Biopesticides derived from entomophagus bacteria and fungi can help in solving ecological problems resulting from misuse of toxic pesticides with effective control of pest population. By considering the benefits and potential of entomopathogenic fungi, an experiment was conducted to evaluate the efficacy of entomopathogenic fungi under laboratory condition on the larvae of *P.signata*.

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MATERIALS AND METHODS

The present study on laboratory evaluation of entomopathogenic fungi against *Plusia signata* was undertaken in the Insectary premises of Entomology Section, College of Agriculture, Nagpur during the *kharif* season of 2010.

On the basis of monitoring, when peak larval population of the *Plusia signata* was observed in untreated field of soybean, 2nd/3rd instar healthy larvae were collected in plastic containers. These field collected larvae were subjected to bioassay to determine the LC_{50} and LC_{90} as well as LT_{50} and LT_{90}.

The field doses of the fungal suspension were decided as per the LC_{90} value, as 1×10^8 spores ml^{-1} reported earlier for *M. anisopliae* (Wadyalkar, 2001) and 1×10^7 spores ml^{-1} for *B. bassiana* (Easwaramoorthy and Santhalakshmi, 1993). Two higher doses than LC_{90} were considered for laboratory evaluation along with lower doses to have four concentrations of each bioagent alongwith one unprotected control.

The treatment details are as given below. These treatments were replicated thrice.

T_1 *M. anisopliae* (1×10^7 spores ml^{-1})
T_2 *M. anisopliae* (1×10^8 spores ml^{-1})
T_3 *M. anisopliae* (1×10^9 spores ml^{-1})
T_4 *M. anisopliae* (1×10^{10} spores ml^{-1})
T_5 *B.bassiana* (1×10^7 spores ml^{-1})
T_6 *B.bassiana* (1×10^8 spores ml^{-1})
T_7 *B. bassiana* (1×10^9 spores ml^{-1})
T_8 *B. bassiana* (1×10^{10} spores ml^{-1})
T_9 Control (Water spray)

Culture of both the entomopathogenic fungi were obtained from Pathology Section, College of agriculture, Nagpur.

For standardization of the fungal suspension, 20 g each inoculated medium with respective fungus was mixed in 70 ml sterilized distilled water in a separate flask. Thus, the mixture prepared was kept in rotary mixer for homogenization. The homogenate was screened through muslin cloth followed by Whatman No.1 filter paper. Final volume of 100 ml as a stock solution (1×10^{10} spores ml^{-1}) was made by adding sufficient quantity of sterilized distilled water.

The fungal suspension containing the spores of *M. anisopliae and B. bassiana* were obtained from stock solution, diluted separately upto 1:1000; with serial dilution method to obtain desired concentration by observing under phase contrast microscope for spore count with the help of Neaubaur's haemocytometer.

A set of 30 larvae of *P. signata* was kept separately in petriplate for each of the nine treatments. Then, these larvae were topically treated with 2 ml fungal suspension of desired concentration with the help of Potter's tower. Distilled water was used for spraying the larvae in an untreated control. The sprayed petridish containing the insects were allowed to dry for 5 minutes. Then, these treated larvae were transferred to plastic vials containing natural diet (soybean leaves) daily and incubated at 25 ± 1ºC temperature (Khan *et al.,*1993). The larval body showed white mycelial growth i.e. disease symptom of white muscardine fungus in case of *B. bassiana* and greenish mycelial growth i.e. disease symptom of green muscardine fungus in case of *M. aniospliae* within few days.

Observations on larval population reduction of *Plusia signata* :

The larval mortality was recorded on 3rd, 5th, 7th and 10th day from initiation of treatment, regarding development of disease. The moribund larvae, not giving any response were also considered as dead. From these observations, per cent larval mortality was calculated. Mortality was corrected by using Abbott's formula (Abbott, 1925 and Phokela *et al.,* 1997).

$$\text{Per cent larval Mortality} = \frac{\text{Pre- treatment population} - \text{post- treatment population}}{\text{Pre - treatment population}} \times 100$$

$$\text{Corrected mortality} = \frac{T - C \times 100}{100 - C}$$

Where,

T - % mortality in the treatment
C - % mortality in the control

The mortality data, thus, obtained was subjected to probit analysis (Finney, 1964) and the LC_{50}, LC_{90}, LT_{50} and LT_{90} values were worked out.

Table 1. Probit analysis results on LC_{50} and LC_{90} values against *P. signata*

Treatments	LC_{50} spore ml^{-1}	Fiducial limit	LC_{90} spore ml^{-1}	Fiducial limit	Chi Square (Cal.)
M. anisopliae	7.0×10^4	1×10^4 to 8.0×10^9	2.5×10^{11}	6.8×10^9 to 1.0×10^{15}	0.034
B. bassiana	6.0×10^4	1×10^4 to 1.1×10^8	7.6×10^8	2.1×10^8 to 9.3×10^9	0.098

Table 2. Probit analysis result on LT_{50} and LT_{90} values against *P. signata*

Treatment	LT_{50} (Days)	Fiducial limit	LT_{90} (Days)	Fiducial limit	Chi square(cal.)
T_1–*M.anisopliae*@10^7 spores ml^{-1}	5.72	5.08 to 6.43	16.65	13.02 to 25.04	0.870
T_2–*M.anisopliae*@10^8 spores ml^{-1}	5.25	4.63 to 5.87	15.03	11.98 to 21.80	0.987
T_3–*M.anisopliae*@10^9 spores ml^{-1}	4.94	4.33 to 5.33	14.19	11.40 to 21.80	1.447
T_4–*M.anisopliae*@10^{10}spores ml^{-1}	4.72	4.16 to 5.26	12.64	10.44 to 17.09	2.251
T_5 – *B.bassiana*@10^7 spores ml^{-1}	5.43	4.83 to 6.07	15.20	12.15 to 21.87	0.758
T_6 – *B.bassiana*@10^8 spores ml^{-1}	4.86	4.28 to 5.42	13.39	10.92 to 18.55	1.640
T_7 – *B.bassiana*@10^9 spores ml^{-1}	4.52	4.00 to 5.00	11.16	9.47 to 14.32	3.787
T_8 – *B.bassiana*@10^{10} spores ml^{-1}	4.14	3.67 to 4.57	9.43	8.22 to 11.51	5.159

RESULTS AND DISCUSSION

LC_{50} and LC_{90} of entomopathogenic fungi :

The data presented in table 1 revealed that the LC_{50} and LC_{90} of *B. bassiana* against *P. signata* were 6 x 10^4 spore ml^{-1} and 7.6 x 10^8 spore ml^{-1} respectively. The LC $_{50}$ and LC $_{90}$ value of *M. aniospliae* against the same pest were 7.0 x 10^4 spore ml^{-1} and 2.5 x 10^{11} spore ml^{-1}. These results indicate that *B. bassiana* was more effective than *M. anisopliae.*

Kencharaddi and Jayaramaiah (1997) inoculated the larvae of *Adisura atkinsoni* and *Heliothis armigera* with entomopathogenic fungi *B. bassiana* and *M. anisopliae.* The LC_{50} value of *B. bassiana* was found to be 2.07 x 10^2 , 2.13 x 10^4 and 1.39 x 10^5 against 1^{st}, 3^{rd} and 5^{th} instar larvae of *A. atkinsoni* respectively. While LC_{50} value of *M. anisopliae* was found as 1.96 x 10^3, 1.22 x 10^4 and 1.21 x 10^7 against same instar larvae of *A. atkinsoni* respectively.

In case of *H. armigera,* LC_{50} value of *B. bassiana* was recorded as 4.75 x 10^2, 2.34 x 10^4 and 1.40 x 10^8. On the other hand LC_{50} value of *M. anisopliae* was found as 6.07 x 10^4 , 6.15 x 10^7 and 1.10 x 10^8 against against 1^{st}, 3^{rd} and 5^{th} instar larvae of *H. armigera* respectively.

LT_{50} and LT_{90} of entomopathogenic fungi :

The data regarding LT_{50} and LT_{90} against *P. signata* are given in table 2 which revealed that, LT_{50} of *B. bassiana* at different concentrations ranging from 1x10^{10} to 1x10^7 spores ml^{-1} was recorded as 4.14, 4.52, 4.86 and 5.43 days respectively. On the other hand LT_{90} was recorded as 9.43, 11.16, 13.39 and 15.20 days respectively at these concentrations. While LT_{50} of *M. anisopliae* was recorded at different concentrations ranging from 1x10^{10} to 1x10^7 spores ml^{-1} as 4.72, 4.94, 5.25 and 5.72 as well as LT_{90} as 12.64, 14.19, 15.03 and 16.65 days respectively.

Nandanwar (2009) carried out studies on efficacy of some entomopathogenic fungi against *P. xylostella* and reported LT_{50} of *B. bassiana* at different concentrations ranging from 10^8 to 10^5 spores ml^{-1} as 4.375, 3.515, 3.499 and 3.111 days respectively. Whereas, LT_{50} for *M. anisopliae* recorded at concentration ranging from 10^5 to 10^8 spores ml^{-1} as 3.531, 3.147, 2.930 and 2.741 days, respectively.

Fungal concentration is directly proportional with mortality, as the concentration increases, the mortality increases and vice versa. On the other hand lethal time is inversely proportional with concentration i.e. when concentration increases lethal time decreases and vice versa.

From these results, it could be inferred that although both the entomophagous fungi were effective, *B. bassiana* was more effective than *M. anisopliae* against *P. signata* with the lower fungal concentration required to 50% larval mortality as compared to *M. anisopliae*.

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SIMPLIFIED TRIPLE TEST CROSS ANALYSIS IN LINSEED (*Linum usitatissimum* L.)

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ABSTRACT

A field experiment was conducted during 2012-13 at All India Coordinated Research Project on Linseed, Dr.P.D.K.V, Nagpur, with thirty two hybrids produced by line x tester mating design 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 to study genetics of yield contributing traits. Observations were recorded 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}. Analysis of variance revealed significant differences among progenies. The epistasis was detected for all the traits. Additive and dominance components were significant for all traits with preponderance of additive component. Correlation coefficient between sums and differences was non-significant for all traits except days to maturity. The parents *viz.*, EC-1392, GS-234 and F-14 with maximum additive genetic component identified to be useful for improvement of economic traits through hybridization programme.

(Key words: Linseed, epistasis, yield contributing traits)

INTRODUCTION

The success of plant breeding operations relies heavily on the nature and extent of genetic components of variation. Thus, it is imperative to have reliable estimates of such components in order to formulate an efficient breeding strategy. However, the estimation of these components gets significantly biased in presence of epistasis, which leads to erroneous estimation of genetic parameters and expected genetic grain under selection. Since most of economic traits in crop plants are governed by polygene, therefore it is hard to imagine a situation where epistasis can be thought of being absent. TTC (Triple test cross) analysis and its modifications are available since 1968 which detect epistasis and estimate additive and dominance components of genetic variation in self pollinating crops. Therefore, the present study was undertaken to get an insight into the genetic factors underlying expression of quantitative traits.

MATERIALS AND METHODS

Experimental material for the present study consisted of twelve linseed genotypes involving four female parents, NL-97, PKVNL-260, Padmini, Neelum and eight male parents viz., A-95B, EC-1392, EC-1424, IC-15888, GS-234, JRF-4, JRF-5, F-14 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 statistical and biometrical analysis was performed as per the methodology suggested by Panse and Sukhatme (1954) for analysis of variance and for Simplified triple test cross analysis by Jinks *et al.* (1969).

RESULTS AND DISCUSSION

The analysis of variance (Table 1) revealed significant mean squares due to parents (both males and females) and crosses indicating that the inbred lines used in present study were diverse and that significant differences were present in progenies for all traits. Significant mean squares due to parents v/s crosses were recorded for all traits studied except in case of number of branches plant^{-1} and plant height. The analysis of variance for detection of epistasis (Table 2) revealed significant overall epistasis L1i + L2i – Pi for all traits. Singh *et al*. (2006) reported epistasis to contribute significantly for number of branches plant^{-1}, number of capsules plant^{-1} and seed yield plant^{-1}. In the present study the estimates of individual line contributing to the epistatic comparison were presented in table 3. The maximum epistatic variation was contributed by the parent GS-234 for days to 50%flowering, number of branches

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Table 1. Analysis of variance for yield and its component traits of 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 (g)	Seed yield plant^{-1} (g)
Replication	1	6.01	13.92	56.16	0.76	25.32	0.01	0.52
Genotypes	43	37.71**	11.21**	226.59**	1.46**	585.59**	3.65**	3.31**
Parents	11	46.68**	15.58**	390.06**	2.34**	442.18**	7.57**	0.80**
Crosses	31	24.92**	8.95**	175.61**	1.18**	437.38**	1.90**	3.20**
Parents vs. Crosses	1	335.68**	33.25**	8.60	0.40	6757.47**	14.93**	34.07**
	43	2.62	3.80	20.94	0.26	22.64	0.20	0.18

*Significant at 5% ** Significant at 1%

Table 2. Analysis of variance for epistasis, sums and differences for yield and its component traits 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 (g)	Seed yield plant^{-1} (g)
Epistasis ($\overline{L1}$i + $\overline{L2}$i - Pi)	7	45.04**	28.28*	547.81**	1.73*	838.83**	4.67**	3.68**
Sums ($\overline{L1}$i+$\overline{L2}$i)	7	51.28**	24.75**	561.50**	1.12*	833.27**	3.53**	5.29**
Differences ($\overline{L1}$i-$\overline{L2}$i)	7	3.53	4.53	44.39**	0.70	67.45*	3.58**	1.17**

Table 3. Estimation of individual line (Pi) contribution to the epistasis comparison (L1i + L2i – Pi) for different characters

Sr. no	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)
1	A-95B	39.50	101.00	47.00	1.30	57.50	10.00	1.35
2	EC-1392	51.00	113.50	95.30*	4.40*	132.70	8.70	6.19
3	EC-1424	46.50	109.00	67.30	3.20	98.00	9.40	6.50
4	GS-234	64.50*	118.00	93.35	5.90	145.20*	7.25	9.46*
5	IC-15888	40.00	113.50	38.35	4.40*	93.20	7.30	4.64
6	JRF-4	48.50	114.00	15.20	3.90	56.00	11.30	4.97
7	JRF-5	47.50	114.00	51.35	1.40	58.05	13.95*	4.17
8	F-14	56.00	123.50*	85.35	4.70	118.70	13.90	6.75

*Maximum epistatic parent

Table 4. Estimates of additive and dominance components, degree of dominance, r(sums and differences) for yield and its traits in linseed

Parameters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)
Additive (D)	46.68	18.5	546.7	0.95	802.62	3.47	4.96
Dominance (H)	-1.18	2.32	38.24	0.18	55.1	3.40	1.01
Degree of dominance	-0.16	0.35	0.26	0.43	0.26	0.99	0.45
r(sums &difference)	-0.43	-0.76*	-0.26	0.68	0.01	-0.6	0.24

*Significant at 5% ** Significant at 1%

Table 5. Estimation of individual line (Pi) contribution to the additive component ($\overline{L1i} + \overline{L2i}$) for different characters

Sr. No.	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches plant^{-1}	Number of capsules plant^{-1}	1000 seed weight (g)	Seed yield plant^{-1} (g)
1	A-95B	106.0	223.5	109.5	7.1	132.15	15.95	4.44
2	EC-1392	109.5	229.5	164.15*	8.7	189.55	18.20	9.39
3	EC-1424	103.0	224.0	105.8	8.0	160.15	17.40	9.25
4	GS-234	118.5	231.0	139.2	9.9*	209.50*	17.85	12.54*
5	IC-15888	101.5	230.5	100.85	9.4	173.85	17.30	8.07
6	JRF-4	114.0	231.0	106.35	9.9*	128.00	17.00	7.25
7	JRF-5	112.5	231.5	121.2	7.5	137.70	19.40	7.47
8	F 14	121.5*	239.5*	150.35	8.5	155.00	22.10*	7.83

*Maximum additive genetic component parent plant^{-1}, number of capsules plant^{-1} and seed yield plant^{-1}, parent F-14 showed maximum epistatic variation for days to maturity. The parent EC-1392 for plant height and parent JRF-5 for 1000 seed weight recorded maximum epistatic variation.

The estimation of additive and dominance genetic components of variance were based on analysis of sums and differences (Table 2). Both sums and differences i.e. L1i+L2i and L1i-L2i were significant for all traits except plant height and number of branches plant^{-1} for which L1i+L2i only was significant. However, in all cases, L1i+L2i was relatively greater in magnitude as compared to corresponding L1i-L2i. Reddy (2008) also reported that additive genetic component was higher than dominant genetic component for the traits like plant height, number of branches plant^{-1} and seed yield plant^{-1}. Additive component (Table 4) was observed for all traits whereas dominance component was observed for all traits except number of branches plant^{-1} and plant height. In all cases, additive component was greater in magnitude as compared to corresponding dominance component. The maximum additive genetic component (Table 5) was contributed by the parent GS-234 for number of branches plant^{-1}, number of capsules plant^{-1} and seed yield plant^{-1}. The parent F-14 recorded maximum additive genetic component for days to 50% flowering, days to maturity and 1000 seed weight. For plant height EC-1392 showed high additive genetic component.

The degree of dominance was in the range of partial dominance for all traits. The correlation coefficient of sums and differences was non-significant for all traits except days to maturity. However, since the results pertain to single location and are not ignore epistasis x location component, therefore, studies need to be conducted across environments (locations and years) for better elucidation of genetic systems governing yield components.

The additive component was preponderant for all traits in this study. Sood *et al*. (2007) and Jadhav *et al*. (2011) reported that the preponderance of additive component for expression of seed yield and other traits indicate the amenability of these traits to improvement through simple selection procedure. The perusal of table 4 reveals non-significant correlation coefficients due to sums and differences, which depict the direction of dominance. Thus, positive and negative genes are equally distributed among the parents used in the present study. The additive genetic component is predominantly exploited in varietal improvement programme in linseed. Therefore, the parents with high additive genetic component may be utilized in linseed breeding programme. The parents GS-234, EC-1392 and F-14 with high additive genetic component may be utilized in linseed breeding programme. But in the present study as both additive and dominance components play important role in the inheritance of characters under study. The presence of additive gene action for most of the traits including seed yield plant^{-1} implies that early generation selection may be useful for these traits. However, for the traits showing both additive and dominance components of variants, heterosis breeding may be useful but chances of exploiting hybrid vigour through hybrid vaieties in linseed due to autogamous nature are bleak at present. The autogamous nature of crop and absence of genetic cytoplasmic male sterility warrants diallele selective mating/biparental mating or recurrent selection for its improvement. The parents *viz*., EC-1392, GS-234 and F-14 with maximum additive genetic component identified to be useful for improvement of economic traits through hybridization programme.

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RESPONSE OF ZINC, IRON AND BIOFERTILIZERS ON NODULATION AND YIELD OF BLACKGRAM (*Vigna mungo* (L.) Hepper)

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ABSTRACT

A field experiment was conducted to study the response of zinc, iron and biofertilizers on nodulaion and yield of blackgram during the *kharif* season of 2012-2013 at Plant Pathology Section, College of Agriculture , Nagpur. The experiment was laid out in Factorial Randomized Block Design with three main factors ($ZnSO_4$, $FeSO_4$, $ZnSO_4$ + $FeSO_4$) and four sub-factors (*Rhizobium,* PSB, *Rhizobium* + PSB, control). Results of the investigation showed that the number of nodules plant^{-1}, nodules dry weight, shoot length and root length, ancillary observation and grain yield were found to be higher in treatment combination $ZnSO_4$ + $FeSO_4$ + *Rhizobium* + PSB. In case of micronutrient it is higher in treatment of $ZnSO_4$ and biofertilizers it is higher in the treatment of *Rhizobium.*

(Key words: Micronutrients, biofertilizers, yield attributes, yield)

INTRODUCTION

Blackgram (*Vigna mungo*) is the third important pulse crop in India. It is the annual pulse crop and native to Central Asia. It is also extensively grown in West Indies, Japan and other tropical and subtropical countries. Blackgram seeds are highly nutritious containing 26.2 per cent protein, 1.2 per cent fat and 56.6 per cent carbohydrate. It is rich in minerals having 185 mg calcium, 8.7 mg iron, and 345 mg of phosphorus. It also contains 0.42 mg vitamin B1, 0.37 mg vitamin B2 and 2.0 mg niacin. (Anonymous, 2006).

It has calorific value of 350 calories 100^{-1} g of edible protein. Among pulse crops blackgram is the second most important crop grown throughout Maharashtra. Maharashtra is the largest producer accounting nearly 23.36 % of total production. In India it is grown on an area of 31 lakh hectares with annual production of 14 lakh tones. In Maharashtra it is grown on area of 5.75 lakh hectares with annual production of 3.27 lakh tones and productivity of 568.70 kg ha^{-1}. (Anonymous, 2011).

Every micronutrient has certain specific role to play in the plant system. Their presence in optimum concentration is must for the plants to complete its life cycle. Thus, one essential nutrient can't take the place of another and the deficiency of one can be only corrected by applying through biofertilizer or by taking such step which will improve nutrient availability of that essential nutrient to crop. Zinc is essential for synthesis of tryptophan, a precursor of Indole-acetic acid (IAA). It plays an important role in synthesis of nucleic acid and protein. It is required for the activity of various types of enzymes, including dehydrogenase aldolase, isomerases and RNA and DNA polymerases. Iron has been regarded as a necessary element for synthesis and maintenance of chlorophyll and related photosynthesis activity in plants. It plays a key role in plant nutrition. It acts as catalyst or oxygen carrier in oxidation reduction processes and in the respiration of living cell. It is also a constituent of nitrogenous and ferrodoxin enzymes. Biofertilizers are used on commercial scale by the farmers. Due to the deficiency of Zn and Fe in soil, the productivity of the crop is decreasing. Its use in the production will help to increase the soil health and productivity of the crop. Looking into the above view, an experiment was planned with an objective to know the effect of Zn and Fe with biofertilizers combination on nodulation and yield of blackgram.

MATERIALS AND METHODS

Seeds of blackgram variety TAU-1 were obtained from Botany Research field, College of Agriculture, Nagpur during *kharif* season 2012-2013. The carrier based inoculants of *Rhizobium* and Phosphate Solubilizing Bacterial (PSB) culture were obtained from Plant Pathology Section, College of Agriculture, Nagpur. The experiment was laid out in Factorial Randomized Block Design. The treatments consisted of three main factorial treatments of micronutrients viz., $ZnSO_4$ @ 2 g kg^{-1} seed, $FeSO_4$ @ 2 g kg^{-1} seed and combined application of $ZnSO_4$ and $FeSO_4$ both @ 2 g kg^{-1} and four sub treatments of biofertilizers viz., *Rhizobium* @ 20 g kg^{-1} seed, PSB @ 20 g kg^{-1} seed, combination of *Rhizobium* and PSB each @ 20 g kg^{-1}.The seeds of blackgram variety TAU-1 were first treated with micronutrients as per

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main treatments and then biofertilizers as per treatments. The seeds were sown in the plotted field with spacing of 30 x 10 cm between rows and plants. The plants were sampled at 25 and 45 DAS. From each net plot, five plants were randomly selected for recording the observations on root nodules plant^{-1}, nodule dry weight, shoot length (cm) and root length (cm). Number of pods plant^{-1}, seeds pod^{-1}, 100 grain weight and grain yield were recorded at harvest.

RESULTS AND DISCUSSION

Effect of micronutrients and biofertilizers on number of nodules plant^{-1}

Effect of micronutrients :

The data presented in table 1 shows that, the nodules plant^{-1} recorded at 25 and 45 days after sowing were significantly influenced by various micronutrient levels over uninoculated control.

The seed treatment with micronutrients increased the nodulation at 25 DAS and then decreased at 45 DAS. At 25 DAS, the treatment $ZnSO_4$ + $FeSO_4$ gave significantly maximum number of nodules (24.62 nodules plant^{-1}) which was statistically at par with $ZnSO_4$ (24.16 nodules plant^{-1}) but significantly superior over $FeSO_4$ (23.63 nodules plant^{-1}). Dash *et al.* (2005) reported that application of 5 kg Zn ha^{-1} along with crop residue 5 t ha^{-1} + FYM 5 t ha^{-1} recorded maximum number of root nodules plant^{-1} at 30,60 and 90 DAS (8.41,39.86 and 14.19 plant^{-1}). There was substantial decrease in root nodules at 90 DAS. However, there was substantial decrease in nodulation under all micronutrient treatments at 45 DAS.

Effect of biofertilizers :

The data presented in table 1 revealed that the number of nodules plant^{-1} was significantly influenced by biofertilizers both at 25 and 45 DAS and significantly more nodules were obtained in these treatments over untreated control.

At 25 DAS, seed treatment with *Rhizobium* (20 g kg^{-1}) and PSB (20 g kg^{-1}) together increased the nodulation to the maximum (28.20 nodules plant^{-1}) at 25 DAS followed by *Rhizobium* (24.87) and PSB (22.97 nodules plant^{-1}), having significant difference amongst them. However, as in case of micronutrients nodulation was decreased at 45 DAS maintaining the same trend. Selvakumar *et al*. (2009) showed that biofertilizer had significant effects on number of nodules plant^{-1} and Nitu and Haider (2009) reported that nodules appeared at 7 DAS and reached maximum number after 21 DAS. Equal number of nodules was observed from 21-42 DAS and then after 42 days nodules declined. Thus, present revelations conform these findings.

Interaction effect :

The interaction effect due to seed inoculation of biofertilizers and micronutrient was found to be significant on number of nodules^{-1}plant at 25 and 45 DAS. Seed treatment with $ZnSO_4$ (2 g kg^{-1}) + $FeSO_4$ (2 g kg^{-1}) and combined inoculation with *Rhizobium* +PSB had produced higher nodulation at 25 days (28.63 nodules plant^{-1}) but nodulation decreased (15.66 nodules plant^{-1}) at 45 DAS with same trend. It was followed by combined interaction of $ZnSO_4$ and *Rhizobium* + PSB (28.30) and $FeSO_4$ and *Rhizobium* + PSB (27.66 nodules plant^{-1}). All these interactions were at par.

