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SHORT COMMUNICATIONS

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VARIETAL SUSCEPTIBILITY OF SAFFLOWER CULTIVARS TO APHID, *Uroleucon carthami* Hille Ris Lambers (Aphididae : Homoptera)

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ABSTRACT

Field screening of fifty eight safflower cultivars was undertaken during rabi season of 1985-86 to study their reaction to the aphid (Uroleucon carthami) under field conditions and none exhibited complete resistance to aphids. On the basis of yield potential, seven cultivars viz. JLSF-92, JLSF-88, 175-1, 279-2, NRS-209, JLSF-49 and N-673-1-5 were found to be promising. These seven promising cultivars were selected for studying the antibiosis effect under field and glasshouse conditions by confining ten aphid nymphs per plant and observing the total progeny nymphs produced at the end of 20 days. In these studies cultivar JLSF-92 was found to be the most promising recording a minimum population of nymphs per plant. However, it was statistically at par with JLSF-88 under field condition. Although, there was positive correlation between stem girth and aphid infestation, plant height did not have any correlation with aphid infestation.

Key words: Safflower; Carthamus tinctorius; Varietal susceptibility; Aphid; Uroleucon carthami.

INTRODUCTION

Despite a large area under the safflower crop in India (8.7 lakh hectares), the average per hectare yield is very low (571 kg/ha). Of the various factors responsible for low yield, the damage caused by aphids (*Uroleucon carthami, HRL*) is the one most important. Damage to the tune of 60 to 80% and reduction in yield to the extent of 35% has been reported by Bindra and Vaishampayan (1965). Although systemic and contact insecticides are recommended against aphids, they are not commonly used by cultivators because of the low economic returns. Deokar *et al*., (1984) tested 450 cultivars of safflower against aphids and they reported that aphid incidence was negatively and yield positively correlated with plant spineness. It is, therefore, necessary to test different cultivars of safflower for their reaction to aphid so as to identify resistant varieties and to study any antibiosis in promising cultivars against aphids.

MATERIALS AND METHODS

Seeds of fifty eight safflower cultivars (Table 1) were sown on 7-11-1985 in flat beds measuring 2.65 x 3.60 m, with a spacing of 45 x 30 cm. The experiment was conducted in a Randomised Block Design with two replications. The observations on aphids were recorded on five randomly selected plants of each cultivar at an interval of ten days commencing from 20 days after sowing. Aphids (nymphs) on six leaves (two each from top, middle and bottom) were counted with the help of magnifying lens (10X). The observations were also recorded on the girth and height of the selected plants of each cultivar to find out their correlation if any with the aphid infestation. The girth of a plant at 60 days after germination was measured at the base of top leaves with the help of thread. Similarly, the yield potential of different cultivars under natural unprotected condition was noted by recording weight of seed of five plants.

Seven promising cultivars along with susceptible checks (Table 2) were sown on 7-11-1986 for antibiosis study under field as well as glasshouse conditions. Two plants from

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each replication were randomly selected and covered with muslin cage in both field and glasshouse conditions. On each caged plant 10 nymphs were released at 20 days after germination and observations on progeny nymphs were taken after 20 days. In glasshouse, the individual plants were covered with plastic box (18 x 12 cm) having holes, covered with muslin cloth for ventilation.

RESULTS AND DISCUSSION

Field screening of safflower cultivars against aphids

It is seen from the Table 1 that the incidence of aphids started in the second week of November i.e. 20 days after sowing. The cultivar HOP-123 had the lowest mean population of 0.1 nymph per plant while cultivar N-673- 1-5 had the highest population of 7.0 nymphs/plant.

The observations recorded at 30 days after sowing showed that cultivar JLSF-92 sustained the lowest population of 14.1 nymphs per plant which was significantly lower than that in all the other cultivars. The next promising cultivar was JLSF-88. The cultivar HUS-1157 recorded the maximum mean population of 61.8 nymphs per plant. The mean infestation in the remaining cultivars ranged between 19.5 and 60.9 nymphs per plant. On the whole, the nymphal population at this stage of observations was higher than that noticed at 20 days after sowing.

At 40 days after sowing the cultivar JLSF-92 again recorded the lowest mean nymphal population of 23 nymphs per plant which was significantly lower than that in all the other cultivars. Cultivars JLSF-88, 175-1 and 279-2 were next in order of promise were statistically at par with each other. Cultivar HUS-1974-6 exhibited the highest mean nymphal population of 99.4 and was statistically at par with 322-2 and HUS-1157. The mean infestation in the remaining cultivars ranged between 27.2 and 90.5. It was observed that the incidence of aphids was on its increase as compared to that at the two previous stages.

The nymphal population recorded at 50 days after sowing indicated that the cultivar JLSF-92 again emerged as the most promising one recording mean nymphal population of 35.8 nymphs per plant. This population level was significantly lower than that in all the other cultivars followed by cultivar JLSF-88 in low population. Cultivar 322-2 exhibited the highest mean nymphal population which was significantly higher than that in all the other cultivars. The mean infestation in the remaining cultivars ranged between 41.9 and 125.6 nymphs per plant. It was observed that the incidence of aphids was on its increase as compared to that at the three previous stages.

Nymphal population recorded at 60 days after sowing indicated that the cultivar JLSF-92 still registered the lowest mean population of 8.9 nymphs per plant, which was significantly lower, compared to all other cultivars. The cultivar HUS-1974-6 recorded the maximum mean population of 204.3 nymphs per plant which was significantly higher except cultivar 322-2. The population level in the remaining entries ranged between 54.2 and 200.8 nymphs per plant. At this stage also the pest population persisted at high level. No further observation could be recorded due to the drying of many cultivars.

Table 1. Field screening of safflower cultivars to aphids

Sr. No.	Cultivars	Av. No. of nymphs/plant at the days after sowing						% population in comparison with local check	Girth of stem (cm)	Yield (g/5 plants)
		20	30	40	50	60	Compiled mean			
1.	SF-92	0.6	14.1	23.0	35.8	48.9	24.48	46.38	0.7	16.47
2.	JLSF-88	1.2	17.6	27.2	38.9	52.6	27.50	52.11	0.8	11.60
3.	175-1	1.1	19.5	27.9	41.9	54.2	28.92	54.80	0.94	9.40
4.	279-2	5.8	20.2	28.6	42.2	56.3	30.62	58.02	0.93	8.50
5.	NRS-209	1.3	20.1	29.8	42.7	61.1	31.00	58.14	0.99	7.05
6.	JLSF-49	0.9	22.1	34.4	46.7	76.2	36.16	68.33	1.17	3.10
7.	N-673-1-5	7.0	22.0	34.8	46.2	70.8	36.16	68.52	1.14	3.22
8.	NC-1585-2	1.3	24.6	35.9	50.7	77.2	37.94	71.90	1.20	2.27
9.	JLSF-95	1.8	26.3	36.4	54.7	80.2	39.88	75.57	1.23	1.75
10.	N-123-3-3	1.5	28.3	35.8	59.2	82.0	41.36	78.38	1.77	1.50
11.	N-1527-1-3	1.5	26.6	39.8	60.9	84.4	42.44	80.42	1.60	1.22
12.	N-248	3.0	26.1	40.4	61.1	94.1	44.94	85.16	1.50	1.04
13.	JLSF-90	2.3	26.6	39.7	60.3	96.5	45.08	85.43	1.50	1.02
14.	JLSF-94	0.6	27.0	41.3	60.3	95.2	45.10	85.46	1.71	1.02
15.	JLSF-96	0.7	27.0	43.0	61.6	98.5	46.16	87.47	1.42	0.55
16.	JLSF-54	2.3	27.8	43.4	66.1	103.8	48.68	92.25	-	0.20
17.	JLSF-79	1.5	28.6	43.6	65.8	104.2	48.74	92.36	2.60	0.20
18.	SSF-31	1.2	28.4	43.2	65.6	107.8	49.24	93.31	1.82	0.70
19	JLSF-98	1.3	29.7	44.1	71.0	109.8	51.18	96.97	1.94	0.05
20.	JLSF-83	1.4	29.9	43.8	70.9	110.1	51.22	97.06	1.50	0.05

Contd..

Table 1. contd..

Sr. No.	Cultivars	Av. No. of nymphs/plant at the days after sowing						% population in comparison with local check	Girth of stem (cm)	Yield (g/5 plants)
		20	30	40	50	60	Compiled mean			
21.	JLSF-51	0.2	29.0	43.9	72.2	112.5	51.36	97.32	1.27	0.05
22.	JLSF-89	2.9	29.6	46.3	72.8	114.4	52.28	99.07	1.44	0.05
23.	203-3	1.4	29.6	46.3	72.8	111.4	52.30	99.10	1.28	0.05
24.	JSI-9	3.3	29.8	45.0	73.9	111.0	52.60	99.67	1.67	0.05
25.	K-1776	3.1	29.7	45.2	72.4	112.7	52.62	99.71	1.54	0.05
26.	N-887	3.2	29.5	44.2	72.5	113.8	52.64	99.75	1.44	0.05
27.	JLSF-93	3.9	30.6	46.5	74.2	110.9	53.22	100.85	1.46	0.05
28.	JLSF-80	3.1	29.7	46.6	73.2	266.2	53.24	100.89	1.52	0.02
29	JLSF-91	4.0	30.1	46.7	74.0	115.9	54.14	100.60	1.55	-
30.	JLSF-86	1.7	34.4	51.4	85.7	110.1	56.66	107.37	1.90	-
31.	JLSF-97	2.1	35.7	53.2	86.2	111.2	57.68	109.30	1.98	-
32.	JLSF-81	1.9	35.2	49.2	74.4	131.6	58.46	110.78	1.95	-
33.	JLSF-99	3.0	34.3	48.1	76.7	131.4	58.70	111.23	1.92	-
34.	HUS-890	0.4	35.7	54.5	86.0	100.7	61.26	116.08	1.88	-
35.	305-3	0.6	32.0	48.4	82.4	144.4	61.56	116.65	1.99	-
36.	JLSF-101	2.4	36.5	51.8	92.9	125.8	61.88	117.26	1.23	-
37.	JLSF-87	0.8	38.1	53.8	94.2	127.3	62.84	119.08	1.34	-
38.	157.31	0.5	35.1	56.0	87.3	144.0	64.58	122.38	1.92	-
39.	HOP-123	0.1	28.7	51.5	90.6	161.7	66.52	126.05	2.05	-
40.	N-2204	1.5	56.0	72.3	91.3	118.5	67.92	128.70	1.78	-
41.	SSF-55	4.2	59.2	81.0	91.5	112.4	59.66	132.00	1.34	0.05
42.	SSF-33	3.0	59.0	88.5	97.3	120.3	73.42	139.13	1.69	0.03

Contd..

Table 1. contd..

Sr. No.	Cultivars	Av. No. of nymphs/plant at the days after sowing						% population in comparison with local check	Girth of stem (cm)	Yield (g/5 plants)
		20	30	40	50	60	Compiled mean			
43.	HUS-3123	2.1	35.5	55.2	93.7	184.4	74.18	140.57	1.99	-
44.	SSF-17	1.2	60.0	90.5	96.4	125.5	74.72	141.60	1.59	0.02
45.	HOP-120	0.4	38.7	65.8	91.9	186.3	76.62	145.20	2.04	-
46.	HUS-3143	5.8	46.0	67.0	94.1	171.1	76.80	145.54	2.53	-
47.	SSF-56	0.8	60.2	88.9	98.4	138.8	77.42	146.71	1.87	0.02
48.	HUS-3044	1.9	47.5	56.5	91.9	195.6	78.68	149.10	2.10	-
49.	JLSF-19-A	2.0	34.7	60.5	102.5	198.5	79.64	150.92	1.96	-
50.	JOP-132	0.2	47.4	71.9	101.0	189.6	82.02	155.93	2.00	-
51.	HOP-128	1.3	60.9	89.5	104.2	192.6	79.70	169.98	2.00	-
52.	SSF-49	0.8	60.9	90.5	111.3	183.9	90.28	171.08	2.00	-
53.	SSF-50	1.5	59.1	86.6	105.7	200.8	90.68	171.84	2.40	-
54.	HUS-1974-6	0.5	57.8	99.4	94.0	204.3	91.20	172.82	1.93	-
55.	HUS-1157	1.5	61.8	98.5	125.6	179.4	93.36	176.92	2.13	-
56.	322-2	0.5	60.5	92.6	132.5	202.0	98.62	186.89	2.50	-
57.	A.1(National check)	3.3	26.8	35.9	58.0	82.4	41.28	78.26	1.36	1.52
58.	S-4(Local check)	3.6	22.9	42.2	71.2	118.2	52.77	100.00	1.50	-
	S E ±	0.94	0.51	0.74	0.51	1.13	7.6	-	-	0.80
	C D at 5%	2.66	1.46	2.10	1.45	3.20	21.15	-	-	2.26

From the results of the compiled analysis of the entire data it is observed that the infestation of the aphids at 20 days after sowing was low ranging from 0 to 7 nymphs per plant on the 58 cultivars under study whereas at 60 days it ranged between 48.9 and 204.3 showing increasing trend irrespective of cultivars.

From the mean infestation of the aphids, it would be seen that the cultivar JLSF-92 was the most promising though at par with other 13 cultivars viz., JLSF-88, 175-1, 279-2, NRS-209, JLSF-49, N-673-1-5, NC-1585-2, JLSF-95, N- 123-3-3, N-1527-1-3, N-248, JLSF-94 and A.1. The maximum mean infestation of 98.62 nymphs per plant was observed on the cultivar 322-2 which is in turn was at par with the cultivars HUS-3044, JLSF-19 A, HOP-132, BOP-128, SSF-49, SSF-50, HUS-1974-6, HUS-1157 and S-4. The incidence in the remaining cultivars ranged between 46.16 and 77.42. The present findings are in conformity with those recorded by the research workers of Agricultural Research Station, Jalgaon and Solapur (AICORPO, 1985 and 1986, Anonymous, 1986 and 1987).

Comparison with local check

It could be seen from the Table 1 that 26 entries showed less aphids than the local check. The differences in percentage of population of aphid were extremely meagre regarding sixteen cultivars. Cultivars JLSF-92, JLSF-88, 175-1, 279-1, NRS-209, JLSF-49, N-673-1-5, NC-1585-2, JLSF-95 and national check showed from 46.38 to 78.38 per cent superiority over the local check. The cultivar JLSF-92 showed 46.38 per cent population in comparison with local check. The rest of the cultivars showed higher percentage of population than local check ranged between 100.85% and 186.87%. However, the results obtained by the research workers at Agricultural Research Station, Jalgaon (Anonymous, 1986; AICORPO, 1986 and Jagtap *et al.*, 1985) indicated that these promising cultivars were more or less similar to the reaction to that of local check "Bhima". The present findings are quite contradictory which might be due to the variation in method of recording observation and effect of location. Patil *et al.*, (1986) reported that SSF-3 was aphid tolerant and gave higher yield than "Bhima".

Relationship between stem girth and aphid population

Studies on the correlation between infestation levels of aphids on safflower and girth of the stem were carried out. The aphid population positively correlated with girth of stem ($r = +0.76^{**}$). JLSF-92 which recorded 0.72 cm girth of stem supported the aphid population of only 48.9 nymphs per plant which was significantly lower than that in all other cultivars except JLSF-88, 279-2, 175-1, NRS-209 which were at par with it. Cultivar JLSF-79 which recorded the maximum stem girth of 2.60 cm exhibited the aphid population of 104 nymphs per plant. It was statistically at par with the other 23 varieties showing aphid population 107.8 to 204.3. Other cultivars ranged between the stem girth 1.50 cm and 1.78 cm supported the aphid population 82 to 131.6. The present findings are in agreement with those reported by Kelkar and Karve (1976).

There was no correlation between height of safflower cultivars and aphid population as the correlation was statistically non-significant.

Influence of incidence of aphids on yield

Despite aphid infestation, some cultivars were able to produce seed. The yield data presented in Table 1 indicated that the cultivar JLSF-92 was the most promising recording the mean yield 16.47 g per plant which was significantly higher than that in all other cultivars. The next promising cultivar for yield was JLSF-88 and was at par with cultivar 185-1. The next position was that of cultivar 279-2 which was however, statistically at par with cultivar NRS-209, N-673-1-5 and JLSF-49 which recorded 8.80, 7.05, 3.22 and 3.10 g seed respectively. Thus the JLSF-92, JLSF-88, 175-1, 279-2, NRS-209, N-673-1-5, JLSF-49 showed some promise in respect of yield though they were infested by the pest. Yield in other cultivars ranged between 0.0 and 2.27 g. Samele (1983) reported that S-144 suffered the lowest aphid infestation and gave the highest yield. The above mentioned seven promising cultivars were selected to study the antibiosis, if any, during the year 1986-87 along with local check "Bhima" and National check A.1.

Study of antibiosis of promising cultivars in field

Mean population development was minimum in the case of cultivar JLSF-92 (661) which was significantly lower than that in other cultivars except JLSF-88 which was at par with it (Table 2). Local check "Bhima" registered the highest aphid population development (2162). All the other remaining varieties showed a range of 879 to 1441 nymphs per plant.

Table 2. Antibiosis against aphid in promising cultivars of safflower

Sr. No.	Name of cultivar	No.of progeny nymphs at 20 days after release		
		Field condition		Glasshouse condition
		No. of progeny nymphs/plant	No. of nymphs/day	No. of progeny nymphs/plant
1.	JLSF-92	661	3.3	143
2.	JLSF-88	748	3.7	177
3.	175-1	879	4.4	183
4.	279-2	1055	5.3	191
5.	NRS-209	1252	6.3	195
6.	JLSF-49	1346	6.7	197
7.	N-673-1-5	1404	7.0	198
8.	A.1(National check)	1441	7.2	201
9.	S-4 (Local check)	2162	10.8	229
	S E ±	31.3		5.3
	C D at 5%	93.7		15.9

Rate of reproduction of released aphids on different cultivars was as follows : JLSF-92, 3.3; JLSF-88, 3.7; 175-1, 4.4; 279-2, 5.3; NRS-209, 6.3; JLSF-49, 6.7; N-673-1-5, 7.0; A.1, 7.2 and "Bhima" 10.8 nymphs per day.

Study of antibiosis of promising cultivars in glasshouse condition

Mean population was minimum in JLSF-92 (143) which was significantly lower than that in any other cultivar (Table 2). Local check "Bhima" (54) registered the highest aphid population (229). All other remaining varieties showed range between 177 and 201 nymphs per plant.

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NITROGEN PHOSPHORUS AND SULPHUR NUTRITION OF GROUNDNUT (*ARACHIS HYPOGAEA* L.) GROWN IN ALFISOLS*

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ABSTRACT

Studies on nitrogen, phosphorus and sulphur nutrition of groundnut grown during kharif season of 1988 in Alfisols reveal that application of nitrogen, phosphorus and sulphur increased pod and haulm yields, shelling percentage, oil content and concentration of nutrients and their uptake. Kernels were highest in N,P and S concentrations and lowest in Ca, Mg and K concentrations, while haulms were highest in Ca, Mg and K concentrations. Significant positive correlation was observed between pod yield and uptake of nutrients by groundnut.

Key words : Pod yield; Haulm yield; Nutrient concentration and uptake; Shelling percentage; Oil content; Correlation co-efficient.

INTRODUCTION

Oilseed crops occupying about 19 million hectares with an annual production of over 13 million tonnes play a vital role in the agricultural economy of India. India ranks first both in area (7.5 m. ha) and production of world groundnut (6.06 m. tons), but productivitywise it is among the lowest (870 kg/ha). The reasons for such a low yield have been ascribed to several constraints which include nutrient deficiency. It is essential to pay greater attention to the nutrition of the crop for increasing its productivity (Reddi and Reddi, 1979). Jayadevan and Sreedharan (1975) observed significant increase in pod yield and nutrient uptake due to nitrogen and phosphorus application. Sulphur application increased the uptake of N, P, K, Ca, Mg, S and oil content of groundnut (Yadav and Singh, 1970). Taking above facts into consideration the present investigation was made to study the effect of nitrogen, phosphorus and sulphur containing fertilizers on the yield, shelling percentage, oil content and concentration of different nutrients in groundnut.