Effect of micronutrients and biofertilizers on nodule dry weight plant^{-1}

Effect of micronutrients :

It is revealed from the data that there were significant differences due to various micronutrient treatments at 25 and 45 DAS. Maximum dry weight of nodule was registered by the application of $ZnSO_4$ and $FeSO_4$ @ 2 g each (23.39 mg plant^{-1}) followed by $ZnSO_4$ (21.69 mg plant^{-1}). Similar trend was noticed at 45 DAS and $ZnSO_4$ + $FeSO_4$ showed maximum nodule dry weight (8.56 mg plant^{-1}). However, there was a substantial reduction in weight at 45 DAS. Sharma and Namdeo (1999) proved highly beneficial activity of combined inoculation of *Rhizobium* + PSB on soybean

Effect of biofertilizers :

It is observed that the higher dry weight of nodule plant^{-1} was recorded by the treatment *Rhizobium* + PSB (25.98 mg plant^{-1}) at 25 DAS but there was decrease in weight at 45 DAS maintaining the same trend with *Rhizobium* + PSB showing maximum nodule dry weight (8.98 mg plant^{-1}). As the nodules disintegrate after 42 DAS, the nodule dry weight decreases at 45 DAS. Nitu and Haider (2009) reported that nodule dry weight plant^{-1} was found maximum at 42 DAS and then after 42 days the nodules declined.

Interaction effect :

The interaction effect (Table 2) due to seed inoculation of biofertilizer and micronutrient application on nodule dry weight at 25 was found to be significant. Seeds treated with $ZnSO_4$ + $FeSO_4$ @ 2 g each kg^{-1} and *Rhizobium* + PSB gave the highest nodule dry weight (27.02 mg) and it was found to be at par with interaction of *Rhizobium* + ZnSO4 (26.21 mg). At 45 DAS, the interaction effect was non-significant with reduced values of dry nodules.

Effect of micronutrients and biofertilizers on shoot length and root length of plant :
Effect of micronutrients :

At 25 DAS, the treatment $ZnSO_4$ + $FeSO_4$ gave significantly maximum shoot length and root length of plant (30.63 and 10.17 cm). However, it was followed by $FeSO_4$ (29.85 and 9.52 cm). At 45 DAS, the maximum shoot length and root length (42.31 and 21.85 cm) respectively was also recorded in the combined application $ZnSO_4$ + $FeSO_4$ and followed by $ZnSO_4$ (41.80 and 21.09 cm) respectively.

Effect of biofertilizers :

At 25 DAS treatment *Rhizobium* + PSB revealed significantly higher shoot and root length (32.81 and 11.84 cm) followed by *Rhizobium* (29.61 and 9.40 cm). However at 45 DAS the shoot and root length was found to be in increasing trend and *Rhizobium* + PSB treatment recorded maximum length (45.27 and 22.16 cm) followed by *Rhizobium* (41.58 and 21.64 cm). Pratibha *et al.* (1999) reported that there was significant increase in root length at 30 and 60 DAS (10.9 and 15.7 cm) over untreated control. Selvakumar *et al*. (2009) showed that biofertilizer had significantly effects on shoot and root length in blackgram.

Interaction effect :

Interaction effect (Table 2) due to micronutrients and biofertilizers on shoot length was found to be significant at 25 DAS. Among all the treatments, $ZnSO_4$ + $FeSO_4$ and *Rhizobium* + PSB treatment produced maximum shoot length (34.73 cm). This interaction was significantly superior over rest of the interactions and it was followed by interaction of $FeSO_4$ and *Rhizobium* + PSB (33.60 cm). However, the root length at 25 and 45 DAS and shoot length at 45 DAS were found to be non-significant.

Effect of micronutrients and biofertilizers on yield attributes :
Effect of micronutrients :

The data presented in table 3 revealed significant differences due to micronutrient levels on various yield attributes. The treatment $ZnSO_4$ + $FeSO_4$ recorded the highest number of pods (25.75 plant^{-1}) followed by $ZnSO_4$ and $FeSO_4$ (25.01 and 24.7 plant^{-1}) respectively.

Similarly number of seeds^{-1}plant was also increased in the same treatment i.e $ZnSO_4$ + $FeSO_4$ (7.99 plant^{-1}) and was at par with $ZnSO_4$ (7.86 plant^{-1}). Higher 100 grain weight (4.39 g) was also found in combined treatment of $ZnSO_4$ and $FeSO_4$ and was at par with $ZnSO_4$ (4.31 g). The protein content was maximum in $ZnSO_4$ + $FeSO_4$ (26.90%).

Effect of biofertilizers :

It would be seen from the data presented in table 3 that there were significant differences due to inoculation of biofertilizers. Among the different treatments, *Rhizobium* + PSB gave the highest number of pods^{-1}plant (27.23 plant^{-1}) and was found to be at par with *Rhizobium* (26.61 plant^{-1}). The same trend was noticed for number of seeds pod^{-1}, 100 grain weight and protein content. Balchandran and Nagarajan (2002) and Selvakumar *et al.* (2012) showed positive effect of dual inoculation of *Rhizobium* and PSB on blackgram.

Interaction effect :

The interaction effect of application of micronutrient and biofertilizer were found to be non-significant.

Table 1. Interaction effect of micronutrient and biofertilizers on number of nodule, nodule dry weight and shoot and root length at various interval

Treatments	No. of nodules $plant^{-1}$		Nodule dry weight (mg $plant^{-1}$)		Shoot length (cm)		Root length (cm)	
	25 DAS	45 DAS	25 DAS	45 DAS	25 DAS	45 DAS	25 DAS	45 DAS
Micronutrients								
$ZnSO_4$ (2g kg^{-1})	24.16	10.30	21.69	8.42	29.34	41.80	9.26	21.09
$FeSO_4$ (2g kg^{-1})	23.63	10.13	20.78	8.29	29.85	41.56	9.52	20.99
$ZnSO_4$ + $FeSO_4$ (2g kg^{-1} each)	24.62	11.11	23.39	8.56	30.63	42.31	10.17	21.85
S E ± (m)	0.220	0.146	0.212	0.054	0.150	0.112	0.094	0.177
CD (P = 0.05)	0.647	0.429	0.620	0.159	0.439	0.329	0.275	0.518
Biofertilizers								
Rhizobium (20g kg^{-1})	24.87	9.82	23.28	8.41	29.61	41.58	9.40	21.64
PSB (20g kg^{-1})	22.97	9.35	20.25	8.20	28.81	40.97	8.73	20.95
Rhizobium + PSB (20g kg^{-1} each)	28.20	13.95	25.98	8.98	32.81	45.27	11.84	22.16
Control	20.51	8.94	18.31	8.10	28.54	39.74	8.64	20.50
S E ± (m)	0.255	0.169	0.244	0.062	0.173	0.130	0.108	0.204
CD (P = 0.05)	0.746	0.495	0.717	0.184	0.508	0.381	0.317	0.599
Interaction								
S E ± (m)	0.441	0.293	0.424	0.109	0.301	0.225	0.188	0.354
CD (P = 0.05)	1.294	0.860	1.242	--	0.881	--	--	--

Table 2: Effect of interaction between micronutrients and biofertilizers for nodulation and shoot length

Treatments	Number of nodule plant^{-1}								Nodule dry weight (mg plant^{-1})				Shoot length (cm)			
	25 DAS				45 DAS				25 DAS				25 DAS			
	C1	C2	C3	Mean	C1	C2	C3	Mean	C1	C2	C3	Mean	C1	C2	C3	Mean
B1	25.26	23.63	25.73	24.87	9.80	9.59	10.06	9.82	22.35	21.29	26.21	23.28	29.80	29.06	29.96	29.61
B2	23.23	21.83	23.86	22.97	9.23	9.13	9.7	9.35	19.82	18.98	21.96	20.25	28.83	28.60	29.00	28.81
B3	28.30	27.66	28.63	28.20	13.2	12.93	15.66	13.9	26.42	24.49	27.02	25.98	30.10	33.60	34.73	32.81
B4	19.86	21.40	20.26	20.51	8.93	8.86	9.03	8.94	18.19	18.35	18.38	18.31	28.63	28.16	28.83	28.54
Mean	24.16	23.63	24.62	-	10.3	10.13	11.11	-	21.69	20.78	23.39	-	29.34	29.85	30.63	-
SE ± (m)	0.441				0.293				0.424				0.301			
CD(P= 0.05)	1.29				0.860				1.242				0.881			

Table 3: Influence of micronutrient and biofertilizers and their interaction on yield and ancillary characters of blackgram

Treatments	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 grain weight	Protein content (%)	Grain yield (kg ha^{-1})
Micronutrients					
$ZnSO_4$ (2g kg^{-1})	25.01	7.86	4.31	25.55	877
$FeSO_4$ (2g kg^{-1})	24.76	7.72	4.13	25.23	873
$ZnSO_4$ + $FeSO_4$ (2g kg^{-1} each)	25.75	7.99	4.39	26.90	894
S E ± (m)	0.250	0.078	0.047	0.179	5.95
CD (P = 0.05)	0.732	0.228	0.138	0.526	17.47
Biofertilizers					
Rhizobium (20g kg^{-1})	26.61	8.28	4.41	25.67	891
PSB (20g kg^{-1})	24.78	7.90	4.27	25.55	866
Rhizobium + PSB (20g kg^{-1} each)	27.23	8.57	4.63	26.04	947
Control	22.07	6.67	3.80	24.97	822
S E ± (m)	0.288	0.090	0.055	0.207	6.87
CD (P = 0.05)	0.846	0.265	0.161	0.607	20.17
Interaction					
S E ± (m)	0.500	0.156	0.095	0.358	11.91
CD (P = 0.05)	--	--	--	--	--

Effect of micronutrients and biofertilizers on grain yield :

Effect of micronutrients :

It is evident from the data that there were significant differences in treatments. Maximum grain yield was obtained with treatment $ZnSO_4$ + $FeSO_4$ (894 kg ha^{-1}) and this treatment was found significantly superior over all other treatments. Bothe *et al.* (2000) reported that seed inoculation with PSB significantly increased the yield (31.01 q ha^{-1}) over its no use.

Effect of biofertilizers :

It would be seen from the data furnished in table 3 that there was significant difference due to inoculation of biofertilizers. Among the different treatments the treatment *Rhizobium* + PSB gave the highest yield (947 kg ha^{-1}) which was found significantly superior over *Rhizobium* (891 kg ha^{-1}) and PSB (866 kg ha^{-1}). Shrinivas and Shaik (2002) reported that *Rhizobium* application significantly raised the seed yield from 1033 kg ha^{-1} control to 1150 kg ha^{-1} in green gram.

Interaction effect :

Interaction effects due to micronutrient and biofertilizer have been found to be non-significant.

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GROWTH, YIELD AND QUALITY OF SUMMER SESAME AS INFLUENCED BY THE FERTILIZER AND SULPHUR LEVELS

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ABSTRACT

An experiment was conducted at Agriculture College, Nagpur during *summer* season of 2011-2012. The experiment was laid out in split plot design with three fertilizer levels as main plot treatments viz., 100% RDF, 125% RDF, 150% RDF and five sulphur levels as subplot treatments viz., 0 kg S ha^{-1}, 10 kg S ha^{-1}, 20 kg S ha^{-1}, 30 kg S ha^{-1} and 40 kg S ha^{-1}. There were fifteen treatment combinations replicated three times. The soil was clayey in texture with pH 7.76 indicating slightly alkaline in reaction.Treatment 150% RDF recorded maximum and significantly higher plant height, number of branches plant^{-1}, dry matter accumulation plant^{-1}, number of capsules plant^{-1} (80.7), number of grains capsule^{-1} and seed yield plant^{-1}. Test weight was not influenced significantly. Seed yield (kg ha^{-1}) were also significantly more due to 150% RDF over 100% RDF but 125% RDF was at par with it. Oil content (%) and oil yield (kg ha^{-1}) were also significantly more due to 150% RDF over 100% RDF but 125% RDF was at par with it.

The plant height, number of branches plant^{-1} was not significantly influenced by sulphur application. Dry matter accumulation recorded highest due to 40 kg S ha^{-1} application and was at par with 30 kg S ha^{-1} and 20 kg S ha^{-1}. Application of 40 kg S ha^{-1} recorded maximum and significantly higher number of capsules plant^{-1}, number of grains capsule^{-1} and seed yield plant^{-1}. Test weight was not influenced significantly. Seed yield (kg ha^{-1}) was recorded maximum in 40 kg S ha^{-1} (471 kg ha^{-1}) and was at par with 30 kg S ha^{-1} (465 kg ha^{-1}). Oil content (%) and oil yield (kg ha^{-1}) were also significantly more due to application of 40 kg S ha^{-1} over control and 10 kg S ha^{-1}. But application of 20 kg S ha^{-1} and 30 kg S ha^{-1} were found at par with 40 kg S ha^{-1}.

Interaction effects of fertilizer levels with sulphur were found to be not significant in respect of all growth characters, yield attributes and yield of sesame.

(Key words ; Fertilizer, growth attributes, oil content, sulphur)

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important oilseed crop in the tropics as major source of high quality, unique edible oil and thus occupies premier place in farming system. India ranks first in area (29%), production (26%) and export (40%) of sesame in the world. Adoption of improved varieties and suitable crop management practices are important factors for improving 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 the objectives to study the effect of fertilizer and sulphur levels on growth, yield and quality of sesame.

MATERIALS AND METHODS

A field experiment was conducted at Agronomy Farm, College of Agriculture, Nagpur during *summer* season of 2011-2012. The experiment was laid out in split plot design with three fertilizer levels 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 kg NPK ha^{-1}) as main plot treatments and five sulphur levels 0 (Control), 10, 20, 30, 40 kg S ha^{-1} as subplot treatments with 15 treatment combinations replicated three times. The soil of experimental 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. In general, available sulphur below 10 mg kg^{-1} is said to be deficient and between 10 – 20 mg kg^{-1} said to be medium and above 20 mg kg^{-1} it is sufficient. The soil of experimental plot was deficient in available sulphur (6.02 mg kg^{-1}). During the growing season of crop the maximum temperature varied from 27.0^{o}C to 42.1^{o}C and minimum temperature ranged from 11.5^{O}C to 27.7 ^{O}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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The crop variety AKT–101 was used with spacing of 30 cm × 10 cm. Gross plot size was 3.60 m × 4.80 m and net plot size was 2.40 m × 3.60 m. The observations were taken in respect of plant height, number of branches plant^{-1} and total dry matter accumulation plant^{-1} (g). At the time of harvesting number of capsules plant^{-1}, number of seeds capsule^{-1}, seed yield plant^{-1} (g), test weight plant^{-1} (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), oil content (%) and oil yield (kg ha^{-1}) were also recorded. The harvest index was also calculated. In order to represent the plot, five plants of sesame from each net plot in every net plot were selected randomly for various biometric observations on growth and post harvest studies. The selected five plants were labeled and all biometric observations were recorded properly on them. For the observation on dry matter accumulation plant^{-1}, two representative plants from each net plot were selected and used for the observation. Oil content in seed was estimated with nuclear magnetic resonance (NMR) spectrometer and the oil yield ha^{-1} was worked out by multiplying with oil content.

RESULTS AND DISCUSSION

Effect on growth attributes :

The data pertaining to various growth attributes studied viz., mean plant height at harvest, mean number of branches plant^{-1} and mean dry matter plant^{-1} as influenced by various treatments are presented in table 1.

Effect of fertilizer levels :

The plant height at harvest was maximum and significantly more due to application of 150% RDF (37.5:37.5:0 NPK kg ha^{-1}) over 125% RDF and 100% RDF. Higher levels of nutrients might be involved in increasing number and size of cell, which ultimately increased plant height. Similar results were also obtained by Kathiresan and Dharmalingam (1999) who reported the highest plant height due to 150% RDF which was significantly higher than its lower level.

Application of 150% RDF recorded maximum number of branches plant^{-1} and was significantly superior over 125% RDF and 100% RDF. Increase in number of branches plant^{-1} was observed with the increase in fertilizer levels, which might be due to more availability of nutrients. Similar results were obtained by Purushotham *et al.* (2009) who reported that, application of 40 kg N ha^{-1} is beneficial in getting higher number of branches in sesame.

Application of 150% RDF significantly increased the total dry matter accumulation plant^{-1} over 125% RDF and 100% RDF. The increase in dry matter production might be due to more photosynthesis which might be due to more nutrient availability. The data in our present research was also supported by Kathiresan and Dharmalingam (1999) who also reported the highest dry matter production of sesame due to 150% RDF which was significantly higher than its lower level.

Effect of sulphur levels :

Application of 40 kg S ha^{-1} produced maximum number of branches and more plant height but these parameters were not significantly influenced by sulphur levels. This might be due to the fact that sulphur do not have role in producing branches.

Maximum dry matter accumulation was recorded in treatment 40 kg S ha^{-1} which was significantly superior over other treatments but 20 kg S ha^{-1} and 30 kg S ha^{-1} were found at par with this treatment. This might be due to application of sulphur improved the physiological parameters viz., crop growth rate, biomass production contributing towards stronger reproductive phase resulting into more dry matter production. The results are in line with the findings of Daury and Mandal (2005) who reported the maximum plant height in sesame due to the application of 40 kg sulphur ha^{-1}.

Interaction effect :

The interaction effect due to fertilizer and sulphur on plant height, mean number of branches plant^{-1} and mean dry matter plant^{-1} were found to be non significant.

Yield attributes :

The data pertaining to various yield attributes studied viz., number of capsules plant^{-1}, number of seeds capsule^{-1}, test weight (g) and seed yield plant^{-1} as influenced by various treatments are presented in table 1.

Effect of fertilizer levels :

Fertilizer levels influenced the number of capsules plant^{-1} significantly. Maximum number of capsules plant^{-1} were recorded in 150% RDF which was significantly superior over 100% RDF and 125% RDF. Maximum number of grains capsule^{-1} was recorded in 150% RDF which was significantly superior over 100% RDF and 125% RDF. The findings are close accordance with Singh *et al.* (2006) who also recorded more number of seeds capsule^{-1} due to 150% RDF. Test weight was not significantly influenced by fertilizer levels. Test weight was maximum in 150% RDF which was followed by 125% RDF and 100% RDF. Seed yield plant^{-1} was maximum in 150%RDF which was significantly superior over 100%RDF and at par with 125%RDF. Similar observations were recorded by Purushotham *et al.* (2009) who also observed that application of 150% RDF increased the yield in seasmum.

Effect of sulphur levels :

The 40 kg S ha^{-1} application recorded significantly higher number of capsules plant^{-1} (78.83) than control and 10 kg S ha^{-1} but was at par with 30 kg S ha^{-1} and 20 kg S ha^{-1}. The treatment 40 kg S ha^{-1} recorded maximum and significantly higher number of grains capsule^{-1} (49.62) over all other levels. Same treatment recorded higher test weight (3.04 g) but results were non significant. Seed yield (g plant^{-1}) was maximum due to 40 kg S ha^{-1} followed by 30 Kg S ha^{-1} and 20 kg S ha^{-1}. Increase in yield attributing characters and yield could be attributed to the overall improvement in growth and vigor with S application. 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 number of capsules plant^{-1} and seed yield in summer sesame. Nagavani *et al. (*2001) reported that S at 40 kg ha^{-1} had a profound influence on yield components viz., number of capsules plant^{-1}, number of seeds capsule^{-1}, test weight, seed and oil yield of sesame which support the present findings.

Interaction effect:

Interaction effects were found non-significant.

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 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. 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 found 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 enhanced seed yield. The increase in seed yield may be attributed to stimulatory effect of applied sulphur on the synthesis of protein, which in turn might have accelerated photosynthesis, improved most of the yield contributing components which ultimately might have 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

Table 1. Growth, yield attributes , oil content and yield of sesame as influenced by the fertilizer and sulphur levels

Treatments	Growth attributes at harvest			Yield attributes				Yield		Harvest index (%)	Oil (%)	Oil yield (kg ha^{-1})
	Plant height (cm)	Number of branches $plant^{-1}$	Dry matter $plant^{-1}$ (g)	No. of capsules $plant^{-1}$	No. of seeds $capsule^{-1}$	Test weight (g)	Seed yield $plant^{-1}$	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})			
Fertilizer levels												
F_1 - 100% RDF	109.1	4.16	23.3	60.96	39.26	2.81	3.66	430	1204	26.31	48.64	209.57
F_2 - 125% RDF	112.9	4.68	24.34	75.26	46.31	2.95	4.14	447	1313	25.43	48.78	218.55
F_3 - 150% RDF	119.5	5.03	26.17	80.70	51.92	2.99	4.53	463	1382	25.11	48.90	228.77
SE (m) ±	1.17	0.12	0.32	1.07	0.51	0.07	0.30	4.02	28.74	-	-	2.59
C D (P=0.05)	3.29	0.31	0.89	2.98	1.44	--	0.86	16.74	82.52	-	-	7.194
Sulphur levels												
S_0 - 0 kg S ha^{-1}	115.0	4.48	22. 5	62.63	40.66	2.75	3.73	415	1270	24.62	48.46	201.17
S_1 - 10 kg S ha^{-1}	116.0	4.56	23.24	66.81	43.75	2.84	3.98	431	1281	25.17	48.59	209.59
S_2 - 20 kg S ha^{-1}	117.8	4.60	24.16	75.86	47.09	2.95	4.12	453	1299	25.98	48.75	221.19
S_3 - 30 kg S ha^{-1}	118.0	4.65	26.71	77.40	48.08	2.99	4.28	465	1316	26.10	48.89	227.51
S_4 - 40 kg S ha^{-1}	118.2	4.83	26.41	78.83	49.62	3.05	4.43	471	1333	26.11	49.19	232.03
SE (m) ±	1.77	0.13	0.40	0.81	0.48	0.14	0.24	5.97	20.62	-	-	2.92
C D (P=0.05)	--	--	0.83	1.69	1.01	--	0.50	17.41	61.88	-	-	8.54
Interactions												
SE (m) ±	3.07	0.23	0.71	1.00	0.60	0.24	0.42	10.33	8.83	-	-	5.067
C D (P=0.05)	--	--	--	--	--	--	--	--	--	-	-	--

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 found 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.

Quality studies(Oil content and oil yield) :

Data pertaining to the oil content and oil yield of summer sesame as influenced by different treatments are presented in table 1.

Effect of fertilizer levels :

Oil percentage and oil yield were significantly influenced by fertilizer levels. Maximum oil percentage and oil yield were obtained in 150% RDF which was significantly superior over 100% RDF and at par with 125% RDF. The increased seed yield was mainly responsible for increased oil yield. Kathiresan and Dharmalingam (1999) also reported significantly more oil yield with 150% RDF over 100% RDF in summer sesamum.

Effect of sulphur levels :

Sulphur levels influenced oil content whereas oil yield was significantly differed due to different treatments. Maximum oil yield (kg ha^{-1}) was recorded due to 40 kg ha^{-1} which was at par with 30 kg ha^{-1} and 20 kg ha^{-1} and significantly superior over treatment 10 kg ha^{-1} and control. Sulphur can be identified as a key element for increasing oil yield. The increase in oil content with sulphur application might be because of role of sulphur in oil synthesis as sulphur is constituent of amino acid that play a vital role in oil synthesis. Nagavani *et al.* (2001) also found that application of sulphur up to 40 kg ha^{-1} significantly increased the oil content of sesamum. Maragatham *et al*. (2006) reported that, application of 40 kg S ha^{-1} in sesame, increased seed oil content from 47.63 (control) to 49.83%.

Interaction effect:

Interaction effects between fertilizer levels and sulphur levels were found to be non-significant.

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MORPHOLOGICAL AND BIOCHEMICAL CHARACTERIZATION OF *Azotobacter chroococcum* FROM SOILS OF DIFFERENT LOCATIONS OF NAGPUR DISTRICT

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ABSTRACT

An investigation entitled "Morphological and Biochemical characterizations of *Azotobacter chroococcum* from soils of different locations of Nagpur district" was under-taken at Plant Pathology Section. College of Agriculture, Nagpur during the year 2012-13. Out of twenty two soil samples of different locations and collected from the rhizosphere region of cultivated field crops only 12 samples could form the colonies of *Azotobacter chroococcum* on the Jensen's medium. Morphological characters viz., gram reaction, cell shape and biochemical characters viz., H2S production, gelatin liquefaction, starch hydrolysis, catalase test, KOH test, phosphate solubilization and IAA production test were carried out. All bacteria were gram -ve and rod shaped. All the tests were +ve except KOH reaction. The study revealed that 1% sucrose salt found better for carbohydrate utilization. As regards antagonist studies, AZ 8 isolate was found significantly superior for control of *Rhizoctonia solani*, AZ 21 isolate for *Sclerotium rolfsil* and AZ 1 for *Fusarium oxysporium* f. sp. ciceri.

(Key words ; *Azotobacter chroococcum*, *Rhizoctonia solani*, *Sclerotium rolfsil*, *Fusarium oxysporium* f. sp. ciceri)

INTRODUCTION

Azotobacter spp. are gram negative, aerobic, asymbiotic, free living nitrogen fixing bacteria belongs to family Azotobacteriaceae. Nitrogen fixing bacteria *Azotobacter* was discovered by Beijerinck (1901). It is a pleomorphic often motile (Polar or peritrichus flagella) non spore forming relatively large rods or even yeast like appearance, mesophilic (optimum growth temperature 30^{0}C), obligate aerobes macrocyst forming, capable of fixing atmospheric nitrogen asymbiotically and widely distributed in soil (Dobereiner, 1961).

Azotobacter chroococcum and *Azotobacter agilis* are studied by Beijerinck (1901). *Azotobacter* release ammonia into the soil. The first period of the research on the genus was marked by studies on its morphological cytological and biochemical characteristics. *Azotobacter chroococcum* happens to be the dominant inhabitant of the rhizosphere.

Azotobacter chroococcum happens to be the dominant inhabitant of the rhizosphere. It benefits plants in multiple ways which includes a) production of indole acetic acid and other auxins such as gibberllins and cytokinins which enhance root growth and aid in nutrient absorption, b) inhibition of phytopathogenic fungi through antifungal substances and c) production of siderophores which solubilize Fe*** and suppress plant pathogens through iron deprivation. (Mali and Bodhankar, 2009). In the local soils, *Azotobacter* fixes annually about 60 - 90 kg N ha^{-1} and it may be used in crop production as a substitute for absorption of mineral nitrogen fertilizers. Inoculation with *Azotobacter* increased the yield by 5-28% of wheat crops. (Milosevic *et al*., 2012). Considering the importance of *Azotobacter chroococcum* in atmospheric nitrogen fixation, a study was undertaken to derive its morphological and biochemical characters from the soils of different locations of Nagpur district.

MATERIALS AND METHODS

Collection of soil samples for isolation of *Azotobacter chroococcum*

Collection of soil samples :

In the present study, twenty two soil samples were collected from rhizosphere of cultivated field of different locations of Nagpur district (Table 1) and were processed in the laboratory for isolation. These soil samples include five each from maize and jowar, nine from cotton, two from bajra and one from rice respectively. For each soil sample collection code have been given as AZ 1 to AZ 22.

Isolation of *Azotobacter chroococcum* :

The *Azotobacter chroococcum* was isolated from soil sample collected from rhizosphere of

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Table 1. Collection of *Azotobacter chroococcum* from different locations

Sr. No.	Name of cultivator(s)	Location	Crop name	Isolation code
1.	Manoj Chalakh	Kanolibara	Maize	AZ 1
2.	Pravin Shelote	Kolar	Cotton	AZ 2
3.	Vinod Pise	Vyahad	Bajra	AZ 3
4.	Vasantrao Bahurupe	Devali	Maize	AZ 4
5.	Ramkrishna Lende	Sindhkheda	Cotton	AZ 5
6.	Shard Dofe	Ghanikhapari	Jowar	AZ 6
7.	Lomeshwar Balpande	Ladgaon	Maize	AZ 7
8.	Shripatrao Balpande	Ladgaon	Cotton	AZ 8
9.	Prabhakar Marotkar	Mohpa	Jowar	AZ 9
10.	Manohar Marotkar	Mohpa	Cotton	AZ 10
11.	Kishor Dakre	Khapari	Jowar	AZ 11
12.	Kiran Nimbalkar	Burijwada	Cotton	AZ 12
13.	College of Agriculture farm Nagpur	Nagpur (Urban)	Maize	AZ 13
14.	CICR,Nagpur	Nagpur (urban)	Cotton	AZ 14
15.	Divalu Durugvar	Sonegaon	Cotton	AZ 15
16.	Hemraj Nakhede	Gundri	Jowar	AZ 16
17.	Krishna Badule	Mushewadi	Cotton	AZ 17
18.	Subhash Parteti	Mauda	Rice	AZ 18
19.	Sudhakar Patiye	Mauda	Jowar	AZ 19
20.	Harish Pawnikar	Kalmna	Maize	AZ 20
21.	Sanjay Bhutmange	Dongarmauda	Cotton	AZ 21
22.	Jagan Bhutmange	Dongarmauda	Bajra	AZ 22

cultivated different fields by serial dilution method (Mostara *et al*., 1988). For isolation of *Azotobacter chroococcum* Jensen's nitrogen free media (Sucrose 20g, $K_2HPO_4$1.0g. $MgSO_4.7H_2O$ 0.5g, CaCO 2.0g, NaCI 0.5g, $FeSO_47H_2O$ 0.1g, Agar 15g. Distilled water 1 liter, pH7) was used. The inoculated plates were incubated at 28±2^{0}C for 3 days. The Colonies were developed and transferred in Jensen's medium slants and the pure culture so obtained was stored in BOD incubator at 4^{0}C for further investigation.

Morphological and biochemical characters of *Azotobacter chroococcum* :

Isolated from rhizopheric soils were identified based on morphological and biochemical test. All the isolates were tested for their shape, gram reaction, H_2S production, gelatin liquefaction, starch hydrolysis, catalase activity, KOH test, phosphate solubilisation and IAA production test was carried out as per standard methods (Salle, 1967).

Screening :

The isolate of *Azotobacter chroococcum* was subjected to different sugar concentrations which influence the 'N' content (Kalaygandhi *et al*., 2010). Hence, the strains were grown in varying sugar (sucrose) concentrations like 1,2,3 and 4 per cent and influence of sugar was recorded with Burk's broth for estimating nitrogen in 1 per cent sugar of Burk's broth by using kjelhdahi method (Bermner, 1960).

In Vitro antibiosis :

After screening high nitrogen fixing *Azotobacter chroococcum*, isolates were selected and studied for their antagonistic ability against three soil borne plant pathogens i.e. *Fusarium oxysporum*, *Rhizoctonia solani* and *Sclerotium rolfsil*. The bacterial isolates were screened by dual culture test as followed by Morton and Stroube, 1955. In petriplates containing 20 ml PDA medium (without antibiotics) and loopful of fresh bacterial culture was streaked at sides and fungal mycelial disk at center towards the edge of petriplates (Kapoor and Kar, 1989) and petriplates were incubated at 28±2^{0}C for 7 days. The per cent inhibition of test fungi with each bacterial isolate was calculated. The per cent growth inhibition was calculated using following formula (Vincent, 1947).

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

Where
I= Per cent inhibition
C= Growth of fungus in control (mm)
T = Growth of fungus in treatment (mm)

RESULTS AND DISCUSSION

Isolation of *Azotobacter chroococcum* :

After three days of incubation, milky whitish to brown or black colonies were obtained on Jensen's agar medium which were later picked and streaked on fresh Jensen's agar medium for pur culture and used for investigation. Out of twenty two, twelve samples were used for isolation only, because twelve samples could produce *Azotobacter chroococcum* colonies and designated as AZ1, AZ3, AZ 4, AZ 5, AZ 6, AZ 8, AZ 9, AZ 12, AZ 13, AZ 18, AZ 21 and AZ 22 respectively.

Morphological and biochemical test of *Azotobacter chroococcum* isolates :

It can be seen from table 2 that all the isolates were rod shaped and gram negative in reaction. The entire isolates exhibited positive test for H_2S production, gelatin liquefaction, starch hydrolysis, catalase test, phosphate solubilization and Indole acetic acid prodction while all the isolates showed negative test for KOH test. The isolates responded to the gram negative and were rods that produced smooth circular colonies and with brownish to blackish pigment production. This confirmed isolates as *Azotobacter chroococcum*. The biochemical tests i.e. test and indole acetic acid production test further confirmed to be *Azotobacter chroococcum*. These morphological and biochemical characters are similar with the earlier report of Ahamad *et al*. (2005) who reported that *Azotobacter* had +ve test namely gram raction, IAA production, H_2S production, catalase test and starch utilization test. Dhamangaonkar (2009) reported the potential of *Azotobacter* produce IAA and also noted +ve effect of phosphate solubilisation activity.

Screening of *Azotobacter chroococcum* isolates :

The per cent nitrogen fixed by all these isolates was determined by Micro-kjeldhal method.

These isolates were categorized into the following segment and the results are interpreted in table 3.

1. **Highly efficient :** Four isolates (AZ1, AZ 8, AZ 21 and AZ 22) having more than 0.190 mg nitrogen fixed 10 g^{-1} (1%) of sucrose consumed.
2. **Moderately efficient :** Four isolates (AZ3, AZ 12, AZ 13 and AZ 18) having 0.120 mg to 0.190 mg nitrogen fixed 10 g^{-1} (1%) of sucrose consumed.
3. **Less efficient :** Four isolates (AZ 4, AZ 5, AZ 6 and AZ 9) having less than 0.120 mg nitrogen fixed 10 g^{-1} (1%) sucrose consumed.

The data presented in table 3 indicate that there were significant differences due to various isolates on 1% sucrose solution over uninoculated control. The results were ranging from 0.046% to 0.224% N fixed mg 1% sucrose^{-1}. Out of 12 isolates, isolate no AZ 21 fixe the highest amount of N fixed 0.224 mg sucrose^{-1} concentration and was found significantly superior as compared to all other isolates except AZ 8 (0.218 N fixed mg 10 g^{-1} sucrose). However, in control it was 0.037 N fixed mg 10 g^{-1} sucrose. Thus they were categorized into highly efficient isolates 0.190 N fixed mg 10 g^{-1} sucrose (four isolates) and less efficient isolate fixed N less than 0.120 N fixed mg 10 g^{-1} sucrose (four isolates).

Effect of *Azotobacter chroococcum* on growth of *Fusarium oxysporum* f. sp. *ciceri, Sclerotium rolfsii* and *Rhizoctonia solani* at different duration *in Vitro* :

Observations on average colony diameter at 7th DAI and per cent growth inhibition were recorded. All isolates under the test showed their potentiality to check the mycelial growth of all three pathogens i.e. *Fusarium oxysporum, Sclerotium rolfsii* and *Rhizoctonia solani*.

The data presented in table 4 indicate that there were significant differences in radial mycelial growth due to various isolates over uninoculated control. Minimum radial mycelial growth was recorded by the isolate AZ 8 (68.60 mm) and it was at par with all the isolates followed by AZ 22 (70.00 mm) with per cent inhibition of 23.77 and 22.22 % on 7^{th} DAI respectively. All the four isolates produced a

Table 2. Morphological and biochemical test of Azotobacter chroococcum isolates

Characters	Reaction of isolates											
	AZ1	**AZ3**	**AZ4**	**AZ5**	**AZ6**	**AZ8**	**AZ9**	**AZ12**	**AZ13**	**AZ18**	**AZ21**	**AZ22**
Morphological properties												
Gram reaction	**-ve**	**-ve**	**-ve**	**-ve**	**-ve**	**-ve**	**-ve**	**-ve**	**-ve**	**-ve**	**-ve**	**-ve**
cell shape	**Rod**	**Rod**	**Rod**	**Rod**	**Rod**	**Rod**	**Rod**	**Rod**	**Rod**	**Rod**	**Rod**	**Rod**
Biochemical properties												
H_2S Production	+	+	+	+	+	+	+	+	+	+	+	+
Gelatin liquefaction	+	+	+	+	+	+	+	+	+	+	+	+
Starch hydrolysis	+	+	+	+	+	+	+	+	+	+	+	+
Catalase test	+	+	+	+	+	+	+	+	+	+	+	+
KOH test	-	-	-	-	-	-	-	-	-	-	-	-
Indole acetic acid production	+	+	+	+	+	+	+	+	+	+	+	+
Phosphate solubilization	+	+	+	+	+	+	+	+	+	+	+	+

'+' indicate positive test. '-' indicate negative test.

Table 3. Nitrogen fixing capacity by *Azotobacter chroococcum* isolate

Sr. No.	Number of strain isolate	N fixed (mg sucrose^{-1} conc.)
1	AZ 1	0.196
2	AZ 3	0.158
3	AZ 4	0.084
4	AZ 5	0.112
5	AZ 6	0.046
6	AZ 8	0.218
7	AZ 9	0.065
8	AZ 12	0.130
9	AZ 13	0.121
10	AZ 18	0.121
11	AZ 21	0.224
12	AZ 22	0.212
13	Control	0.037
	F Test	Sig.
	SE±(m)	0.015
	CD(P=0.05)	0.043

Table 4. Antifungal activity of *Azotobacter chrococcum* against *Fusarium oxysporum*, *Sclerotium rolfsii* and *Rhizoctonia solani*.

Sr. No.	*Azotobacter chrococcum* isolates	Radial mycelial growth (mm) DAI			Growth inhibition (%) DAI		
		Fusarium	*Sclerotium*	*Rhizoctonia*	*Fusarium*	*Sclerotium*	*Rhizoctonia*
1	AZ 1	56.0	66.6	74.6	37.77	26.00	17.11
2	AZ 8	57.6	67.0	68.6	36.00	25.55	23.77
3	AZ 21	57.3	65.3	71.3	36.33	27.44	20.77
4	AZ 22	56.3	66.3	70.0	37.44	26.33	22.22
5	Control	90.0	90.0	90.0	-	-	-
	F Test	Sig.	Sig.	Sig.			
	SE±(m)	0.578	0.495	0.60			
	CD						
	(P=0.05)	1.174	1.490	1.820			

antifungai compounds which might have inhibited the growth of *R. solani*. These results are in line with the report of Maiyappan *et al.* (2010), who reported 84.94% inhibition with *Azotobacter* strain 4. Then *Azotobacter* 1 and *Azotobacter* 3 were the next best strains showing 65,72% and 54.45% inhibition, respectively.

Similarly the antifungal activity of *Azotobacter chrococcum* was tested against *Sclerotium rolfsii* and the data are presented in table 4. The observations were recorded at various interval i.e. 3,5 and 7th DAI. It was revealed from the data that there were significant differences at all the intervals. Minimum radial mycelial growth was recorded by the isolate AZ 21 (65.30 mm) followed by AZ 22 (66.30 mm) with higher per cent inhibition of 27.44% and 26.33% respectively. All the isolates were at par with each other. AZ 8 showed less per cent growth inhibition (25.55%) at 7th DAI. These observations are in agreement with the findings of earlier workers Maareg *et al*. (2003), who reported that the substaintial control of *Sclerotium rolfsii* by microbin was observed on clay loam soils (74%) and also Maiyappan *et al*. (2010) found that the *Azotobacter* 7 strain recorded maximum inhibition against (54.04%) followed by *Azotobacter* strain 6 with (43.18%).

Also data in table 4 indicate significant differences at 3, 5 and 7th DAI on radial mycelia growth of *F. Oxysporum* f. sp. *ciceri* due to *Azotobacter chrococcum* isolates. Minimum radial mycelial growth was recorded by AZ 1 isolates (56.00 mm) followed by AZ 22 isolate (56.30 mm) with maximum per cent inhibition 37.77 and 37.44 % respectively at 7th DAI. This may be due to the antibiotic production of *Azotobacter chroococcum* in the medium. The observations recorded in the present investigation are in conformity with the findings of Maiyappan *et al*. (2010), who found that the *F. oxysporium* growth was effectively minimized by *Azotobacter* strain 5 (49.84%) followed by *Azotobacter* strain 9 (49.04%). Kapoor and Kar (1989) reported the antagonistic activity of *Azotobacter chroococcum* against *Fusarium oxysporium*. The *Azotobacter chroococcum* strains showing inhibition by 11.7 to 24.7 per cent after 7 days. The results showed that the *Azotobacter chrococcum* can play an important role in biocontrol of soil borne diseases of rhizosphere.

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FEEDING AND MANAGEMENT PRACTICES ADOPTED BY MILCH BUFFALO OWNERS UNDER FIELD CONDITION OF RAMTEK TAHSIL

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ABSTRACT

The present investigation was carried at Ramtek Tahsil of Nagpur district during the year 2012 – 13, to study the feeding and management practices adopted by milch buffalo owners under field condition. Four villages viz., Bhilewada, Chargaon, Chichala and Nagardhan were randomly selected. The information on feeding management, health and sanitation and breeding aspects were collected by contacting with 200 buffalo owners. Few scientific recommendations in feeding were adopted by majority of buffalo owners. The results reviewed that the scientific feeding practices like feeding of balanced ration at regular interval, enrichment of poor quality roughages by urea, ammoniation and molasses, feeding at least 3-5 kg green fodder, feeding of concentrate @ 50% of milk production, use of 60 g common salt, mineral mixture and mineral bricks were not adopted by majority of the (more than 75 %) buffalo owners. However, majority of the farmers belonging to the category 7-10 buffalo owners (66.66%) and 4-6 buffalo owners (58.03 %) adopted feeding of dry, green and concentrate in required proportion. 81.5%, 84.00% and 75.00% buffalo owners adopted the feeding practices like processing of roughages and concentrates before feeding, chaffing / water soaking, feeding of dry matter @ 2-2.5 kg 100^{-1} kg body wt. and inclusion of agroindustrial byproducts like tur, chunni, bran etc. Thus, the results revealed that there is wide scope of improvement in the adoption of scientific feeding practices by educating properly. Health and sanitation measures such as cleaning of utensils, cleaning of sheds, washing of udder before milking and wallowing of buffalo were adopted by 100% buffalo owners. Similarly, most of the buffalo owners (95.5%) adopted vaccination. Most of the buffalo owners (88.50%) adopted natural service method for breeding in the area of study. Only 11.50% buffalo owners adopted artificial insemination. It indicates that there is wide scope for initiating artificial insemination techniques for obtaining high milching breeds.

(**Key words**: **Scientific feeding practices, housing pattern, health and sanitation, breeding method**)

INTRODUCTION

India ranks first in population of buffalo in world (Anonymous, 2007). It is estimated that milk production in India would be 121.7 MT during the year 2012. It is further projected that by the year 2020 the milk production in India will be 168 million tons (Gandhi, 2005). In India $capita^{-1}$ consumption of milk is 214 g day^{-1} which is just short to that recommended (280 g day^{-1}) by ICMR.

The buffaloes have unique ability to utilize coarse feeds, crop residues and straw and convert them into protein rich milk and meat even under adverse agro-climate situations. Buffalo milk contains higher percentage of fat, protein and minerals (especially calcium) and it makes milk richer in nutrients. Buffalo milk contains more fat along with SNF $unit^{-1}$ volume than indigenous cow milk. It is observed that in her lifespan buffalo secretes more solids than cow assuming the number of lactation to be similar in both species. It is clear that the country buffalo secretes almost three time more fat and SNF in milk than the indigenous cows (Ganguli, 2000).

The low productivity of buffalo is mainly due to lack of proper knowledge for balanced feeding. Buffalo owners from the rural area feed their buffaloes with roughages and concentrate but they do not have consciousness about quality and quantity of feed and also do not follow proper management practices which lead the dairy business uneconomical. Keeping these in view, an attempt was made to study the feeding and management practices adopted by milch buffalo owners under field conditions of Ramtek Tahsil, Dist. Nagpur (M.S.).

MATERIALS AND METHODS

The study was carried out in Ramtek tahsil of Nagpur district during the year 2012 – 13. Four villages viz., Bhilewada, Chargaon, Chichala and Nagardhan were randomly selected. The information on feeding and management practices was obtained from the buffalo owners through personal interaction with the help of questionnaire from the villages selected for the study. The list of buffalo owners was prepared for each village with the help of Gramsevak and Livestock Development officers of Ramtek Panchayat Samiti. These Buffalo owners were contacted from each village and accordingly total buffalo owners contacted were 200 i.e. 50 buffalo owners from each village.

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The data with regards to various aspects of study such as recommended scientific feeding practices viz., feeding of balance ration, feeding of roughages and concentrates in required quantity, processing of roughages, enrichment of poor quality roughages, rate of feeding of various feeding componants (green, dry, concentrates and mineral mixture) and data on housing pattern, health and sanitation and breeding aspects were also collected. These data were tabulated carefully while tabulating the information. To study the recommended scientific feeding practices aspect, the data were further categorized on the basis of size of herd of buffalo owners in the following groups.

1. 1 – 3 Buffaloes	3. 7 – 10 Buffaloes
2. 4 – 6 Buffaloes	4. Above 10 Buffaloes

The data collected in respect of above parameters were tabulated and subjected to statistical evaluation by adopting the standard technique prescribed by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Adoption of scientific feeding practices :

Data on adoptions of recommendations regarding scientific feeding practices by various categories of buffalo owners are presented numerically in table 1.

It is revealed from the table 1 that among the scientific feeding practices, majority of the buffalo owners from all categories did not adopt many feeding practices such as feeding of balance ration at regular interval, enrichment of poor quality roughages by urea, ammoniation and molasses, feeding at least 3-5 kg green fodder, feeding of concentrate @ 50% of the milk production, use of mineral mixture and use of mineral bricks and feeding concentrate mixture @ 1 to 1.5 kg to pregnant buffaloes.

Adoption of feeding of dry and green fodder and concentrate in required proportion was done by the buffalo owners of 7-10 buffalo category (66.66%) followed by the category of 4-6 buffalo owners (58.03%). 1-3 buffalo owners (33.33%) and above 10 buffalo owners (30.76%) had low adoption on these feeding practices. Processing of roughages and concentrate before feeding, chaffing / water soaking was adopted by the 4-6 buffalo owners category (95.53%), followed by 7-10 buffalo owners (76.66%) and above 10 buffalo owners (53.84%). However, only 20% buffalo owners having 1-3 buffaloes adopted these practices. Inclusion of agroindustrial byproducts like tur, chunni, bran etc. in the feeding of buffaloes was adopted by 93.75% buffalo owners belonging to 4-6 buffaloes category, followed by 58.33% by 7-10 buffalo owners and (53.84%) by buffalo owners having more than 10 buffaloes. However, poor adoption for these practices was found by the 1-3 buffalo owners category.

Thus, regarding adoption of recommended scientific feeding practices majority of the practices were not adopted even upto 30.00% and only few practices like feeding of dry and green fodder and concentrate in required proportion, feeding of dry matter @ 2 – 2.5 kg 100^{-1} kg body wt., inclusion of agroindustrial byproducts have been adopted by majority of the farmers belonging to the category of 4-6 buffalo owners followed by 7-10 buffalo owners and above 10 buffalo owners but the buffalo owners having 1-3 buffaloes had also poor adoption of these practices. This indicates that there is wide scope to educate the buffalo owners to adopt advanced scientific feeding practices to produce quality and quantity milk. Jagdale *et al.* (2000), Kavathalkar (2002) and Aulakh *et al.* (2011) observed that adoption of scientific recommendation i.e. feeding of dairy animals were meager.

Housing management :

Data regarding housing pattern adopted by buffalo owners are presented in table 2.

It is observed from the data that 91.00% buffalo owners adopted open shed for housing their buffaloes and only 9.00% had closed shed. It was further noticed that 95.00%, 97.50%, 93.00% and 96.50% buffalo owners adopted kaccha shed, separate shed, kaccha flooring and no drain for urine respectively for housing their buffaloes and 100% buffalo owners had fully ventilated housing shed for their buffaloes. On the other hand 5.00%, 7.00%, 2.50% and 3.50% buffalo owners adopted pacca shed, parts of residence for buffalo shed, pacca flooring and pacca drain for urine to drain out respectively.

Table 1. Adoption of recommended scientific feeding practices to milch buffaloes by various sizes of herd buffalo owners in Ramtek Tahsil

Sr. No.	Recommended scientific feeding practices	1-3 buffalo owners (15)	Per cent	4-6 buffalo owners (112)	Per Cent	7-10 buffalo owners (60)	Per cent	Above 10 buffalo owners (13)	Per cent	Over All (200)	Per cent
1.	Feeding of balanced ration at regular interval	4	26.66	22	19.64	12	20.00	3	23.07	41	20.50
2.	Feeding of dry, green and conc. in required proportion	5	33.33	65	58.03	40	66.66	4	30.76	114	57.00
3.	Processing of roughages and concentrates before feeding, chaffing / water soaking	3	20.00	107	95.53	46	76.66	7	53.84	163	81.5
4.	Enrichment of poor quality roughages by Urea, ammoniation and molasses.	-	-	2	1.78	1	1.66	-	-	3	1.50
5.	Feeding at least 3-5 kg green fodder	2	13.33	15	13.39	18	26.66	5	38.46	40	20.00
6.	Feeding of dry matter @ 2-2.5 kg 100^{-1} kg, body wt.	4	26.66	111	99.10	42	70.00	11	84.61	168	84.00
7.	Inclusion of agroindustrial byproducts like tur, chunni, bran etc.	3	20.00	105	93.75	35	58.33	7	53.84	150	75.00
8.	Feeding of conc. @ 50% of milk production	2	13.33	55	49.10	10	16.66	2	15.38	69	34.50
9.	Use of 60 g common salt	3	26.66	40	35.71	10	16.66	-	-	53	26.50
	Use of mineral mixture	2	13.33	4	3.57	2	3.33	-	-	8	4.00
	Use of mineral bricks	-	-	-	-	-	-	-	-	-	-
10.	Feeding of conc. mixture @ 1 to 1.5 kg to pregnant buffalo	2	13.33	30	26.78	11	18.33	2	15.38	45	22.50

Table 2. Housing pattern adopted by selected buffalo owners (N=200)

Sr.No.	Component	Name of selected villages				Overall Total	Per cent
		Bhilewada	Chargaon	Chichala	Nagardhan		
1	Open Shed	46	43	47	46	182	91.00
	Closed Shed	4	7	3	4	18	9.00
2	Kaccha Shed	48	47	49	46	190	95.00
	Pacca Shed	2	3	1	4	10	5.00
3	Separate Shed	45	46	48	47	186	93.00
4	Kaccha Flooring (without Cement concrete)	5	4	2	3	14	7.00
	Pacca Flooring (Cement concrete)	50	50	47	48	195	97.50
5	Ventilated	-	-	3	2	5	2.50
	Non ventilated	50	50	50	50	200	100
6	Pacca drain for urine to drain out is available	2	2	-	3	7	3.50
	Drain for urine not available	48	48	50	47	193	96.50

Table 3. Health and sanitation adopted by buffalo owners (N=200)

Sr.No.	Component	Name of selected villages				Overall Total	Per cent
		Bhilewada	Chargaon	Chichala	Nagardhan		
A	Cleaning						
1	Cleaning of milking utensils	50	50	50	50	200	100
2	Cleaning of sheds	50	50	50	50	200	100
3	Washing of udder before milking	50	50	50	50	200	100
B	Health						
1	Removals of hairs regularly	48	47	46	50	191	95.50
	Not regularly	2	3	4	-	9	4.50
2	Wallowing	50	50	50	50	200	100
3	Vaccination	48	46	47	50	191	95.50
C	Breeding						
1	Natural service	44	42	45	46	177	88.50
2	Artificial Insemination	6	8	5	4	23	11.50

Thus, ideal housing pattern was not used by any of the buffalo owners and used the traditional way of housing their buffaloes**.** The housing pattern reported by Bainwad *et al.* (2007) are in conformity with the findings of present study. They also observed that Kaccha flooring adopted by 92 per cent buffalo owners. They further noticed that due to absence of pucca floor drain out not available to maximum number of buffalo owners (90.5 per cent).

Health and sanitation and breeding method management :

The data regarding health and sanitation adopted by the respondents buffalo owners are given in table 3. It is seen from the data that all the buffalo owners were careful in maintaining the highest standard of sanitation (100%) pertaining to cleaning of milking utensils, cleaning of shed and washing of udder before milking.

So far as maintaining the health of buffaloes is concerned, wallowing of buffaloes was adopted by 100% buffalo owners followed by removal of hairs regularly by 95.50% buffalo owners and vaccination also by 95.50%. However, so far as breeding method is concerned, 88.50% buffalo owners adopted breeding by natural service method and only 11.50% buffalo owners adopted artificial insemination method. It indicates that there is wide scope for improved breeds with increased milk production through artificial insemination. The results of present study are in line with the findings of Jagdale *et al*. (2000). They also noticed that washing of buffalo was adopted by cent per cent (100 per cent) buffalo owners. With regards to adoption of breeding methods, Bainwad *et al.* (2007) reported that due to availability of purchased the buffalo breeding bull all buffalo owners used natural service method of breeding and were also well aware about adoption of vaccination (95.00 per cent).