MATERIALS AND METHODS

A field experiment was conducted on Alfisols at the College of Agriculture, Rajendranagar, Hyderabad during *kharif* 1988 under rainfed conditions to study the influence of N, P and S on yield, shelling percentage and concentration of different nutrients in groundnut (Var. TMV-2). The soil of the experiment was red sandy loam in texture, neutral in reaction (pH 7.5), low in available nitrogen (240 kg/ha), available P_2O_5 (23.8 kg/ha) and available sulphur (8.12 ppm) but high in available potassium (308.6 kg/ha). The treatments consisted of two levels of nitrogen @ 20 and 40 kg/ha as urea and diammonium phosphate in combination, two levels of P_2O_5 @ 35 and 50 kg/ha as diammonium phosphate and two levels of sulphur @ 60 and 120 kg/ha as gypsum. Thus 8 selected combinations of N,P and S were adopted including one control (no fertilizer). All the treatments were tested on a Randomized Block Design replicated thrice. Sulphur was applied in two splits at the time of sowing (25% of above level) alongwith whole nitrogen and phosphorus and at 30 DAS (75% of the above

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level). The decrease in the amount of calcium at different levels of sulphur was corrected with the application of calcium carbonate including control. Seeds were dibbled by adopting a spacing of 30 x 10 cm. A total of 426.6mm rainfall was received during the crop period. Pod yield, haulm yield, shelling percentage and oil content in kernels were recorded treatment wise. Plant samples collected at harvest were partitioned into haulm and kernels for chemical analysis. Oil content was estimated by Nuclear Magnetic Resonance technique and expressed in percentage. Nitrogen by Microkjeldahl method, phosphorus by Vanadomolybdate yellow colour method (Jackson, 1967), potassium by flame photometer method, sulphur by turbidimetric method, Ca and Mg by atomic absorption spectro-photometer (Varian Techtron AA 120) were determined in haulm and kernels. Uptake of each nutrient was calculated in haulm and kernels and was expressed in terms of kg/ha.

RESULTS AND DISCUSSION

Yield

A pod yield ranging from 20.42 to 20.43 q ha^{-1} was recorded when nitrogen, phosphorus and sulphur were applied @ 40, 50 and 120 kg ha^{-1} respectively. These levels were significantly superior over their other levels (Table 1). Response of groundnut crop to nitrogen was limited to 10-40 kg ha^{-1} (Jadhav and Narkhede, 1982 and Jackhro, 1983). Increase in pod yield due to phosphorus might be due to its favourable influence on pod development and its filling capacity (Charan and Kalra, 1983). Similar trend was observed with sulphur too, recording an yield potential of 20.43 q ha^{-1}, when it was applied @ 120 kg S ha^{-1}. Such response to sulphur was attributed to low initial status of sulphur in the soil and these findings are in accordance with the observations of Reddy and Patil (1980).

The haulm yield of about 27.9 q ha^{-1} was significantly higher with the application of nitrogen, phosphorus and sulphur (Table 1). The influence of these nutrients in increasing haulm yield was attributed to the better root and shoot growth (Jayadevan and Sreedharan, 1975). Similar results were also observed in case of the shelling percentage, shelling percentage increased with the application of N, P and S when compared to control. Increase in shelling percentage might be due to better synthesis of carbohydrates, fats and proteins in the availability of N, P and S. Similar results were also reported by Giridhara Krishna *et al.*, (1989).

Oil content (%)

The oil content recovered was 48.24, 47.8 and 47.6 with nitrogen, phosphorus and sulphur when they were applied @ 40, 50 and 120 kg ha^{-1} respectively (Table 1). These values were significantly higher over other levels. The increase in oil content with the application of nitrogen might be due to increased uptake of sulphur with increasing level of nitrogen. Surajbhan and Misra (1971) reported that oil content was increased in groundnut with application of nitrogen on desert soils of Jodhpur. The increase in oil content with phosphorus might be due to enhancement in the triacyl glycerol, the major component of groundnut oil accompanied by a corresponding decrease in free fatty acids and sterols (Sukhija *et al.*, 1984). The response of groundnut to sulphur elucidated that as an integral part of Sulph-hydryl (-SH) group which is essential for biosynthesis of oil. Increase in oil content with sulphur application was reported by Reddy and Patil (1980).

Table 1. Influence of N, P and S on yield (q/ha) and shelling percentage of groundnut

Treatment	Pod yield ($q\ ha^{-1}$)	Haulm yield ($q\ ha^{-1}$)	Shelling percentage	Oil content (%)
Levels of N ($kg\ ha^{-1}$)				
20	19.13	25.55	71.41	44.06
40	20.42	27.89	75.44	48.22
F test	**	**	**	**
S E ±	0.451	1.018	1.657	1.326
CD at 5%	0.955	2.159	3.513	2.811
Levels of P ($kg\ P_2O_5\ ha^{-1}$)				
35	19.14	25.56	71.47	44.60
50	20.42	27.88	75.38	47.68
F test	**	**	**	**
S E ±	0.451	1.018	1.657	1.326
CD at 5%	0.955	2.159	3.513	2.811
Levesl of S ($kg\ ha^{-1}$)				
60	19.13	25.58	71.52	44.67
120	20.43	27.86	75.33	47.61
F test	**	**	**	**
S E ±	0.451	1.018	1.657	1.326
C D at 5%	0.955	2.159	3.513	2.811
Control vs. Rest				
Control	14.47	20.72	64.20	40.53
Rest	19.78	26.72	73.20	46.14
F test	**	**	**	**
S E ±	0.675	1.527	2.485	1.989
C D at 5%	1.432	3.238	5.270	4.217

Interaction effects were not significant
** Significant at 1% level

Nutrient concentration and uptake

The data indicated that concentrations of nitrogen, phosphorus and sulphur in the kernel were more than that of haulm. But contrary to this, concentrations of Ca, Mg, and K were high in haulm than that of kernal (Table 2). Reddy and Murthy (1985) reported similar trend of results in groundnut. Application of different levels of nitrogen, phosphorus and sulphur increased both concentration and uptake of N, P, K, Ca, Mg and S in the groundnut (Table 2 and 3). But the interaction effects were non significant. Similar results were also reported by Singh and Ahuja (1985). Increase in uptake of K and Ca with application of N, P and S might be due to the Synergistic effect of N, P and S on K and Ca absorption by groundnut (Dongale and Zende, 1976 and Yadav and Singh, 1970).

Table 2. Influence of N, P and S on nutrient concentration (%) of groundnut haulm and kernal at harvest

Treatment	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium		Sulphur	
	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel
Levels of N (kg ha^{-1})												
20	1.56	3.12	0.15	0.20	1.56	0.56	1.49	0.55	0.50	0.14	0.35	0.36
40	1.84	3.38	0.21	0.25	2.08	0.61	1.59	0.58	0.51	0.14	0.38	0.41
F test	**	**	**	**	**	**	**	**	NS	NS	**	**
S E ±	0.110	0.108	0.012	0.013	0.123	0.013	0.022	0.013	0.005	0.005	0.012	0.013
C D at 5%	0.232	0.229	0.026	0.028	0.261	0.027	0.046	0.27	-	-	0.026	0.027
Levels of P (kg P_2O_5 ha^{-1})												
35	1.55	3.12	0.16	0.20	1.62	0.57	1.48	0.55	0.50	0.14	0.33	0.37
50	1.85	3.38	0.20	0.26	2.03	0.61	1.61	0.59	0.51	0.15	0.39	0.41
F test	**	**	**	**	**	**	**	**	NS	NS	**	**
S E ±	0.110	0.108	0.012	0.013	0.123	0.013	0.022	0.013	0.005	0.005	0.012	0.013
C D at 5%	0.232	0.229	0.026	0.028	0.261	0.027	0.046	0.027	-	-	0.026	0.027
Levels of S (kg ha^{-1})												
60	1.57	3.13	0.15	0.21	1.52	0.56	1.50	0.54	0.50	0.14	0.34	0.36
120	1.83	3.37	0.21	0.25	2.13	0.62	1.59	0.60	0.51	0.14	0.38	0.42
F test	**	**	**	**	**	**	**	**	NS	NS	**	**
S E ±	0.110	0.108	0.012	0.013	0.123	0.013	0.022	0.013	0.005	0.005	0.012	0.013
C D at 5%	0.232	0.229	0.026	0.028	0.261	0.027	0.046	0.027	-	-	0.026	0.027
Control vs. Rest												
Control	1.34	2.35	0.10	0.13	1.17	0.50	1.36	0.49	0.47	0.14	0.30	0.31
Rest	1.70	3.25	0.18	0.23	1.82	0.59	1.54	0.57	0.50	0.14	0.36	0.39
F test	**	**	**	**	**	**	**	**	NS	NS	**	**
S E ±	0.164	0.162	0.018	0.020	0.184	0.019	0.032	0.019	0.007	0.008	0.018	0.019
C D at 5%	0.348	0.343	0.038	0.042	0.392	0.040	0.069	0.040	0.016	-	0.039	0.041

Interaction effects were not significant

Table 3. Influence of N, P and S on nutrient uptake (kg/ha) by groundnut haulm and kernal at harvest

Treatment	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium		Sulphur	
	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel	Haulm	Kernel
Levels of N (kg ha^{-1})												
20	40.60	43.27	3.98	2.82	42.83	7.75	38.27	7.62	12.88	1.95	8.91	5.04
40	52.15	52.56	5.86	3.98	59.09	9.51	44.65	9.05	14.12	3.52	10.57	6.42
F test	**	**	**	**	**	**	**	**	NS	NS	**	**
S E ±	4.614	3.331	0.494	0.308	5.254	0.506	2.122	0.493	0.649	1.210	0.690	0.396
C D at 5%	9.783	7.063	1.047	0.654	11.130	1.072	4.498	1.045	-	-	1.462	0.840
Levels of P (kg P_2O_5 ha^{-1})												
35	40.39	43.12	4.18	2.76	42.57	7.83	37.91	7.53	12.80	2.26	8.55	5.10
50	52.36	52.71	5.65	4.03	59.35	9.44	45.01	9.13	14.19	3.21	10.92	6.36
F test	**	**	**	**	**	**	**	**	**	NS	**	**
S E ±	4.614	3.331	0.494	0.308	5.254	0.506	2.122	0.493	0.649	1.210	0.690	0.396
C D at 5%	9.783	7.063	1.047	0.654	11.139	1.072	4.488	1.045	1.376	-	1.462	0.840
Levels of S (kg ha $^{-1}$)												
60	40.96	43.36	3.96	2.91	41.57	7.69	38.52	7.42	12.90	2.22	8.81	4.99
120	51.79	52.48	5.88	3.89	60.34	9.58	44.40	9.25	14.10	3.25	10.67	6.48
F test	**	**	**	**	**	**	**	**	NS	NS	**	**
S E ±	4.614	3.331	0.494	0.308	5.254	0.506	2.122	0.493	0.649	1.210	0.690	0.396
C D at 5%	9.783	7.063	1.047	0.654	11.139	1.072	4.498	1.045	-	-	1.462	0.840
Control Vs. Rest												
Control	27.92	21.97	2.12	1.24	23.93	4.68	28.24	4.59	9.72	1.29	6.25	2.90
Rest	46.37	47.91	4.92	3.40	50.96	8.63	41.46	8.33	13.50	2.73	9.74	5.73
F test	**	**	**	**	**	**	**	**	**	NS	**	**
S E ±	6.921	4.997	0.740	0.462	7.881	0.758	3.182	0.739	0.973	1.815	1.034	0.594
C D at 5%	14.674	10.594	1.569	0.980	16.708	1.608	6.747	1.567	2.064	-	2.192	1.259

Interaction effects were not significant

Correlation coefficients

Correlation coefficients were worked out between pod yield and haulm yield, shelling percentage and uptake of N, P, K, Ca, Mg and S by haulm and kernel at harvest (Table 4). The correlation coefficients between haulm yield and pod yield, shelling percentage and pod yield, and nutrient uptake and pod yield showed positively significant association. Similar results were also reported by Giridhara Krishna *et al.*, (1989).

Table 4. Correlation coefficients (r) between pod yield and other parameters

Parameter	Pod yield
Haulm yield	0.9918
Shelling percentage	0.9632
Nutrient uptake by haulm (kg/ha)	
N	0.8952
P	0.8854
K	0.8660
Ca	0.8399
Mg	0.9321
S	0.9014
Nutrient uptake by kernel (kg/ha)	
N	0.9810
P	0.9244
K	0.9555
Ca	0.9577
Mg	0.9442
S	0.9391

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DIFFUSION AND ADOPTION OF CASTOR PRODUCTION TECHNOLOGIES IN MAHBOOBNAGAR DISTRICT OF ANDHRA PRADESH

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ABSTRACT

The diffusion and adoption study in Mahboobnagar district revealed that there is no significant difference among small, medium and large categories of farmers for access to Government officials to get information on modern agricultural practices. The knowledge level of different categories of farmers regarding the technologies are more or less equal. The adoption level of different technologies are medium to high. Specifically, the non-monetary inputs and low monetary inputs are easily adopted by the farmers. Extension efforts should be intensified for creating awareness of the technologies like seed treatment, spacing, stage of harvest of the crop and time of pest control. The adoption level of high monetary inputs can be enhanced by arranging credit, announcing remunerative price and demonstrating technical skills to the farmers about superiority of judicious application of fertilizers and pesticides over conventional practices.

Key words : Castor; Production technology; Technology diffusion; Technology adoption

Castor is an important cash crop raised in Telangana region of Andhra Pradesh. This is extensively grown as a rainfed crop in the districts of Nalgonda, Mahboobnagar, Ranga Reddy, Prakasam and Warangal.

The district, Mahboobnagar was selected for the study because it has the lowest per hectare yield (164 kg/ha) when data were considered from 1979-80 to 1983-84 ; which may be due to adoption of traditional method of cultivation by the farmers. De Datta *et al*., (1978) have emphasised that the farm survey part of the study supplies information on the knowledge level of the farmers that need to be improved to get higher yield in the study area. A review of the literature on adoption of agricultural innovations by Feder *et al.,* (1985) indicates that most of the research on adoption behaviour concentrated on the *explanans,* the factors that contribute to an explanation of adoption. The *explanandum*, the level of adoption or the time of adoption, in contrast, appears to have been treated as a primitive variable by most authors, not worthy of much attention. In this study attention has also been paid to assess the level of adoption and to find out the ways and means to improve it.

The present study was undertaken with a view i)to find out the contact of different categories of farmers with Government officials to obtain information on Modern Agricultural Technology (hereafter referred as MAT) for castor production, ii) to identify the various communication sources and its frequency, the farmers used for getting MAT iii) to assess the knowledge level of different categories of farmers regarding MAT and iv) to evaluate adoption level of different technologies by different size groups of farmers.

The hypotheses adopted in the present study for each of the above said objectives are :

For objective (i)

Ho : There is no difference among the small, medium and large farmers to have access to Government officials for MAT on castor.

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H1 : The large farmers having higher social status and mobility **have more access** to Government officials than small farmers for MAT on castor.

For objective (iii)

Ho : There is no difference among the small, medium and large farmers' knowledge regarding MAT on castor.

H1 : The large farmers having more educational status and mobility have more knowledge regarding MAT on castor.

For objective (iv)

Ho : The dryland farmers irrespective of land holding size adopt low or no cost technologies than technologies involving high monetary inputs.

H1 : The dryland farmers are risk averse in nature and hesitant to adopt any MAT on castor.

METHODOLOGY

A) Sampling plan and Data

Mahboobnagar district consists of thirteen taluks. The talukwise area under castor crop was collected for five years from 1980-81 to 1984-85. It was observed that Kalwakurthy taluk comprising two blocks covers 51.39% of castor area in the district and hence selected for the study. From each block four villages were selected by systematic random sampling procedure.

The farmers were selected by following stratified random sampling with proportional allocation technique. Thus in total 120 farmers were selected covering 50, 39 and 31 from small (0-2 ha), medium (2-4 ha) and large (4 ha) size groups, respectively. The desired information was obtained with the help of structural schedules by survey method in the year 1985-86.

B) MEASUREMENT

The farmers were asked whether they have contact with the Government officials like Village Development Officer, Agricultural Officer, Block Development Officer, Assistant Director of Agriculture, Subject Matter Specialist (Agriculture) or any other Government personnel for advice on modern agricultural practices of castor. If the answer comes in affirmative, they were further questioned regarding the frequency of contact i.e. weekly, fortnightly, monthly or more than a month.

Regarding the use of different communication sources to get MAT and its frequency, the farmers were questioned. The different sources enquired were neighbours, relatives, progressive farmers, radio, television, film show, demonstrations, field trips and personal contact with officials of Agriculture Department.

The present knowledge level of MAT on castor cultivation were enquired from the farmers. The MAT were i) improved seed (ii) seed rate iii) seed treatment iv) time of sowing v) method of sowing vi) spacing vii) fertilizer application viii) time and method of weed control ix) insect pests and diseases x) stage of harvest of the crop and xi) method of threshing.

After obtaining information on the knowledge level of farmers regarding MAT, the farmers were interviewed regarding the adoption level of the same which are listed in the above paragraph. Scoring technique was used to find out the level of adoption. Score 1 was awarded if the practice was adopted and 0, if not adopted. The farmers were classified under high adoption category if they scored 8-11 points, medium adoption category if they scored 4-7 points and low adoption category if they scored 3 points or less.

RESULTS AND DISCUSSION

Extension contact

The Table 1 revealed that 23 % of the farmers had no contact with the Government personnel while 38 % had weekly contact with either of the personnel. The fortnightly, monthly and more than a month contact with the Government personnel on an average were 21%, 8% and 10% respectively. The contact of different categories of farmers were of the same order as that of the average figures with little variations.

Table 1. Frequency of contact of different categories of farmers with Government personnel

Categories of farmers	Frequency of contact					Total
	Weekly	Fortnightly	Monthly	More than a month	Nil	
Small	19(38)	13(26)	2(4)	4(8)	12(24)	50(100)
Medium	15(38)	7(18)	4(10)	5(13)	8(21)	39(100)
Large	12(39)	5(16)	4(13)	3(10)	7(22)	31(100)
Total	46(38)	25(21)	10(8)	12(10)	27(23)	120(100)

Figures in parentheses indicate percentage

The χ^2 test carried out to test the first hypothesis showed that the table value of χ^2 at 5 % level of significance for 2 degrees of freedom was 5.99 which was much more than the calculated value of 0.261 leading to the conclusion that the null hypothesis is true, and there are equal opportunities for all categories of farmers to have access to Government officials for MAT on castor. (Table 2).

Table 2. Extent of contact of different categories of farmers with Government personnel

Particulars	Category of farmers			Total	χ^2 Value
	Small	Medium	Large		
Contacted	38(39)	31(30)	24(24)	93	0.261
Not contacted	12(11)	8(9)	7(7)	27	

Figures in parentheses indicate expected frequencies

Use of communication sources

On an average 87% of the farmers used different sources of communication more frequently (less than 15 days) to obtain MAT on castor than the rest 13%. When different size groups of farmers were considered, the medium farmers used one communication source or the other less frequently than the small and large farmers. It can be inferred that small farmers are equally interested like large farmers for the modern agricultural technology on castor (Table 3).

Table 3. Use of different communication sources and its frequency by different categories of farmers

Categories of farmers	Frequently (once within 15 days)	Less frequently (more than 15 days)	Total
Small	46 (92)	4 (8)	50 (100)
Medium	29 (74)	10 (26)	39 (100)
Large	29 (94)	2 (6)	31 (100)
Total	104 (87)	16 (13)	120 (100)

Figures in parentheses indicate percentage.

Knowledge of farmers regarding modern agricultural technologies

Before enquiring the adoption level of different practices, the knowledge regarding MAT was enquired and it was found that more than 90% of the farmers from different size groups were aware of the technologies like improved seed, seed rate, time of sowing, method of sowing, fertilizer application, time and method of weed control and method of threshing. The farmers were lacking in knowledge to different degrees in the technologies (Table 4) and the technologies like seed treatment and stage of harvest of the crop were at the introduction stage. All the farmers lack the knowledge about the new recommended spacing of 90 cm x 20 cm. Though a sizeable portion of the farmers were aware of the methods to control insect pests and diseases they were not clear about the doses of chemicals and time of spraying.

Table 4. Knowledge of farmers on different modern agricultural technologies

Sl. No.	Technologies	Small	Medium	Large	Total
		$N_1 = 50$	$N_2 = 39$	$N_3 = 31$	$N_4 = 120$
1.	Improved seed	50(100.0)	39(100.0)	31(100.0)	120(100.0)
2.	Seed rate	46(92.0)	39(100.0)	29(74.4)	114(95.0)
3.	Seed treatment	-	1(2.6)	3(9.7)	4(3.3)
4.	Time of sowing	49(98.0)	39(100.0)	31(100.0)	119(99.2)
5.	Method of sowing	50(100.0)	39100.0)	31(100.0)	120(100.0)
6.	Spacing	-	-	-	-
7.	Fertilizer application	50(100.0)	39(100.0)	31(100.0)	120(100.0)
8.	Time and method of weed control	47(94.0)	35(89.7)	31(100.0)	113(94.2)
9.	Insect pests & diseases	33(66.0)	22(56.4)	29(93.5)	84(70.0)
10.	Stage of harvest of the crop	9(18.0)	9(23.1)	5(16.1)	23(19.2)
11.	Method of threshing	50(100.0)	39(100.0)	31(100.0)	120(100.0)

Figures in parentheses indicate percentage

It is evident from the Table 4 that the large farmers were **in no way superior to medium** and small farmers regarding knowledge in MAT on castor.