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EFFECT OF PHOSPHORUS AND SULPHUR ON GROWTH, YIELD AND ECONOMICS OF LINSEED

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ABSTRACT

A field experiment was conducted during *rabi*, 2011-12 to study the effect of phosphorus and sulphur on growth and yield economics of linseed. Application of phosphorus @ 40 kg ha^{-1} recorded the highest grain yield with improved growth parameters which was significantly superior over its lower levels. Similarly, application of sulphur @ 30 kg ha^{-1} recorded the highest grain yield with improved growth parameters which was significantly superior over its lower levels. Foliar spray of 2% DAP at flowering and capsule development recorded significantly higher grain yield with improved growth parameters as compared to no foliar spray. Application of 40 kg phosphorus ha^{-1} recorded the highest gross and net monetary return and B:C ratio(2.41) which was significantly superior over its lower levels. Application of 30 kg sulphur ha^{-1} recorded the highest gross and net monetary return and B:C ratio(2.09) which was significantly superior over its lower levels. Foliar spray of 2% DAP at flowering and capsule development recorded the highest gross and net monetary return and B:C ratio (2.05) as compared to no foliar spray. However, the effect of different interaction among the parameters tested were found to be non significant.

(Key words: Linseed, grain yield, phosphorus, sulphur)

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is an important oilseed crop of central India, locally known as jawas. It has been grown from ancient time for flax (fiber) and for seed purpose which is rich in oil. It is purely a cool season *rabi* crop.

Linseed is an important oilseed crop in India and occupies 468.0 thousand ha with the productivity of 349 kg ha^{-1}. In Maharashtra linseed is grown on 68.0 thousand ha with the productivity of 279 kg ha^{-1} which is well below national average (Anonymous, 2010). Among the nutrients, phosphorus and sulphur play important role in improving the quality and quantity of linseed (Yawalkar *et al*., 2002). Majority of cultivated area of the linseed needs fertilization for good yield as phosphorus and sulphur content in soil is low. Prasad and Prasad (2002) conducted two years field experiment on sulphur deficient soil on linseed with different sources and levels of sulphur. The highest seed yield was obtained with the application of 30 kg sulphur ha^{-1} through gypsum which was significantly superior to other sources of sulphur.

Phosphorus stimulates root development and growth in the seedling stage. It also stimulates fruit setting and seed formation (Yawalkar *et al*., 2002). Sulphur is involved in the chlorophyll formation and encourages vegetative growth. Sulphur is essential for the synthesis of certain amino acids and oils (Das, 1996). It can be called as master nutrient for oilseed production. In present crop management condition in India, intensive agriculture is necessary due to limited land resources. Therefore, to meet the requirement of growing population, it is necessary to increase the productivity of the crop and nutrient management is one of the answers to this issue. Since linseed crop is taken in the study area, the knowledge of cost, returns and its profitability will be useful for the farmers who want to substitute this crop for the traditional crop grown in the area. The findings of study would be helpful to economic management of linseed.

MATERIALS AND METHODS

A field experiment on "Effect of phosphorus and sulphur on growth, yield and economics of linseed" was carried out during *rabi* season of 2011-2012 at Agronomy Farm, College of Agriculture, Nagpur. Nagpur is located at North latitude of 20º 10' and East longitude of 79º 10' having an elevation of 321 m above MSL and has subtropical climate. Representative soil samples were taken randomly from 0-30 cm soil profile from the experimental site before sowing and were analysed for various physico-chemical properties. Soil of the experimental site was clayey in texture (clay % - 54.43) estimated by using Standard international Pipette method (Piper,1966), low in available nitrogen (198.43 kg ha^{-1}) estimated by using alkaline potassium permagnate method (Subbiah and Asija, 1956), low in available phosphorus (11.20 kg ha^{-1}) estimated by using Olsen's method (Jackson, 1967)and low in available sulphur (7.16 mg ha^{-1})

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estimated by using Turbidimetric method (Jackson, 1967) and very high in available potash (304.56 kg ha^{-1}) estimated by using flame photometer (Jackson, 1967). Organic carbon content was medium (0.55%) estimated by using Walkey and Black method (Jackson, 1967) and soil reaction was slightly alkaline (PH- 7.6) estimated by using glass electrode pH meter (Jackson, 1967). The experiment was laid out in Factorial Randomized Block Design (FRBD) with 18 treatment combinations with net plot of 2.4 m x 3.0 m. Treatment combinations consisted of three levels of phosphorus (viz., P_1-20, P_2-30 and P_3-40 kg ha^{-1}), three levels of sulphur (viz., S_1-10, S_2-20 and S_3-30 kg ha^{-1}) and two levels of foliar spray (F_0 - No foliar spray and F_1 - foliar sprays of 2% DAP once at flowering and capsule development). Seed was treated with thirum @ 3 g kg^{-1} of seed to control seed borne diseases. The sowing of linseed variety NL-260 was done by drilling method keeping 30 cm distance between the rows. Recommended dose of nitrogen *i.e.* 60 kg N ha^{-1} was applied through urea and DAP to all treatments, in two equal splits first at sowing second at flower initiation, while phosphorus was applied through DAP and sulphur was applied through elemental sulphur as per treatments at the time of sowing. One foliar spray of 2% DAP was applied at flowering and capsule development of linseed crop.

In order to represent the plot, five plants from each net plot were selected randomly and labeled properly for recording for various biometric observations i.e plant height, number of branches $plant^{-1}$, number of capsules $plant^{-1}$ of linseed at harvest. Five randomly selected separate plants from each net plot were uprooted for recording dry matter accumulation at harvest and kept in brown paper bag and labeled properly. These sample plants were first dried in sun and then in hot air oven at 105 ^{0}C. The numbers of matured capsules from five observation plants were counted at harvest and average number capsules $plant^{-1}$ was worked out. The five sample plants from each net plot were harvested and dried separately. The seeds were separated and weighted to record seed yield $plant^{-1}$. A random sample of 1000 seeds from the produce of each net plot was drawn and its weight was recorded as test weight. As per seed yield obtained from each net plot, the grain yield ha^{-1} was worked out. The weight of straw from each net plot was recorded and straw yield ha^{-1} was worked out. The total cost of cultivation was calculated considering the inputs used in each treatment with prevailing market rates. Yield of linseed was converted into money value (Rs. ha^{-1}) at the market rate and gross monetary return (Rs. ha^{-1}) was calculated. Net monetary return was calculated by subtracting the cost of cultivation from gross monetary return. The benefit : cost ratio was worked out by dividing gross monetary return with total cost of cultivation. Selling rate of linseed was considered as Rs.4000 q ha^{-1}. Selling rate of linseed straw was considered as Rs.100 q ha^{-1}.

RESULTS AND DISCUSSION

Growth attributes :

Effect of phosphorus:

Application of phosphorus at incremental dose significantly increased the plant height, number of branches $plant^{-1}$ and dry matter accumulation $plant^{-1}$. The highest values of plant height (62.52 cm), number of branches $plant^{-1}$(3.81) and dry matter accumulation $plant^{-1}$(13.11g) were recorded with application of 40 kg phosphorus ha^{-1} which was significantly superior over 30 and 20 kg phosphorus ha^{-1}. This might be due to more availability of phosphorus, which might have promoted the plant height, number of branches $plant^{-1}$ and helped in increasing dry matter accumulation $plant^{-1}$. Sune *et al.* (2006) conducted a field experiment on linseed with different levels of phosphorus and sulphur. They observed that application of every incremental level of phosphorus significantly increased the plant height, number of branches $plant^{-1}$ and dry matter accumulation in linseed. So, our results are in agreement with their results.

Effect of sulphur:

Application of different levels of sulphur significantly increased the plant height, number of branches $plant^{-1}$ and dry matter accumulation $plant^{-1}$. The highest values of plant height (56.80 cm), number of branches $plant^{-1}$(3.48) and dry matter accumulation $plant^{-1}$(11.86 g) were recorded with the application of 30 kg sulphur ha^{-1} which was significantly superior over 20 and 10 kg sulphur ha^{-1}. The significant increase in plant height with sulphur application might be attributed to direct and indirect involvement of sulphur in the photosynthetic process of plant. Jagtap (2003) conducted a field experiment on linseed with three sources and three levels of sulphur and found that maximum plant height and dry matter accumulation recorded with 30 kg sulphur ha^{-1} through gypsum, as against the lowest with control i.e. 0 kg sulphur ha^{-1}. So, our results were in confirmatory with her results.

Effect of foliar spray:

Foliar spray of 2% DAP at flowering and capsule development significantly increased the plant height (55.58cm), number of branches plant^{-1}(3.32) and dry matter plant^{-1}(11.18g) as compared to no foliar spray. This might be due to better nutrient availability through foliar spray in linseed crop. Chandrasekaran *et al.* (2008) conducted a field experiment on groundnut. The results of the experiment revealed that, 2% DAP foliar spraying at 1st flowering and 15 days thereafter recorded higher dry mater production, number of branches plant^{-1}. So, our results confirm their results.

Interaction:

The effect of different interactions among the parameters tested were found to be non significant.

Yield attributes :

Effect of phosphorus:

Application of phosphorus at incremental levels significantly increased various yield contributing characters such as number of capsules plant^{-1}, test weight, seed yield plant^{-1}and seed and straw yield ha^{-1}. The highest values of number of capsules plant^{-1} (31.12), test weight (8.18 g), seed yield (8.72 q ha^{-1}) and straw yield (28.84 q ha^{-1}) were recorded with the application of 40 kg phosphorus ha^{-1} which was significantly superior over 30 and 20 kg phosphorus ha^{-1}. This might be because of vigorous growth of crop due to availability of phosphorus leading to increase in number of capsules plant^{-1} and improve seed formation which ultimately reflected as increase in seed yield plant^{-1}. Increase in yield attributes with each increase in the levels of phosphorus was also reported by Sune *et al.* (2006). So, our results confirm their results.

Effect of sulphur:

Application of 30 kg S ha^{-1} also recorded the highest values of yield contributing parameters like number of capsules plant^{-1}(27.97), seed yield (7.50 q ha^{-1}) and straw yield (25.86 q ha^{-1}) which was significantly superior over 10 and 20 kg sulphur ha^{-1}. This might be because of better growth of plant due to availability of sulphur leading to increased number of capsules plant^{-1} as seed yield is directly related to the growth and yield attributes. Increase in yield attributes with each increase in the levels of sulphur was also reported Sune *et al.* (2006). So, our results support their results. However, sulphur levels did not register any significant effect on the test weight of linseed.

Effect of foliar spray:

2% DAP as a foliar spray at flowering and capsule development recorded the highest values of yield contributing parameters like number of capsule plant^{-1}(27.53), test weight (7.50 g), seed yield (7.12 q ha^{-1}) and straw yield (24.77 q ha^{-1}). This might be due to better growth of plant as a result of rapid and timely availability of nutrients through foliar spray, which might have helped in higher metabolic activity, and improved growth and yield parameters, which ultimately reflected in increased yield. Raju *et al.* (2008) conducted an experiment on rainfed cotton. They found that foliar application of 2% DAP, produced 10 per cent more seed cotton yield and 7 per cent higher number of bolls over control.

Interaction:

The effect of different interactions among the parameters tested were found to be non significant in case of yield attributes.

Economics of linseed :

Effect of phosphorus:

The highest gross and net monetary return of Rs. 38783 and 22689 ha^{-1} respectively, were recorded with the application of 40 kg phosphorus ha^{-1} which was significantly superior over application of 30 and 20 kg phosphorus ha^{-1}. Increase in net and gross monetary return is due to significant increase in the economic yield of linseed with each increasing level of phosphorus. Also, the highest B:C ratio of 2.41 was recorded with the application of 40 kg phosphorus ha^{-1} followed by application of 30 kg phosphorus ha^{-1} (2.00) and 20 kg phosphorus ha^{-1} (1.55). Sune *et al.* (2006) found that application of 40 kg phosphorus ha^{-1} recorded the highest B:C ratio (3.92) while the lowest B:C ratio (3.56) was observed with the application of 20 kg phosphorus ha^{-1}. So, our results confirm their results.

Table 1. Growth attributes and yield attributes as influenced by various treatments

Treatments	Height (cm)	Number of branches plant^{-1}	Dry matter plant^{-1} (g)	Number of capsules plant^{-1}	Test weight (g)	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})
Phosphorus levels (P)							
P_1 (20 kg ha^{-1})	46.23	2.71	8.88	23.01	5.75	5.12	19.37
P_2 (30 kg ha^{-1})	54.64	3.23	10.94	27.17	7.00	6.93	23.99
P_3 (40 kg ha^{-1})	62.52	3.81	13.11	31.12	8.18	8.72	28.84
SE (m) ±	0.87	0.05	0.15	0.30	0.09	0.14	0.57
CD at 5%	2.50	0.13	0.45	0.87	0.26	0.40	1.64
Sulphur levels (S)							
S_1 (10 kg ha^{-1})	52.22	3.03	10.13	26.13	6.86	6.34	22.56
S_2 (20 kg ha^{-1})	54.37	3.25	10.94	27.20	6.98	6.94	24.08
S_3 (30 kg ha^{-1})	56.80	3.48	11.86	27.97	7.09	7.50	25.86
SE (m) ±	0.87	0.05	0.15	0.30	0.09	0.14	0.57
CD at 5%	2.50	0.13	0.45	0.87	-	0.40	1.64
Foliar spray of 2% DAP at flowering and capsule development (F)							
F_1 (Two foliar sprays)	53.35	3.19	10.77	26.67	6.45	6.72	23.36
F_0 (No foliar spray)	55.58	3.32	11.18	27.53	7.50	7.12	24.77
SE (m) ±	0.71	0.04	0.13	0.24	0.07	0.11	0.46
CD at 5%	2.04	0.11	0.36	0.71	0.21	0.33	1.33
Interaction P x S							
SE (m) ±	1.51	0.08	0.26	0.52	0.15	0.24	0.98
CD at 5%	-	-	-	-	-	-	-
Interaction P x F							
SE (m) ±	1.23	0.07	0.22	0.42	0.13	0.20	0.80
CD at 5%	-	-	-	-	-	-	-
Interaction S x F							
SE (m) ±	1.23	0.07	0.22	0.42	0.13	0.20	0.80
CD at 5%	-	-	-	-	-	-	-
Interaction P x S x F							
SE (m) ±	2.13	0.11	0.38	0.74	0.22	0.34	1.39
CD at 5%	-	-	-	-	-	-	-

Table 2. Economic studies of linseed as influenced by various treatments

Treatments	Total cost of cultivation (Rs. ha^{-1})	GMR	NMR	B: C ratio
Phosphorus levels (p)				
P_1 (20 kg ha^{-1})	15092	23428	8336	1.55
P_2 (30 kg ha^{-1})	15592	31136	15544	2.00
P_3 (40 kg ha^{-1})	16094	38783	22689	2.41
SE (m) ±	-	546	546	-
CD at 5%	-	1569	1569	-
Sulphur levels (S)				
S_1 (10 kg ha^{-1})	15118	28616	13499	1.89
S_2 (20 kg ha^{-1})	15593	31174	15581	2.00
S_3 (30 kg ha^{-1})	16068	33557	17489	2.09
SE (m) ±	-	546	546	-
CD at 5%	-	1569	1569	-
Foliar spray of 2% DAP at flowering and capsule development (F)				
F_1 (Two foliar sprays)	15103	30235	15133	2.00
F_0 (No foliar spray)	16083	32996	16913	2.05
SE (m) ±	-	446	446	-
CD at 5%	-	1280	1280	-
Interaction P x S				
SE (m) ±	-	946	946	-
CD at 5%	-	-	-	-
Interaction P x F				
SE (m) ±	-	772	772	-
CD at 5%	-	-	-	-
Interaction S x F				
SE (m) ±	-	772	772	-
CD at 5%	-	-	-	-
Interaction P x S x F				
SE (m) ±	-	1338	1338	-
CD at 5%	-	-	-	-

Effect of sulphur:

The highest gross monetary return of Rs. 33557 ha^{-1} and net monetary return of Rs. 17489 ha^{-1} were recorded with the application of 30 kg S ha^{-1} which was significantly more than application of 20 and 10 kg S ha^{-1}. Each increasing level of sulphur increased the economic yield significantly which ultimately resulted in increased gross and net monetary return ha^{-1}. The highest B:C ratio of 2.09 was observed with the application of 30 kg S ha^{-1} followed by application of 20 kg S ha^{-1} (2.00) and 10 kg S ha^{-1} (1.89). Jagtap (2003) conducted a field experiment on linseed at Nagpur with three sources of sulphur and three levels of sulphur (10, 20, 30 kg ha^{-1}). He obtained the highest GMR, NMR and B: C ratio with the application of 30 kg sulphur ha^{-1}. So, our results further support their results.

Effect of foliar spray:

The highest gross monetary (Rs.32996 ha^{-1}) and net monetary return (Rs.16913 ha^{-1}) were recorded due to foliar spray of 2% DAP at flowering and capsule development which was significantly superior to no foliar spray of DAP. Foliar spray of 2% DAP at flowering and capsule development stage recorded higher B:C ratio (2.05) as compared to no foliar spray of 2% DAP (2.00). Application of 2% DAP as foliar spray at flowering and capsule development resulted in significant increase in the yield and ultimately the economic return, when compared with the cost involved in the treatment. Kumar and Yadav (2010) conducted field experiments for two years at Kanpur to study the effect of foliar application of nutrients on seed yield and economics of cotton and revealed that application 2% urea and 2% DAP recorded significantly the highest B:C ratio.

Interaction:

The different interactions among levels of phosphorus, sulphur and foliar spray were found to be non significant.

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CHEMICAL 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 chemical quality of khoa sold in Wardha city. The maket khoa samples were collected from four sources viz., East, West, North and South region of Wardha city. It was found that East, West, North and South region khoa samples possessed on an average 29.58,28.09,29.71 and 30.28 per cent moisture, 27.24, 28.15, 27.53 and 23.93 per cent fat, 17.58, 17.97, 16.27 and 17.93 per cent protein, 3.57, 4.44, 3.36 and 3.54 per cent ash and 70.28, 70.77, 71.21 and 69.78 per cent total solids respectively. The khoa produced and marketed in West region had better chemical quality than East, North and South region of Wardha city which were fair but below standards specified by the Bureau of Indian Standard.

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

INTRODUCTION

India is the largest producer of milk in the world since 1999 with annual production over 127.29 million tones in 2011-12 (Anonymous, 2012). But out of total milk production, only 55 per cent of milk is converted into milk products. So, it is needed to convert more and more milk into milk products to satisfy the demand of consumers. The dairy sector in 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 products in the world.

Khoa is (also khoo-wah) milk food widely used in India, made of either dried whole milk or milk thickened by heating in an open iron pan. It is major intermediate base product for a variety of sweets. It is obtained by rapidly evaporating milk in shallow pans to total solid content of about 72 per cent. The product could be preserved for several days and is also used as base for different kinds of sweets like Pedha, Burfi, Gulabjamun, Kalakand etc.

The demand for milk and milk products of Wardha city is high and it is increasing rapidly day by day. In the city, wholesalers, halwai, hoteliers etc. prepare khoa by purchasing milk from milkmen of different areas. While other purchase readymade khoa from producers of surrounding areas i.e. Goras bhandar, Mangal sangralhay, etc. The main business of purchase and sale 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 Bureau of Indian Standard (Anonymus, 1968), khoa shall not contain moisture more than 28 per cent and the fat content of it shall not be less than 20 per cent on dry matter basis.

The 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). Keeping these in mind, present paper was focused on chemical aspects of khoa sold in various areas of Wardha city.

MATERIALS AND METHODS

The study of chemical qualities of khoa sold in Wardha city was conducted during 2012-13 at Animal Husbandry and Dairying Section, College of Agriculture, Nagpur. The samples were collected from the four localities of Wardha city viz., (A) Eastern area (East), (B) Western area (West), (C) Northern area (North) and (D) Southern area (South). 5 samples were collected from each region at a time i.e. 20 samples were collected during one visit. Likewise subsequently same numbers of samples were collected twice at forth nightly interval. Thus, Collection of samples were replicated thrice. The

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samples were collected in suitable containers and stored in refrigerator till the samples were used for physico chemical analysis viz., moisture, protein, fat, ash and total solids. Fat content was determined by Sozhiet extraction method as prescribed by A.O.A.C. (Anonymus,1990). Total solids were estimated by hot oven method and moisture content in khoa sample was determined by subtracting the percentage of total solids content from 100 in the sample.

Moisture (%) = 100 - total solids (%)

Protein content of khoa samples was determined by kjeldahal's method described by Aggrawal and Sharma (1961). Ash content of khoa samples were determined as per procedure prescribed by IS-1165 (Anonymus, 1967) as per equation given bellow.

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

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

RESULTS AND DISCUSSION

The results on chemical composition of khoa samples collected from four localities of Wardha city viz., East, West, North and South regions are presented in table 1.

Moisture :

The moisture content of khoa samples collected from four different localities is that East, West, North and south region of Wardha city was recorded in range of 28.61 to 30.87, 26.15 to 29.61, 28.12 to 31.38, 29.33 to 30.95 with an average 29.58, 28.09, 29.71 and 30.28 per cent respectively. Moisture content of khoa sources showed significant differences. However, the maximum average moisture content was recorded in South region khoa and minimum in West region khoa. West region khoa was significantly superior over East, North and south in respect of moisture content. So, West Wardha khoa samples meet the Bureau of India Standard specification (Anonymous, 1968) in respect of moisture content (28.00 per cent maximum).

Moisture level in dairy product like khoa is deciding factor so far as yield and profit is concerned. It appears from the results that West region khoa contained on an average 28.0 9% moisture. Kurand *et al.* (2011) noticed that khoa sold in Washim was significantly superior (27.20) over Karanga and Risod khoa in respect of moisture content. These observations are in line with the results of present investigation. Similarly, Katole (2002) also noticed moisture content of 26.94 per cent in khoa prepared by traditional method.

Fat :

It was observed from table 1 that the fat percentage of khoa sold in Wardha city ranged from 28.15 to 23.93 per cent in which values of fat content of East, West, North and South region khoa recorded in the range of 25.84 to 28.00, 27.59 to 28.28, 22.82 to 26.26, 22.56 to 25.34 with an average of 27.24, 28.15, 27.53 and 23.93 per cent respectively for this attributes. These differences were found to be significant for fat content. However, the maximum fat content was recorded in West region khoa collected samples followed by East, North and South region khoa. The fat content of West region khoa was significantly superior over East, North and South region khoa. However, East, North and South region Wardha khoa which contained less per cent of fat in khoa than West region of Wardha. However, all the samples conformed to Bureau of Indian Standard specification (Anonymous, 1968) in respect of fat content (20.00 per cent minimum).

Sharma (2006) reported that Pindi, Danedar, Dhap and Laboratory khoa contained fat per cent of 22.50, 20.90, 19.40 and 22.40 respectively. Kurand et al. (2011) found that Washim, Karanja and Risod Khoa samples had 27.70, 22.50 and 23.29 per cent fat respectvely. Thus, observations during the present study are supportive to their observations.

Protein :

The protein content of khoa samples collected from four different localities is that East, West, North and South regions of Wardha city was recorded in the range of 16.97 to 18.55, 15.78 to 19.05, 15.77 to 16.97, 17.44 to 18.60 with an average of 17.58,17.97, 16.27 and 17.93 per cent respectively. The maximum average protein content of market khoa was recorded by West region khoa followed

Table 1. Chemical composition of khoa samples collected from Wardha city

Sources	Moisture %	Fat %	Protein %	Ash %	Total solids %
East					
1	29.50	25.84	17.75	3.89	70.50
2	28.61	27.37	17.30	3.79	71.39
3	29.82	28.00	18.55	3.14	70.18
4	30.87	27.59	16.97	3.39	69.12
5	29.14	27.41	17.34	3.33	70.23
Mean	29.58	27.24	17.58	3.57	70.28
West					
1	26.15	27.90	18.20	4.37	71.06
2	29.61	28.11	15.78	4.24	70.39
3	29.08	28.00	18.41	4.26	71.14
4	27.67	27.59	19.05	4.55	71.20
5	27.95	28.28	18.44	4.26	70.05
Mean	28.09	28.15	17.97	4.44	70.77
North					
1	28.12	24.35	16.18	3.08	71.44
2	29.55	22.82	16.97	3.18	69.62
3	28.76	26.26	16.11	3.35	71.70
4	31.38	25.40	16.29	3.58	71.15
5	31.07	23.83	15.77	3.65	71.12
Mean	29.71	27.53	16.27	3.36	71.21
South					
1	29.33	24.22	17.95	3.61	70.66
2	30.95	25.34	18.60	3.94	69.05
3	30.88	23.36	17.44	3.45	69.45
4	30.33	24.25	17.96	3.75	69.66
5	29.94	22.56	17.72	3.95	70.07
Mean	30.28	23.93	17.93	3.54	69.78
SE(m)±	0.24	0.66	0.28	0.14	0.23
CD at 5%	1.02	2.83	1.20	0.61	0.98

South, East and North region khoa. West region khoa samples were significantly superior over East, North and South region in respect of protein content. These results are in line with the results of Kurand *et al.* (2011). They found protein content of khoa in the range of 17.26 to 18.89 per cent and Kakade *et al.* (2013) found that protein content of khoa in four regions (i.e. East, North, West and South region) of Nagpur city was in the ragne of 16.06 to 8.70 per cent.

Ash :

The ash content of khoa samples collected from four different localities i.e. East, West, North and South regions of Wardha city was recorded in the range of of 3.14 to 3.89, 4.24 to 4.55, 3.08 to 3.65, 3.45 to 3.95 with an average of 3.57, 4.44 , 3.36 and 3.54 per cent respectively. These differences were found to be significant in respect of ash content. The maximum percentage of ash was recorded by West region while minimum ash content was noticed in East, North and South region khoa.

The findings of present investigation are in accordance with the findings of Katole (2002) who noticed 3.70 per cent ash content of khoa for traditional method and 3.80 per cent for vaccum evaporated method. Kurand *et al.* (2011) observed that ash content of khoa in Washim, Karanja and Risod was 3.91, 4.06 and 3.47 respectively.