Adoption of MAT by farmers

It was observed that there is no farmer under low adoption category implying that, each farmer was using at least four of the eleven technologies. The percentage of adoption under medium and high adoption category were 73 and 27, respectively. Almost similar percentage of farmers were under medium and high adoption categories when intersize farmers were considered (Table 5).

Table 5. Adoption of modern agricultural technologies by different size groups of farmers

Adoption Category	Size group of farmers						Total	
	Small N_1 = 50		Medium N_2 = 39		Large N_3 = 31		N = 120	
	No.	%	No.	%	No.	%	No.	%
High adoption (8-11)	13	26	11	28	9	28	33	27
Medium adoption (4-7)	37	74	28	72	22	72	87	73
Low adoption (3 & less)	-	-	-	-	-	-	-	-

Adoption of important technologies

Five technologies were considered important for increasing castor production. They were improved seed, time of sowing, fertilizer application, time of weed control and control of insect pests and diseases (Table 6). The rate of adoption of these technologies by dryland farmers revealed that non-monetary inputs like time of sowing, time of weed control and low monetary inputs like improved seed were widely adopted by the farmers. As dryland farmers are risk aversing in nature, due to uncertainity of rain they always prefer to invest less on monetary inputs such as fertilizer and pesticide.

The monetary inputs like fertilizer application was adopted by 77% of the farmers, though few among them used optimum doses due to capital scarcity and risk involved in such practices. However, more percentage of big farmers used fertilizer than small farmers.

The pest control measures were not adopted by 81% of the farmers due to capital scarcity, risk involved in such practice and lack of technical guidance.

Table 6. Adoption of important technologies by different categories of farmers

Sl No.	Practices		Size group of farmer			Total N = 120
			Small $N_1 = 50$	Medium $N_2 = 39$	Large $N_3 = 31$	
1.	Improved seed	A	49(98.0)	39(100)	31(100)	119(99.2)
		NA	1(2.0)	-	-	1(0.8)
2.	Time of sowing	A	49(98.0)	39(100)	31(100)	119(99.2)
		NA	1(2.0)	-	-	1(0.8)
3.	Fertilizer application	A	34(68.0)	29(74.4)	29(93.5)	92(76.7)
		NA	16(32.0)	10(25.6)	2(6.5)	28(23.3)
4.	Time of weed control	A	45(90.0)	35(89.7)	31(100)	111(92.5)
		NA	5(10.0)	4(10.3)	-	9(7.5)
5.	Control of insect pests and diseases	A	8(16.0)	10(25.6)	5(16.1)	23(19.2)
		NA	42(84.0)	29(74.4)	26(83.9)	97(80.8)

Figures in parentheses indicate percentage
A = Adopted, NA = Not Adopted

CONCLUSION

It is concluded from the study that extension efforts should be intensified for creating awareness about the importance of non-monetary technologies like seed treatment, spacing, stage of harvest of the crop, time of pest control with wide spread demonstrations to boost the castor production in the study area.

The adoption level of high monetary inputs can be increased by providing credit, announcing favourable support price of castor and offering technical guidance to the farmers on the judicious application of fertilizers and pesticides through demonstrations.

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EFFECT OF NITROGEN AND PHOSPHORUS LEVELS ON GROWTH, YIELD AND PROTEIN CONTENT OF SOYBEAN (*Glycine max* (L) Merr.)*

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ABSTRACT

An experiment was conducted at IGKVV, Raipur for two seasons (Kharif 1987 and 1988) to study the response of nitrogen and phosphorus on growth, yield and protein content of soybean. The studies revealed that the growth, yield contributing parameters, yield as well as protein content was influenced with increasing levels of nitrogen and phosphorus. Application of 45 kg N and 90 kg P2 O5 produced higher yield of seed and stalk. However, application of 30 kg N and 60 kg P2 O5 /ha was found more economic. Medium and higher levels of nitrogen significantly increased the protein content of seed. Phosphorus application did not bring significant increase in protein content of seed during first year, but during second year protein content increased with phosphorus levels.

Key words : Soybean; Nitrogen; Phosphorus

INTRODUCTION

Soybean contains about 40 per cent protein. It requires large amount of nitrogen for optimum production. A good crop of soybean utilizes upto 240- 250 kg N/ha, out of which approximately 100-110 kg N/ha is fixed symbiotically from atmosphere (Chandel and Saxena, 1988). Besides the symbiotically fixed nitrogen it also requires supplemental nitrogen (20-30 kg/ha) for its early establishment. Soybean has relatively higher phosphorus requirement, which helps to stimulate root development and nodulation necessary for nitrogen fixation. Very little information is available on response of soybean to nitrogen and phosphorus on Chhatisgarh region. Therefore, the present study was under taken to find out the optimum dose of nitrogen and phosphorus for yield and quality.

MATERIALS AND METHODS

The experiment was conducted at Research Farm, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur during *kharif* seasons of 1987 and 1988. The soil of the experimental field was of "Vertisol" group locally called "Kanhar". The average pH of the soil was 7.4 and its organic carbon, available N, P_2O_5 and K_2O were 0.58 per cent, 172.3, 9.5 and 318.3 kg/ha respectively. The four levels each of nitrogen (0, 15, 30 and 45 kg/ha) and phosphorus (0,30,60 and 90 kg/ha) were tried in a Randomised Block Design with factorial arrangement with four replications. The gross plot size was 6 x 5 m. A uniform basal dose of 30 kg K_2O/ha was applied at the time of field preparation. Full quantity of N and P_2O_5 were drilled at sowing according to treatment.

The crop was sown keeping 30 cm row spacing in the last week of June and harvested in second week of October during both the years. All the recommended cultural practices were followed to raise the crop. Ten plants from each treatment were selected randomly for growth and yield attributing parameters. The seed and straw yield was recorded net plot (4.80 x 4.00 m) wise and finally expressed in to quintal per hectare. The protein content (per cent)

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in seed was estimated by multiplying the per cent concentration of nitrogen (Kjeldhal method) in seed. The protein production (kg/ha) was computed by multiplying the per cent value of protein with respective seed yield. A total of 702.5 mm in 1987 and 575.2 mm rainfall in 1988 were received during the crop period. In general 1988 was drought year as the rice is cultivated predominantly in this region.

RESULTS AND DISCUSSION

Growth and yield attributes

The data presented in Table 1 showed that different levels of nitrogen had significant influence on plant height, number of pods per plant, seeds per pod and test weight. However, the number of branches per plant was not affected significantly in both the years. Nitrogen has been widely accepted as a dominant growth promotor and significant increase in plant height was due to the vigorous root growth and early seedling establishment till the nitrogen fixation by nodules was activated and reached to the requisite level. Increase in number of pods per plant may be due to the higher plant height because the number of flowers increased with the plant height. Significant increase in 100 seed weight (12.94 g in 1987 and 13.28 in 1988) at higher level of nitrogen (45 kg N/ha) but not at lower doses, may be due to the fact that at lower dose of nitrogen plant could not attain normal vigour and growth in absence of optimal dose of nitrogen. This may be a possible reason. Similar findings were also obtained by Paikera *et al.*, (1988) and Jayapaul and Ganesaraja (1990).

Among the different levels of phosphorus higher plant height, number of pods per plant and 100 seed weight were obtained with the application of higher doses of phosphorus (90 kg P_2O_5/ha). The differences in number of pods/plant amongst 0 - 30, 30 - 60 and 60 - 90 kg P_2O_5/ha were comparable in 1987, while in 1988 all the phosphorus levels produced higher number of pods over control. Higher weight of 100 seeds (12.79 g) was recorded with 90 kg P_2O_5/ha over 30 kg P_2O_5/ha and control. The weight of 100 seeds remained identical in 1988. The number of branches and seeds per pod were statistically non significant in both the years. Phosphorus played an important role in root development, rhizobium infection and nitrogen fixation. Its application increased the metabolic activities of the plant. The increase in number of pods per plant and 100 seed weight with higher phosphorus doses may be due to making the system balanced with nutrition and consequently producing healthy seeds. Rao *et al.*, (1972) also observed similar effect of phosphorus fertilization on pods per plant and 100 seed weight. Superiority of phosphorus application was also reported by Kaliya *et al.*, (1984), Vyas *et al.*, (1987) and Upadhyay *et al.*, (1988).

Seed and straw yield

Significant increase in seed and straw yield was obtained by increasing in levels of nitrogen. Maximum seed yield of 18.45 and 19.86 q/ha was obtained with the application of 45 kg N/ha during 1987 and 1988 respectively (Table 2). The seed yield at 45 kg N/ha was 7.26, 29.02 and 59.74 per cent higher in 1987 over 30, 15 and 0 kg N/ha, while it was 10.58, 28.46 and 39.27 per cent higher in 1988 over the respective treatments. The increase in seed and stalk yield with increasing nitrogen levels may be due to the conducive effect of nitrogen levels on pods per plant, seeds per pod and 100 seed weight. Although soybean has the capacity to meet the major part of its nitrogen requirement by symbiotic nitrogen fixation, but it may not be

Table 1. Growth and yield attributing characters of soybean as influenced by nitrogen and phosphorus levels

Trea- tments	Plant height (cm)		Mean	Branches/plant		Mean	No.of pods/plant		Mean	No. of seeds/pod		Mean	Test wt. of 100 seeds(g)		Mean
	1987	1988		1987	1988		1987	1988		1987	1988		1987	1988	
N kg/ha															
0	73.5	82.0	77.7	3.51	3.70	3.60	31.60	33.88	32.74	1.68	1.70	1.69	11.90	11.93	11.92
15	75.1	83.9	79.5	3.51	3.66	3.58	34.09	41.24	37.66	1.75	1.70	1.72	12.26	12.26	12.26
30	77.8	87.7	82.7	3.52	3.70	3.61	36.64	43.85	40.24	1.87	1.84	1.85	12.44	12.56	12.50
45	81.4	89.4	85.4	3.82	3.72	3.62	39.68	49.86	44.77	1.95	1.98	1.96	12.94	13.28	13.11
SEm ±	1.91	0.41		0.035	0.042	0.031	0.90	0.83	0.61	0.028	0.028	0.023	0.155	0.226	
CD (5%)	5.47	1.17		NS	NS	NS	2.56	2.38	1.71	0.08	0.08	0.06	0.44	0.64	
P_2O_5 kg/ha															
0	73.5	84.2	78.8	3.51	3.68	3.59	32.83	39.24	36.03	1.76	1.76	1.76	12.06	12.38	12.22
30	77.5	86.1	81.8	3.50	3.65	3.57	34.72	42.09	38.40	1.79	1.79	1.79	12.33	12.34	12.33
60	77.5	86.3	81.9	3.51	3.68	3.59	36.35	43.38	39.86	1.86	1.81	1.83	12.36	12.57	12.46
90	79.4	86.4	82.9	3.54	3.76	3.65	38.12	44.18	41.15	1.85	1.84	1.84	12.79	12.72	12.75
SEm ±	1.91	0.41		0.035	0.042	0.031	0.90	0.83	0.61	0.028	0.028	0.023	0.155	0.226	
CD (5%)	NS	1.17		NS	NS	NS	2.56	2.38	1.71	NS	NS	NS	0.44	NS	
N X P	NS	NS		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	

Table 2. Yields, protein content and protein yield (kg/ha) of soybean as influenced by nitrogen and phosphorus levels

Treatments	Seed yield (q/ha)		Mean	Straw yield (q/ha)		Mean	Protein content (%)		Mean	Protein yield (kg/ha)		Mean
	1987	1988		1987	1988		1987	1988		1987	1988	
N (kg/ha)												
0	1155	14.26	12.90	17.01	24.46	20.73	38.41	38.29	38.35	444.09	546.19	495.14
15	14.30	15.46	14.88	21.82	26.75	24.28	38.95	39.14	39.04	557.79	605.48	581.63
30	17.20	17.96	17.58	27.32	33.88	30.60	39.29	39.79	39.54	676.43	715.06	695.74
45	18.45	19.86	19.15	30.84	38.72	34.78	39.59	39.90	39.74	730.59	793.04	761.81
SEm ±	0.39	0.38	0.28	0.41	1.17		0.25	0.17		16.84	14.86	11.39
CD(5%)	1.13	1.09	0.78	1.17	3.35		0.70	0.48		48.11	42.64	31.95
P2O5 (kg/ha)												
0	13.60	14.74	14.17	21.68	27.28	24.48	38.67	38.83	38.75	527.04	573.37	550.20
30	14.91	16.68	15.79	23.69	30.16	26.92	38.91	39.23	39.07	581.11	655.93	618.52
60	15.92	17.48	16.70	24.99	32.54	28.76	39.25	39.43	39.34	626.19	690.64	658.41
90	17.07	18.65	17.86	26.64	33.83	30.23	39.42	39.63	39.52	674.57	739.84	707.20
SEm ±	0.39	0.38	0.28	0.41	0.17		0.25	0.17		16.84	14.86	11.39
CD(5%)	1.13	1.09	0.78	1.17	3.35		NS	0.48		48.11	42.64	31.95
N X P	NS	NS	NS	NS	NS		NS	NS		NS	NS	NS

sufficient to attain maximum growth and yield. Therefore, it needs some initial quantity of nitrogen as a starter dose (Singh, 1989). Favourable response of soybean to nitrogen (upto 240 kg N/ha) was also indicated by Singh and Saxena (1972). The increased straw yield with higher doses of nitrogen was due to favourable growth components.

Maximum seed yield was obtained at 90 kg P_2O_5/ha (17.07 q/ha in 1987 and 18.65 q/ha in 1988) which was significantly superior to lower doses. The percentage increase in seed yield at 90 kg P_2O_5/ha over 60,30 and 0 kg P_2O_5ha was 7.22, 14.48 and 25.15 in 1987 and 6.69, 11.81 and 26.52 in 1988 respectively. The seed yield obtained with 30 and 60 kg P_2O_5/ha levels did not differ significantly in individual years. However, on the basis of mean value the seed yield increased significantly with every increase in rate of phosphorus application. This may be due to favourable effect of phosphorus on plant height, number of pods per plant and 100 seed weight. The importance of phosphorus is known for early root development, manufacture and translocation of food material in the plant body, which resulted in better uptake of nutrients. This may be the possible reason for increased seed yield at higher dose of phosphorus. Similar results were also reported by Kaliya *et al.*, (1984). The increased stalk yield with phosphorus application may be due to the increased plant height and number of pods per plant as reported earlier by Kaliya *et al.*, (1984). The interaction between nitrogen and phosphorus was non-significant during both the years.

The linear regression equation between yield attributes and seed yield were worked out separately as shown below.

$Y = -20.7424 + 10.2308$ x number of branches ($R^2 = 0.19$)

$Y = +0.1648 + 0.4109$ x number of pods/plant ($R^2 = 0.70$)

$Y = +2.4406 + 7.4440$ x number of seeds/pod ($R^2 = 0.25$)

$Y = -38.9135 + 4.4094$ x 100 seed weight ($R^2 = 0.60$)

The R^2 values for number of pods/plant is 0.70 indicating that it is responsible for 70 per cent of yield variability. This was followed by 100 seed weight with R^2 value 0.60. The R^2 value for number of branches is only 0.19 which indicated that it explained only 19 per cent of yield variability. This shows that the number of pods/plant is one of the important variable to influence the seed yield.

Protein content

The protein content of seed increased with the increase in nitrogen levels. Maximum protein content (39.59 % in 1987 and 39.90% in 1988) was recorded at 45 kg/ha in both the years. The protein content is directly related with the nitrogen content of the seed. The plant absorbed nitrogen proportionately as the pool of available nitrogen increased in soil by addition of higher dose of nitrogen. This trend was also observed by Katoch *et al.,* (1983) and Jayapaul and Ganesaraja (1990). Protein content was not affected significantly due to phosphorus application in the first year of study but during second year significant increase in protein content was noticed. However, the protein content increased numerically in both the years. Similar results were also reported by Lutz *et al.*, (1973) and Lutz and Jones (1975).

Protein yield

Almost a similar trend of response as described earlier in seed yield was noticed in case of protein yield. Nitrogen application had marked influence on protein yield in both the years, each increase in levels of nitrogen increased the protein yield for individual years as well as for the mean value. Maximum protein yield of 730.59 kg and 793.04 kg/ha was harvested during 1987 and 1988 respectively with the application of 45 kg N/ha.

Phosphorus application had significant effect on protein yield. The protein yield increased significantly with every increase in levels of phosphorus during 1988, whereas in 1987 the lower and medium (30 and 60 kg P_2O_5/ha) dose of phosphorus were found identical, but further increase in phosphorus dose (90 kg P_2O_5/ha) produced significantly higher protein per hectare over lower and medium doses.

The yield attributes like number of pods per plant, seeds per pod and 100 seed weight increased appreciably with increasing nitrogen levels, whereas the phosphorus application had significant effect on number of pods in both the years and 100 seed weight in 1987. The number of branches per plant was found identical with both the nutrients. The seed, straw yield and protein yield increased significantly with each increase in nitrogen doses. The lower and medium doses of phosphorus were identical for seed yield in both the years and for straw yield in 1988. On the mean basis the protein yield enhanced significantly with increasing nitrogen and phosphorus levels.

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THE EFFECT OF SEED MOISTURE CONTENT ON THE PHYSICAL PROPERTIES OF JSF-1 SAFFLOWER

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ABSTRACT

The effect of moisture content on physical properties, viz., spatial dimensions, shape, bulk density, angle of repose etc. of safflower (Carthamus tinctorius) seed (Cv.JSF-1) was studied. The best approximate shape of seed was found to be a prolate spheroid among prolate and oblate spheroid. At 7.5% moisture content db, the measurements yielded an average 1000 grain weight of 0.071 kg, mean surface area 466.4 mm^2 and sphericity of 63%. In the moisture range between 7.5 to 31.6% db, studies on rewetted safflower showed that the bulk density varied from 604 to 624 kg/m^3, specific gravity from 1.050 to 0.824, porosity from 40.4 to 26.7% and static co-efficient of friction from 0.38 to 0.47 over GI surface. The angle of repose was observed to change from 28.6^0 to 33.3^0 in the moisture range between 7.5 to 31.6% db. Regression equations were developed to represent relationship between size, volume, 1000 grain weight, bulk density and angle of repose with moisture content. correlation coefficients worked out in regression equations ranged from 0.931 to 0.999, which shows the regression equations developed are highly significant.

Key words : Seed moisture; Physical properties; Safflower JSF-1

INTRODUCTION

Safflower (*Carthamus tinctorius*) has gained importance recently as it contain nutritious oil. In order to design equipment/machines for handling, aeration, storing and processing safflower, its physical properties have to be studied. However, there appears to be no previously published work relating to physical properties of this oilseed. Therefore, it was planned to investigate some important moisture dependent physical properties of the seed such as spatial dimensions, size, sphericity, shape and surface area, 1000 grain weight, bulk density, specific gravity, volume, porosity, static co-efficient of friction and angle of repose.

MATERIALS AND METHODS

For the present study, safflower JSF-1 was obtained and seeds were cleaned to remove the impurities like trashes, dirt and dust. To achieve the desired level of moisture, the seeds were moistured with pre-determined quantity of water and periodically stirred in air tight plastic bags. The treated samples were preserved in a refrigerator at 5^0C for 5 days to ensure uniform distribution of moisture. Before starting a test, the required quantity of the grains were taken out of the refrigerator and allowed to warm upto the room temperature (Sreenarayanan *et al.*, 1985). To determine the moisture content of the grains, three samples each weighing between 25-30 g were placed in hot-air oven at 100^0C for 72 h (Hall, 1957). The samples were then cooled in a desoicator, weighed and moisture content of grains was calculated.

For evaluating the volume of set of irregularly shaped pebbles, several researchers have described the size of the grains by measuring their three principal dimensions whereas, sphericity is defined as the ratio of the surface area of a sphere which has the same volume as that of the solid (Dutta *et al.*, 1988). To determine the size and sphericity, the spatial

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dimensions of seed were measured with the help of a micrometer having least count 0.01mm. Size and sphericity were then calculated using the following expressions (Monsenin, 1980).

$$\text{Size} = (\textit{length x breadth x thickness})^{1/3}$$

$$\text{and Sphericity} = \frac{\textit{Size}}{\textit{largest dimension}}$$

To find the surface area of the grain, the projected area of grain was measured.

Bulk density is the ratio of the mass sample of a grain to its total volume. It is a moisture dependent property and was found by filling up a kettle of 500ml with grains from a height of 15 cm, striking off the top level and then weighing the contents (IS : 4333 part IV - 1967). The specific gravity and volume of grain were determined by the liquid displacement method using a general purpose reagent toluene rectified (Sp. gravity : 0.856).

$$\text{Specific gravity} = \frac{\textit{Weight of grains in air x Sp. gravity of liquid used}}{\textit{weight of displaced liquid}}$$

$$\text{and volume} = \frac{\textit{weight of displaced liquid}}{\textit{weight of density of liquid used}}$$

Porosity is the property of grain which depends on its bulk and true density. Porosity was determined indirectly using the following formula (Monsenin, 1980).

$$\text{Porosity} = \frac{\textit{true density} - \textit{bulk density x } 100}{\textit{true density}}$$

Static co-efficient of friction was measured by using a table provided with changeable surfaces. The set-up consists of mainly a friction-less pulley fitted on a frame and a sample holder connected to the weight pan (Sreenarayanan *et al.*, 1985).

When a granular material is allowed to flow freely from a point into a pile, the angle which the side of the pile make with horizontal plane is called the angle of repose. To determine the angle of repose of grains, the standard method was followed in which a specially constructed funnel and measuring container were used (IS : 6663 - 1972).

RESULTS AND DISCUSSION

The results of the experiments conducted for determining the various physical properties of safflower JSF-1 are given in Table 1.

Size and sphericity

Size increased with an increase of grain moisture content between 7.5 to 31.6 (Fig.1). A linear relationship between size of the grain and moisture content was obtained as per $S = 1.9 \times 10^{-2} M + 5.556$ where, S = Size of the grain, mm and M = Moisture content, % db Correlation Co-efficient, $R^2 = 0.987$

Sphericity does not show any specific trend with moisture content (Table 1)

Table 1. Spatial dimensions and sphericity of JSF-1 safflower seed

Moisture content % db	Length(mm)	Breadth(mm)	Thickness(mm)	Sphericity
7.5	8.93	4.67	4.33	0.63
10.3	9.09	4.81	4.35	0.64
13.6	9.24	4.95	4.38	0.60
17.2	9.27	4.97	4.43	0.64
21.9	9.43	5.13	4.48	0.64
25.3	9.50	5.16	4.51	0.64
31.6	9.67	5.21	4.58	0.63

Shape and surface area

For small objects such as seeds, the shape can be approximated by one of the geometric shapes, 1) prolate spheroid which is formed when an ellipse rotates about its major axis 2) oblates spheroid which is formed when an ellipse rotates about its minor axis and 3) right circular cone or cylinder. Since, safflower seed represents length as a major axis and breadth as a minor axis (Table 1), is close in shape to a prolate or an oblate spheroid. To decide the best approximate shape of JSF-1, the volumes are obtained for the two assumptions from :

$$V_{\text{prolate}} = \frac{4}{3}\pi\, ab^2 \quad \text{------------}1$$

and $$V_{\text{oblate}} = \frac{4}{3}\pi\, a^2 b \quad \text{------------}2$$

Where a and b are major and minor semi-axis of the ellipse rotation respectively.

Equation 1 gave the resulting volume higher than the actual volume of the seed by 33.8% whereas equation 2 yielded a volume which was 152.4% higher than the actual volume of the grain. Based on these calculations it may be concluded that the grain is closest to a prolate spheroid. Taking the shape of the grain as a prolate spheroid, the surface area of the grain was calculated by using the following mathematical expression

$$S = 2\pi b^2 + 2\pi \frac{ab}{e}\sin^{-1} e$$

Where a and b are respectively major and minor semi-axis of the ellipse of rotation and e is eccentricity given by $e = [1 - \left(\frac{b}{a}\right)^2]^{1/2}$. The surface area using above expression was found as 427.6 mm^2. However, experimentally it was measured as 466.4.mm^2 by measuring the projected area of the grain.

Volume

The single grain volume increased between 7.5 to 31.6% moisture content. The rate of increase in grain volume was found to be more up to 21% moisture content compared to 21 to 31.6% moisture content (Fig.2). It may be due to the fact that at high moisture level the starch molecules get saturated and further increase in moisture content results in lesser change in volume (Browne, 1962). The experimentally observed data on volume and moisture content can be represented by the following regression equation ;

$$V_g = 3.89 \times 10^{-1} M + 0.784 \times 10^2$$

Where, V_g = volume of grain, mm^3 and M = moisture content, % db

Correlation co-efficient, $R^2 = 0.970$

Thousand grain weight

Thousand grain weight varied from 0.071 kg to 0.094 kg for the moisture range between 7.5 to 31.6% (Fig. 3). A linear relationship between thousand grain weight and moisture content was obtained as follows,

$$W_{1000} = 9.624 \times 10^{-4} M + 6.30 \times 10^{-2}$$

Where, W_{1000} = Weight of 1000 grains, kg and M = moisture content, % db

Correlation co-efficient, $R^2 = 0.999$

Bulk density

The bulk density was found to decrease with an increase in moisture content between 7.5 to 31.6 % (Fig. 4). In general, increase in moisture content of grain increases its volume as well as mass of the grain. But increase in net volume is slightly more as compared with net increase in mass of grains in bulk. Therefore, the ratio of mass divided by volume which in turn called as bulk density decreases as the moisture content of grain increases (Mohsenin, 1980). The relationship between the bulk density and moisture content of the grain was obtained as follows :

$$\rho_g = 6.318 \times 10^2 - 7.93 \times 10^{-1} M$$

where, ρ_g = bulk density, kg/m^3 and M = moisture content, % db Correlation coefficient, $R^2 = 0.931$

Specific gravity and porosity

Specific gravity was found to vary from 1.05 to 0.824 when the moisture level increases from 7.5 to 31.6% whereas, porosity varied from 40.4% to 26.7% when the moisture level increases from 7.5 to 31.6%.

Static Co-efficient of friction and angle of repose

It was observed that the co-efficient of friction for JSF-1 safflower increased with moisture content on GI structured surface. It was found to vary from 0.38 to 0.47 when the

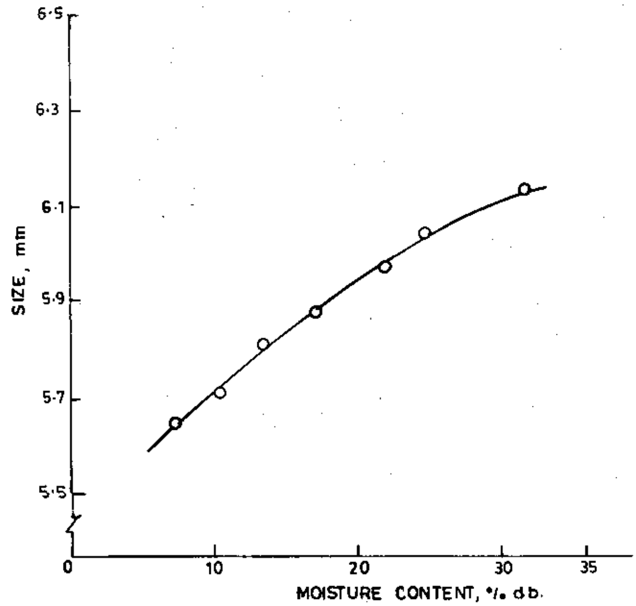

Fig. 1 Variation of size with moisture content

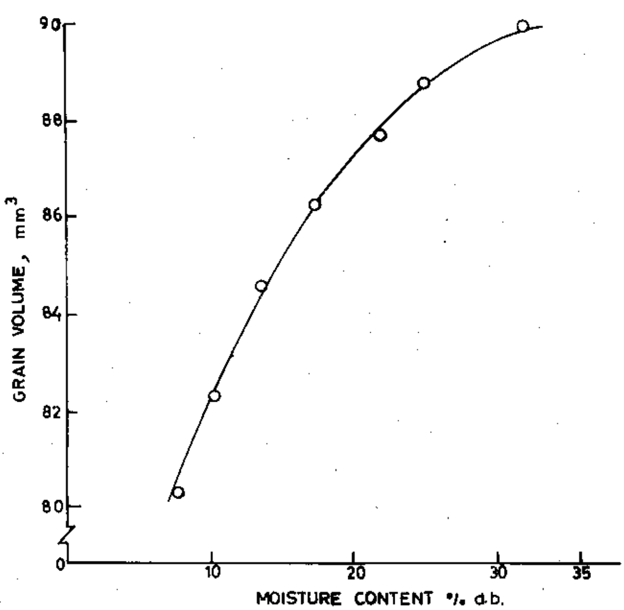

Fig. 2 Variation of grain volume with moisture content

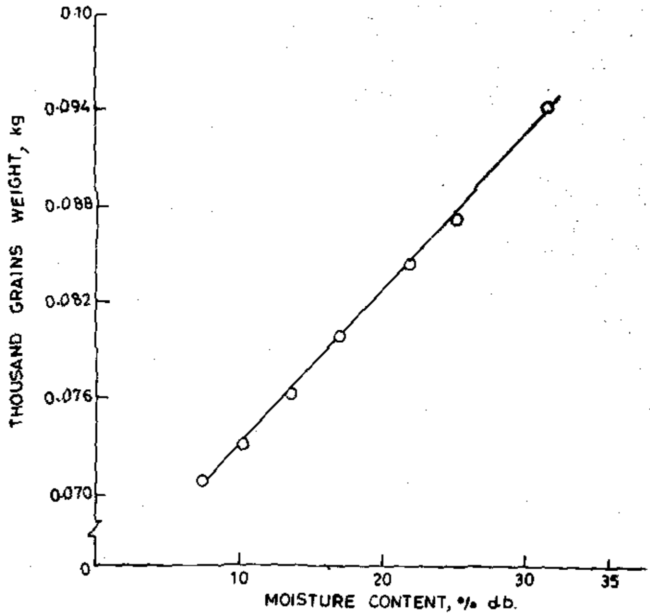

Fig. 3 Variation of thousand grains weight with moisture content

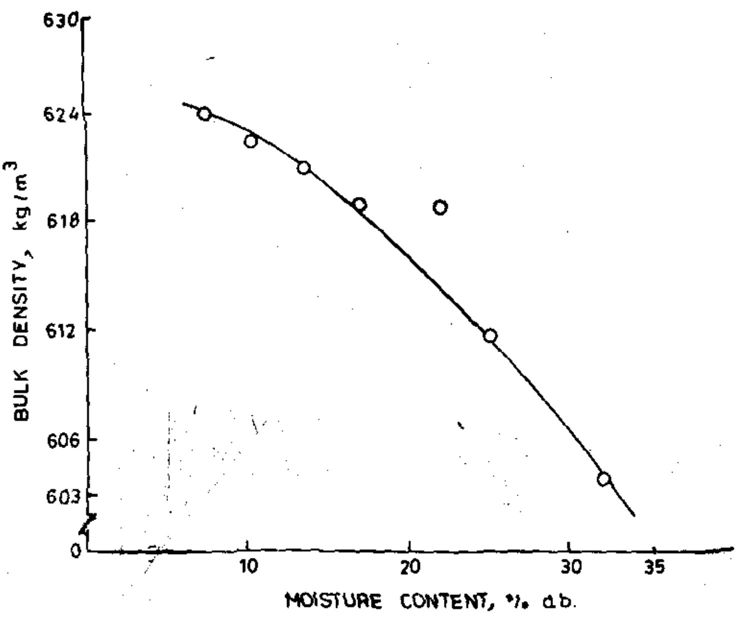

Fig. 4 Variation of bulk density with moisture content

moisture level increases from 7.5 to 31.6 %. The experimental results for angle of repose with respect to moisture content are shown in Fig.5. It was found that the angle of repose increased with increase in moisture content. The experimental values for angle of repose bear the following relationship with moisture content,

$$\theta = 1.94 \times 10^{-1} M + 2.721$$

Where, θ = angle of repose, degree and M = moisture content, % db correlation coefficient $R^2 = 0.990$

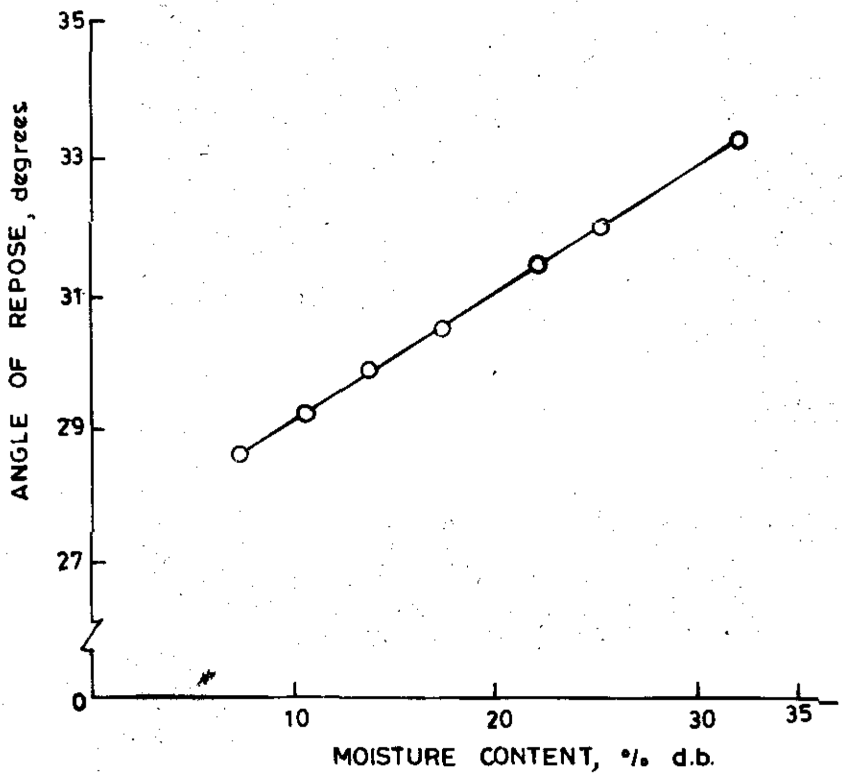

Fig. 5 Change of angle of repose with moisture content

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ECONOMICS OF OILSEED BASED CROPPING SYSTEMS

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ABSTRACT

A set of six oilseed based intensive cropping sequences was tested at Cropping System Research Centre, Marathwada Agricultural University, Parbhani, during 1988-89 to 1990-91 to evaluate productive and profitable cropping systems which would improve the economic status of farming community as well as help to reduce the country's dependance on oil import. Experimental findings revealed that the productivity of pre-monsoon groundnut and soybean in kharif sunflower and safflower in rabi and groundnut in summer was superior while under sequence, the productivity of cotton was comparatively higher when grown after summer groundnut, and rabi sunflower sown after pre-monsoon groundnut fared well. Summer groundnut grown after cotton was better than when grown after rabi sunflower. In terms of monetary returns the sequence of groundnut-sunflower-sesamum recorded significant highest per hectare gross monetary returns (Rs.35.3 thousand/ha) and vegetable oil yield (16.24 q/ha). Sesamum- sunflower-groundnut and Cotton-groundnut were the next best remunerative crop sequences. The above sequences have also improved the fertility status of soil. These sequences can be adopted under adequate inputs and assured irrigation conditions.

Key words : Oilseeds; Cropping systems ; Oil yield ; Fertility.

INTRODUCTION

Our present oilseed production is inadequate to meet ever increasing demands of edible oils. The import bill of oils is touching to a mark of Rs.1400 crores (Saini *et al.*, 1989). Government of India is implementing different crash programmes to boost-up the oilseed production in order to make India self sufficient in vegetable oils and to reduce our dependance on imports and to save valuable foreign exchange. The modern improved technology recently developed in respect of multiple cropping has provided an effective tool for meeting the challenges of food needs of the increasing population of our country (Swaminathan, 1972 and Bains and Randhawa, 1970). The efforts are therefore, need to be made to enhance the oilseed production/unit area/unit time through multiple cropping systems with the inclusion of different oilseed crops and with conserving the soil fertility. With this view in mind an experiment, to find out most productive and remunerative oilseed based cropping system for Marathwada region, was planned.

MATERIALS AND METHODS

The present investigation was conducted during 1988-89 to 1990-91 for three successive years at the Cropping System Research Centre, Marathwada Agricultural University, Parbhani. The experiment was laid out with six different cropping systems in a Randomised Block Design with four replications. The *kharif* crops included in the sequence were pre-monsoon groundnut (ICGS-XI), sesamum(PB-1), soybean(JS-80-2), cotton (NHH-44) and sorghum (CSH-9). During *rabi*, sunflower (LDMRSH-1) and safflower (S-4) were tried while in summer, sesamum (PB-1), groundnut (ICGS-XI), and sunflower (LDMRSH-1) were included. The experiment was conducted on the same site without changing the randomisation of the treatments to assess the residual effects. The gross and net plot sizes were 5.40 x 8.40 m^2 and 3.60 x 7.20 m^2, respectively. The soil of the experimental plot was medium in available

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nitrogen (141.17 kg/ha), and available phosphorus (22.18 kg P_2O_5/ha), and high in available potassium (422.64 K_2O/ha). It was clayey in texture and slightly alkaline in reaction (7.9 pH); with 0.317 mmhos/cm E.C. and 0.55 per cent organic carbon. Recommended package of practices were adopted for all the crops.

In order to derive the gross monetary returns the market rates of respective crop, prevailing during the specific year were used.

The seed yield (economic yield) of *kharif*, *rabi* and summer crops in the sequence were considered for calculating the oil yield wherein groundnut pods and cotton yields were converted into kernals and cotton seed. The conversion factors (mean) considered were:

a) Groundnut kernals from groundnut pods 60 per cent, and

b) Cotton seeds from cotton yield 65 per cent,

In order to work out the oil production from respective sequence, standard oil percentages of different crops, considered were, groundnut (48), sunflower (42), sesamum(49), soybean (19), safflower(30) and cotton(2), as stated by Reddy, 1989.

RESULTS AND DISCUSSION

Results of three years were pooled and the data on productivity, gross monetary returns, oil yield and soil fertility status are presented in Table 1. Perusal of data on production potential shown in Table 1 indicates that in *kharif*, groundnut and soybean yields were higher; while in *rabi* both sunflower and safflower were better and groundnut fared well in summer. Sesamum in summer was at lowest level.

Considering the mean productivity of crops in different sequences showed that cotton grown after summer groundnut gave higher yields than cotton grown after summer sunflower. This may be due to preceding leguminous crop. *Rabi* sunflower grown after *kharif* groundnut performed well than sown after sorghum and sesamum, while summer groundnut fared well when grown after cotton than when sown after *rabi* sunflower. Data on monetary returns revealed that during the year 1988-89, the sequence of groundnut-sunflower- sesamum, Sorghum-sunflower-groundnut and Sesamum-sunflower-groundnut recorded highest monetary returns in the range of Rs.31.5 to 30.8 thousand per hectare per annum and remained statistically at par.

The sequences viz., sesamum-sunflower-groundnut and groundnut-sunflower-sesamum maintained their superiority, accruing gross monetary returns of Rs.33.3 and 32.9 thousand per hectare respectively in the year 1989-90 also. The cotton-summer groundnut sequence obtained monetary returns of Rs.32.8 thousand per hectare and remained on par with above two sequences.

In the third year (1990-91), groundnut-sunflower-sesamum recorded gross monetary returns of Rs.41.8 thousand per hectare and remained significantly superior over all the sequences tried. The sequences with cotton-summer groundnut, and sorghum-sunflower-groundnut gave gross returns of Rs.33.7 and Rs.33.2 thousand per hectare respectively and remained statistically on par with each other.

Table 1. Production potential, monetary returns and oil production of different crop sequences

Trt. No.	Crop sequences			Gross monetary returns (Rs.'000/ha)				Mean oil yield (q/ha)	Fertility status after three years in (kg/ha)		
	Kharif	Rabi	Summer	'88-89	'89-90	'90-91	Pooled mean		N	P	K
T-1	Groundnut (16.99)	- sunflower (20.09)	- sesamum (5.96)	31.5	32.9	41.8	35.3	16.24	156	26	513
T-2	Sesamum (5.60)	- sunflower (17.67)	- groundnut (16.39)	30.8	33.3	32.3	32.0	14.87	162	26	519
T-3	Soybean (17.62)	- safflower (16.90)	- sesamum (5.39)	23.1	22.7	21.1	22.1	11.05	170	27	465
T-4	Cotton (16.92)	- contd.	- groundnut (18.50)	25.5	32.8	33.7	30.6	7.51	185	26	528
T-5	Cotton (15.72)	- contd.	- sunflower (8.02)	14.6	21.5	21.3	19.1	5.40	103	21	447
T-6	Sorghum (21.99)	- sunflower (18.41)	- groundnut (16.95)	30.9	27.8	33.2	30.5	12.61	154	25	499
C D at 5%				1.9	4.0	3.6	3.31	-	-	-	-
Initial status of soil NPK (kg/ha)				-	-	-	-	-	135	23	465

(Figures in parentheses indicate yield q/ha);
Note the calculations of oil yield percentage are based on groundnut kernal yield (60%) of the pod yields and cotton seed yields (65%) of the seed cotton yield

Mean market prices of crops (Rs.quintal)

Crops	Main produce	By produce
Sorghum	180	50
Sesamum	1008	20
Soybean	341	-
Groundnut	708	75
Sunflower	633	20
Safflower	614	20
Cotton	787	25

The pooled results indicated that the crop sequence of groundnut-sunflower- sesamum, recording gross returns of Rs.35.3 thousand per hectare, was significantly superior over rest of the sequences tried. The sequences viz., sesamum-sunflower-groundnut and cotton-summer groundnut were next in the order of merit at second and third position, obtaining gross monetary returns of Rs.32.0 and 30.6 thousand per hectare per annum respectively. These higher returns from the sequences may be due to inclusion of leguminous and high value crops in the sequences. Similar observations were also reported by Giri and De (1980), Singh and Sahu (1981), Morey and Bagde (1982), Faroda and Singh(1983), and Shinde, *et al.*, (1984). The sequence sorghum-sunflower-groundnut also recorded comparable higher monetary returns of Rs.30.5 thousand per hectare. The lowest returns were observed with cotton-summer sunflower during all the three years of experimentation and also when pooled (Rs.19.1 thousand) which may be due to lower yields obtained under sunflower during summer, possibly because of influence of preceding cotton crop.