Total Solids :

The total solid content of khoa samples collected from four different localities i.e. East, West, North and South region of Wardha city was found in the range of 69.12 to 71.39,. 70.05 to 71.20, 69.62 to 70.66 with an average of 70.28, 70.77, 71.21 and 69.78 per cent, respectively for total solids content. It was noticed that North khoa recorded maximum percentage of total solids followed by West, East and South region khoa.

The protein content and fat content were less in North Wardha region khoa but total solids were more. It might be due to addition of some solids from external source. These results are in line with the results of Kurand *et al.* (2011). They reported total solids content of khoa were in the range of 69.89 to 72.80 per cent.

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EFFECT OF PHOSPHORUS AND POTASSIUM ON GROWTH AND FLOWERING OF AFRICAN MARIGOLD

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ABSTRACT

An experiment to study the effect of phosphorus and potassium on growth and flowering 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 viz., 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, application of 75 kg ha^{-1} each of phosphorus and potassium produced significantly maximum plant height, number of primary branches plant^{-1}, stem diameter and spread of plant with respect to growth parameters and minimum days to first flower bud initiation, days to fully opened bud from flower bud initiation, days to 50% flowering, days to harvesting and maximum number of flowers plant^{-1} with respect to flowering parameters, which were at par with the results obtained with the application of 50 kg ha^{-1} each of phosphorus and potassium. The interaction effects revealed that they were significant in respect of height of the plant, number of primary branches plant^{-1} and number of flowers plant^{-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, growth , flowering)

INTRODUCTION

Floriculture is one of the most important branch of Horticulture in aesthetic, social and commercial sense. It has been closely associated with Indian culture from Vedic times. Now a days, there is great demand for cut flowers in local and export market. The important flowers having more demand are Rose, Gerbera, Carnation, Gladiolus, Chrysanthemum, Marigold, Aster, Orchids etc.

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

Marigold (*Tagetes* spp.), a member of family Asteraceae, is native of Central and South America, especially Mexico. Marigold is broadly divided into two groups, viz., African marigold (*Tagetes erecta* Linn.) and French marigold (*Tagetes patula* Linn). It is commercially cultivated in India for making garland, wreath, religious offerings and cut flower purposes. It occupies special importance due to its hardiness, easy culture including inexpensive packaging, low pest damage and wider adaptability to varied agro climatic conditions.

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 promotes early flowering and it is important for reproductive parts of the plants (Das, 2009). Potassium helps in formation of proteins and chlorophyll which are important for photosynthesis. It increases the quality of flower (Das, 2009). Gnyandev (2006) reported increased plant height, number of branches and flower yield with the application of higher dose of fertilizer (180:150 kg PK ha^{-1}) in China aster. In marigold, these fertilizers can also manipulate plant growth and flowering behaviour. Hence, in order to find out the optimum doses of phosphorus and potassium fertilizers under Nagpur conditions, the present investigation was under taken.

MATERIALS AND METHODS

The present investigation was carried out at Horticulture section, 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

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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 as per the treatments were applied at the time of transplanting. The remaining 50 kg N ha^{-1} was applied 30 days after transplanting. Package of practices including irrigation were adopted as per recommendation. Five plants were selected randomly from each plot for recording various growth parameters *viz*., plant height, number of branches, stem diameter which were recorded at 90 days after transplanting at peak maturity of the plants and spread of plant was recorded at 50 per cent flowering and flowering parameters like days to emergence of first bud, days to full opening of flower, days to 50% flowering, days to harvesting of flowers and number of flowers $plant^{-1}$ were recorded on these randomly selected plants. 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 growth and flowering parameters of African marigold.

Growth parameters:

Significantly the highest plant height (87.10 cm), number of primary branches $plant^{-1}$ (14.79), stem diameter of plant (1.23 cm) and spread of the plant (41.05 cm) were recorded at highest level of phosphorus i.e. 75 kg P ha^{-1} which was found at par with the treatment 50 kg P ha^{-1} (85.76 cm, 14.60, 1.21 cm and 39.77 cm respectively), This might be due to increase in uptake of nutrients. Phosphorus is an essential part of photosynthesis and it is involved in various metabolic processes of plant. Whereas, application of 0 kg P ha^{-1}(control) had produced significantly minimum plant height (77.83 cm), number of primary branches $plant^{-1}$ (12.63), stem diameter (1.13 cm) and spread of plant (30.98 cm). Kishore *et al*. (2010) reported that maximum plant height, number of primary branches $plant^{-1}$ and plant spread were obtained with the application of phosphorus @ 20 g m^{-2} in marigold. Our results are in close conformity with the above given results.

With respect to potassium, the treatment 75 kg K ha^{-1} had produced significantly maximum plant height (85.83 cm), number of primary branches $plant^{-1}$ (14.73), stem diameter of plant (1.22 cm) and spread of the plant (40.01 cm) and it was found at par with the treatment 50 kg K ha^{-1} (84.95 cm, 14.35, 1.20 cm and 38.67 cm respectively) This increase in growth 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 produced significantly minimum plant height (79.38 cm), number of primary branches $plant^{-1}$ (12.96), stem diameter (1.14 cm) and spread of plant (32.71 cm). Pal and Gosh (2010) reported that, application of 200 kg K ha^{-1} gave maximum plant height, number of primary branches $plant^{-1}$ and plant spread .

The interaction effect due to phosphorus and potassium on growth parameters like height of the plant and number of primary branches $plant^{-1}$ were found significant for which data are give in table 2, whereas the remaining growth parameters like stem diameter and spread of plant were found to be non significant. The effect of combined application of P and K on the height of plant revealed that the maximum and significantly more height was obtained due to application of 75 kg P ha^{-1} + 75 kg K ha^{-1} over rest of the treatment combinations except 75 kg P ha^{-1} + 50 kg K ha^{-1}. In case of number of primary branches $plant^{-1}$, the best and significantly superior combination was 75 kg ha^{-1} each of P and K. The next best treatment combinations were 75 kg P ha^{-1} + 50 kg K ha^{-1} and 50 kg P ha^{-1}+75 kg K ha^{-1} which were at par but significantly superior over rest of the treatment combinations .

Flowering parameters :

The flowering parameters like days to first flower bud initiation (37.08), days to full opening of flower bud from bud initiation (7.24), days to 50% flowering (49.09), days to harvesting from transplanting (84.07) were found minimum with the application of 75 kg P ha^{-1} and maximum number of flowers $plant^{-1}$ (34.93) was also recorded in the same treatment which was found at par with the treatment 50 kg P ha^{-1} (38.24, 7.80, 50.13, 85.25 and 32.35

Table 1. Effect of phosphorus and potassium on growth and flowering parameters of African marigold

Treatments	Plant height (cm)	Number of primary branches	Stem diameter of plant (cm)	Spread of plant at 50% flowering (cm)	Days to first flower bud initiation	Days to full opening of flower bud	Days to 50% flowering	Days to harvesting	Number of flowers $plant^{-1}$
Phosphorus									
P_1 – 0 kg P ha^{-1}	77.83	12.63	1.13	30.98	46.63	9.86	57.98	89.90	16.51
P_2 – 25 kg P ha^{-1}	81.79	13.61	1.17	35.61	42.11	8.70	54.08	87.64	23.98
P_3 – 50 kg P ha^{-1}	85.76	14.60	1.21	39.77	38.24	7.80	50.13	85.25	32.35
P_4 – 75 kg P ha^{-1}	87.10	14.79	1.23	41.05	37.08	7.24	49.09	84.07	34.93
SE (m) ±	0.39	0.06	0.005	0.37	0.36	0.11	0.45	0.53	0.40
CD (P= 0.05)	1.15	0.17	0.015	1.67	1.05	0.34	1.30	1.55	1.17
Potassium									
K_1 – 0 kg K ha^{-1}	79.38	12.96	1.14	32.71	44.85	9.38	56.24	88.98	18.70
K_2 – 25 kg K ha^{-1}	82.28	13.62	1.18	36.02	42.06	8.73	53.57	87.63	25.01
K_3 – 50 kg K ha^{-1}	84.95	14.35	1.20	38.67	39.30	7.94	51.28	85.76	30.87
K_4 – 75 kg K ha^{-1}	85.83	14.73	1.22	40.01	37.86	7.54	50.19	84.50	33.19
SE (m) ±	0.39	0.06	0.005	0.37	0.36	0.11	0.45	0.53	0.40
CD (P= 0.05)	1.15	0.17	0.015	1.67	1.05	0.34	1.30	1.55	1.17
Interaction effect									
P x K									
SE (m) ±	0.79	0.12	0.01	0.74	0.73	0.23	0.90	1.07	0.81
CD (P= 0.05)	2.30	0.35	--	-	-	-	-	-	2.35

Table 2. Interaction effect of phosphorus and potassium on growth and flowering parameters of African marigold

Treatments combinations	Height of the plant (cm)	Number of primary branches plant^{-1}	Number of flowers plant^{-1}
0 kg P ha^{-1} + 0 kg K ha^{-1}	75.92	12.13	13.13
0 kg P ha^{-1} + 25 kg K ha^{-1}	77.47	12.45	15.59
0 kg P ha^{-1} + 50 kg K ha^{-1}	78.60	12.93	18.27
0 kg P ha^{-1} + 75 kg K ha^{-1}	79.31	13.02	19.06
25 kg P ha^{-1} + 0 kg K ha^{-1}	77.58	12.75	16.58
25 kg P ha^{-1} + 25 kg K ha^{-1}	80.36	13.16	19.81
25 kg P ha^{-1} + 50 kg K ha^{-1}	83.70	13.95	28.39
25 kg P ha^{-1} + 75 kg K ha^{-1}	85.53	14.60	31.13
50 kg P ha^{-1} + 0 kg K ha^{-1}	82.73	13.68	24.40
50 kg P ha^{-1} + 25 kg K ha^{-1}	84.52	14.22	30.42
50 kg P ha^{-1} + 50 kg K ha^{-1}	87.71	15.90	36.22
50 kg P ha^{-1} + 75 kg K ha^{-1}	88.10	15.42	38.35
75 kg P ha^{-1} + 0 kg K ha^{-1}	81.31	13.29	24.40
75 kg P ha^{-1} + 25 kg K ha^{-1}	86.75	14.65	34.21
75 kg P ha^{-1} + 50 kg K ha^{-1}	89.79	15.43	40.61
75 kg P ha^{-1} + 75 kg K ha^{-1}	90.53	15.98	44.20
Interaction effect			
P x K			
SE (m) ±	0.79	0.12	0.81
CD (P= 0.05)	2.30	0.35	2.35

respectively). This might be due to abundant availability of phosphates in the rooting medium, which promotes the earlier maturation of plant that tends to develop the flowers. Whereas, application of 0 kg P ha^{-1} had produced significantly maximum days to first flower bud initiation (46.63), days to full opening of flower bud from bud initiation (9.86), days to 50% flowering (57.98), days to harvesting from transplanting (89.90) and minimum number of flowers $plant^{-1}$ (16.51). Sharma *et al*. (2010), while conducting the experiment on marigold, revealed that the minimum days to first flower bud initiation, days to 50% flowering, days to harvesting and maximum number of flowers were obtained with the application of 200 kg P ha^{-1}.

Among the different levels of potassium applied, significantly minimum days were required for first flower bud emergence (37.86 days), days to full opening of flower bud from bud initiation (7.54 days), days to 50% flowering (50.19 days) and days to harvesting from transplanting (84.50 days) and maximum number of flowers $plant^{-1}$ (33.19) were obtained with the individual application of 75 kg K ha^{-1} which was found at par with the treatment 50 kg K ha^{-1} (39.30, 7.94, 51.28, 85.76 days and 30.87 respectively). This might be due to 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 required significantly maximum days to first flower bud initiation (44.85), days to full opening of flower bud from bud initiation (9.38 days), days to 50% flowering (56.24 days), days to harvesting from transplanting (88.98 days) and number of flowers $plant^{-1}$ (18.70). These results are in close conformity with Talukdar *et al*. (2003) who reported that, minimum number of days were required for emergence of spike in tuberose with the application of 60 g K per m^2 as compared to other doses of potassium.

The interaction effect due to phosphorus and potassium on flowering parameters like days to first flower bud emergence, days to full opened flower from flower bud emergence, days to 50% flowering and days to harvesting were found to be non significant but for number of flowers $plant^{-1}$,these effects were significant.

In case of number of flowers $plant^{-1}$,the best and significantly superior combination was 75 kg ha^{-1} each of P and K. The next best treatment combinations were 75 kg P ha^{-1} + 50 kg K ha^{-1} and 50 kg P ha^{-1}+ 75 kg K ha^{-1} both being at par with each other but significantly superior over rest of the treatment combinations.

From the study it can be inferred that, application of 75 kg ha^{-1} each of phosphorus and potassium improved the growth and flowering parameters of marigold.

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BIO EFFICACY OF SOME INSECTICIDES AGAINST FRUIT FLIES INFESTING RIDGE GOURD

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ABSTRACT

Field Experiment was carried out at College of Agriculture, Farm, Dr. B.S.K.K.V., Dapoli during *kharif* 2011 and *kharif* 2012, the relative efficacy of different insecticides were evaluated under field conditions. The cumulative pooled data of the year 2011 and 2012 pertaining to the fruit damage by fruit fly revealed that treatment deltamethrin (0.0016 %) recorded significantly the lowest (20.15 %) fruit damage, however it was statistically at par with DDVP (0.05 %), emamectin benzoate (0.0016 %) and azadirachtin (0.0025 %) with 22.83, 24.05 and 24.79 % fruit damage, respectively. The highest marketable yield was obtained in treatment of deltamethrin 0.025 % (20.95 t ha^{-1}) which was significantly more than rest of the treatments except DDVP 0.05 % (19.96 t ha^{-1}), whereas, DDVP 0.05 % was also found at par with emamectin benzoate 0.0016 %. The treatment emamectin benzoate 0.0016 per cent recorded 18.80 t ha^{-1} yield which was at par with azadirachtin 0.0025 per cent (17.54 t ha^{-1}).

The highest incremental benefit : cost ratio (ICBR) of 1:47.38 was obtained in deltamethrin 0.0025 per cent followed by DDVP 0.05 per cent (1:26.51).

(Key words: Cucurbit fruit flies, ridge gourd, insecticides, bio pesticides, bioefficacy, econimics)

INTRODUCTION

Cucurbits are vegetable crops belonging to family Cucurbitaceae which are consumed as food worldwide. The family consists of about 118 genera and 825 species. In India, number of cucurbits *viz.,* ridge gourd [*Luffa acutangula* (L.) Roxb.], snake gourd (*Trichosanthes anguina* L.), cucumber (*Cucumis sativus* L.), bitter gourd (*Momordica charantia* L.), bottle gourd [*Lagenaria siceraria (Malina)* Standl.], watermelon [*Citrullus lanatus* (Thunb)], sponge gourd (*Luffa cylindrical* Roem), pumpkin [*Cucurbita moschata* (Ducherne)], winter squash [*Cucurbita maxima* (Duchesne)], ash gourd [*Benincasa hispida* Thunb], sweet gourd (*Momordica cochinchinensis*) etc. are cultivated on about 9 million ha with the production of 10.52 t ha^{-1} (Anonymous, 2012).It is estimated that India will need to produce 215,000 tons of vegetables by 2015 to provide food and nutritional security. In recent era of globalization, it has become a challenge for the country not only to feed its own population but also to export fruits and vegetables to various developed countries with strict quality control. Being large group of vegetables, cucurbits provide better scope to enhance overall productivity and production (Rai *et al.,* 2008). The melon, fly also called as fruit fly, *Bactrocera cucurbitae* is a major pest of cucurbitaceous vegetables, particularly ridge gourd, bittergourd, muskmelon, snapmelon and snakegourd causing losses to the extent of even upto 100% (Pareekh and Kavadia, 1995 and Kapoor, 2005). The field experiment on assessment of losses caused by cucurbit fruit fly in different cucurbits has been reported in terms of yield loss to the tune of 28.7-59.2, 24.7-40.0, 27.3-49.3, 19.4-22.1 and 0-26.2% in case of pumpkin, bittergourd, bottlegourd, cucumber and spongegourd respectively (Pradhan, 1976). Nath and Bhushan (2006) screened thirteen cucurbit crops *viz.,* bottle gourd, cucumber, water melon, round gourd, musk melon, bitter gourd, long melon, pumpkin, sponge gourd, smooth gourd, ridge gourd, ash gourd and snake gourd for their resistance to the *B. cucurbitae* in Varanasi, Uttar Pradesh during summer and rainy season and observed maximum damage in bitter gourd (26.11 and 31.96 %) during summer, and minimum in pumpkin (2.78 and 1.39 %). Similarly during rainy season, damage was maximum in bitter gourd (46.8 and 45.3 %) and minimum in pumpkin (7.44 and 11.1 %) in 2011 and 2012, respectively which revealed that bitter gourd followed by bottle gourd was the most preferred host of *B. cucurbitae.* Whereas, the percentage of fruit damage by the melon fruit fly was observed 28.5% and 31.27% in watermelon and bittergourd respectively (Singh *et al.,* 2000).

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The adult female is directly involved in initiating the damage by way of preparing the place in the fruit by scrapping and then depositing the eggs within the fruit. The maggots emerged from eggs feed on the fruit tissue and cause damage in the growing fruit and damage varies a lot on the prevailing climatic condition and the diversity of other hosts in a particular agro-ecosystem. Banerji *et al.* (2005) recorded the activity of melon fly at Kalyani, West Bengal during *kharif*, initial activity was noticed during first week of August, however, the highest incidence was noticed during middle of October and then infestation started declining. In *rabi* season, the peak population of the fruit fly (33.33%) was recorded during 2nd and 3rd week of April. The highest infestation level was found in the first week of June (43.33%) during summer. Dhillon *et al.* (2005) while investigating on melon fly, *B. cucurbitae,* stated that the losses vary from 30 to 100 % depending on the cucurbit species and the season and abundance of the fly which increases when the temperature fall below 32°C and the relative humidity ranges between 60 and 70 %. However, Raghuvanshi *et al.* (2012) monitored seasonal abundance of fruit fly, *B. cucurbitae* in cue lure baited traps at Varanasi, indicated that there were two peaks in summer and *kharif* coincided with 14 SW (1st week of April) and 43 SW (4th week of October), respectively. As regarding bitter gourd fruit damage, 62.70 % damage was occurred at 45 SW (2nd week of November) and the second peak was in the 15 SW (2nd week of April) with 49.70 % fruit damage. Morde (2003) reported *B. cucurbitae* and *B. tau* infesting little gourd, cucumber, bottle gourd and wild cucurbits. However, *B. cucurbitae* observed to be predominant in bottle gourd, bitter gourd and sponge gourd in Panvel area of Maharashtra to the extent of 100 %. Whereas, *B. tau* was observed to be the predominant and recorded 100 % population in sponge gourd and ridge gourd from Wakawali area in Maharashtra, whereas both the species were found infesting ridge gourd, snake gourd cucumber and wild cucurbits in Dapoli area of Maharashtra.

In India, an approximate loss of Rs. 26,902 million occurred in case of cucurbits from such a single dreadfull insect pest where control measures were not applied (Stonehouse, 2001). Ravindranath and Pillai (1986) observed Deltamethrin 15 g a.i. hectare^{-1} effective in reducing damage of *D. cucurbitae* in bitter gourd as compared to malathion. Bhatnagar and Yadava (1992) evaluated efficacy of the five insecticides *viz.* carbaryl 50 WDP, fenitrothion 50 EC, malathion 50 EC, quinalphos 25 EC and dichlorovos 100 EC against fruit fly (*D. cucurbitae*) infesting bottle gourd, sponge gourd and ridge gourd. Among them, malathion 0.05 % proved to be the best treatment with minimum infestation of 6.9 % followed by carbaryl, quinalphos, dichlorovos, and fenitrothion which recorded 11.1, 12.9, 14.9 and 17.9 % fruit damage, respectively in ridge gourd.

Thus, apart from nutritional management, the menace by the fruit flies is a serious bottleneck in enhancing production of cucurbits. In this context, the present investigation was undertaken to evaluate bio efficacy of some insecticides against fruit flies infesting ridge gourd.

MATERIALS AND METHODS

A statistically designed field experiment with randomised block design was conducted during *kharif* season of 2011 and 2012 at College of Agriculture Farm, Dr.B.S. Kokan Krishi Vidyapeeth, Dapoli, District Ratnagiri using eight treatments replicated thrice (Table 1). A promising variety of ridge gourd, 'Kokan Harita' was transplanted in plots measuring 3 m x 2 m with a spacing of 3 m x 0.6 m on 28/06/2011 and 11/06/2012. The recommended package of practices was followed for successful cultivation of ridge gourd crop. The desired concentrations of test insecticides were prepared on the basis of active ingredient present in respective trade products. The actual quantity of spray volume required treatment^{-1} plot^{-1} was calibrated by using water. For preparation of spray emulsion, the measured quantity of insecticides was mixed with desired quantity of water and one per cent each Jaggery and Hydrolysed yeast were added in spray solution. The spray solution was thoroughly stirred with the help of wooden stick before application. Total three sprays were taken on date 16/9/2011, 1/10/2011, 16/10/2011 and 18/8/2012, 1/9/2012, 16/9/2012 during 2011 and 2012 respectively at an interval of 15 days, commencing from initiation of fruit set. Care was taken to wash the spray pump with water thoroughly well before switching to other treatment. For spraying, Knapsack sprayer was used. The healthy and the infested fruits were plucked separately after 7 days of the first, second and third sprays and subsequent pickings were undertaken in each treatment as per the growth of fruits to marketable size. Total 8 pickings and 11 pickings were undertaken in 2011 and 2012 respectively and the number of fruits damaged on the basis of the cumulative number of fruits during entire cropping season was recorded in each treatment. The cumulative per cent fruit infestation was worked out on the basis of healthy and damaged fruits from each treatment plot from all the pickings. The yield data of healthy marketed fruits was compiled from all the pickings to report the yield of fruits ha^{-1}. The data, thus, obtained were subjected to arc sin transformation and were analysed statistically. Economics of application of various insecticides with respect to yield under each treatment was calculated and ICBR was determined.

Table 1. Treatment details

Treatment No.	Treatments	Trade Name	Concentration (%)
T_1	DDVP 76WSC	Doom	0.05
T_2	Malathion 50 EC	Milthion	0.05
T_3	Emamectin Benzoate 5 SG	Proclaim	0.0016
T_4	Spinosad 45 SC	Tracer	0.016
T_5	Carbaryl 50 WDP	Sevin	0.1
T_6	Deltamethrin 2.8 EC	Decis	0.0025
T_7	Azadirachtin 10,000 ppm	Neem Fighter	0.0025
T_8	Control (Water spray)		--

RESULTS AND DISCUSSION

Bioefficacy of some insecticides against fruit fly (2011) :

The results of *kharif* 2011 are presented in table 2. The observations on cumulative percentage of fruit infestation recorded upto last picking indicated that the fruit damage varied from 19.94 to 45.40 % in various treatments. The treatment deltamethrin (0.0025%) was found to be the most effective with 19.94 % fruit damage, however, it was at par with DDVP (0.05%) and emamectin benzoate (0.001%) wherein 24.58 and 24.70 % fruit infestation were noticed, respectively. On the other hand, the treatment emamectin benzoate was also found at par with rest of the treatments except control.

Bioefficacy of some insecticides against fruit fly (2012) :

The data presented in table 2 of *kharif* 2012, indicated that the cumulative percentage of fruit infestation ranged from 20.25 to 46.13 %, in various treatments. The treatment deltamethrin (0.0025%) was also found significantly effective with 20.25 % fruit damage and it was at par with DDVP (0.05%), emamectin benzoate (0.0016%), azadirachtin (0.0025%) and spinosad (0.016%) with 22.04, 23.80, 24.27, 24.96 % fruit infestation, respectively. Whereas, treatment DDVP was also at par with rest of the all treatment except control (46.13 % fruit damage).

Pooled per cent fruit damage by fruit fly in different treatments (2011 and 2012) :

The cumulative pooled data of the year 2011 and 2012 pertaining to the fruit damage by fruit fly (Table 2 and Fig. 3) revealed that the treatment deltamethrin (0.0025%) recorded significantly the lowest fruit damage of 20.15 % however, it was statistically at par with DDVP (0.05%), emamectin benzoate (0.0016%) and azadirachtin (0.0025%) with 22.83, 24.05 and 24.79% fruit damage, respectively. For the remaining treatments, the order of efficacy was spinosad (0.016%) > malathion (0.05%) > carbaryl (0.1%) with 25.44, 26.84 and 27.72 % fruit damage, respectively. The highest fruit damage was recorded in the control plot (44.95%).

The results envisage that the insecticide deltamethrin observed to be the most effective treatment against fruit fly. Ravindranath and Pillai (1986) observed Deltamethrin 15 g a.i. $hectare^{-1}$ effective in reducing damage of *D. cucurbitae* in bitter gourd as compared to malathion and Sood and Sharma (2004) reported the bioefficacy of synthetic pyrethroids alongwith gur solution 1 per cent. The treatment deltamethrin (37.5 g a.i.ha^{-1}), cypermethrin (75 g a.i. ha^{-1}) and fenvalarate (75 g a.i. ha^{-1}) gave significantly less fruit infestation of fruit fly on summer squash as compare to malathion (37.5 g a.i. ha^{-1}). The neem derivatives *viz,.* achook, econeem and neemjeevan were found comparatively less effective than synthetic insecticides.

Similarly, dichlorovos (DDVP) was also observed equally effective to that of deltamethrin. Deshmukh and Patil (1996) reported that DDVP (0.05%) + hydrolyzed yeast + gur gave maximum protection and malathion (0.05%) + 1.0 % gur was found next best treatment against fruitflies infesting ridge gourd. Emamectin benzoate was observed effective and at par with DDVP in the present study. However, earlier it was reported comparatively less effective than spinosad and neem derivatives by Waseem *et al.* (2009). The effectiveness of neem oil at 1.2 per cent was reported by Ranganathan *et al.* (1997) in reducing damage of fruit fly on cucumber. They also observed neem cake at 4.0 per cent and dichlorovos at 0.2 per cent the most effective against fruit fly on ridge gourd. Nath *et al.* (2007) reported NSKE @ 5 per cent bait spray with Malathion 50g + Molasses 500g + 50 litre water and cypermethrin applied one after another as per schedule, resulted in minimum fruit damage by the fruit fly in bottle gourd fruits.

Marketable fruit yield :

(a) *Kharif* 2011 :

The yield data presented in table 3 indicated that the highest yield of marketable fruits was recorded in the plots treated with deltamethrin 0.0025 % (14.50 ton ha^{-1}) which was significantly more than rest of the treatments. The next treatments which recorded comparatively good yield were DDVP 0.05 % (12.92 ton ha^{-1}), emamectin benzoate 0.0016 % (12.82 ton ha^{-1}), azadirachtin 0.0025 % (12.50 ton ha^{-1}) and were found at par with each other. The treatment carbaryl 0.1 % recorded significantly more yield than malathion 0.05 %, however, it was also at par with azadirachtin 0.0025 % and spinosad 0.016 %. The lowest yield of 7.53 ton ha^{-1} was recorded in control.

(b) *Kharif* 2012 :

The maximum marketable fruit yield of ridge gourd (Table 3) was obtained in the treatment deltamethrin 0.0025 % (27.40 ton ha^{-1}), however it was at par with DDVP 0.05 % (26.99 ton ha^{-1}) and both were significantly superior over rest of the treatments. The treatment emamectin benzoate 0.0016 % (24.77 ton ha^{-1}) recorded significantly more yield over rest of the treatments except azadirachtin 0.0025 % (22.85 ton ha^{-1}). On the other hand, azadirachtin 0.0025 % was also at par with spinosad 0.016 % (22.63 ton ha^{-1}) and malathion 0.05 % (21.69 ton ha^{-1}).

Pooled results of marketable fruit yield (2011 and 2012) :

The pooled yield data of the year 2011 and 2012 presented in table 3 and depicted in fig. 6, indicated that the highest yield was obtained in deltamethrin 0.0025 % (20.95 t ha^{-1}) which was significantly more than rest of the treatments except DDVP 0.05 % (19.96 t ha^{-1}). However, DDVP 0.05 % was also at par with emamectin benzoate 0.0016 %. Treatment emamectin benzoate recorded 18.80 t ha^{-1} yield and was at par with azadirachtin 0.0025 % (17.68 t ha^{-1}) and spinosad 0.016 % (17.54 t ha^{-1}) followed by malathion 0.05 % (16.24 t ha^{-1}) and carbaryl 0.1 % (16.04 t ha^{-1}). However, the minimum yield of 11.00 t ha^{-1} was obtained in the control plot.

Economics :

Economics of different insecticidal treatments are presented in table 4. The highest ICBR 1:47.38 was obtained in deltamethrin 0.0025 % followed by DDVP 0.05 % (1:45.40) and malathion 0.05 % (1:26.51). The remaining treatments in descending order of ICBR were emamectin benzoate 0.0016 % (1:20.43), azadirachtin 0.0025 % (1:20.27), carbaryl 0.1 % (1:19.20) and spinosad 0.016 % (1:19.03).

Considering the effectiveness of the treatments, deltamethrin 0.0025 %, DDVP 0.05 %, emamectin benzoate 0.0016 % and azadirachtin 0.0025 % were found effective in reducing the fruit damage, which in turn resulted in higher yield. These treatments gave higher net returns over control, which was worked out to Rs. 2,18,177 (deltamethrin 0.0025 %), Rs. 1,96,670 (DDVP 0.05 %), Rs. 1,67,292 (emamectin benzoate 0.0016 %) and Rs. 1,43,750 (azadirachtin 0.0025 %) hectare^{-1}. The remaining treatment viz., spinosad 0.016 %, malathion 0.05 % and carbaryl 0.1 % gave comparatively less net returns to the tune of Rs. 1,40,385, 1,14,830, 1,09,080, respectively over control.

Table 2. Bio-efficacy of some insecticides against fruit fly (Pooled 2011 - 2012)

Tr. No.	Treatment	Concentration (%)	Cumulative Effect- 2011	Cumulative Effect- 2012	Pooled
T_1	DDVP 76 WSC	0.05	24.58 (29.69)	22.04 (27.99)	22.83 (28.53)
T_2	Malathion 50 EC	0.05	27.88 (31.86)	26.54 (31.00)	26.84 (31.20)
T_3	Emamectin benzoate 5 SG	0.0016	24.70 (29.73)	23.80 (29.17)	24.05 (29.32)
T_4	Spinosad 45 SC	0.016	26.67 (30.98)	24.96 (29.96)	25.44 (30.29)
T_5	Carbaryl 50 WDP	0.1	27.25 (31.45)	27.72 (31.70)	27.72 (31.74)
T_6	Deltamethrin 2.8 EC	0.0025	19.94 (26.52)	20.25 (26.73)	20.15 (26.66)
T_7	Azadirachtin 10,000 ppm	0.0025	26.09 (30.70)	24.27 (29.45)	24.79 (29.82)
T_8	Water spray (Control)	---	45.40 (42.36)	46.13 (42.77)	44.95 (42.09)
	SEm +	---	**1.27**	**1.36**	**1.13**
	CD (p=0.05)	---	**3.86**	**4.13**	**3.43**

Figures in the parenthesis are arc sin value

Table 3. Effect of insecticidal spray on marketable fruit yield

Tr. No.	Treatments	Concentration (%)	Fruit yield (ton ha^{-1})		
			2011	2012	Pooled
T_1	DDVP 76 WSC	0.05	12.92	26.99	19.96
T_2	Malathion 50 EC	0.05	10.79	21.69	16.24
T_3	Emamectin benzoate 5 SG	0.0016	12.82	24.77	18.80
T_4	Spinosad 45 SC	0.016	12.45	22.63	17.54
T_5	Carbaryl 50 WDP	0.1	11.96	20.13	16.04
T_6	Deltamethrin 2.8 EC	0.0025	14.50	27.40	20.95
T_7	Azadirachtin 10,000 ppm	0.0025	12.50	22.85	17.68
T_8	Water spray (Control)	---	7.53	14.47	11.00
	S.Em. $\pm$		**0.30**	**0.67**	**0.42**
	CD (p=0.05)		**0.92**	**2.02**	**1.32**

Table 4. Economics of different treatments for the control of fruit flies infesting Ridge gourd

Treatments	Marketable fruit yield (tons ha^{-1})	Cost of cultivation (Rs) (excluding cost of treatment)	Total quantity of insecticide required for kg ha^{-1} (3 sprays)	Total quantity of insecticide required	Price of insecticide (Rs/lit or Kg)	Total cost of insecticide ha^{-1} (Rs)	Cost of jaggary + hydrolysed yeast ha^{-1} (Rs)	Labour charges (Rs ha^{-1}) (3 sprays)	Total cost of treatmen (Rs ha^{-1})	Total cost of cultivation (Rs ha^{-1})	Gross realization (Rs.)	Net return (Rs.)	Net realization over control	ICBR ration
DDVP 76 WSC	19.96	1,15,349	0.33	0.99	450	450	1770	2112	4332	119681	4,39,120	319439	196670	1:45.40
Malathion 50EC	16.24	1,15,349	0.50	1.5	300	450	1770	2112	4332	119681	3,57,280	237599	114830	1:26.51
Emamectin benzoate 5 SG	18.80	1,15,349	0.16	0.49	8,600	4,308	1770	2112	8190	123539	4,13,600	290061	167292	1:20.43
Spinosad 45 SC	17.54	1,15,349	0.077	0.23	15,000	3,495	1770	2112	7377	122726	3,85,880	263154	140385	1:19.03
Carbaryl 50 WDP	16.04	1,15,349	1.0	3	900	1,800	1770	2112	5682	121031	3,52,880	231849	109080	1:19.20
Deltamethrin 2.8 EC	20.95	1,15,349	0.44	1.33	540	723	1770	2112	4605	119954	4,60,900	340946	218177	1:47.38
Azadirachtin 10,000 ppm	17.68	1,15,349	1.24	3.73	700	3,210	1770	2112	7092	122441	3,88,960	266519	143750	1:20.27
Water spray (Control)	11.00	1,15,349	---	---	---	---	1770	2112	3882	119231	2,42,000	122769	---	---

Market value of ridge gourd fruits – Rs. 22 kg^{-1},
12 Labours ha^{-1} @ Rs. 176/-
15 kg jaggary@ Rs. 40 kg^{-1} & Hydrolysed yeast @ Rs. 78 kg^{-1}

Mehta *et al.* (2000) recorded the highest fruit yield of cucumber in deltamethrin + molasses treatment (13.00 and 12.78 kg plot^{-1}) and was significantly superior than other treatments viz., malathion, endosulfon, carbaryl, cypermethrin, deltamenthrin alone and acephate varying from 5.26-7.68 and 5.76-8.13 kg as compared to 3.80 and 4.10 kg in untreated control during 1998 and 1999, respectively. Sood and Sharma (2004) also reported maximum fruit yield of summer squash in the deltametherin treatment (205.61 q ha^{-1}) followed by cypermethrin (186.13 q ha^{-1}), fenvalerate (174.71 q ha^{-1}), malathion (168.22 q ha^{-1}), deltametherin + achook(163.29 q ha^{-1}) as compared to control (95.73 q ha^{-1}).

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ON FARM RESPONSE OF SOYBEAN – CHICKPEA CROPPING SYSTEM TO N, P AND K IN CENTRAL VIDARBHA ZONE

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ABSTRACT

Twelve on farm trials were conducted at three locations during 2004-05, 2005-06 and 2006-07 respectively in Chandrapur, and part of Nagpur district of central Vidarbha zone in Maharashtra, to study the response of recommended doses of N, P and K alone and in combinations in Soybean-chickpea cropping system. Among the different treatments, the highest yield of both soybean and chickpea (17.77q ha^{-1} and 15.76q ha^{-1}) was recorded with the application of recommended dose of NPK kg ha^{-1} (30:75:30 and 20:40:20 respectively). The highest total benefit (Rs.17038 ha^{-1}) was also obtained with the recommended application of NPK in soybean-chickpea cropping sequence.

(Key words : Soybean-chickpea cropping system, grain yield, economics, Central Vidarbha zone).

INTRODUCTION

Central Vidarbha zone comprises of Nagpur, Wardha, Yavatmal and part of Chandrapur district of Vidarbha region in Maharashtra State. The zone is characterized by semi-arid ecosystem with hot and dry summer and mild to cool winter. The average rainfall is 1133 mm received in average 43 rainy days. The soils are vertisols and associated ones derived from basalt rock, black in colour with varying depth, predominantly rich in montmorilonite type of clay. On an average the zone has 17.6 % heavy, 33% medium and 49.7% light soils. Average fertilizer consumption is 45.60 kg N, 16.19 kg P_2O_5 and 3.43 kg K_2O ha^{-1}. This is quite inadequate considering requirement of mono or double crop in a year. Farmers hesitate to apply recommended dose of fertilizer to the crops because of varied problems and therefore, imbalance application of NPK is also commonly observed. Imbalance use of fertilizer is one of the reason for low yield of chickpea. Therefore, it is essential to use full recommended dose of chemical fertilizer (Chourasia and Gupta ,2003). The object of study was to popularize the impact of application of recommended fertilizer dose to increase the productivity of crops. Keeping this in view, the present investigation entitled "On farm response of soybean-chickpea cropping system to N, P and K" was conducted in three blocks of Central Vidarbha zone.

MATERIALS AND METHODS

Field experiments were conducted at 12 locations (Villages) each year during 2004-05, 2005-06 and 2006-07 respectively with five treatments, treating locations as replications. Villages were selected in Chimur block (Chimur, Rengabodi, Chichghat and Aamdi) and Warora block (Chinora, Borda, Jamgaon and Pawana) of Chandrapur district and Bhiwapur block (Naxhi, Chatoli, Borkala, Virkhandi) of Nagpur district respectively. Treatments consist of T_1 - no NPK (control),T_2 - recommended dose of N alone, T_3 - recommended dose of NP alone, T_4 - recommended dose of NK alone and T_5 - recommended dose of NPK (30:75:30 and 20:40:20 kg NPK ha^{1}) for soybean and chickpea respectively, applied to both the crops on plot size of 20 m x 5 m.

The soils of experimental site is mostly medium in texture, fairly medium in clay content, light in lime reserve and slightly alkaline in reaction with high base saturation of exchange complexes (Table 1). Well distributed rainfall ranged between 1033 and 1166 mm which was received during the crop growth period. Soybean (JS-335) was sown from 20th June to 14th July in 2004-05, 24^{rth} to12th July in 2005-06 and 22nd to 10th July in 2006-07. Chickpea (AKG-46) was sown from 7th to 26th November in 2004-05, 10th to 25th November in 2005-06 and 12th to 23rd November in 2006-07. Soybean was harvested in last week of October to first week of November and chickpea was harvested in first week of March during studied years. Both the crops were raised with recommended package of practices except fertilization. Nitrogen, phosphorus and potassium were supplied through Urea, single super phosphate and murate of potash at recommended timings as per treatments.

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Life saving irrigations were given to chickpea at flowering and pod development stages and the recommended package of practices were adopted. Yield data net^{-1} plot was recorded at harvest in both the crops. Soil samples were air-dried, ground to pass through a 2 mm sieve and analyzed for PH, organic carbon of soils, which were determined by following the standard method (Jackson, 1973). Available N was estimated by alkaline permanganate oxidation method as outlined by Subbiah and Asija, (1956). Available P was determined by using Spectrophotometer and available K was estimated by Flame photometer (Jackson,1973).

Crop response kg^{-1} of nutrients (N,P,K) was determined by following equation

$$\text{Response kg}^{-1}\text{ of nutrient} = \frac{\text{System equivalent yield due to nutrient} - \text{System equivalent yield of control}}{\text{Sum of nutrients applied}} \times 100$$

RESULTS AND DISCUSSION

Data on the yield of soybean and succeeding crop chickpea (Table 2) indicated that the application of recommended dose of NPK to soybean was significantly superior over all other treatments. Application of NP increased the yields significantly over the control , recommended dose of NK and recommended dose of N alone, in the year 2004-05,2005-06 and 2006-07 respectively. Such effect of application of 100 % NPK+FYM have also been reported earlier by Deshmukh *et al.*(2005) in soybean.

In case of chickpea, application of recommended dose of NPK was found significantly superior but treatment NP increased the yield significantly over control, recommended dose of NK and recommended dose of N alone, in the year 2004-05,2005-06 and 2006-07. Similar result of increase in yield due to application of recommended N and P were reported by Chaudhary *et al.*(1998) in chickpea.

Pooled data indicated that the yield of soybean was the highest with the recommended dose of NPK. It was followed by the treatment NP which increased the yield significantly over control, recommended dose of NK and recommended dose of N alone. In case of chickpea, application of recommended dose of NPK was found significantly superior but treatment NP increased the yield significantly and was significantly superior over rest of the treatments. These results are in line with the finding of Thakur and Girothia (2010) who reported increase in the soybean-chickpea system productivity (202 kg ha^{-1}) to about 30 % with the application of phosphorus @ 39.6 kg ha^{-1}.

Economic analysis :

Data on economics of soybean-chickpea sequence as affected by fertilizer application (Table 3) indicated that total hectare^{-1} monetary benefit was augmented by Rs. 4702, 12394, 9111 and 17038 due to fertilization with only N, NP, NK and NPK respectively over control. The increased total benefit due to recommended NPK application was 262% higher than N application alone, 37 per cent higher than NP application alone and 87 per cent higher than NK application alone. These results conform by Chavan *et al.* (2007) on soybean,in which they reported that the application of recommended dose of fertilizer (30:75:30 kg NPK ha^{-1}) recorded higher net monetary returns (Rs.38,846 ha^{-1}), gross monetary returns (Rs.52,631 ha^{-1}) and B:C ratio (3.81).

Response of N, P and K :

The data on response to N, P and K in terms of soybean equivalent yield (Table 4) indicated that the response to N was 9.61, for P_2O_5 it was 7.12 while that for K_2O was 8.93 kg kg^{-1} of nutrients.

Table 1. Initial soil fertility status of experimental sites

Parameters	2004-05		2005-06		2006-07	
	Maxi.	Mini.	Maxi.	Mini.	Maxi.	Mini.
Available N kg ha^{-1}	228.3	106.2	232.5	221.5	306.2	218.6
Available P kg ha^{-1}	19.4	9.2	20.1	11.5	20.4	10.2
Available K kg ha^{-1}	528.6	502.3	412.2	398.4	496.8	368.2
O.C. (%)	0.67	0.61	0.43	0.34	0.62	0.36
pH	8.0	7.8	7.6	7.1	7.8	7.4
E C (dsm^{-1})	0.24	0.16	0.22	0.15	0.23	0.16

Table 2. Effect of NPK on yield (q ha^{-1}) of soybean and chickpea

Treatments	2004-05		2005-06		2006-07		Pooled	
	Soybean	Chickpea	Soybean	Chickpea	Soybean	Chickpea	Soybean	Chickpea
No NPK	10.29	6.79	8.56	8.45	11.75	8.91	10.20	8.50
Rec. N	12.04	8.87	10.56	11.06	13.95	11.04	12.36	10.32
Rec. NP	14.17	11.89	15.75	16.04	17.58	14.20	15.00	14.04
Rec. NK	12.94	10.08	14.02	13.50	15.45	12.45	14.14	12.01
Rec. NPK	15.98	13.42	17.50	17.70	19.87	16.16	17.77	15.76
SE(m) ± CM	0.27	0.47	0.28	0.18	0.27	0.23	0.27	0.29
CD (0.05)	0.77	1.34	0.78	0.49	0.75	0.67	0.79	0.82

Economic analysis

Table 3. Economic benefit due to the treatments

Treatment	Increased yield due to treatment		Value of increased yield (Rs.ha^{-1})	Expenditure due to treatment (Rs.ha^{-1}) for both crops	Total benefit due to treatment (Rs.ha^{-1})
	Soybean	Chickpea			
No NPK	-	-	-	-	-
Rec. N	2,60	1.82	5443	741	4702
Rec. NP	5.63	5.54	15435	3041	12394
Rec. NK	3.94	3.51	10227	1116	9111
Rec.NPK	7.57	7.26	20454	3416	17038

Response of N, P and K

Table 4. Crop response to applied N, P and K (kg soybean equivalent yield kg^{-1} nutrients)

Nutrient	2004-2005	2005-2006	2006-2007	Mean
N	8.36	9.68	10.80	9.61
P	6.03	6.67	8.68	7.12
K	7.66	8.68	10.46	8.93

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STUDIES ON GENETIC VARIABILITY IN LOCAL COLLECTIONS OF MUSTARD *(Brassica juncea* L.*)*

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ABSTRACT

Studies on genetic variability in local collections of mustard were conducted during *rabi* 2011 at the farm of Agricultural Botany Section, College of Agriculture, Nagpur with the objectives to assess the variability parameters among local collections of mustard. Twenty local lines collected from different regions of Vidarbha were evaluated during *rabi* 2011 by growing in RBD with three replications for days to first flower, days to maturity, plant height (cm), number of primary branches plant^{-1}, number of seeds siliqua^{-1}, 1000 seed weight (g), number of siliquae plant^{-1} and seed yield plant^{-1}(g). High magnitude of variability in terms of GCV and PCV percentage was recorded for 1000 seed weight, seed yield plant^{-1}, number of seeds siliqua^{-1} and number of siliquae plant^{-1}. Analysis of variance for the experimental design revealed high significant mean squares for all the characters which indicated significant variation among the experimental material and hence can be exploited in a better way in breeding programme. Within line variation was observed to be high for seed yield plant^{-1}, number of siliquae plant^{-1}, number of primary branches plant^{-1} and 1000 seed weight indicating the existence of significant variations in local collections which were exploited by selecting 200 Individual plant selections for their evaluation in the next generation.

(Key words : Mustard, Local lines, variability)

INTRODUCTION

Brassicas collectively known as rapeseed mustard are important oilseed crops of India and stands second after soybean production among eight annual edible oil seeds cultivated in our country. The current productivity level of 1190 kg ha^{-1} in India is far below than that of developed countries (2500 – 3000 kg ha^{-1}) as well as the world average of about 1900 kg ha^{-1} (Yadava *et al*., 2011). Though they have the varieties with high yield potential (2000 – 2500 kg ha^{-1}) yet there is wide fluctuation in area, production and productivity of this crop. This fluctuation is mainly due to its cultivation on marginal lands either rainfed or with limited irrigation facilities and non availability of biotic and abiotic stress resistance / tolerant varieties for different mustard growing regions of the country.

Rapeseed – mustard crops in India are grown in diverse agro climatic conditions ranging from North Eastern / North Western hills to South under irrigated / rainfed, timely / late sown, saline soils and mixed cropping. Indian mustard accounts for about 75 – 80 % of the 5.8 million hectare under these crops in the country during 2009-10 crop season. Globally India account for 21.7% and 10.7% of the total acreage and production (Anonymous, 2010). Soybean, groundnut and rapeseed – mustard are the major oilseed crops in India contributing nearly 79 % and 88 % to its total acreage and production, respectively. The contribution of rapeseed – mustard to the total oilseed acreage and production is 23.7% and 26.0% respectively. During 2009 – 10, rapeseed – mustard contributed 25.9% and 22.0 % to the total oilseeds production and acreage (Anonymous, 2010). In India, the area, production and productivity was 6.69 million hectare, 6.60 million tonnes and 1145 kg ha^{-1} respectively (Anonymous, 2011a). In Maharashtra area, production and productivity were 1200 hectares, 4000 tonnes and 308 kg ha^{-1} respectively (Anonymous, 2011a). In Vidarbha area under mustard cultivation was 865 hectares with the production of 330 tonnes and with an average productivity of 380 kg ha^{-1}. The districts in which mustard is grown were Chandrapur, Gondia, Bhandara, Gadchiroli, Nagpur and Wardha (Anonymous, 2011b).

The success of any breeding programme in general and improvement of specific trait through selection in particular, totally depends upon the genetic variability present in the available germplasm of a particular crop. Main thrust in any crop improvement programme is to enhance yield. As an established fact yield is a complex trait and is dependent on many other ancillary characters which are mostly inherited quantitatively. The different traits vary in their relationship with yield in terms of their nature as well as magnitude, though they show a continuous variation and are influenced by environment. The knowledge of genetic parameters of variation provides an idea about the extent of genetic improvement possible for different characters.

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Hence, in this study attempt was made to estimate the variability parameters among the local lines collected from different places of Vidarbha.

MATERIALS AND METHODS

The present study was carried out during *rabi* 2011 with 20 local collections of mustard viz., ACNM1, ACNM 2, ACNM 3, ACNM 4, ACNM 5, ACNM 6, ACNM 8, ACNM 22, ACNM 10, ACNM 11, ACNM 12, ACNM 13, ACNM 14, ACNM 15, ACNM 16, ACNM 17, ACNM 18, ACNM 19, ACNM 20 and ACNM 21 which were collected from different regions of Vidarbha. The genotypes were planted in a randomized block design replicated thrice with row length of 3 m and spacing between two rows 45 cm. Five plants were randomly selected from each genotype for recording agronomical observations. Data on eight characters viz., days to first flower, days to maturity, plant height(cm), number of primary branches plant^{-1}, number of siliquae plant^{-1}, number of seeds siliqua^{-1},1000 seed weight(g) and yield plant^{-1} (g) were recorded. The analysis of variance for experimental design was performed to test the significance of differences between the lines for all the characters as per the methodology suggested by Panse and Sukhatme (1954). Different genetic parameters like mean, variance, coefficient of variance, genotypic coefficient of variance and phenotypic coefficient of variance were estimated by the method given by Allard (1960) and Johanson *et al.(*1955) for all the characters studied.

RESULTS AND DISCUSSION

Analysis of variance (Table1) showed significant differences among local collections for all the eight characters studied. Variance due to mustard local collections were highly significant for all eight characters studied, indicating the presence of sufficient variability among the local collections selected for the study. The estimates of parameters of variability are presented in table 2. From table 2 it was observed that, among 20 local collections under study ACNM 17 (38.80 days) initiated early first flower followed by ACNM 1(39.53 days) and ACNM 21(41.20 days). Late flowering was observed in ACNM 18 (49.60 days) followed by ACNM 8 (48.80 days) and ACNM 11(48.13 days). For days to maturity ACNM17 (93.13 days) attained maturity early followed by ACNM 11 (93.60 days) and ACNM 6 (94.33 days). Late maturity was attained by ACNM 5 (100.07 days) followed by ACNM 1(99.07 days) and ACNM 8 (97.13 days). Maximum plant height was shown by ACNM 8 (134.20 cm) followed by ACNM 12 (131.73 cm) and ACNM 3 (131.67 cm). Minimum height was shown by ACNM 17(62.73 cm) followed by ACNM 15 (106.33 cm) and ACNM 16 (116.40 cm). Maximum number of primary branches were recorded in ACNM 12 (5.47) and ACNM 8 (5.47) followed by ACNM 2 (5.40) and ACNM 10 (5.27). Minimum number of primary branches was recorded in ACNM 17 (2.40) followed by ACNM 5 (3.53) and ACNM 20 (3.93). Highest amount of siliquae was produced by ACNM 8 (177.80) followed by ACNM 12 (171.60) and ACNM 10 (168.60). Lowest number of siliquae was produced by ACNM17 (34.67) followed by ACNM 5 (110.73) and ACNM 18 (116.20). Maximum number of seeds siliqua^{-1} was counted in ACNM 11(18.00) followed by ACNM 22 (16.67) and ACNM 10 (16.13). Minimum number of seeds siliqua^{-1} was counted in ACNM 5 (8.93) followed by ACNM 6 (9.93) and ACNM 4 (10.53). 1000 seed weight was recorded highest in ACNM 5 (4.87 g) followed by ACNM 18 (4.01 g) and ACNM 21(3.13 g). 1000 seed weight was lowest in ACNM 2 (0.72 g) followed by ACNM 4 (0.88 g) and ACNM14 (1.04 g). Maximum seed yield was recorded in ACNM1 (6.29 g) followed by ACNM 20 (6.15 g) and ACNM 3 (4.82 g). Minimum seed yield was recorded in ACNM 4 (1.49 g) followed by ACNM 15 (1.67 g) and ACNM 17 (1.80 g).