Considering the oil yield potential also, the sequence of groundnut- sunflower-sesamum proved to be best of all producing 16.18 q/ha oil per annum, followed by sesamum-sunflower-groundnut (14.83 q/ha). The lowest oil production (5.41 q/ha) was observed with cotton-summer sunflower sequence.

Data on fertility status of soil indicated that all the sequences have improved the available nitrogen status of soil except in cotton-summer sunflower sequence. The cotton-groundnut, and soybean-safflower-sesamum sequences proved more effective in improving N status of soil. This is due to inclusion of leguminous crop in the sequence, Sonar and Zende (1984), Patil (1985) and Jadhav (1989) also pointed out that, inclusion of leguminous crop in the sequence leads to an improvement in soil nutrients and consequently results in increasing the yields of succeeding crops in the sequences. All the sequences maintained the phosphorus and potash status of soil except cotton-sunflower sequence in which maximum depletion of phosphorus and potash was observed.

On the basis of results obtained in the study, it can be concluded that the sequences viz., groundnut-sunflower-sesamum and sesamum-sunflower- groundnut, are possible to adopt under adequate inputs and assured water availability conditions, to enhance the production of vegetable oil and improve the economic conditions of the oilseed growers and ultimately reducing the dependence on country's oil import, with improvement in soil fertility.

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RESPONSE OF MUSTARD TO SULPHUR AND NITROGEN UNDER IRRIGATED VERTISOL CONDITION I. EFFECT ON GROWTH AND CHLOROPHYLL CONTENT

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ABSTRACT

Field experiments were conducted during rabi seasons of 1988-89 and 1989-90 at Zonal Agricultural Research Station, Powarkheda, Hoshangabad (M.P.) on clayey-loam soils. Nitrogen application upto 90 kg/ha significantly increased the plant height, LAI, number of primary and secondary branches, dry matter production/plant, chlorophyll content "a" and "b" and grain yield. Increasing levels of sulphur upto 40 kg/ha significantly increased the LAI, number of primary and secondary branches/plant and chlorophyll content "b" only. Plant height, chlorophyll content "a" and seed yield significantly increased upto the level of 30 kg S/ha during both the years. Grain yield was positively and significantly correlated with LAI and dry matter production.

Key words : Mustard; Sulphur; Nitrogen; Leaf area index (LAI); Chlorophyll; Correlation.

The beneficial effect of nitrogen in increasing the growth characters of mustard has been reported by various workers (Singh and Singh, 1984 and Tandon, 1990). During the past few years sulphur has received increasing attention. Very little information is available about the effect of nitrogen and sulphur on growth, chlorophyll content and seed yield of mustard particularly in Tawa Command Area of Central Narmada Valley. Therefore, the present investigation was carried out to find out the response of mustard to application of nitrogen and sulphur.

MATERIALS AND METHODS

Field experiments were conducted at JNKVV, Zonal Agricultural Research Station, Powarkheda, Hoshangabad, (M.P.) during *rabi* seasons of 1988-89 and 1989-90 on clayey-loam soils. The soil contained 183.7 and 202.6 kg/ha available nitrogen, 13.6 and 13.4 kg/ha available phosphorus, 8.03 and 7.95 kg/ha available sulphur and 301.4 and 333.8 kg/ha available potash during 1988-89 and 1989-90, respectively. The treatments consisting of 4 nitrogen levels (0, 30,60 and 90 kg/ha) and 6 sulphur levels (0, 10, 20, 30, 40 and 50 kg S/ha) were laid out in Randomised Block Design with three replications. Mustard variety varuna was sown in rows of 30 cm apart using 5 kg seeds/ha on October 28, 1988 and November 3, 1989 and harvested 118 days after sowing. Basal application of 60 kg P_2O_5/ha through triple super-phosphate, 40 kg K_2O/ha through muriate of potash, full dose of sulphur (as per treatments) through gypsum and half dose of nitrogen (as per treatments) through urea were applied at the time of sowing. Remaining half N was top-dressed at the stage of 35 days after first irrigation. Two irrigations were applied at 35 and 60 DAS in all to the crop in both the seasons. Plant population was maintained uniformly by thinning done to keep 15 cm plant to plant distance. The chlorophyll

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(a) and (b) contents at 60 days stage of crop growth was determined by the method of Arnon (1949).

RESULTS AND DISCUSSION

Response to nitrogen

With the increase in nitrogen levels from 0 to 90 kg/ha there was significant increase in plant height, leaf area index (LAI), branches/plant and dry matter production/plant at different growth stages (Table 1). This increase at higher nitrogen levels might be due to poor available N status in soil leading to better crop response. Beneficial effect of nitrogen on growth had been reported by Antil *et al.*, (1986). The increase in dry matter/plant might be due to higher N availability causing accelerated photosynthetic rate and thus leading to more production of carbohydrates. Singh (1987) also recorded similar results.

Chlorophyll (a) content increased significantly with increasing levels of nitrogen upto 90 kg/ha during both the years and chlorophyll (b) content upto the level of 60 and 90 kg/ha during 1988-89 and 1989-90, respectively (Table 2). The seed yield increased significantly with increasing levels of nitrogen upto 90 kg/ha during both the years. The yield increase due to 90 kg N/ha over no nitrogen was of the order of 223 and 145 per cent during 1988-89 and 1989-90, respectively. Similar results were reported by Joshi *et al.*, (1991).

Response to sulphur

Sulphur application enhanced markedly the growth characters during both the years (Table 1 and 2). Application of sulphur upto 30 kg/ha increased significantly the plant height. Similarly, total number of branches/plant, LAI and dry matter/plant increased significantly only upto 40 kg/ha during various crop growth stages. Further increase in sulphur levels did not have any beneficial effect. This increase in growth attributes might be attributed to better nutritional environment for plant growth at active vegetative growth. Similar results were obtained by Saran and Giri (1990).

Chlorophyll (a) content increased significantly with the increasing levels of sulphur upto 30 during 1988-89 and 40 kg/ha during 1989-90. The chlorophyll (b) content increased significantly with increasing levels of sulphur upto 40 kg/ha during both the years (Table 2). Thus, an adequate supply of sulphur enhanced the number of leaves and size and higher chlorophyll content. Upasani and Sharma (1986) also obtained similar results. The seed yield increased significantly with increasing level of sulphur upto 30 kg/ha during both the years. The per cent increase in seed yield due to 30 kg S/ha over no sulphur was 30.4 and 44.1 during 1988-89 and 1989-90 respectively. Singh and Singh (1984) also reported similar results.

Correlation between growth character and seed yield

The seed yield was positively and significantly correlated with plant height, LAI and dry matter which reflected the better plant growth (see the Table in the next page). Saraf and Hegde (1984) also observed a positive correlation of grain yield with LAI and dry matter production in pigeonpea.

Table 1. Effect of nitrogen and sulphur application on growth of mustard

Treatments	Plant height (cm)		Total number of branches/plant						Dry matter production/plant (g)					
	At harvest		60 DAS		90 DAS		At harvest		45 DAS		75 DAS		105 DAS	
	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90
N-levels (kg/ha)														
0	119.07	123.04	7.03	9.61	11.02	15.29	12.81	17.08	5.47	6.69	14.02	18.28	21.16	23.65
30	123.59	136.98	8.29	10.16	13.74	17.23	14.90	18.72	7.09	9.53	17.21	23.27	25.70	32.35
60	143.98	151.81	9.98	10.97	15.99	19.28	17.48	22.04	8.61	10.95	19.94	26.98	32.26	37.96
90	161.23	167.50	11.66	11.68	18.44	22.56	20.43	25.94	15.28	17.48	25.93	29.56	38.69	40.55
SEm ±	0.96	1.31	0.11	0.12	0.12	0.13	0.10	0.17	0.13	0.12	0.32	0.25	0.52	0.30
CD at 5%	2.81	3.87	0.33	0.35	0.37	0.40	0.30	0.52	0.38	0.36	0.94	0.74	1.53	0.88
S-levels (kg/ha)														
0	131.54	137.61	8.05	9.70	13.91	17.07	15.18	18.11	6.68	8.46	16.79	21.66	24.64	28.41
10	134.59	140.32	8.54	10.24	14.58	17.87	15.97	18.95	7.38	9.18	18.44	23.15	26.72	32.88
20	139.52	144.75	8.96	10.50	15.01	18.71	16.31	19.85	7.77	9.46	19.86	24.18	28.86	34.66
30	144.09	147.57	9.35	11.02	15.55	19.40	16.89	20.60	7.91	10.06	20.28	25.59	30.28	36.76
40	146.27	149.39	9.76	11.43	15.92	20.49	17.14	21.23	8.15	10.04	22.00	26.25	32.23	37.79
50	146.78	149.36	9.75	11.44	15.84	20.47	17.11	21.41	8.25	10.42	22.07	26.02	31.82	37.67
SEm ±	1.16	1.61	0.13	0.14	0.15	0.16	0.12	0.21	0.16	0.15	0.39	0.31	0.64	0.37
CD at 5%	3.44	4.74	0.40	0.43	0.45	0.49	0.37	0.63	0.47	0.45	1.16	0.91	1.87	1.09

Table 2. Effect of nitrogen and sulphur application on LAI, Chlorophyll content and seed yield of mustard

Treat-ments	Leaf area index (LAI)						Chlorophyll content (mg/g)				Seed yield in (q/ha)	
	45 DAS		60 DAS		75 DAS		60 DAS (a)		60 DAS (b)			
	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90	1988-89	1989-90
N-levels (kg/ha)												
0	0.38	0.28	1.24	0.98	1.94	1.15	1.18	1.20	0.51	0.52	4.68	6.22
30	0.55	0.41	2.73	1.28	2.96	2.35	1.29	1.32	0.58	0.60	8.20	9.20
60	0.79	0.55	3.39	1.95	3.45	4.99	1.43	1.43	0.63	0.64	12.38	12.80
90	1.04	1.04	4.60	2.26	4.59	5.54	1.48	1.52	0.65	0.68	15.12	15.24
SEm ±	0.016	0.023	0.06	0.04	0.08	0.08	0.014	0.02	0.01	0.01	0.50	0.16
CD at 5%	0.05	0.07	0.18	0.12	0.23	0.24	0.04	0.07	0.03	0.03	1.43	0.46
S-levels (kg/ha)												
0	0.59	0.48	2.04	1.27	2.56	2.80	1.23	1.24	0.56	0,57	8.38	8.14
10	0.60	0.51	2.49	1.42	2.77	3.08	1.26	1.27	0.61	0.60	9.06	9.86
20	0.68	0.55	2.82	1.54	3.10	3.31	1.30	1.32	0.65	0.65	9.98	10.67
30	0.72	0.61	3.23	1.71	3.36	3.71	1.37	1.34	0.68	0.68	10.93	11.73
40	0.78	0.64	3.51	1.88	3.82	4.08	1.40	1.43	0.70	0.69	11.12	12.08
50	0.77	0.64	3.69	1.89	3.80	4.06	1.40	1.43	0.69	0.70	11.11	12.02
SEm ±	0.02	0.03	0.07	0.05	0.09	0.10	0.017	0.03	0.01	0.01	0.61	0.19
CD at 5%	0.06	0.08	0.22	0.15	0.28	0.30	0.05	0.08	0.03	0.03	1.72	0.56

Correlation coefficients between seed yield and growth characters

S.No.	Characters correlated with seed yield	Correlation coefficient	
		1988-89	1989-90
1.	Plant height	0.79**	0.86**
2.	LAI	0.74**	0.83**
3.	Dry matter production	0.91**	0.92**

** = Significant at P = 0.01

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EFFECT OF LAND TREATMENT SYSTEMS AND PHOSPHORUS FERTILIZATION ON GROUNDNUT (*Arachis hypogaea* L.) IN VERTISOLS

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ABSTRACT

A field experiment was conducted on deep vertisols at Bhopal, receiving high rainfall, during monsoon seasons of 1990 and 1991 to study the effectiveness of broadbed and furrow system in groundnut and response to phosphorus application, under rainfed condition. Broadbeds and furrows at 1.5 m interval improved drainage during peak rainfall period and soil remained at or below 1/3 bar moisture. The moisture storage at harvest of groundnut was increased by 3 to 4 % in 0 -90 cm soil profile. The system also improved rooting density, nodulation, pegging and dry matter of groundnut. The pod yield was increased by 15 % over the flat system. Oil and protein yields were also significantly increased and the soil bulk density was reduced. Increasing the phosphorus levels from 30 to 60 and 90 kg P_2O_5/ha significantly improved growth characters like rooting density, nodulation, dry matter and yield attributes but the yields of pods, oil and protein were increased up to 60 kg P_2O_5/ha only.

Key words : Broadbed and furrow system; Vertisol; Moisture storage; Oil yield; Protein yield.

INTRODUCTION

In high rainfall deep vertisol region of Madhya Pradesh, drainage of water from the cropped lands is a major problem in monsoon season. The farmers cultivate groundnut as a rainfed crop for their own consumption. But the yields are low due to oxygen stress in the root zone and poor fertility. For augmenting the groundnut yield per unit area, provision of optimum soil moisture conditions and adequate fertilization are essential. A technique of forming broadbeds and furrows at 1.5 m interval was recommended (Rajput *et al.*, 1985) for sorghum + pigeonpea and maize - chickpea systems at Bhopal since it gave 10 % higher total production over the usual flat system. Gupta *et al.*, (1984) found it better both for productivity and moisture retention at harvest at Jabalpur. It was thus used in groundnut crop to find out its suitability and effectiveness. Groundnut being a legume, needs higher doses of phosphorus for better nodulation and nitrogen fixation. The response to phosphorus up to 40 to 50 kg P_2O_5/ha has been reported (Reddy and Giri, 1989 and Tomar *et al.*, 1990). In the modified moisture regime conditions of broadbed and furrow system, the response to phosphorus may further increase from the present recommended level of 30 kg/ha to some higher level. The optimum level therefore needs to be determined and as such the experiment was conducted.

MATERIALS AND METHODS

The experiment was conducted for two years during 1990 and 1991 monsoon seasons on a deep vertisol at Bhopal. The area received an average annual rainfall of 1200 mm out of which 90 % was received in monsoon. The soil was silty clay as it contained 15 % sand 32 % silt and 54 % clay. The average moisture retention capacity of soil at 1/3 and 15 bar was 31 and 19 %, respectively. The hydraulic conductivity was high at 0 - 40 cm depth (22.7 mm/day) and very low at 180 cm (1.3 mm/day). The bulk density of the soil averaged 1.48 g/cm^3. The pH was 7.5 and electrical conductivity 0.2 mmhos/cm. The soil was medium in organic carbon (0.55 %) and low in available N (138 kg/ha) and medium in available P (11 kg/ha) and available K (260 kg/ha).

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The experiment was laid out in factorial Randomised Block Design with five replications. The treatments consisted of making broadbeds and furrows at an interval of 1.5 m and compared with flat system. Three levels of phosphorus at 30, 60 and 90 kg P_2O_5/ha were also tried. The broadbeds and furrows (BBF) were formed by using the bullock drawn tropiculture attached with furrow openers. The plot size was 3 x 10m. The furrows were connected to the lateral drain. Each plot under flat system was also connected to a lateral drain taken out between two replications at 10 m interval to remove excess of rain water.

The crop (Cv. JL-24) was sown using the groundnut planter in rows 30 cm apart and placing the seeds at 5 cm interval on 4 July, 1990 and 3 July, 1991. Nitrogen as urea was applied by hand in rows behind seed planter at 20 kg N/ha and phosphorus was applied as superphosphate by seed-cum- fertilizer planter as per the treatments at sowing. Weed control was done through pre-sowing incorporation of 1.5 l/ha of fluchloralin followed by one hand weeding at 35 to 40 DAS.

RESULTS AND DISCUSSION

Effect of land treatments

The soil moisture content measured at 10 days interval in 0-20 cm depth (Fig.1) showed that upper 20 cm layer under BBF did not reach 1/3 bar moisture even for a very brief period while it was at 1/3 bar for a period 3 to 22 August in flat system. This indicated a better drainage in BBF system as compared to flat system even in the peak rainfall periods. At harvest of groundnut, the moisture content of 90 cm soil profile (Fig. 2) was higher in BBF than that in flat system by 3 % in 0 - 30 cm and 4 % in 30 -90 cm depth. Thus more water was stored in the soil up to 90 cm depth under BBF which can be available to the second crop for its germination and early growth. Gupta and Sharma (1990) also observed similar advantage in BBF after the soybean crop.

The BBF system significantly improved the plant population of groundnut from 6.13 (Flat system) to 6.49 lakhs plants/ha (Table 1) due to higher moisture regime in the initial stages of crop growth. The soil moisture content was 20.4 and 25.3 % in BBF and 18.6 and 24.5 % in flat system on 15 and 25 July, respectively. Subsequently, with increase in the amount of rainfall and increase in soil profile moisture, drainage of water became the major concern. At this stage also BBF gave better drainage and thus there was significantly higher rooting density, nodulation, pegging and dry matter accumulation. Weed density was, however, lower in BBF due to lower moisture content but dry weight was not significantly influenced. The bulk density of the soil in 0-15 and 15-30 cm depth after the harvest of groundnut crop was significantly lower in BBF than in flat system (Table 1). This may be due to higher moisture content of soil at harvest in BBF system. It may also be due to higher root density which opened up the compact soil and increased its aeration. Similar observations on bulk density were also made by Gupta *et al.*, (1984).

The pod yield was increased by BBF system in both the years but significantly during 1991 only (Table 3). An increase of 10.9 % in 1990 and 19.5 % in 1991 (average increase of 15 %) was recorded over flat system. The increase was due to significant improvement in growth characters and yield attributes like number of pods and kernels/plant and 100 kernel weight (Table 2). These results also confirm the earlier findings of Gupta *et al.*, (1984) and Gupta and

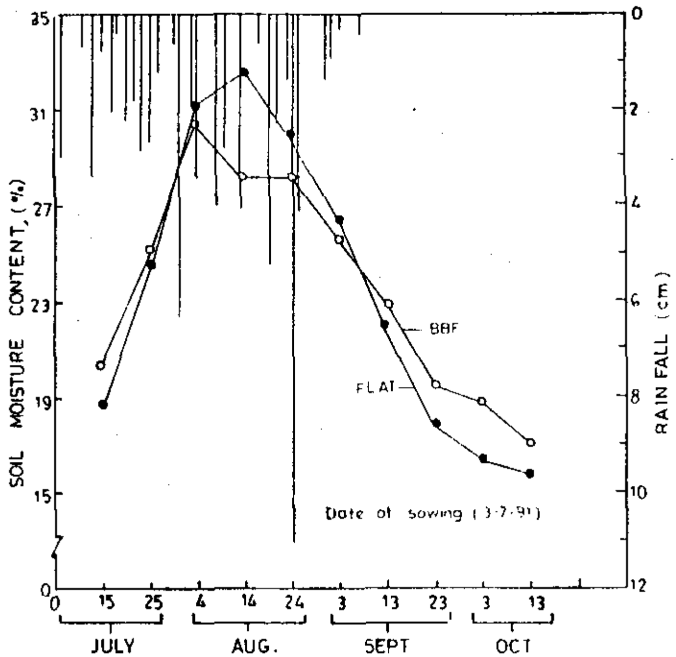

Fig. 1 **Effect of Broadbeds and Furrow (BBF) and Flat system on soil moisture content (0.20 m depth) during monsoon season**

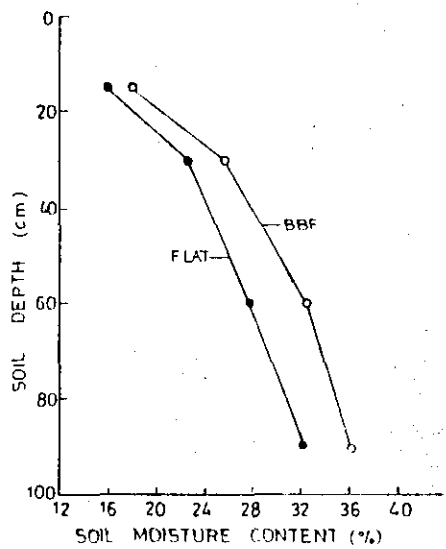

Fig. 2 Effect of Broadbeds and Furrow (BBF) and Flat system on soil moisture profile of deep vertisol at harvest

Table 1. Effect of land treatment and phosphorus on growth parameters of groundnut (Average data of two years)

Treatment	Plant population (lakh/ha)	Dry matter at harvest (g/plant)	Pegs/plant	Nodulation		Root density		Weed density/m^2	Weed dry weight g/m^2	Bulk density g/cm^2	
				Nodules/ plant	Nodule dry weight (mg/ plant)	(0-20 cm) Podding stage	(mg/cm) Harvesting stage			0/15 cm	15-30cm
Land treatment											
BBF	6.49	87.11	16.72	85.88	11.49	0.64	0.29	53.33	52.71	1.39	1.45
Flat	6.13	79.03	13.00	71.50	7.33	0.49	0.25	57.40	53.07	1.43	1.47
C D (5 %)	0.06	3.50	1.29	1.66	0.76	0.020	0.008	3.19	NS	0.008	0.007
P2O5 (kg/ha)											
30	6.18	75.70	13.25	74.02	7.74	0.53	0.25	51.50	51.44	1.43	1.48
60	6.34	83.05	14.16	79.14	9.33	0.56	0.28	55.10	52.83	1.41	1.46
90	6.41	90.47	17.18	82.92	10.17	0.59	0.30	59.50	54.45	1.40	1.45
CD (5 %)	0.07	4.29	1.58	2.04	0.93	0.024	0.010	3.91	NS	0.010	0.009
Interaction effects											
C D (5 %)	NS	NS	NS	NS	1.32	NS	NS	NS	NS	NS	NS

Table 2. Effect of land treatment systems and phosphorus on yield attributes and oil and protein content of groundnut

Treatment	Pods/Plant	Pod weight /plant	Kernal/plant	Kernal weight/plant(g)	100-Kernel weight (g)	Shelling per centage	Oil %	Protein %
Land treatment								
BBF	13.10	22.87	12.24	15.66	27.97	69.47	43.29	22.98
Flat	10.75	19.53	11.46	13.55	27.45	68.98	41.88	21.83
C D (5 %)	0.36	0.94	0.38	0.33	NS	0.31	0.84	0.65
P_2O_5 (kg/ha)								
30	10.82	18.80	10.88	13.48	26.40	68.09	41.31	22.21
60	12.17	21.40	11.78	14.88	27.89	69.53	42.66	22.48
90	12.78	23.40	13.09	15.46	28.84	70.10	43.79	22.53
C D (5 %)	0.44	1.15	0.46	0.41	0.79	0.41	1.03	NS
Interaction effects								
C D (5 %)	NS	1.63	NS	NS	NS	NS	NS	NS

Sharma (1990). The shelling percentage of groundnut was significantly improved by BBF system and so also the protein and oil content and their yields.

Effect of phosphorus levels

Phosphorus fertilization at increasing rates from 30 to 90 kg/ha significantly increased dry matter accumulation, pegging, nodulation, rooting density and weed density (Table 1). Similar increases in root biomass and dry matter with phosphorus application were also reported by Reddy and Giri (1989). The bulk density of soil was significantly reduced by increase of phosphorus application from 30 to 90 kg P_2O_5/ha probably due to better root development and greater activity of micro-organisms which decomposed the organic residues and improved soil aggregation as was earlier reported by Biswas *et al.*, (1970) and Sharma *et al.*, (1981).

Pod yield increased significantly with the increase in phosphorus levels from 30 to 60 kg P_2O_5/ha (Table 3). There was no further increase at 90 kg P_2O_5/ha in both the years. The increase was 20.7 % in 1990 and 13.5 % in 1991 (average 17.1 %) at 60 kg and only 4.7 % (average) at 90 kg/ha. Similar observations were also made by Patil *et al.*, (1983) and Jana *et al.*, (1990). However, phosphorus application up to 90 kg/ha resulted in significant increase in number of pods and kernels/pant and 100 kernel weight of groundnut (Table 2). But this could not reflect in the increase of pod yield beyond 60 kg P_2O_5/ha. The increases in yield attributed with phosphorus levels were attributed to the increased root density and nodulation of plants which might have enabled plants to extract more nutrients and water from the soil. Jana *et al.*, (1990) also reported increased absorption of nitrogen and phosphorus with increase in phosphorus application rate from 0 to 52 kg P_2O_5/ha. Tomar *et al.*, (1990) also reported similar results. Phosphorus application at both 60 and 90 kg/ha also raised the kernel oil content significantly over 30 kg/ha. But the oil yield (Table 3) was significantly increased with phosphorus level up to 60 kg/ha only and no increase was observed thereafter in both the years. Similar results were also obtained by Chavan and Kalra (1983) and Rao and Singh (1985). The application of increased levels of phosphorus from 30 to 90 kg/ha did not however, increase the protein content while the protein yield was significantly improved only up to 60 kg P_2O_5/ha.

Table 3. Effect of land treatment systems and phosphorus on pod and oil and protein yield of groundnut

Treatment	pod yield (q/ha)		Oil yield (q/ha)		protein yield (q/ha)	
	1990	1991	1990	1991	1990	1991
Land treatment						
BBF	10.80	11.15	3.25	3.35	1.72	1.78
Flat	9.74	9.33	2.81	2.69	1.47	1.40
CD (5 %)	NS	0.84	0.40	0.22	0.20	0.17
P_2O_5 (kg/ha)						
30	8.88	9.24	2.50	2.60	1.34	1.40
60	10.72	10.49	3.18	3.11	1.67	1.64
90	11.21	11.00	3.44	3.38	1.77	1.74
CD (5 %)	1.50	1.03	0.63	0.43	0.27	0.23
Interaction effects						
CD (5 %)	NS	NS	NS	NS	NS	NS

It was thus concluded that broadbed and furrow system was effective for groundnut for draining of excess of water in areas having deep vertisols with high rainfall. The moisture thus stored could be utilised efficiently by increasing present recommended phosphorus level of 30 kg to 60 kg P_2O_5/ha in soils where available P is medium.

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STUDIES ON EFFECTIVE *KHARIF* CROPS FOR SUCCEEDING CROP OF RAYA (*BRASSICA JUNCIA* CZERN (L.) COSS.) UNDER IRRIGATED CONDITIONS

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ABSTRACT

The field experiment was conducted for two consecutive years (1989-90 and 1990-91) on the inceptisol soil at College of Agriculture, Gwalior (M.P.) with an objective to increase the cropping intensity of northern Madhya Pradesh. The study revealed that the crop sequence of black gram - mustard gave the maximum additional net returns of Rs.2968/ha followed by sorghum (fodder) - mustard Rs.1566/ha and pearlmillet (fodder) - mustard Rs.1525/ha.

Key words: Black gram; Mustard; Crop sequence; Crop intensity

INTRODUCTION

In northern Madhya Pradesh cropping intensity is very low (114 %) despite the availability of irrigation facility. Mustard is a predominant crop of the region and generally sown in fallow fields as timely sowing is a must in order to get higher yields of mustard, delayed sowing causes drastic reduction in yield. Thus fallow - mustard sequence has become a common practice amongst the farmers under irrigated conditions. However, to find out an alternative profiteering crop sequence in place of fallow - mustard, the present study was therefore undertaken to increase the cropping intensity by selecting the suitable crop sequence for replacing the fallow - mustard sequence prevalent in this area.

MATERIALS AND METHODS

The study was conducted at College of Agriculture, Gwalior (M.P.) during 1989-90 and 1990-91 on inceptisol soil, containing organic carbon 0.41 per cent, available nitrogen 174 kg/ha, available phosphorus 13 kg/ha and available potash 301 kg/ha. The pH of the soil was 7.6 (on the basis of two years average value). The study consisted of eight cropping sequences viz. fallow - mustard (control), blackgram (grain) - mustard, greengram (grain) - mustard, Lobia (grain) - mustard, sorghum (fodder) - mustard, pearlmillet (fodder) - mustard, maize (fodder) - mustard and guar (fodder) - mustard. The treatments were replicated four times in a Randomised Block Design with a plot size of 4.5 x 6.0 m. The varieties used for mustard, blackgram, greengram, lobia, sorghum, pearlmillet, maize and guar were Kranti, K-851, T-9, Pusa barsati, Vidisha 60-1, BJ-104, Kaveri-ganga and RGC-964, respectively. Crops were raised with recommended package of practices. Pre-sowing irrigation was given after the harvest of *kharif* crops to ensure good germination of mustard. The total rainfall received during 1989-90 and 1990-91 (July to March) was 803.7 and 957.9 mm, respectively.

RESULTS AND DISCUSSION

The results showed that mustard could successfully succeed both grain crops as well as fodder crops (Table 1). It was possible to utilize the duration of the crops grown before sowing of mustard crop for possible higher yields. The data of two years pooled average indicated that the legume crops of grain as well as fodder increased the yield of mustard significantly as

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Table 1. Mean crop yield and net returns under different crop sequences (Based on two years pooled average)

S. No.	Treatments	Yield (q/ha)		Operational cost (Rs./ha)			Gross returns (Rs./ha)			Net returns (Rs./ha)			Additional net returns over control (Rs./ha)
		1st crop	2nd crop	1st crop	2nd crop	Total	1st crop	2nd crop	Total	1st crop	2nd crop	Total of the system	
1.	Fallow-mustard (control)	-	20.42	-	4025	4025	-	16336	16336	-	12311	12311	-
2.	Blackgram(grain)-mustard	5.89	20.16	2954	3785	6739	5890	16128	22018	2936	12343	15279	+ 2968
3.	Greengram(grain)-mustard	4.65	19.48	2943	3781	6724	4650	15584	20234	1707	11803	13510	+ 1199
4.	Lobia(grain)-mustard	3.57	19.80	2537	3783	6320	3570	15840	19410	1033	12057	13090	+ 779
5.	Sorghum(fodder)-mustard	242.00	16.04	1232	3773	5005	6050	12832	18882	4818	9059	13877	+ 1566
6.	Pearlmillet(fodder) - mustard	205.05	17.15	1232	3778	5010	5126	13720	18846	3894	9942	13836	+ 1525
7.	Maize(fodder)-mustard	185.10	17.05	1253	3781	5034	4627	13640	18267	3374	9859	13233	+ 922
8.	Guar(fodder)-mustard	105.10	19.57	1330	3781	5114	2627	15656	18283	1297	11875	13172	+ 861
	C D at 5%	-	2.23	-	-	-	-	-	-	-	-	-	324

-Note: Sale price of produce (Rs./ha)
Greengram (grain) Rs. 1000/-, Blackgram (grain) Rs. 1000/-, Lobia (grain) Rs. 1000/-, Sorghum (green fodder) Rs. 25/-, Pearlmillet (green fodder) Rs. 25/-, Maize (green fodder) Rs. 25/-, Guar (green fodder) Rs. 25/- and Mustard Rs. 800/-

expected (on the basis of two years pooled average). However, in view of long term maintenance of soil fertility and for seed production, mustard followed by legume crops (Table 1) has been observed beneficial. The mustard yield in fallow-mustard (control) sequence gave the highest mean yield of 20.42 q/ha followed by blackgram (grain) - mustard (20.16 q/ha) sequence, whereas, the yield of mustard in cereal fodder - mustard sequence showed drastic reduction in seed yield of mustard. The results are in conformity with the findings of Tomar and Tiwari (1990). However, the increase in seed yield of mustard was recorded in legume fodder guar-mustard (19.57 q/ha) sequence.

Economics : Blackgram (grain) - mustard sequence gave significantly maximum additional total net returns of Rs.2968/ha over all the sequences tried in the experiment followed by sorghum (fodder) - mustard (Rs.1566/ha) sequence and pearlmillet (fodder) - mustard (Rs.1525/ha). These two sequences were on par with each other, but were significant with the remaining crop sequences tried in the experiment. However, the lowest net return was recorded in fallow - mustard (control) treatment. Anonymous (1984, 1987), Kumar (1986), Tomar and Tiwari (1990) and Gupta and Rai (1990) also reported that blackgram (grain) - mustard crop sequence was the most remunerative one.

Thus the adoption of blackgram - mustard cropping sequence may help in increasing the cropping intensity under northern region of Madhya Pradesh where irrigation facilities exist.

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CHARACTER ASSOCIATION AND COMPONENT ANALYSIS IN SOYBEAN (*GLYCINE MAX* L. MERRILL)*

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ABSTRACT

An attempt was made to analyse the association between seed yield and related components in soybean by the method of correlation and path coefficients using 64 diverse genotypes. A slight increase of genotypic correlation coefficients over phenotypic correlation coefficient was noticed for all the character combinations. Seed yield per plant showed significantly positive association with plant height, primary branches per plant, pods per plant and harvest index. Oil content had negatively significant association with seed yield. Since plant height, primary branches and pods per plant are intercorrelated among themselves, selection for these traits will result in increased seed yield. Path coefficient analysis revealed that, among all the traits studied, pods per plant contributed the most directly to seed yield. All other yield contributing traits had sizeable influence on seed yield indirectly only through pods per plant.

Key words: Soybean, Path analysis; Character association

INTRODUCTION

Yield is a complex quantitative trait constituted by many component traits. Since all the yield components are complexly inherited, a simultaneous selection for all the component traits combining superiority for each one of them will be very difficult. However, if correlation coefficients between different traits and yield are high, it will reduce the burden of the breeder to a considerable extent. Thus, association of component traits with yield assumes special importance in selection of desired genotypes. Further, the knowledge of the direct and indirect influence of contributing characters on the ultimate end product "yield" is of prime importance in any selection programme. Hence an attempt was made to examine the inter-relationship of various economic traits in soybean through association and path analysis.

MATERIALS AND METHODS

Sixty four geographically diverse genotypes collected from different states of India and different countries were raised in a Randomised Block Design with three replications during *kharif,* 1989. Each genotype was raised in a single row of 6 m length by adopting a spacing of 45 x 10 cm. In each row, 20 randomly selected plants were observed for days to 50% flowering, plant height, primary branches per plant, pods per plant, pod length, seeds per pod, seed yield per plant, 100 seed weight, harvest index, protein content and oil content. The mean value of 20 plants represented each genotype. Phenotypic and genotypic correlation co-efficients for all character combinations were computed following Al-Jibouri *et al.*, (1958). The procedure suggested by Dewey and Lu (1959) was used to arrive at path coefficients. The direct and indirect effects were rated as very high (1 and above), high (0.30 to 0.99), moderate (0.20 to 0.29), low (0.10 to 0.19) and negligible (below 0.10) as suggested by Lenka and Mishra (1973).

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RESULTS AND DISCUSSION

The list of soybean genotypes studied along with the mean values for different characters is presented in Table 1.

Phenotypic and genotypic correlations

Correlation coefficients obtained both at phenotypic and genotypic levels for different character combinations are presented in Table 2. A slight increase of genotypic correlation coefficients over phenotypic correlation coefficients was noticed for all the character combinations indicating that, though there is a strong inherent association between many traits studied, the phenotypic expression of the association is reduced under the influence of environment (Kaw and Madhavamenon, 1972). Johnson *et al.*, (1955), Kwon and Torrie (1964) and Nirmalakumari (1986) reported such higher genotypic correlation coefficients over phenotypic correlation coefficients in soybean.

Seed yield per plant was significantly and positively correlated with plant height, primary branches per plant, pods per plant and harvest index, Kaw and Madhavamenon (1972), Amarnath (1986) and Sahu and Mishra (1988) observed similar positive significant correlations for these traits, except harvest index, with seed yield. Reports made by Tong (1986) was in accordance with the present study of positive association of harvest index with seed yield per plant. High positive correlation of pods per plant with seed yield may be attributed to the increased sink strength (Nakaseko, 1984). Increase in pods per plant was due to the increase in plant height which in turn produce more primary branches. Thus, increase of plant height and primary branches per plant resulted in more pods per plant ultimately leading to more of harvest index and finally resulting in increased seed yield. Days to 50% flowering, though had significant positive association at genotypic level, exhibited non-significant association with seed yield at phenotypic level due to the hindering effect of environment (Sharma *et al.*, 1983).

No significant relationship was found to exist between seed yield and the traits viz., pod length, seed per pod, 100 seed weight and protein content owing to their non-significant positive or negative correlation coefficients. But, oil content had significantly negative association with seed yield (Hrustic *et al.*, 1985 and Momirovic, 1987).

The important yield contributing traits viz., plant height, primary branches, pods per plant and days to 50% flowering had positively significant association among themselves. Rajasekaran *et al.*, (1980) and Sahu and Mishra (1988) reported positive significant association of pods per plant with plant height, primary branches and days to 50% flowering. The harvest index was positively associated with pods per plant. The oil content had negatively significant association with plant height, primary branches and pods per plant.

From the foregoing points, it may be concluded that an intensive selection for pods per plant, plant height and primary branches per plant will automatically improve seed yield in soybean. Again, since all these three traits are intercorrelated among themselves, selection in any one of the traits will result in improvement of other traits, thereby finally increasing the seed yield. Eventhough, the harvest index is positively associated with seed yield, it is not included as one of the important traits for selection, because, the estimation of harvest index

Table 1. List of soybean genotypes with mean values

Sl. No.	Genotype	Days to 50 per cent flowering	Plant height (cm)	Primary branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	Seed yield per plant	100 seed weight (g)	Harvest index	Protein content (%)	Oil content (%)
1.	EC 94038	35.0	58.9*	5.7	125.8	4.2*	2.4*	36.1*	10.9	0.40	45.8*	13.9
2.	AMSS 52	31.7*	80.4*	8.0*	97.0	4.0	2.2	28.9*	13.0	0.31	34.6	15.1
3.	SDP (L)	34.0	46.0*	4.7*	161.4*	3.8	2.2	31.7*	11.5	0.42*	45.0*	17.0*
4.	EC 50084	34.3	50.5*	3.8	175.5*	3.3	2.2	35.9*	13.4*	0.45*	35.6	14.1
5.	EC 3294	35.6	62.5*	4.1	136.6*	3.8	2.1	38.0*	11.6	0.46*	33.0	15.3*
6.	EC 50082	33.6	54.3*	4.6*	150.0*	3.7	2.3	34.9*	11.8	0.43*	35.7	14.0
7.	EC 14434	33.3	56.0*	4.0	126.8*	3.8	2.5*	31.7*	13.6*	0.48*	41.1*	12.1
8.	ACC No.2004	34.0	53.2*	4.0	119.4*	3.8	2.4	36.1*	13.1	0.46*	36.8	14.8*
9.	IC 16900	31.0*	80.4*	4.7*	106.3*	4.1*	2.2*	21.6	12.7	0.34	44.0*	16.9*
10.	EC 95287	33.6	55.8*	4.3	107.1	4.1*	2.5*	31.9*	13.0	0.47*	36.1	15.1*
11.	EC 62384	33.3	81.1*	4.1	108.1*	3.3	2.7*	25.7*	11.0	0.49*	38.9*	12.9
12.	EC 14426	37.6	59.7*	5.6*	136.9*	3.5	2.4*	26.0*	9.5	0.41	40.6*	12.3
13.	PBN 104	35.3	52.9*	3.6	122.8*	3.6	2.2	32.8*	14.0*	0.42*	39.6	13.0
14.	KB 80	33.3	45.7	6.1*	84.5	3.9*	2.5*	34.6*	15.1*	0.43*	31.2	11.5
15.	AMSS 49	36.6	63.4*	3.4	128.6*	3.4	2.1	30.0	12.5	0.43*	38.0	13.1
16.	37656	32.3	56.2*	6.7*	92.0	3.7	2.5*	32.1*	13.5*	0.20	41.2*	12.2
17.	MACS 125	33.3	43.2	3.8	118.7*	3.8	2.3	32.0*	14.0*	0.48*	35.7	13.1

Contd...

Table 1 contd...