The data in table 2 also reveals that there were higher estimates of genotypic and phenotypic variances for all the characters studied except days to maturity, which is in confirmity with the studies of Kumar and Mishra (2007) who reported genetic variability, heritability and genetic advance in F_3 population in Indian mustard and suggested that selection for different characters can bring about improvement in mustard. The genotypic coefficients of variation helps in the measurement of the range of genetic diversity in quantitative characters. The phenotypic coefficient of variation was found to be higher than genotypic coefficient of variation for all the characters studied (Table 2). High magnitude of variability in terms of GCV and PCV percentage was recorded by 1000 seed weight (58.46% and 59.38 %) followed by seed yield plant^{-1} (34.34 % and 57.04%),

Table 1. Analysis of variance for the experimental design in mustard local collections

		Mean squares							
Sources	**d.f.**	**Days to first flower**	**Days to maturity**	**Plant height (cm)**	**No.of primary branches plant^{-1}**	**No. of siliquae plant^{-1}**	**No.of seeds siliqua^{-1}**	**1000 seed weight (g)**	**Seed yield plant^{-1} (g)**
Replication	2	4.19	2.73	527.81	1.35	1888.80	0.03	0.0003	0.44
Local collections	19	26.85**	7.58**	700.29**	1.63**	3014.13**	22.36**	4.28**	5.62**
Error	38	4.19	1.01	95.94	0.48	1216.63	0.11	0.05	2.08

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

Table 2. Estimates of variability parameters in mustard local collections

a) Days to first flower

Sr.No	Genotypes	Mean ± SE	Range	Variance	CV(%)
1	ACNM 1	39.53 ± 0.559	36.00 to 43.00	4.695	5.481
2	ACNM 2	42.13 ± 0.486	39.00 to 45.00	3.552	4.473
3	ACNM 3	44.93 ± 0.283	43.00 to 46.00	1.209	2.447
4	ACNM 4	48.07 ± 0.987	42.00 to 55.00	14.638	7.959
5	ACNM 5	42.80 ± 0.296	40.00 to 44.00	1.314	2.678
6	ACNM 6	45.07 ± 1.021	39.00 to 51.00	15.638	8.774
7	ACNM 8	48.80 ± 0.545	45.00 to 52.00	4.457	4.326
8	ACNM 22	46.73 ± 0.907	40.00 to 50.00	12.352	7.520
9	ACNM 10	47.93 ± 0.344	44.00 to 49.00	1.780	2.784
10	ACNM 11	48.13 ± 0.893	39.00 to 54.00	11.980	7.191
11	ACNM 12	44.60 ± 0.735	37.00 to 48.00	8.114	6.386
12	ACNM 13	47.20 ± 0.242	45.00 to 49.00	0.885	1.993
13	ACNM 14	45.73 ± 1.016	37.00 to 50.00	15.495	8.600
14	ACNM 15	45.00 ± 0.946	39.00 to 51.00	13.428	8.143
15	ACNM 16	46.40 ± 0.607	40.00 to 49.00	5.542	5.073
16	ACNM 17	38.80 ± 0.340	36.00 to 41.00	1.742	3.402
17	ACNM 18	49.60 ± 0.630	43.00 to 53.00	5.971	4.926
18	ACNM 19	44.93 ± 0.315	43.00 to 47.00	1.495	2.721
19	ACNM 20	44.33 ± 0.590	39.00 to 47.00	5.238	5.162
20	ACNM 21	41.20 ± 0.354	38.00 to 43.00	1.885	3.333
		Grand Mean	45.09		
		S E±	1.18		
		Range	38.80 to 49.60		
		GCV (%)	6.09		
		PCV(%)	7.59		

b) Days to maturity

Sr.No.	Genotypes	Mean ± S E	Range	Variance	CV(%)
1	ACNM 1	99.07 ± 0.206	98.00 to101.00	0.638	0.806
2	ACNM 2	94.53 ± 0.165	93.00 to 95.00	0.409	0.676
3	ACNM 3	95.80 ± 0.222	94.00 to 97.00	0.742	0.899
4	ACNM 4	96.27 ± 0.315	94.00 to 98.00	1.495	1.270
5	ACNM 5	100.07 ± 0.228	99.00 to 102.00	0.780	0.883
6	ACNM 6	94.33 ± 0.484	92.00 to 97.00	3.523	1.989
7	ACNM 8	97.13 ± 0.336	95.00 to 99.00	1.695	1.340
8	ACNM 22	96.67 ± 0.251	95.00 to 99.00	0.952	1.009
9	ACNM 10	96.00 ± 0.169	95.00 to 97.00	0.428	0.681
10	ACNM 11	93.60 ± 0.505	92.00 to 97.00	3.828	2.090
11	ACNM 12	96.53 ± 0.236	95.00 to 98.00	0.838	0.948
12	ACNM 13	96.27 ± 0.300	94.00 to 98.00	1.352	1.208
13	ACNM 14	95.93 ± 0.266	94.00 to 97.00	1.066	1.076
14	ACNM 15	96.07 ± 0.206	95.00 to 97.00	0.638	0.831
15	ACNM 16	96.67 ± 0.159	96.00 to 98.00	0.380	0.638
16	ACNM 17	93.13 ± 0.542	90.00 to 96.00	4.409	2.254
17	ACNM 18	96.67 ± 0.159	96.00 to 98.00	0.380	0.638
18	ACNM 19	96.67 ± 0.210	96.00 to 99.00	0.666	0.844
19	ACNM 20	96.73 ± 0.181	96.00 to 98.00	0.495	0.727
20	ACNM 21	96.13 ± 0.191	95.00 to 97.00	0.552	0.773
		Grand Mean	96.21		
		S E±	0.58		
		Range	93.13 to 100.07		
		GCV (%)	1.54		
		PCV(%)	1.86		

Table 2 cont...

c) Plant height (cm)

Sr.No.	Genotypes	Mean ± SE	Range	Variance	CV(%)
1	ACNM 1	121.87 ± 4.602	90.00 to 140.00	317.695	14.625
2	ACNM 2	123.20 ± 3.214	105.00 to 150.00	155.028	10.106
3	ACNM 3	131.67 ± 4.420	100.00 to 155.00	293.095	13.002
4	ACNM 4	129.40 ± 3.573	108.00 to 150.00	191.542	10.695
5	ACNM 5	125.60 ± 4.534	90.00 to 155.00	308.400	13.981
6	ACNM 6	123.40 ± 3.404	100.00 to 150.00	173.820	10.684
7	ACNM 8	134.20 ± 2.678	115.00 to 150.00	107.600	7.729
8	ACNM 22	125.33 ± 2.44	110.00 to 140.00	89.380	7.543
9	ACNM 10	131.53 ± 2.953	115.00 to 150.00	130.830	8.696
10	ACNM 11	124.13 ± 2.53	110.00 to 140.00	96.266	7.904
11	ACNM 12	131.73 ± 3.934	110.00 to 155.00	232.209	11.567
12	ACNM 13	124.40 ± 3.451	100.00 to 150.00	178.685	10.745
13	ACNM 14	122.73 ± 2.903	100.00 to 145.00	126.495	9.163
14	ACNM 15	106.33 ± 2.444	83.00 to 120.00	89.666	8.905
15	ACNM 16	116.40 ± 2.716	102.00 to 135.00	110.685	9.038
16	ACNM 17	62.73 ± 1.890	52.00 to 75.00	53.638	11.674
17	ACNM 18	118.47 ± 3.404	92.00 to 135.00	173.838	11.129
18	ACNM 19	125.67 ± 3.228	110.00 to 158.00	156.381	9.951
19	ACNM 20	124.27 ± 3.679	110.00 to 162.00	203.066	11.467
20	ACNM 21	124.13 ± 2.906	105.00 to 150.00	126.695	9.067
		Grand Mean	120.49		
		S E±	5.65		
		Range	62.73 to 134.20		
		GCV (%)	11.78		
		PCV(%)	14.31		

d) Number of primary branches plant^{-1}

Sr.No.	Genotypes	Mean ± SE	Range	Variance	CV(%)
1	ACNM 1	5.20 ± 0.326	3.00 to 8.00	1.600	24.325
2	ACNM 2	5.40 ± 0.362	3.00 to 8.00	1.970	26.001
3	ACNM 3	4.47 ± 0.215	3.00 to 6.00	0.695	18.667
4	ACNM 4	4.87 ± 1.695	3.00 to 7.00	1.695	26.753
5	ACNM 5	3.53 ± 0.255	2.00 to 6.00	0.980	28.031
6	ACNM 6	5.00 ± 0.258	3.00 to 6.00	1.000	20.000
7	ACNM 8	5.47 ± 0.321	4.00 to 8.00	1.552	22.791
8	ACNM 22	4.53 ± 0.236	3.00 to 7.00	0.838	20.194
9	ACNM 10	5.27 ± 0.315	3.00 to 7.00	1.495	23.217
10	ACNM 11	4.73 ± 0.266	3.00 to 6.00	1.066	21.819
11	ACNM 12	5.47 ± 0.165	4.00 to 6.00	0.409	11.706
12	ACNM 13	4.53 ± 0.273	3.00 to 6.00	1.123	23.384
13	ACNM 14	4.40 ± 0.130	4.00 to 5.00	0.257	11.524
14	ACNM 15	4.13 ± 0.290	3.00 to 6.00	1.266	27.230
15	ACNM 16	5.13 ± 0.336	3.00 to 7.00	1.695	25.363
16	ACNM 17	2.40 ± 0.130	2.00 to 3.00	0.257	21.128
17	ACNM 18	4.33 ± 0.251	3.00 to 6.00	0.952	22.520
18	ACNM 19	4.40 ± 0.362	2.00 to 7.00	1.971	31.910
19	ACNM 20	3.93 ± 0.153	3.00 to 5.00	0.352	15.091
20	ACNM 21	4.47 ± 0.236	3.00 to 6.00	0.838	20.495
		Grand Mean	4.58		
		S E±	0.39		
		Range	2.40 to 5.47		
		GCV (%)	13.52		
		PCV(%)	20.23		

Table 2 cont....

e) Number of siliquae plant^{-1}

Sr.No.	Genotypes	Mean ± SE	Range	Variance	CV(%)
1	ACNM 1	159.00 ± 19.36	80.00 to 390.00	5622.143	47.160
2	ACNM 2	148.53 ± 14.549	60.00 to 240.00	3175.124	37.940
3	ACNM 3	141.00 ± 9.665	90.00 to 230.00	1401.286	26.548
4	ACNM 4	145.33 ± 9.298	98.00 to 210.00	1296.810	24.778
5	ACNM 5	110.73 ± 7.872	78.00 to 200.00	929.638	27.534
6	ACNM 6	151.27 ± 8.584	93.00 to 210.00	1105.352	21.978
7	ACNM 8	177.80 ± 13.103	94.00 to 280.00	2575.600	28.543
8	ACNM 22	146.73 ± 13.681	45.00 to 268.00	2807.924	36.113
9	ACNM 10	168.60 ± 15.604	100.00 to 308.00	3652.543	35.845
10	ACNM 11	152.00 ± 12.351	80.00 to 230.00	2288.571	31.473
11	ACNM 12	171.60 ± 11.188	110.00 to 255.00	1877.829	25.252
12	ACNM 13	123.13 ± 5.727	92.00 to 170.00	491.981	18.013
13	ACNM 14	128.40 ± 8.199	90.00 to 208.00	1008.543	24.733
14	ACNM 15	118.47 ± 7.293	83.00 to 169.00	797.838	23.843
15	ACNM 16	164.27 ± 15.423	80.00 to 310.00	3568.210	36.364
16	ACNM 17	34.67 ± 1.358	24.00 to 45.00	27.666	15.172
17	ACNM 18	116.20 ± 8.800	68.00 to 200.00	1161.60	29.330
18	ACNM 19	122.33 ± 12.908	50.00 to 205.00	2499.524	40.870
19	ACNM 20	121.73 ± 11.405	80.00 to 254.00	1951.352	36.287
20	ACNM 21	143.47 ± 8.927	98.00 to 225.00	1195.410	24.099
		Grand Mean	136.57		
		S E±	20.14		
		Range	34.67 to 177.80		
		GCV (%)	17.92		
		PCV(%)	31.20		

f) Number of seeds siliqua^{-1}

Sr.No.	Genotypes	Mean ± SE	Range	Variance	CV(%)
1	ACNM 1	11.07 ± 0.206	10.00 to 12.00	0.638	7.218
2	ACNM 2	14.27 ± 0.266	13.00 to 16.00	1.066	7.239
3	ACNM 3	15.73 ± 0.283	14.00 to 17.00	1.209	6.990
4	ACNM 4	10.53 ± 0.133	10.00 to 11.00	0.266	4.902
5	ACNM 5	8.93 ± 0.206	8.00 to 10.00	0.638	8.941
6	ACNM 6	9.93 ± 0.206	9.00 to 11.00	0.638	8.041
7	ACNM 8	14.93 ± 0.206	14.00 to 16.00	0.638	5.349
8	ACNM 22	16.67 ± 0.287	15.00 to 18.00	1.238	6.676
9	ACNM 10	16.13 ± 0.191	15.00 to 17.00	0.552	4.606
10	ACNM 11	18.00 ± 0.195	17.00 to 19.00	0.571	4.199
11	ACNM 12	13.87 ± 0.191	13.00 to 15.00	0.552	5.359
12	ACNM 13	9.00 ± 0.218	8.00 to 10.00	0.714	9.390
13	ACNM 14	13.07 ± 0.181	12.00 to 14.00	0.495	5.385
14	ACNM 15	11.07 ± 0.181	10.00 to 12.00	0.495	6.359
15	ACNM 16	15.73 ± 0.206	15.00 to 17.00	0.638	5.077
16	ACNM 17	12.13 ± 0.191	11.00 to 13.00	0.552	6.125
17	ACNM 18	11.93 ± 0.206	11.00 to 13.00	0.638	6.693
18	ACNM 19	10.87 ± 0.215	10.00 to 12.00	0.695	7.673
19	ACNM 20	11.00 ± 0.195	10.00 to 12.00	0.571	6.872
20	ACNM 21	15.13 ± 0.191	14.00 to 16.00	0.552	4.911
		Grand Mean	12.96		
		S E±	0.19		
		Range	8.93 to 18.00		
		GCV (%)	21.00		
		PCV(%)	21.15		

Table 2 cont..

g) 1000 seed weight (g)

Sr.No.	Genotypes	Mean ± SE	Range	Variance	CV(%)
1	ACNM 1	3.04 ± 0.134	2.30 to 3.80	0.272	17.173
2	ACNM 2	0.72 ± 0.026	0.50 to 0.90	0.010	14.085
3	ACNM 3	3.03 ± 0.030	2.80 to 3.20	0.013	3.874
4	ACNM 4	0.88 ± 0.035	0.70 to 1.20	0.018	15.604
5	ACNM 5	4.87 ± 0.091	4.40 to 5.40	0.125	7.271
6	ACNM 6	2.63 ± 0.044	2.40 to 2.90	0.029	6.524
7	ACNM 8	1.08 ± 0.022	1.00 to 1.20	0.007	8.015
8	ACNM 22	0.89 ± 0.019	0.80 to 1.00	0.005	8.382
9	ACNM 10	1.11 ± 0.067	0.50 to 1.40	0.067	23.530
10	ACNM 11	1.13 ± 0.028	1.00 to 1.40	0.012	9.761
11	ACNM 12	2.76 ± 0.078	2.30 to 3.20	0.092	11.023
12	ACNM 13	1.57 ± 0.045	1.30 to 1.90	0.030	11.130
13	ACNM 14	1.04 ± 0.025	0.90 to 1.20	0.009	9.477
14	ACNM 15	1.19 ± 0.035	1.00 to 1.40	0.018	11.424
15	ACNM 16	1.07 ± 0.031	0.90 to 1.30	0.015	11.572
16	ACNM 17	2.36 ± 0.023	2.20 to 2.50	0.008	3.857
17	ACNM 18	4.01 ± 0.045	3.70 to 4.30	0.030	4.370
18	ACNM 19	1.31 ± 0.033	1.10 to 1.50	0.016	9.913
19	ACNM 20	2.85 ± 0.030	2.70 to 3.10	0.014	4.160
20	ACNM 21	3.13 ± 0.037	2.90 to 3.40	0.020	4.619
		Grand Mean	2.03		
		S E±	0.12		
		Range	0.72 to 4.87		
		GCV (%)	58.46		
		PCV(%)	59.38		

h) Seed yield plant^{-1} (g)

Sr.No.	Genotypes	Mean ± SE	Range	Variance	CV(%)
1	ACNM 1	6.29 ± 1.065	2.50 to 20.00	17.015	65.610
2	ACNM 2	3.35 ± 0.353	1.90 to 7.00	1.878	40.952
3	ACNM 3	4.82 ± 0.489	2.00 to 8.60	3.593	39.326
4	ACNM 4	1.49 ±0.085	1.10 to 2.00	0.110	22.276
5	ACNM 5	3.48 ± 0.402	1.70 to 6.30	2.431	44.810
6	ACNM 6	2.10 ± 0.220	0.80 to 3.20	0.727	40.606
7	ACNM 8	2.49 ±0.202	1.60 to 4.60	0.617	31.524
8	ACNM 22	3.23 ± 0.353	1.50 to 6.00	1.872	42.404
9	ACNM 10	2.69 ± 0.281	1.00 to 4.60	1.189	40.489
10	ACNM 11	1.93 ± 0.196	0.70 to 3.80	0.582	39.599
11	ACNM 12	4.49± 0.470	2.30 to 8.20	3.321	40.618
12	ACNM 13	2.19 ± .197	1.30 to 3.60	0.585	34.993
13	ACNM 14	3.49 ± 0.448	1.80 to 8.40	3.020	49.752
14	ACNM 15	1.67±0.073	1.20 to 2.20	0.080	16.973
15	ACNM 16	2.46 ± 0.202	1.20 to 4.30	0.614	31.852
16	ACNM 17	1.80 ± 0.086	1.20 to 2.50	0.111	18.544
17	ACNM 18	3.61 ± 0.333	1.10 to 7.40	1.664	35.776
18	ACNM 19	2.53 ± 0.344	1.10 to 5.20	1.776	52.750
19	ACNM 20	6.15 ±1.139	2.60 to 15.60	19.488	71.820
20	ACNM 21	3.09 ± 0.322	1.60 to 5.00	1.557	40.348
		Grand Mean	3.16		
		S E±	0.83		
		Range	1.49 to 6.29		
		GCV (%)	34.34		
		PCV(%)	57.04		

number of seeds siliqua^{-1}(21% and 21.15 %) and number of siliquae plant^{-1}(17.19% and 31.20%) as observed from table 2. High magnitude of variability were also reported in Indian mustard germplasm and varieties for various characters by Kumar and Mishra (2007) and Yadava *et al.* (2011) for days to 50 % flowering, days to maturity, plant height, number of siliquae plant^{-1}, 1000 seed weight and seed yield plant^{-1} and indicated the presence of sufficient variability in the genotypes used for the study. The reason of high magnitude of variability may be due to the fact that lines were collected from different regions with different soil and climatic conditions of Vidarbha.

These characters days to first flower, plant height, number of primary branches plant^{-1}, number of siliquae plant^{-1}, number of seeds siliqua^{-1},1000 seed weight and seed yield plant^{-1} except days to maturity were found to be the main yield contributing characters. This result revealed the presence of high amount of genetic variability in the evaluated lines for the major yield contributing characters along with seed yield plant^{-1} which indicated that further improvement for this trait is possible.

Within line variation was observed to be high for seed yield plant^{-1} in ACNM 20 (71.82 %), followed by ACNM 1 (65.61 %) and ACNM 19 (52.75 %). Simillarly, within line variation were also high for characters like number of siliquae plant^{-1}(47.16 % in ACNM 1, 40.87 % in ACNM 19 and 37.94 % in ACNM 2), number of primary branches plant^{-1} (31.91% in ACNM 19, 28.03 % in ACNM 5 and 27.23 % in ACNM 15) and 1000 seed weight (23.53 % in ACNM 10, 17.17 % in ACNM 1 and 15.60 % in ACNM 4). This indicates that significant variations existed as inherent potential in local collections which can be exploited. This study revealed the existence of high variability between and within local lines for seed yield plant^{-1} and most of the important yield components like number of siliquae plant^{-1}, number of primary branches and 1000 seed weight. Hence, to exploit the potential variability for most of the traits in these local lines, ten individual plant selections (IPS) in each of 20 local lines were done based on phenotypic observations. 200 Individual plant selections thus were obtained for evaluation in next season from this study.

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RESPONSE OF CUCUMBER CROP (*Cucumis sativus* L.) TO DRIP IRRIGATION SYSTEM UNDER VARIOUS MULCHES

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ABSTRACT

The field experiment on 'Effect of different irrigation levels of drip irrigation system coupled with various mulches on growth and yield of cucumber (*Cucumis sativus* L.)' was undertaken at Dr. Balasaheb Sawant Konkan Krishi Vidyapoeeth, Dapoli during 2006. The experiment was laid out in split plot design. There were sixteen treatment combinations comprising of four different types of mulches i.e. without mulch (MT_1), white transparent polythene mulch (MT_2), black polythene mulch (MT_3) and paddy straw mulch (MT_4) and four levels of irrigation i.e. control (IL_1), 50 per cent ET (IL_2), 75 per cent ET (IL_3) and 100 per cent ET (IL_4) under drip and replicated five times. The conventional method of irrigation without mulch was taken as control. From the study, it was revealed that the maximum yield of 270 q ha^{-1} was obtained in the treatment combination of white transparent polythene mulch and irrigation level of 100 per cent ET followed by 252.2 q ha^{-1} in the treatment combination of white transparent polythene mulch with control irrigation and black polythene mulch with irrigation by 100 per cent ET by drip. The individual effect of mulch, irrigation and the interaction effect were found to be significant. Even after applying the water of 100 per cent ET for getting the maximum yield (256.5 q ha^{-1}), there was 41.48 per cent saving of water over control. It was revealed from the data that, the maximum benefit : cost ratio was observed (1.90) in treatment combination of transparent polythene mulch with irrigation level of 100 per cent ET, followed by straw mulch with irrigation level of 100 per cent ET (1.73). The maximum net income (Rs. 85,704 ha^{-1}) was observed in treatment combination of white transparent polythene mulch and irrigation level of 100 per cent ET by drip, i.e. about 249 per cent more than the control treatment. It was followed by transparent polythene mulch with control irrigation (Rs. 47,604 ha^{-1}) and black polythene mulch and irrigation level of 100 per cent ET by drip (Rs. 47,260 ha^{-1}).

(**Key words*:* Cucumber, irrigation, mulch, net income, B:C ratio**)

INTRODUCTION

Cucumber cultivation area in Maharashtra State and India is 0.005 M ha and 0.02 M ha with production of 18 t ha^{-1} and 6.67 t ha^{-1}, respectively (Jagtap, 2008). This indicates the area and productivity of cucumber is very low, which needs to be increased substantially by way of developing suitable package of practices. The fruit and vegetable intake among the population in India, Mali and Pakistan is about 100 gram $capita^{-1}$ day^{-1} or less, compared to 300 grams consumed in Australia, several European countries and the USA. Even so, the fruit and vegetable consumption in these high income countries are still less than the WHO/FAO recommended level of 400 grams or five servings day^{-1} (Pollack, 2001). Of the various vegetables grown, cucumber has high place in the diet as a rich source of carbohydrates as a breakfast fruit and as an ingredient of salads. It forms an important and big group of vegetable in our diet due to its high nutritive value (44.5 g of average nutritive value 100 g^{-1} dry matter). The conventional irrigation methods do not apply water efficiently and distribute uniformly causing water losses due to conveyance, seepage, deep percolation especially in light textured soil occurring in most part of Konkan region. As water is scarce commodity, it should be used judiciously. The drip irrigation is the best option for overcoming these problems. The mulching plays an important role in controlling evaporation. In recent years, different kinds of mulching material have been used in controlling evaporation and conserving soil moisture. Clear plastic mulch transmits 85 to 95 per cent solar radiation through it and helps in raising the soil temperature by 4 to 8^0C (Shinde *et al*., 2006).

Limbulkar *et al.* (1998) conducted a field experiment on study of yield response of cucumber variety Himangi to micro irrigation at M.P.K.V., Rahuri. They reported that the yield obtained due to treatment of 110 per cent pan evaporation was significantly superior over all other treatments, but yield of cucumber irrigated with 90 per cent pan evaporation treatment by drip irrigation was higher (23.175 t ha^{-1}) than irrigated with 90 per cent pan evaporation treatment by surface irrigation. Siwek *et al.* (2003) studied the effect of some kinds of direct plant covering as four perforated polythene films and non-woven polypropylene and soil mulching with black polythene film on the soil temperature and yield

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of cucumber Marinda. The early and marketable yields of fruits were the highest in case of applying polythene film with perforations of 6 cm in diameter as a direct cover. Tiwari *et al.* (2003) conducted an experiment on lateritic sandy loam soils of Kharagpur to evaluate the feasibility of growing cabbage crop under drip irrigation with mulches. They concluded that yields were recorded as 111.72, 108.87 and 107.94 $t.ha^{-1}$ for drip with plastic mulch, drip with rice husk and drip with paddy straw, respectively. However, the study of mulching coupled with irrigation scheduling was not available for the cucumber crop. In order to increase the productivity and production of cucumber, there is need to have information about mulches and irrigation scheduling through drip and therefore the present study was undertaken.

MATERIALS AND METHODS

The field experiment was conducted on the research farm of Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during *rabi* season in 2006. During the crop period, the maximum and minimum temperature ranged from 27^0C to 37.8^0C and 6^0C to 19.6^0C, respectively; whereas the minimum pan evaporation was 2.8 mm day^{-1} and maximum was 6.7 mm day^{-1}. The topography of the experimental field was uniform and levelled. The soil was sandy clay loam in texture with 26 per cent field capacity and 14 per cent wilting point. The electrical conductivity (EC) and pH of the experimental plot were 0.49 dSm^{-1} and 6.55, respectively. Also, available N, P and K in soil were 400.50, 14.52 and 250.52 kg ha^{-1}, respectively. The reaction of water was normal in nature and low in salinity, thus was safe for irrigation.

The experiment was carried out in split plot design with four main plot treatments MT_1: without mulch, MT_2: transparent polythene mulch, MT_3: black polythene mulch and MT_4: paddy straw mulch and four sub plot irrigation treatments viz., IL_1: control, IL_2: drip with 50 per cent crop ET, IL_3: drip with 75 per cent crop ET and IL_4: drip with 100 per cent crop ET, replicated for five times. The experiment was laid out with sixteen-treatment combination arranged randomly in a field of 32 m x 36 m size with spacing of 1.0 x 0.5 m. The buffer of 1.5 m was left between two successive treatment plots in order to avoid lateral movement of water from one plot to another. The cucumber variety Himangi was sown on 4^{th} Jan. 2006. Each vine was provided with one turbo key dripper of 4 lph discharge. The crop was supplied with farmyard manure @ 2.5 kg pit^{-1} and thoroughly mixed with soil before sowing. The recommended dose of fertilizer at the rate of 135 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1} was applied. Out of which 50 per cent of N, 100 per cent of P and 100 per cent of K were applied as a basal dose and remaining 50 per cent of N was applied as top dressing at the time of flower initiation.

For scheduling of irrigation, reference evapotranspiration (ETo) was worked out by Penman Monteith method (Allen *et al.*, 1998). It was multiplied by the crop coefficients for cucumber given in FAO-56 (Allen *et al.*, 1998) for calculating crop evapotranspiration. The gross irrigation depth was calculated by dividing the net depth of irrigation by uniformity coefficient of the drip irrigation system. The irrigation was scheduled on alternate day basis for all irrigation levels except control in which the 50 mm irrigation depth was applied after occurring of 50 mm cumulative pan evaporation. Total 43 number of irrigations were applied in all irrigation levels except control, in which eight irrigations were applied. The depth of water applied in different irrigation levels and the quantity of water saved as compared to the control is reported in table 1. To study the effect of different treatments on the growth of cucumber vine, the biometric observations like vine length, number of leaves $vine^{-1}$, number of branches $vine^{-1}$ and fruits $vine^{-1}$ were recorded. For recording the observations in each treatment, five vines $replication^{-1}$ were selected for the observation by adopting the standard procedure of sampling technique. The selected observation vines were properly tagged for their identification. The vine length was measured from the ground level upto the base of terminal leaf bud on the main stem at 10, 20, 35, 50, 65 and 80 days after emergence of seeds with the help of measuring tape. The number of leaves and number of branches $vine^{-1}$ were counted in a similar way. The vine length, number of leaves and number of branches $vine^{-1}$ were recorded on 80 days after emergence of seeds are reported in the table 2 to table 4. The fruits were harvested and counted and the average number of fruits $vine^{-1}$ in each treatment were worked out in table 5.

RESULTS AND DISCUSSION

Biometric observations:

The data regarding biometric observations are reported in table 2 to table 5. The transparent polythene mulch treatment recorded significantly superior (increased) vine length, more number of leaves vine^{-1}, branches vine^{-1} and fruits vine^{-1} over the rest of the treatments. The black polythene mulch recorded significantly superior growth attributes over straw mulch and without mulch, while application of straw mulch showed its supremacy over without mulch. The irrigation by drip at 100 per cent ET recorded significantly more vine length, leaves vine^{-1} and fruits vine^{-1} than other treatments, while more number of branches vine^{-1} was observed in control irrigation. Drip irrigation at 50 per cent ET at all mulching levels recorded significantly higher vine length, number of leaves vine^{-1}, number of branches vine^{-1} and number of fruits vine^{-1} as compared to other treatment combination. Application of transparent polythene mulch to cucumber at all levels of irrigation recorded significantly superior above mentioned biometric observations as compared to other treatment combinations.

Serhat and Cigdem (2009) conducted an experiment on deficit irrigation effects on cucumber yield in unheated greenhouse condition. They applied water to cucumber as 100 (K1cp), 75 (K2cp), 50(K3cp), 25(K4cp) and o(K5cp) per cent (as control) of evaporation from a Class A pan corresponding to 2 days irrigation frequency. Irrigation water applied to crops ranged from 75 to 420 mm, and water consumption ranged from 84 to 424 mm. The effect of irrigation water level on fruit length, fruit diameter, fruit weight and dry matter ratio were found to be significantly affected by the irrigation.

Todd *et al.* (2011) studied the yield of spring planted cucumber using row covers, polyethylene mulch and chilling resistant cultivars. They found that the use of mulch and polyester row covers would allow early production of cucumbers (picking and slicing types) in North Corolina. The field could be planted as early as mid-March, thus anticipating traditional cultivation of one month. Furthermore, the use of mulch and row covers increased yield of commercial cultivars dramatically.

Yield of fruits:

The statistical analysis revealed that different mulches influenced the average yield of fruits significantly (Table 6). The data on average yield of fruits at the time of harvest as influenced by different treatments are presented in table 7. The mulching treatment transparent polythene mulch gave maximum yield of 265.8 q ha^{-1} , which was significantly superior over the other three mulching treatments. The treatment without mulch gave minimum yield (170.8 q ha^{-1}), while the treatment straw mulch gave significantly superior yield over the without mulch. This might be due to the favorable microclimate status in the root zone of crop.

Similarly, irrigation levels had significant effect on the average yield of fruit. The maximum average yield (256.5 q ha^{-1}) was obtained in the 100 per cent ET irrigation by drip which was significantly superior to the average yield obtained in all other treatments. The lowest average yield of fruits was registered in irrigation at 50 per cent ET by drip (158.1 q ha^{-1}). This decrease in yield might be due to lower application of water than required by the crop. The interaction between mulches and irrigation levels for yield of fruits was significant.

The maximum average yield (361.5 q ha^{-1}) of fruits was reported in the treatment transparent polythene mulch with irrigation level of 100 per cent ET by drip and was found significantly superior over rest of the treatments. It was followed by transparent polythene mulch with irrigation level of 75 per cent ET by drip (270.0 q ha^{-1}); followed by transparent polythene mulch with control irrigation method (252.2 q ha^{-1}) and black polythene mulch with irrigation level of 100 per cent ET by drip (252.2 q ha^{-1}). This indicates the superiority of transparent polythene mulch for increasing the yield. These results are almost similar with those obtained by Yaghi *et al.* (2013). They studied the effect of two types of plastic mulch i.e. transparent and black with drip irrigation on water requirement and cucumber yield. The results of the study indicated that drip irrigation with transparent mulch treatment excelled all other treatments for yield and water use efficiency

(WUE). The yield of 63.9 t ha^{-1} and WUE was 0.262 t ha^{-1} mm^{-1} in drip irrigation with transparent mulch, while in drip irrigation with black mulch it was 57.9 t ha^{-1} and 0.238 t ha^{-1} mm^{-1}, respectively. The cucumber yield and WUE declined in the remaining treatments of drip irrigation with no mulch and surface irrigation with no mulch to reach 44.1 t ha^{-1} with WUE 0.153 t ha^{-1}mm^{-1} and 37.7 t ha^{-1} with WUE of 0.056 t ha^{-1} mm^{-1}, respectively. Serhat and Cigdem (2009) observed highest yield of 148 and 108 t ha^{-1} for the K1cp and K2cp treatment, respectively. Crop yield response factor (ky) was 1.213.

Water use efficiency (WUE):

The data regarding WUE as influenced by different treatments are presented in table 8.

Different irrigation levels also affected the WUE and it varies from 5.19 to 13.50 q ha^{-1} cm^{-1}. The highest WUE of 13.50 q ha^{-1} cm^{-1} was observed in irrigation level at 50 per cent ET by drip followed by 75 per cent ET by drip (12.85 q ha^{-1} cm^{-1}) and 100 per cent ET by drip (10.96 q ha^{-1} cm^{-1}). The lowest WUE of 5.19 q ha^{-1} cm^{-1} was observed in control treatment as maximum depth of water i.e. 40 cm was applied in that level. The lowest water depth of 11.71 cm was found in irrigation level of 50 per cent ET by drip, followed by 75 per cent ET by drip (17.56 cm) and 100 per cent ET by drip (23.41 cm).

Kirnak and Demirtas (2006) studied effectiveness of different mulch types on fruit yield and plant growth parameters. The black polythene mulch, wheat straw mulch and the combination of both were used along with other stress and unstressed treatments. The WUE ranged from 3.40 to 5.78 kg m^{-3}, while irrigation water use efficiency (IWUE) varied between 3.39 to 6.08 kg m^{-3}. IWUE and WUE were increased under water stress treatment, as mulching significantly reduced the amount of irrigation water required. Both black polythene mulch and wheat straw mulch improved the fruit yield, fruit size, plant dry matter, total leaf area and chlorophyll and increases in these parameters. The present study confirms in study that limiting soil evaporation with mulches helps to save precious irrigation water and to improve WUE and IWUE.

Satpute *et al.* (2008) conducted an experiment to study the effect of fertigation and irrigation schedule on growth and yield of cucumber. They found the water requirement of cucumber through drip and conventional irrigation method as 19.53 cm and 48 cm, respectively, indicating 59.31 per cent saving of water in drip irrigation over conventional method. Serhat and Cigdem (2009) observed highest values for water use efficiency (WUE) and irrigation water use efficiency (IWUE) as 34.91 and 31.90 kg mm^{-1} for the K1cp treatment. Under the conditions that water resources are scarce, it can be recommended that K1 cp treatment is most suitable as a water application level for cucumber irrigation by drip irrigation under unheated greenhouse condition.

The mulching treatment of transparent mulch shown maximum WUE of 11.35 q ha^{-1} cm^{-1}, followed by black polythene and straw mulch with 9.34 and 8.22 q ha^{-1} cm^{-1}, respectively. The lowest WUE of 7.30 q ha^{-1} cm^{-1} was observed in no mulch by Yaghi *et al.* (2013).

Cost economics for cucumber:

The maximum cost of production (Table 9) was observed in treatment combinations transparent polythene mulch with irrigation at 100 per cent ET by drip (95,046/- ha^{-1}) followed by treatment combinations transparent polythene mulch with irrigation at 75 per cent ET by drip (87,396/- ha^{-1}) and transparent polythene mulch with irrigation at 75 per cent ET by drip (Rs. 85,946/- ha^{-1}). The gross monetary returns show the same trend.

The maximum net monetary returns was gained from treatment combination transparent polythene mulch with irrigation at 100 per cent ET by drip (Rs.85,704/-) followed by transparent polythene mulch with control irrigation (Rs. 47,604 ha^{-1}) and black polythene mulch with irrigation at 100 per cent ET by drip (Rs.47,260/-), whereas minimum net income was reported in black polythene mulch with irrigation at 50 per cent ET by drip treatment combination (Rs. 10,594 ha^{-1}). The maximum B:C ratio was observed in treatment combination transparent polythene mulch with irrigation at 100 per cent ET by drip (1.90), followed by straw mulch with irrigation at 100 per cent ET by drip (1.73) and without mulch with irrigation at 100 per cent ET by drip (1.70) and straw mulch with irrigation at 75 per

Table 1. Depth of water applied and saving of water in different irrigation levels

Sr. No.	Irrigation levels	Depth of water applied, (cm)	Per cent saving in water over control
1.	Control	40.00	-
2.	50 % ET by drip irrigation	11.71	70.73
3.	75 % ET by drip irrigation	17.56	56.09
4.	100 % ET by drip irrigation	23.42	41.46

Table 2. Effect of mulches and irrigation levels on vine length

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	140.75	199.67	183.00	170.30	173.43
IL_2	155.80	203.20	192.50	181.80	183.33
IL_3	137.40	178.55	166.40	153.80	159.04
IL_4	126.45	153.90	143.00	136.85	140.05
Mean	140.10	183.83	171.23	160.69	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.05	0.08	0.15	0.16
CD at 5 %	0.16	0.23	0.43	0.46

Table 3. Effect of mulches and irrigation levels on number of leaves vine^{-1}

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	71.70	107.88	107.01	105.97	98.14
IL_2	89.20	115.29	107.42	97.90	102.45
IL_3	71.57	99.22	86.32	79.47	84.15
IL_4	59.66	79.57	68.15	56.47	65.96
Mean	73.03	100.49	92.23	84.96	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.09	0.15	0.27	0.30
CD at 5 %	0.28	0.42	0.78	0.85

Table 4. Effect of mulches and irrigation levels on number of branches vine^{-1}

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	8.15	9.55	9.10	8.55	8.84
IL_2	7.95	9.35	9.00	8.70	8.75
IL_3	7.75	8.75	8.40	8.00	8.23
IL_4	6.75	8.00	7.50	7.35	7.40
Mean	7.65	8.91	8.50	8.15	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.05	0.06	0.12	0.13
CD at 5 %	0.15	0.18	0.34	0.36

Table 5. Effect of mulches and irrigation levels on number of fruits vine^{-1}

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	16.21	28.79	24.10	14.50	20.90
IL_2	18.81	22.12	15.60	15.79	18.08
IL_3	12.10	22.06	19.30	17.07	17.63
IL_4	17.30	28.39	20.96	23.04	22.42
Mean	16.11	25.34	19.99	17.60	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.08	0.11	0.21	0.23
CD at 5 %	0.24	0.32	0.60	0.64

Table 6. Statistical analysis of average yield of fruits (q ha^{-1})as influenced by different treatments

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	160.3	252.2	224.0	193.0	207.38
IL_2	128.6	179.4	164.2	160.3	158.13
IL_3	193.0	270.0	233.9	205.9	225.70
IL_4	201.2	361.5	252.2	210.9	256.45
Mean	170.78	265.78	218.58	192.53	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	1.24	1.48	2.84	2.95
CD at 5 %	3.83	4.19	8.08	8.39

Table 7. Average yield of fruits as influenced by different treatment combinations

Sr. No.	Treatments	Yield (q ha^{-1})
1.	MT_1 IL_1	160.3
2	MT_1 IL_2	128.6
3.	MT_1 IL_3	193.0
4.	MT_1 IL_4	201.2
5.	MT_2 IL_1	252.2
6.	MT_2 IL_2	179.4
7.	MT_2 IL_3	270.0
8.	MT_2 IL_4	361.5
9.	MT_3 IL_1	224.0
10.	MT_3 IL_2	164.2
11.	MT_3 IL_3	233.9
12.	MT_3 IL_4	252.2
13.	MT_4 IL_1	193.0
14.	MT_4 IL_2	160.3
15.	MT_4 IL_3	205.9
16.	MT_4 IL_4	210.9
	SE	0.30
	CD at 5 %	0.84

Table 8. Water use efficiency as influenced by different treatments

	MT_1	MT_2	MT_3	MT_4	Mean
IL_1	4.01	6.31	5.60	4.83	5.18
IL_2	10.94	15.27	13.97	13.64	13.46
IL_3	10.99	15.38	13.32	11.73	12.85
IL_4	8.59	15.44	10.77	9.01	10.95
Mean	8.63	13.10	10.92	9.80	

	Mulches	Irrigation levels	Two main plot at same subplot	Two subplot at same main
SE	0.05	0.08	0.15	0.16
CD at 5 %	0.16	0.23	0.43	0.46

Table 9. Cost economics of cucumber

Sr. No.	Treatments	Cost of production (Rs. ha^{-1})	Gross monetary returns (Rs.)	Net benefit (Rs.)	B:C ratio
1.	MT_1 IL_1	55,649	80,150	24,501	1.44
2	MT_1 IL_2	53,007	64,300	11,293	1.21
3.	MT_1 IL_3	58,374	96,500	38,126	1.65
4.	MT_1 IL_4	59,057	1,00,600	41,543	1.70
5.	MT_2 IL_1	85,946	1,26,300	40,354	1.46
6.	MT_2 IL_2	79,846	89,700	9,854	1.12
7.	MT_2 IL_3	87,396	1,35,000	47,604	1.54
8.	MT_2 IL_4	95,046	1,80,750	85,704	1.90
9.	MT_3 IL_1	76,490	1,12,000	35,510	1.46
10.	MT_3 IL_2	71,507	82,100	10,594	1.14
11.	MT_3 IL_3	77,315	1,16,950	39,635	1.51
12.	MT_3 IL_4	78,840	1,26,100	47,260	1.59
13.	MT_4 IL_1	59,403	96,500	37,097	1.62
14.	MT_4 IL_2	56,678	80,150	23,472	1.41
15.	MT_4 IL_3	60,476	1,02,950	42,474	1.70
16.	MT_4 IL_4	60,895	1,05,450	44,555	1.73

cent ET by drip (1.70) and the least was found in treatment combination of transparent polythene mulch with irrigation at 50 per cent ET by drip (1.12).

The treatment combination of transparent polythene mulch with irrigation at 100 per cent ET by drip gave the highest B:C ratio of 1.90, as it gave the highest gross monetary returns of Rs. 1,80,750/- at the cost of production of Rs. 95,046/-. This indicates the superiority of this treatment combination in giving the highest yield of crop. In case of straw mulch with irrigation at 100 per cent ET by drip the gross monetary returns were (Rs. 1,05,450/-) lower than the transparent polythene mulch with irrigation at 75 per cent ET by drip (Rs.1,35,000/-). The cost of production of the former combination (Rs. 60,895/-) was lower than that of later combination (Rs.87,396/-).

Hence, the treatment combination of transparent mulch with irrigation level of 100 per cent ET by drip may be recommended for obtaining higher monetary returns and higher B:C ratio for the cucumber crop.

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Short communication :

EFFECT OF DIFFERENT FAT LEVELS OF MILK ON THE QUALITY OF FLAVOURED MILK

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Milk is considered as the most satisfactory, and ideal food as it is high in protein, minerals, lactose, fat, fatty acids elaborated by nature and it is also referred as "Bank of Nutrients". India ranks first milk producing country in the world. Total milk production of country during 2012 was 127.9 million tons (Anonymous, 2012).

The flavoured milk like tea and coffee drinks are now being introduced as a part and parcel of our daily routine life. This is because, these flavours inherit a typical flavour and aroma in the hot milk which is more acceptable to most of the Indians than the milk alone. Flavoured milk is the milk to which some flavours have been added. The very common flavours that are added to the milk are tea, coffee, cocoa and chocolate. Flavoured milk can be prepared and marketed for growing children and adults. Flavoured milk is mostly prepared by using vanilla flavour (Shelke, 2005) and flavoured milk beverages are also prepared using coffee (Steinhart *et al.,* 2006).

Pineapple (*Ananas comosus*) is a tropical berry fruit. It is one of the commercially important fruit crops of India. Pineapple fruit is very nutritious and rich in vitamin C and manganese. It also contain dietary fibers. It has low sugar, fat and no cholesterol. Due to high nutritive value of pineapple, it may increase the quality of flavoured milk. Therefore, present study was focused on incorporation of pineapple flavour in flavoured milk to note the quality of flavoured milk.

During the entire study fresh, clean ,whole cow milk was obtained from Animal Husbandry and Dairy Science section, College of Agriculture, Nagpur. Milk was standardized at 1.5, 2.5 and 3.5 per cent fat. Pineapple flavour @ 1.5 per cent and sugar @ 5 per cent was common in all treatments. Thus, the treatments comprised of Pineapple flavoured milk with 1.5 %, 2.5 % and 3.5 %fat.

Analytical grade chemicals were used for chemical analysis. Fat content was determined by Gerber's method as described in IS: 1244, Part I (Anonymous, 1977). Solids - not- fat (S.N.F.) content was determined by using Zeal lactometer as per IS; 1183 (Anonymous, 1965) revised. Total solids content was determined by gravimetric method as described in IS: 1479, parts-II (Anonymous, 1961). Acidity content was determined as per the procedure recommended in ISI Handbook of food analysis, SP-18, (Part XI) Dairy products (Anonymous, 1981).

The product for sensory characteristics viz., colour and appearance, taste and acceptability of each treatment was evaluated by using score card method prescribed by Pal and Gupta (1984) and according them score for various sensory attributes was considered as follows.

1.	Colour and appearance	-	30
2.	Taste	-	50
3.	Acceptability	-	20
	Total	-	100

The experiment was laid out in CRD with 3 treatments and 6 replications. The significance was evaluated on the basis of critical difference within the treatments and so compared for various parameters studied (Panse and Sukhatme, 1978).

The chemical quality of flavoured milk evaluated with respect to fat, S.N.F., total solids and acidity and data are presented in table 1.

Total solids content :

The mean values of total solids content for different fat levels were 10.55, 11.26 and 11.98 per cent for the flavoured milk with 1.5% milk fat, 2.5% milk fat and 3.5% milk fat respectively with 1.5 % pineapple flavour common in all treatments. The effect of fat levels on total solids content of the flavoured milk was significant. It was observed that, the treatment with 3.5 per cent fat had the highest total solids content (11.98 per cent). From table 1, it was revealed that, the total solids content increased with the increase in milk fat levels of flavoured milk.

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According to Kubde (2004) the mean values of total solids content for different fat levels were 15.63,15.68,16.72,17.40 and 18.50 per cent flavoured with 0.5,1.0,1.5,2.0 and 3.0 per cent fat levels respectively. Thus, results indicate that there was increase in total solids content with the increase in fat content of flavoured milk.

Fat content :

It is revealed from table 1 that, the effect of fat levels in milk on fat content of flavoured milk was significant. The mean values of fat content in flavoured milk were 1.5, 2.5 and 3.5 per cent in the treatments of flavoured milk with 1.5 % milk fat, 2.5 % milk fat, and 3.5 % milk fat respectively with 1.5 % pineapple flavour common in all treatments. It is also observed that the treatment flavoured milk with 3.5 % fat had the highest fat content (3.5 per cent) while, flavoured milk with 1.5 % fat had the lowest fat content (1.5 per cent).

S.N.F. content :

The effect of fat levels on solids-not-fat (S.N.F.) content of flavoured milk was significant. The mean values of S.N.F. content for different fat levels were 9.1, 8.8 and 8.5 per cent in the flavoured milk with 1.5 % milk fat, 2.5 % milk fat and 3.5 % milk fat respectively with 1.5 % pineapple flavour common in all treatments. From this, it was revealed that the solids-not-fat content decreased with increased fat per cent of flavoured milk.

Rathod (2003) observed that chocolate milk prepared from combination of 2 and 1.5 per cent fat recorded 9 and 11 per cent SNF respectively and produced good acceptable product. These findings are comparable with the results of present study.

Acidity content :

The fat levels had a non significant effect on the acidity of flavoured milk. The mean value of acidity percentage for different fat levels was 0.13. Data also showed that the fat levels had non significant effect on the per cent acidity content of flavoured milk.

The findings of present investigation in respect of the acidity per cent content of flavoured milk are comparable with the observation recorded by Shelke (2005), who reported that acidity content of flavoured milk was not affected due to addition of flavor and fat.

Sensory evaluation of milk :

The results with respect to sensory evaluation of flavoured milk (colour and appearance, taste and acceptability) are presented in table 2.

Colour and appearance :

It is observed from table 2, that the fat levels had significant effect on the colour and appearance of flavoured milk. The mean score of colour and appearance from different fat levels were 27.50, 23.00 and 20.16 out of 30 marks for treatments of flavoured milk having 1.5 % milk fat, 2.5 % milk fat and 3.5% milk fat respectively with 1.5 % pineapple flavour common in all treatments. It was found that flavoured milk with 1.5 per cent fat level had scored the highest marks (27.50) and flavoured milk with. 3.5 per cent fat level had scored the lowest marks (20.16) for the colour and appearance of flavoured milk.

Khandwe (2003) observed that, the treatment combination of milk with 3.0 per cent fat and 2.5 per cent chocolate powder had scored the highest marks (25.97). The lowest score was observed in combination of milk with 1.0 per cent fat and 1.5 per cent chocolate powder (23.85). The present findings with respect to colour and appearance are contradictory and are exactly reverse to above findings, may be due to change in flavor and increase in concentration of chocolate powder (flavour).

Taste :

It is observed from table 2, that the fat levels had significant effect on the taste of flavoured Milk. The mean scores for taste from different fat levels were 44.16, 39.33 and 37.33 out of 50 marks for the flavoured milk having 1.5% milk fat, 2.5% milk fat and 3.5% milk fat respectively with 1.5 % pineapple flavour common in all treatments . It is found that flavoured milk with 1.5 per cent fat had scored the highest marks (44.16) while, flavoured milk with 3.5 per cent fat level scored the lowest marks (37.33) for taste of flavoured milk.

Acceptability :

It is observed from table 2 that the fat levels had statistically significant effect on the acceptability of flavoured milk. The mean scores for acceptability for flavoured milk with different fat levels were 17.5, 16.0 and 14.0 out of 20 score in 1.5% milk fat, 2.5% milk fat and 3.5% milk fat respectively with 1.5 %

Table 1. Chemical composition of flavoured milk

Treatments	Fat (%)	S.N.F. (%)	Total solids (%)	Acidity (%)
T_1 (1.5% milk fat)**	1.5	9.1	10.55	0.13
T_2 (2.5% milk fat) **	2.5	8.8	11.20	0.13
T_3 (3.5% milk fat) **	3.5	8.5	11.90	0.13
SE (m) ±	0.139	0.045	0.079	0.048
C D at 5 %	0.287	0.127	0.145	-

** 1.5 % Pineapple flavour common in all treatments

Table 2. Sensory evaluation of flavoured milk

Treatments	Colour and appearance (30)	Taste(50)	Acceptability(20)	Total score (100)
T_1 (1.5% milk fat)**	27.50[a] (91.66)	44.16[a] (88.32)	17.5[a] (87.50)	89.16 (89.16)
T_1 (2.5% milk fat)**	23.00[b] (76.66)	39.33[b] (78.66)	16.0[b] (80.00)	78.33 (78.44)
T_3 (3.5% milk fat)**	20.16[c] (67.20)	37.33[c] (74.66)	14.0[c] (70.00)	71.49 (70.62)
SE (m) $\pm$	0.517	0.814	0.320	-
C D at 5 %	1.103	1.73	0.686	-

** Figures in parenthesis is percentage to total score of attributes pineapple flavour common in all treatments It was found that flavoured milk with 1.5 per cent fat had scored the highest mark (17.5) while, flavoured milk with 3.5 per cent fat had scored the lowest score (14) for acceptability of flavoured milk.

Kubde (2004) observed that, the mean score for acceptability of different fat levels were 15.40,15.40,16.40,17.20 and 17.73 out of 20 marks in flavoured milk containing 0.5,1.0,1.5,2.0 and 3.0 per cent fat levels respectively. When cardamom was used for flavouring the milk. The contradictory results may due to change in flavour.

The results thus, revealed that flavoured milk prepared by 1.5 per cent fat level having 1.5 % pineapple flavor and 5 % sugar was the most acceptable, although the fat content and total solids increased with the increase in fat content. On the other hand , S.N.F. decreased with the increase in fat content. Acidity content was not influenced due to change in fat content.

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