Sl. No.	Genotype	Days to 50 per cent flowering	Plant height (cm)	Primary branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	Seed yield per plant	100 seed weight (g)	Harvest index	Protein content (%)	Oil content (%)
18.	EC 18755	34.6	46.3	5.8*	111.9*	3.6	2.1	25.8*	12.0	0.40	40.3*	14.2
19.	EC 26691	34.6	50.8*	4.7*	129.2*	3.7	2.3	24.5	14.2*	0.36	38.4	11.8
20.	EC 100776	32.0*	49.6*	3.3	108.8*	3.9*	2.3	29.0*	13.7*	0.46*	46.5*	11.3
21.	IC 109545-B	33.6	48.1	4.3	110.8*	3.7	2.3	31.8*	14.5*	0.43*	30.7	12.7
22.	EC 109545-(W)	32.6	48.9	3.6	117.9*	3.6	2.1	24.0	11.7	0.49*	44.6*	15.2*
23.	EC 2541	33.3	60.8*	3.7	118.3*	3.8	2.1	32.6*	13.5*	0.33	29.3	12.4
24.	IC 15086	35.6	50.9*	4.7*	96.5	3.7	2.2	31.9*	14.6*	0.32	35.2	12.4
25.	EC 25166	33.6	46.9	4.6	99.2*	3.6	2.1	31.2*	13.8*	0.38	37.8	13.0
26.	101879	32.3	50.0*	4.3	113.4*	3.6	2.2	26.6*	12.4	0.39	37.0	14.0
27.	15590	33.3	56.8*	4.3	107.5*	3.4	2.2	30.5*	10.4	0.40	34.1	13.0
28.	ANAIKATTI	34.0	51.5*	5.6*	93.1	3.8	2.1	21.5	13.6*	0.44*	31.4	13.0
29.	UGM 34	33.0	61.4*	4.2	115.1*	3.7	2.1	30.4*	10.8	0.35	30.1	12.1
30.	KB 93	35.3	49.8*	3.4	67.6	4.3*	2.7*	21.6	15.5*	0.36	44.0*	14.8*
31.	KB 8	32.6	50.6*	4.1	86.5	3.9*	2.3	28.4*	13.6*	0.46*	33.3	11.3
32.	EC 18226	33.0	52.5*	4.7*	112.7*	3.8	2.2	19.2	12.9	0.44*	34.7	11.1
33.	IC 13006	32.6	41.9	5.0*	76.9	3.8	2.4*	24.7*	13.1	0.40	39.8*	13.1
34.	UGM 30	33.6	54.1*	4.2	124.5*	3.8	2.1	23.5	11.6	0.32	31.3	14.1
35.	ADT 1	35.6	49.4	4.1	120.2*	3.7	2.1	20.9	10.4	0.34	41.3*	14.9

Contd..

Table 1 contd...

Sl. No.	Genotype	Days to 50 per cent flowering	Plant height (cm)	Primary branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	Seed yield per plant	100 seed weight (g)	Harvest index	Protein content (%)	Oil content (%)
36.	EC 18596	33.3	51.7*	4.8*	66.7	3.9	2.2	18.8	14.5*	0.44*	30.9	16.1*
37.	KB 78	33.0	47.9	5.0*	62.8	3.7	2.5*	25.1*	15.5*	0.25	36.9	15.0*
38.	95273	33.0	47.1	4.9*	79.7	3.7	2.4*	18.7	12.8	0.37	32.7	17.1*
39.	PK 634	35.3	49.3	5.4*	82.4	3.6	2.3	16.8	12.6	0.45	34.4	11.3
40.	EC 24058	33.0	73.9*	3.6	96.8	3.3	2.5*	16.1	9.3	0.38	36.9	12.9
41.	PLSO-1	33.3	49.0	5.1*	61.3	3.8	2.1	18.8	13.1	0.46*	37.5	13.1
42.	AVRDC 401	31.3*	34.7	4.1	102.3*	3.8	2.2	26.2*	12.5	0.44*	33.6	12.1
43.	PLSO-3	32.0*	46.3	3.7	103.1*	3.3	2.3	19.5	9.3	0.36	38.3	17.8*
44.	IC 2716	33.6	51.5*	4.9	81.3	3.2	2.2	16.5	11.3	0.30	36.0	16.8*
45.	KC 99990	33.3	47.2	3.0	89.2	3.5	2.2	23.6	13.5*	0.36	38.5	12.4
46.	KB 79	28.3*	20.1	3.2	66.7	3.8	2.4	22.9	16.1*	0.39	45.9*	16.8*
47.	EC 95681	33.6	57.4*	3.0	53.8	3.8	2.6*	18.6	13.0	0.41	38.9*	12.2
48.	EC 18733	33.3	43.6	4.0	76.7	4.0*	2.1	19.0	13.3*	0.39	36.5	13.0
49.	EC 141390	30.6*	32.4	3.0	64.2	4.2*	2.6*	20.4	16.9*	0.43	35.6	13.2
50.	EC 109548	31.3*	57.0	4.2	102.4*	3.7	2.0	12.7	8.0	0.35	35.6	13.2

Contd...

Table 1 contd...

Sl. No.	Genotype	Days to 50 per cent flowering	Plant height (cm)	Primary branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	Seed yield per plant	100 seed weight (g)	Harvest index	Protein content (%)	Oil content (%)
51.	BC 95258	31.6*	33.4*	3.1	59.4	3.4	2.3	15.7	11.9	0.37	39.6*	17.1*
52.	BC 18676	33.0	37.5	5.7*	71.5	3.2	2.0	15.8	14.1*	0.28	35.8	13.9
53.	JS 82-303	30.6*	18.8	4.9*	60.5	4.1*	2.4*	12.6	15.2*	0.39	38.7	16.0*
54.	KB 85	33.0	25.7	3.0	46.6	4.2*	2.1	16.2	21.3*	0.30	39.1*	15.3*
55.	BC 18107 (M)	34.3	54.3*	3.9	74.7	3.4	2.5*	13.6	10.0	0.38	33.2	13.2
56.	MACS 201	31.3*	37.6	4.7*	67.1	3.3	2.1	12.3	11.2	0.51*	35.6	14.1
57.	CO 1	39.6	43.5	3.5	76.9	3.5	2.2	15.6	11.5	0.34	31.5	15.0*
58.	JS 81-714	32.6	21.7	3.3	44.5	4.0*	2.4	11.6	15.7*	0.41	37.0	18.9*
59.	ACC No.1322	32.6	46.1	4.4	80.9	3.2	2.1	10.0	8.8	0.25	42.1*	17.9
60.	MACS 180	31.6	19.0	3.9	59.1	4.0*	2.2	14.6	14.4*	0.33	44.8*	14.9*
61.	KB 83	31.3*	21.7	1.9	46.7	4.7*	2.2	14.3	20.2*	0.35	38.3	14.8*
62.	DS 295	28.0*	22.4	2.7	61.2	4.1*	2.1	17.1	14.5*	0.32	46.3*	15.9*
63.	PK 472	31.6*	23.7	1.1	26.4	4.2*	2.1	7.1	17.0*	0.39	33.8	19.0*
64.	IC 13007	33.6	17.9	3.0	72.9	3.6	2.2	11.5	8.3	0.30	37.1	14.2
	Grand mean	33.3	48.0	4.2	94.4	3.7	2.3	23.1	13.0	0.39	37.4	14.1
	SE	0.42	0.56	0.14	1.29	0.06	0.04	0.55	0.05	0.01	0.49	0.17
	CD 5%	1.18	1.56	0.38	3.60	0.16	0.11	1.55	0.13	0.03	1.38	0.48
	CV (%)	2.19	2.01	5.52	2.36	2.61	2.92	4.09	0.63	4.08	2.28	2.11

Table 2. Phenotypic and genotypic correlation coefficients

Sl. No	Character		Plant height	Primary branches per plant	Pods per plant	Pod length	Seeds per plant	100 seed weight	Harvest index	Protein content	Oil content	Seed yield per plant
1.	Days to 50 per cent flowering	P	0.36**	0.17	0.36**	-0.30*	-0.07	-0.28*	0.04	-0.21	-0.19	0.23
		G	0.39**	0.20	0.39**	-0.35**	-0.07	-0.30*	0.05	-0.24*	-0.20	0.25*
2.	Plant height	P		0.42**	0.55**	-0.29*	0.19	-0.47**	0.12	-0.15	-0.31*	0.46**
		G		0.43**	0.55**	-0.31*	0.20	-0.48**	0.13	0.15	-0.31*	0.47**
3.	Primary branches per plant	P			0.27*	-0.17	0.03	-0.25*	-0.09	-0.12	-0.23	0.31*
		G			0.28*	-0.19	0.01	-0.26*	-0.11	-0.12	-0.24*	0.32**
4.	Pods per plant	P				-0.29*	-0.09	-0.44**	0.30*	0.01	-0.31**	0.73**
		G				-0.31*	-0.10	-0.45**	0.31*	0.01	-0.32**	0.74**
5.	Pod length	P					-0.13	0.62**	0.02	0.13	0.07	0.01
		G					0.10	0.66**	0.01	0.15	0.08	0.01
6.	Seeds per plant	P						-0.04	0.13	0.10	-0.16	0.04
		G						-0.04	0.14	0.12	-0.18	0.04
7.	100 seed weight	P							-0.03	0.03	0.08	-0.03
		G							-0.03	0.04	0.08	-0.03
8.	Harvest index	P								-0.06	-0.20	0.30*
		G								-0.08	-0.21	0.31*
9.	protein content	P									0.22	-0.05
		G									0.23	-0.05
10.	Oil content	P										-0.41**
		G										-0.42**

* Significant at 5% level; ** Significant at 1% level
P = Phenotypic; G = Genotypic

is a laborious process. Moreover, since pods per plant is inter-correlated with harvest index, selection for pods per plant will automatically improve harvest index also. Since environment plays a significant role on the expression of association of days to 50% flowering with seed yield, selection for days to 50% flowering will have little effect on seed yield.

With regard to two important quality characters, protein and oil contents, the breeder is facing real challenge. Since protein content is not significantly related to any of the yield components mentioned above, the selection of these traits will not influence the protein content. But, oil content is negatively correlated not only with seed yield, but also with the three important yield components viz., plant height, primary branches and pods per plant. Hence, there is every chance of reduction in oil content if selection pressure is exerted on these traits in the positive side. Therefore, a compromise has to be arrived at to have an optimum oil content without sacrificing the seed yield.

In soybean, usually protein and oil contents are known to be negatively correlated (Momirovic, 1987). However, in the present study, the inter- correlation between these two traits was positive, though non-significant. Hence, a thorough study of linkage between these two traits is required in soybean.

Path analysis

Path analysis helps in examining the relative contribution (both direct and indirect) of different component traits towards the dependent variable, the yield. The genotypic correlation coefficients were partitioned into direct and indirect effects and are presented in Table 3.

Pods per plant had the highest positive direct effect on seed yield which was in similarity with the findings of Kaw and Madhavamenon (1972), Dixit and Patil (1984) and Hrustic *et al.*, (1985). The direct effect of plant height and primary branches per plant was low on seed yield per plant, but their significant positive correlation with seed yield was due to their respectively high and moderate indirect effects through pods per plant. Similar findings were reported by Bargale *et al.*, (1988) for primary branches per plant. Harvest index, one of the important yield components increased the seed yield mainly by its moderate positive indirect effect through pods per plant. Mishra *et al.*, (1988) also reported that harvest index had moderate positive indirect effect through pods per plant. The significant positive association between days to 50% flowering and seed yield at genotypic level was mainly due to its high positive indirect effect through pods per plant (Bargale *et al.*, 1988).

The direct effect of 100 seed weight on seed yield, though high, got neutralised by its high indirect negative effect through pods per plant resulting in non-significant association with seed yield. Oil content, the only trait which showed highly negative association with seed yield had low negative direct effect. But, its negative influence on seed yield was mainly due to high negative indirect effect through pods per plant as reported by Nirmalakumari (1986).

Even the traits which had no significant association with seed yield viz., pod length and 100 seed weight had moderate indirect influence on seed yield only through pods per plant.

The above findings revealed that whatever may be the character chosen for increasing the seed yield, the improvement could be achieved only through pods per plant. All the

Table 3. Direct and indirect effects as partitioned by path analysis

Sl. No.	Characters	Days to 50 per cent flowering	Plant height	Primary branches per plant	Pods per plant	Pod length	Seeds per pod	100 seed weight	Harvest index	Protein content	Oil content	Seed yield per plant
1.	Days to 50 per-cent flowering	-0.03	0.05	0.03	0.31	-0.02	-0.01	-0.12	0.01	0.01	0.02	0.25*
2.	Plant height	-0.01	0.12	0.06	0.44	-0.01	0.02	-0.19	0.01	0.01	0.03	0.47**
3.	Primary branches per plant	-0.01	0.05	0.13	0.23	-0.01	0.01	-0.10	-0.01	0.01	0.03	0.32**
4.	Pods per plant	-0.01	0.07	0.04	0.80	-0.01	-0.01	-0.18	0.01	-0.01	0.03	0.74**
5.	Pod length	0.01	-0.04	-0.03	-0.25	0.05	0.01	0.26	0.01	-0.01	-0.01	0.01
6.	Seeds per plant	0.01	0.02	0.01	-0.08	0.01	0.09	-0.02	0.01	-0.01	0.02	0.04
7.	100 seed weight	0.01	-0.06	-0.03	-0.36	0.03	-0.01	0.40	-0.01	-0.01	-0.01	-0.03
8.	Harvest index	-0.01	0.02	-0.01	0.25	0.01	0.01	-0.01	-0.03	0.01	0.03	0.31*
9.	Protein content	0.01	-0.02	-0.02	0.01	0.01	0.01	0.01	-0.01	-0.03	-0.02	-0.05
10.	Oil content	0.01	-0.04	-0.03	-0.25	0.01	-0.02	0.03	-0.01	-0.01	-0.11	-0.42**

* Significant at 5% level

** Significant at 1% level

Diagonal values indicate direct effects.

characters exhibited their indirect effect mostly through pods per plant. Hence, it may be concluded that pods per plant is the main trait which is responsible for manipulation of seed yield in soybean. Selection for any other yield contributing character will reflect on yield only through pods per plant.

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INTERCROPPING OF MUSTARD WITH GRAM AND LENTIL

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ABSTRACT

An experiment was conducted at JNKVV, Research station, Tikamgarh (M.P.) during rabi season of 1987-88 and 1988-89 on clay loam soil under irrigated condition, to find out the optimum row ratio of mustard with gram and lentil. Results revealed that pure gram is highly remunerative (Rs.13892/ha) than pure crop of mustard (Rs.6730/ha), lentil (Rs.4338/ha) and intercropping of mustard with gram and lentil. Pure mustard is more profitable than pure lentil crop. Intercropping 2:2 row ratio of lentil and mustard is more economical (Rs.6879/ha) than pure lentil, pure mustard and other row ratio.

Key Words : Mustard; Gram; Lentil; Intercropping

INTRODUCTION

Gram (*Cicer arietinum* L.) and lentil (*Lens culinaris* L.) are grown in mixed stand with mustard (*Brassica juncea* L.) in Bundelkhand region. But, recently intercropping recognised as a beneficial system of crop production. Gangasaran and Giri (1985) and Kushwaha (1985) reported that an intercrop of gram and lentil with mustard is more remunerative than a pure crop of either gram or lentil. An intercrop of gram and mustard gave more total net return than when these were grown separately (Singh 1981 and Verma 1989).

Since information on mustard + Gram + lentil intercropping system for Bundelkhand region of Madhya Pradesh is meagre, an experiment was conducted to find out the optimum row ratio and its economic implication on mustard + gram and lentil intercropping system.

MATERIALS AND METHODS

An experiment was conducted during *rabi* season of 1987-88 and 1988-89 at JNKVV Research station, Tikamgarh (M.P.). Thirteen treatments consisting of different row ratios of gram + mustard, lentil + mustard (Table 1.) tested in Randomized Block Design with three replications. Gram variety "JG-315", lentil variety "Sehore-76" and mustard variety "Varuna" were sown in rows of 25cm apart for gram and lentil and 50cm for mustard in pure and 25cm apart in all intercropping system using recommended seed rates of 80 kg, 20 kg, and 5kg seeds per hectare respectively. The soil of the field was clay loam, medium in available N and P_2O_5 and high in K_2O contents having pH 7.5. The sowing of both the crop was done on November 6th and 2nd in respective years.

Mustard was given 80 + 40 + 20 and gram and lentil 20 + 60 + 20 kg/ha N + P_2O_5 + K_2O respectively. Total grain productivity kg/ha (Gram and lentil equivalent) was worked out on the basis of prevailing market price during corresponding years. Land equivalent ratio (LER) was calculated using the formula suggested by Jha and Chandra (1982).

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RESULTS AND DISCUSSION

Seed yield

A perusal of the data set out in Table 1 indicated that the grain yield of gram and lentil were adversely affected by imposition of intercrop in all the row ratios due to internal competition for nutrients, moisture and light. The lowest gram and lentil yield was recorded when two rows of gram or lentil alternated with two rows of mustard. This seems to be mainly due to shading effect of mustard on gram and lentil. These results are in conformity with findings of Garse and Nikam (1985) and Verma *et al.*, (1989).

The maximum mustard yield was found in pure crop stand and it decreased significantly when sown mixed with gram and lentil crops due to decreased plant population. Row ratio, 2:2 of gram or lentil with mustard produced higher seed yield. The mean index also greater in 2:2 ratio because of varying crop canopy of two crops in the field. Mustard always had higher crop canopy as compared to gram and lentil thus, the solar energy utilization efficiency was more in mustard than that of gram and lentil. Similar results have been reported by Verma *et al.*, (1989), Gangasaran and Giri (1985).

Economics

A perusal of data (Table 2) revealed that there were wide variations among different cropping systems with regard to net return Rs/ha. The highest net return (Rs.13892/ha) was obtained when gram was sown alone. In case of intercropping system, the maximum net profit of Rs.13136/ha was recorded under 3:1 row ratio followed by Rs.11933/ha under 6:2 row ratio.

But in case of pure and intercropping of mustard with lentil, the highest net return (Rs.6879/ha) was found in 2:2 row ratio followed by 3:1 row ratio (Rs.5707/ha). Row ratio 2:2 also gave more net profit than pure mustard and lentil crop. The pure crop of lentil recorded the lowest net profit than all the intercropping systems.

The total productivity in terms of crop equivalent was calculated for all the intercropping system. The gram equivalent due to pure stand was higher than all row ratios. But in case of lentil, the total productivity was higher in all mixed stand than pure crop of lentil (Rehman *et al.*, 1982).

Land equivalent ratio

LER worked out from combined intercrop yields was always greater as compared to sole crop. The highest LER value 1.10 was recorded with 3:1 row ratio in gram and mustard and 1.11 with 2:2 row ratio in lentil and mustard, indicating better land utilization and biological efficiency in intercropping than in sole cropping system.

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Table 1. Seed yield of gram, lentil and mustard (q/ha) and mean yield index

Sl. No.	Treatment	1987-88		1988-89		Mean		Yield index	
		Base crop	Intercrop	Base crop	Intercrop	Base crop	Intercrop	Base crop	Intercrop
1.	Gram alone	31.83	-	30.51	-	31.17	-	100	-
2.	Lentil alone	17.10	-	19.62	-	18.51	-	100	-
3.	Mustard alone	-	12.77	-	13.62	-	13.19	-	100
	Gram + Mustard								
4.	2:2	19.38	5.99	15.99	7.07	17.68	6.53	56	49
5.	3:1	25.38	3.98	21.45	5.57	23.41	4.77	76	36
6.	5:1	20.88	3.88	21.49	4.88	20.16	4.11	64	31
7.	7:1	21.77	2.99	24.55	3.21	23.16	3.10	74	23
8.	6:2	22.05	3.99	20.30	4.98	21.12	4.09	67	31
	Lentil + Mustard								
9.	2:2	9.33	6.09	8.27	11.03	8.80	8.56	47	64
10.	3:1	11.72	4.55	12.28	6.30	12.00	5.42	64	41
11.	5:1	12.55	3.99	11.99	5.99	12.27	4.99	66	37
12.	7:1	12.99	2.98	14.99	4.99	12.66	3.82	68	28
13.	6:2	10.27	4.12	12.17	6.86	11.22	5.49	60	41
	SE (m) ±	1.95	2.01	1.43	0.76				
	CD (5%)	5.89	5.98	4.57	2.27				

Table 2. Net return (Rs/ha), LER and total productivity (kg/ha) of different treatments

Sl. No.	Treatment	Net returns (Rs/ha)			LER			Total grain productivity (base crop equivalent) (kg/ha).
		1987	1988	Mean	1987	1988	Mean	
1.	Gram alone	12729	15055	13892	1	1	1	-
2.	Lentil alone	3379	5298	4338	1	1	1	-
3.	Mustard alone	6125	7336	6730	1	1	1	-
	Gram + Mustard							
4.	2:2	10883	11831	11357	1.06	1.01	1.03	26.23
5.	3:1	12371	13901	13136	1.10	1.10	1.10	29.65
6.	5:1	10028	13361	11694	0.95	1.02	0.99	25.54
7.	7:1	9833	13927	11880	0.91	1.05	1.00	27.97
8.	6:2	10713	13153	11933	1.002	1.04	1.02	26.47
	Lentil + Mustard							
9.	2:2	4792	8967	6879	1.01	1.21	1.11	25.32
10.	3:1	4515	6900	5707	1.03	1.07	1.05	22.46
11.	5:1	4536	6551	5543	1.04	1.03	1.03	21.90
12.	7:1	3992	7033	5512	0.98	1.11	1.04	20.03
13.	6:2	3806	7516	5661	0.92	1.11	1.05	21.81
	SE (m) ±	232	361	-	0.89	0.38	-	-
	CD (5%)	717	1079	-	NS	NS	-	-

Prevailing market rates	1987-88	1988-89
Gram	Rs. 500/q	Rs. 600/q
Lentil	Rs. 350/q	Rs.400/q
Mustard	Rs. 700/q	Rs.750/q

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STUDIES ON INTERCROPPING OF SOME *KHARIF* CROPS IN SESAMUM

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ABSTRACT

A study on intercropping of kharif crops in sesamum indicated that redgram can be successfully taken as an intercrop in sesamum in 2:1 and 3:1 row proportions. The highest benefit cost ratio of 2.87 was observed in 3:1 row proportion with redgram followed by the benefit cost ratio of 2.49 in 2:1 row proportion with the same crop coupled with highest LER viz. 1.45 and 1.33 respectively.

Key words : Sesamum; Redgram; Intercropping; Monetary Returns; Benefit Cost Ratio; Land Equivalent Ratio

INTRODUCTION

Sesamum (*Sesamum indicum* L.) is an important oilseed crop in Khandesh tract occupying 25 to 30 per cent of the total area under the crop in the State. However, it is very sensitive to heavy or scarce rains resulting into instability in its production and economic returns. Under the circumstances, an intercropping gives an insurance against failure of any one crop in adverse seasons/monsoon vagaries/epidemics of crop diseases and pests. Besides, in a normal season it increases the farm income and aims at efficient utilization of solar energy, moisture and nutrients. Oilseeds and pulses form an important component of Indian diet and is the only way to fight against malnutrition.

In recent years, sesame acreage as a sole crop is increasing in Khandesh region with a peak of about 96000 hectares area in Jalgaon district itself during 1988 kharif season. With a view to find out the most remunerative intercropping system for sesamum in assured rainfall condition of Khandesh region, this study was undertaken.

MATERIALS AND METHODS

An experiment was conducted during *kharif* season of 1987, 1988 and 1989 at Oilseeds Research Station, Jalgaon. The soil was medium black having pH 7.5. The different *kharif* crops used as intercrops in sesamum were greengram (S-8), redgram (No.148), sunflower (Morden) and sorghum (CSH-5). These crops were sown with the following spacings and fertilizers.

Treatment	Spacing (cm)	Fertilization (kg/ha)
(A) Sole crops		
(1) Sesamum (JLT-7) Se	30 x 15	50 N
(2) Greengram (S-8) (GG)	30 x 30	25 N + 50 P_2O_5
(3) Redgram (No.148) (RG)	45 x 20	25 N + 30 P_2O_5
(4) Sunflower (Morden) (Sun)	45 x 20	60 N + 50 P_2O_5
(5) Sorghum (CSH-5) (Sor)	45 x 20	100 N + 50 P_2O_5
(B) Intercropping		
(6) Sesamum + Greengram (1:1)	30 x 15/10	50 N

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Treatment	Spacing(cm)	Fertilization (kg/ha)
(7) Sesamum + Redgram (1:1)	30 x 15/20	50 N
(8) Sesamum + Sunflower (1:1)	30 x 15/20	50 N
(9) Sesamum + Sorghum (1:1)	30 x 15/20	50 N
(10) Sesamum + Greengram (2:1)	30 x 15/10	50 N
(11) Sesamum + Redgram (2:1)	30 x 15/20	50 N
(12) Sesamum + Sunflower (2:1)	30 x 15/20	50 N
(13) Sesamum + Sorghum (2:1)	30 x 15/20	50 N
(14) Sesamum + Greengram (3:1)	30 x 15/10	50 N
(15) Sesamum + Redgram (3:1)	30 x 15/20	50 N
(16) Sesamum + Sunflower (3:1)	30 x 15/20	50 N
(17) Sesamum + Sorghum (3:1)	30 x 15/20	50 N

All agronomic practices were followed for all intercrops and sole crops to raise good crops.

The experiment was laid out in a Randomized Complete Block Design with three replications having gross plot size 5.0 x 5.4 m and net plot size 4.4 x 3.6 m. Sowing was done on 2nd July, 1987, 29th June, 1988 and 3rd July, 1989. Necessary plant protection measures were taken to protect the crop from pests and diseases. Grain and by-product yield per plot was recorded in each replication. Economics of the various treatments was worked out considering the prevailing market prices of the grain and by-products.

The rainfall received during crop growth period is presented in Table 1. Rainfall was more during 1988 (937.2 mm) as compared to rainfall of 1987 (683.4 mm) and of 1989 (673.5 mm). Of the total rainfall, maximum was received during August in 1987 and 1989 and in July 1988 resulting in more vegetative growth in 1988.

Table 1. Monthwise rainfall during 1987 to 1989 at Jalgaon

Months	Rainfall in mm		
	1987	1988	1989
June	158.0 (7)	136.7 (12)	153.4 (14)
July	73.4 (9)	374.5 (26)	155.8 (16)
August	290.2 (16)	82.6 (19)	268.1 (24)
September	6.6 (2)	298.4 (16)	89.0 (9)
October	96.0 (5)	45.0 (5)	0.8 (1)
November	46.2 (3)	-	-
December	13.0 (3)	-	6.4 (1)
Total	683.4 (45)	937.2 (78)	673.5 (65)

Figures in parentheses indicate number of rainy days

RESULTS AND DISCUSSION

The data pertaining to grain yield, and monetary returns and LER are presented in Table 2 and 3.

Table 2. Grain yield of sesamum and intercrops as influenced by different intercropping systems

Treatments	Grain yield of main crops (kg/ha)				Grain yield of intercrop (kg/ha)			
	1987-88	1988-89	1989-90	Pooled mean	1987-88	1988-89	1989-90	Pooled mean
Sesamum sole	982	169	563	571	-	-	-	-
Greengram sole	-	-	-	-	1272	128	657	896
Redgram sole	-	-	-	-	1121 (6724)	1643 (7740)	1922 (9559)	1559 (8007)
Sunflower sole	-	-	-	-	637	153	1325	707
Sorghum sole	-	-	-	-	4270 (13310)	787 (11259)	4695 (13373)	3251 (12647)
Sesamum + Greengram (1:1)	488	96	158	247	526	90	316	311
Sesamum + Redgram (1:1)	480	85	279	282	600 (3126)	1304 (3060)	963 (5892)	956 (4026)
Sesamum + Sunflower (1:1)	345	82	147	191	586	89	1034	580
Sesamum + Sorghum (1:1)	379	78	214	223	5638 (15330)	103 (7154)	4013 (11194)	3251 (11226)
Sesamum + Greengram (2:1)	719	104	317	380	340	98	138	192
Sesamum + Redgram (2:1)	566	90	303	320	1003 (3547)	1102 (2863)	1477 (4693)	1193 (3701)
Sesamum + Sunflower (2:1)	441	93	143	226	542	73	849	488
Sesamum + Sorghum (2:1)	515	95	275	295	5021 (14468)	102 (5156)	3163 (9827)	2759 (9817)
Sesamum + Greengram (3:1)	902	112	330	448	349	106	80	178
Sesamum + Redgram (3:1)	690	97	437	408	848 (2224)	1042 (2752)	1731 (1755)	1206 (2244)
Sesamum + Sunflower (3:1)	527	96	206	277	472	83	286	280
Sesamum + Sorghum (3:1)	574	95	407	316	4291 (12876)	78 (5962)	2544 (6376)	2304 (8405)
SE ±	77	9	11	54	257	69	102	623
CD at 5%	213	27	33	157	742	199	296	1787

Figures in parentheses indicate by-product yield (kg/ha)

Table 3. Monetary returns and LER as influenced by different intercropping systems

Treatments	Gross returns (Rs/ha)				LER	Benefit cost ratio (Rs/ha)
	1987-88	1988-89	1989-90	Pooled		
Sesamum sole	11054	1181	5811	6048	1	1.52
Greengram sole	5404	833	3676	3302	1	0.58
Redgram sole	2494	10587	13638	8907	1	2.52
Sunflower sole	3434	922	9276	4545	1	0.97
Sorghum sole	11761	7595	13402	10922	1	2.02
Sesamum + Greengram (1:1)	7734	1250	3426	4135	0.98	0.62
Sesamum + Redgram (1:1)	7222	8580	9891	8567	1.10	2.00
Sesamum + Sunflower (1:1)	7045	1111	8787	5850	1.13	1.01
Sesamum + Sorghum (1:1)	18378	4381	13622	12128	1.08	2.07
Sesamum + Greengram (2:1)	9539	1370	4095	5000	1.05	0.88
Sesamum + Redgram (2:1)	9053	7266	12986	9766	1.33	2.49
Sesamum + Sunflower (2:1)	7885	1086	7447	5473	1.07	0.80
Sesamum + Sorghum (2:1)	19444	3497	12159	11698	1.18	2.24
Sesamum + Greengram (3:1)	11641	1477	3916	5676	1.12	1.12
Sesamum + Redgram (3:1)	10152	6963	15555	10890	1.45	2.87
Sesamum + Sunflower (3:1)	8472	1168	4173	4602	0.99	0.83
Sesamum + Sorghum (3:1)	161130	4173	11256	10518	1.14	2.20
SE ±	1019	431	465	1962	-	-
CD at 5%	2868	1213	1310	5649	-	-

Market rates (Rs/kg)	**1987-88**	**1988-89**	**1989-90**
1. Sesamum	11.25	7.00	10.50
2. Greengram	4.25	6.50	5.60
3. Redgram	5.00	5.50	6.00
4. Sunflower	5.75	6.00	7.00
5. Sorghum	2.30	2.50	2.00
6. Fodder	0.30	0.30	0.30
7. Sticks	0.20	0.20	0.20

Grain yield

Significant differences were observed for yield of sesamum and also intercrops due to various intercropping systems during all the three seasons. The productivity of sesamum was adversely affected by intercropping during all the three seasons. The reduction in grain yield was minimum when it was intercropped with greengram in all row proportions during 1987 and 1988. The sesamum yield increased as the row proportions of sesamum was increased in all the seasons and in all the treatments. Greengram produced higher grain yield in lower row proportion of 1:1. It yielded 526 kg/ha and 316 kg/ha during 1987 and 1989 respectively. It was observed that red gram gave higher grain yield of 1003 kg/ha in 2:1 row proportion in 1987, 1304 kg/ha in 1:1 row proportion in 1988 and 1731 kg/ha in 3:1 row proportion in 1989.

Three years pooled data revealed that the yield of sesamum and other intercrops were found significant due to various intercropping systems. Sesamum alone produced significantly higher grain yield (571 kg/ha) which was more than that in all intercropping treatments except the treatment of sesamum + green gram in 3:1 row proportions which was at par. All the intercrops produced more yield when sown as sole crop than their yield as an intercrop in sesamum. All intercrops gave higher grain yield in lower row proportion with the exception of redgram. Redgram showed yield of 282 kg/ha, 320 kg/ha and 408 kg/ha in 1:1, 2:1 and 3:1 row proportion. This might be due to wider spacing available for redgram after harvest of main crop. Wider spacing to red gram resulted in availability of more nutrients and better utilization of sunlight as the row proportion increased. The reduction in main crop yield due to intercropping was more than compensated by additional yields of intercrops. The increase in total yield was maximum with two rows of sesamum plus one row of redgram and three rows of sesamum plus one row of red gram. This system shows stabilization of yields which was also noted in intercropping of pigeon pea and sorghum by Rao and whilley (1980). However, Desai and Goyal (1980) reported the highest seed yields with the intercrop combination of castor and sesame in 1:1 ratio.

Beneficial effects on yield and net returns due to intercropping of greengram (Bhalerao *et al.*, 1976) mothbean (Daulag *et al.*, 1970), soybean (De *et al.*, 1978) and blackgram (Gangwar and Kalra, 1983) on different cereals were reported earlier. Studies on suitable and profitable companion crop for *kharif* sesamum under khandesh region are first time studied and reported in this paper.

Economics

Significant differences were observed for monetary returns due to various intercropping systems during all the three seasons. Redgram gave the highest monetary returns of Rs.10587/ha and Rs.13638/ha during 1988 and 1989 respectively. However, during 1987 sorghum gave the highest monetary returns of Rs.11761/ha. In case of intercropping, the highest monetary returns of Rs.19444/ha were obtained in sesamum + sorghum (2:1) system during 1987 and sesamum + redgram (1:1) (Rs.8580/ha) and sesamum + redgram (3:1) during 1988 and 1989 respectively.

Three years data of monetary returns (Table 3) revealed significant differences due to various intercropping systems. Among the sole crops, sorghum recorded the highest monetary returns of Rs.10922/ha followed by redgram (Rs.8907/ha), sesamum (Rs.6048/ha), sunflower (Rs.4545/ha) and Greengram (Rs.3302/ha). The highest benefit cost ratio was observed in red gram (2.52) followed by sorghum, sesamum, sunflower and greengram i.e. 2.02, 1.52, 0.87 and 0.58 respectively.

In intercropping systems, the highest monetary returns (Rs.12128/ha) was seen in sesamum + sorghum in 1:1 row proportion followed by sesamum + sorghum in 2:1 row proportion (Rs.11698/ha) and sesamum + redgram in 3:1 row proportion (Rs.10890/ha). However, sesamum + redgram in 3:1 row proportion gave the highest (2.87 Rs/Re) B.C. ratio followed by sesamum + redgram in 2:1 row proportion (2.49 Rs/Re and sesamum + sorghum in 2:1 row proportion (2.24 Rs/Re) and in 3:1 row proportion (2.20 Rs/Re).

In case of sesamum + green gram and sesamum + redgram intercropping, monetary returns and B.C. ratio increased as the row proportion was increased. Thorat *et al*., (1986) observed higher monetary returns in case of 3:1 row proportion of ragi + black gram and ragi + cowpea intercropping system in which ragi + sesamum (3:1 and 2:1) was on par. Evans (1960) and Divekar (1960) indicated beneficial effect of legumes and cereals intercropping system.

Land equivalent ratio (LER)

The land equivalent ratio (LER) is an indicator of efficient land utilization for intercropping systems (Jha and Chandra, 1982). The value of LER were higher for sesamum + redgram in all row proportions than other intercropping systems of greengram, sunflower and sorghum crops. The sesamum + redgram (3:1) registered highest LER (1.45) followed by the same intercropping system in 2:1 row proportion (1.33). The value of LER were increased as the row proportion increases in intercropping of green gram and red gram crops.

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HETEROSIS IN INTER AND INTRA-SUBSPECIES OF GROUNDNUT (*ARACHIS HYPOGAEA* L.)

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ABSTRACT

Eighteen hybrids involving three testers and six lines in line x tester fashion were studied so as to know heterosis in groundnut. Both subspecies namely Fastigiata and Hypogaea were included. Desirable significant negative heterosis over better parent was observed for days to 50% flowering in Spanish x Spanish, Spanish x Valencia and Spanish x Virginia crosses and for days to maturity in Spanish x Spanish and Spanish x Virginia crosses. Significant useful heterosis in positive direction for height of plant was observed in Spanish x Spanish, Spanish x Virginia and Spanish x Valencia. The crosses *JL-24 x TAG-24 and ICGS-11 x NCAC-17500 showed significantly high useful* heterosis for number of branches and pod yield per plant. Spanish x Valencia crosses (i.e. JL-24 x MH-2, S.B.XI x MH-2 and ICGS-11 x MH-2) gave good heterotic effect (useful heterosis) as compared to Spanish x Spanish and Spanish x Virginia for pod yield per plant.

Key words : Heterosis; Groundnut.

INTRODUCTION

In the recent years, improved cultivars are extensively used in hybridization because they possess many favourable genes which may complement each other in hybrid combination. Besides the inter-subspecies crosses are likely to result in superior hybrids because the desirable attributes are clustered separately in such botanical group. The breeder takes up the promising crosses having high heterosis and studies them in segregating generation which in turn may produce desirable transgressive segregants in advanced generations. The present investigation was undertaken to know the extent as well as direction of heterosis for yield and its characters involving inter and intra-subspecies crosses in groundnut and to identify the crosses which will be useful in isolating desirable transgressive segregants.

MATERIALS AND METHODS

Nine diverse parents representing different botanical groups were selected. Three testers viz. JL-24, S.B.XI and ICGS-11 (Spanish, var. Vulgaris) Subspecies *Fastigiata* were crossed with UF-70103, NCAC-343, NCAC-17500 (Virginia var. *Hypogaea*) subspecies *hypogaea*, TAG-24, NARGS(F)-2(Spanish var. Vulgaris) and MH-2 Valencia var. *Fastigiata* under sub-species *Fastigiata* during 1990 to produce 18 F_1s hybrid. All the F_1s and parents were sown in Randomised Block Design with two replications during the rainy season 1991 at Oilseeds Research Station, Jalgaon. The entries were sown in single row of 3 metre length with spacing of 30 cm between rows and 10 cm within row. Observations were recorded on ten randomly selected competitive plants in each entry in each replication for days to 50% flowering, plant height (cm), number of branches/plant, pod yield/plant and days to maturity. The heterotic effects were computed as percentage increase or decrease of F_1 over mid parent (relative heterosis), better parent (heterobeltosis) as well as standard heterosis (useful heterosis).

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RESULTS AND DISCUSSION

The mean differences amongst the treatment (parents and hybrids) were significant for all the characters studied (Table 1) indicating that additive and non-additive gene action play a role for control of these characters.

Table 1. Mean performance of parents and hybrids for different characters

Parents/hybrid	Days to 50% flowering	Plant height (cm)	No. of branches/plant	Yield/plant (g)	Days to maturity
TESTERS (Female)					
JL - 24	26.0	43.0	4.6	10.5	90.5
S.B. XI	28.5	47.0	5.5	8.3	97.5
ICGS - 11	29.0	32.3	5.2	9.4	10.6
LINE (Male)					
TAG - 24	24.0	21.3	4.7	6.7	100.5
NCAC - 343	29.0	27.0	7.1	10.1	102.5
UF - 70103	29.5	28.8	11.8	9.3	107.5
NCAC - 17500	30.5	53.0	7.5	9.3	98.5
MH - 2	26.5	25.0	4.7	9.5	93.5
NARGS (F) - 2	32.0	30.2	8.8	8.6	98.0
CROSSES					
JL - 24 x TAG - 24	24.5	43.4	5.0	12.3	86.0
S.B. XI x TAG - 24	24.0	50.6	4.3	10.5	85.0
ICGS - 11 x TAG - 24	27.0	32.6	5.3	13.6	91.0
JL -24 x NCAC - 343	29.0	39.0	6.9	11.5	96.5
S.B. XI x NCAC - 343	25.0	48.6	7.0	11.9	91.5
ICGS -11 x NCAC - 343	28.5	39.1	4.7	11.9	95.0
JL -24 x UF - 70103	26.0	29.2	7.0	11.6	96.5
S.B. XI x UF -70103	28.0	48.8	6.7	13.8	95.0
ICGS -11 x UF - 70103	28.0	33.6	5.6	10.1	94.5
JL -24 x NCAC -17500	28.0	50.7	9.3	10.2	89.5
S.B. XI x NCAC - 17500	26.0	47.0	6.4	13.7	91.5
ICGS -11 x NCAC - 17500	27.0	44.4	11.1	14.0	98.0
JL - 24 x MH - 2	24.0	51.7	4.5	14.9	91.5
S.B. XI x MH - 2	24.0	46.6	4.2	15.1	91.5
ICGS - 11 x MH - 2	26.0	43.7	4.7	14.9	98.5
JL - 24 x NARGS(F) - 2	28.0	42.6	5.5	10.7	94.5
S.B. XI x NARGS(F) - 2	27.0	46.9	5.6	13.8	97.0
ICGS - 11 x NARGS(F) - 2	22.0	43.8	4.7	10.6	99.5
F value	6.81**	8.02**	5.65**	3.92**	9.48**
SE (diff.)	1.11	4.40	1.79	1.60	2.44

Days to 50% flowering

Twelve cross combinations out of 18 showed desirable significant negative heterosis over mid-parents, whereas seven hybrids showed significant negative heterosis over better parent (flowering earlier). The magnitude of useful heterosis for this trait was found to range from -9.43 (S.B.XI x MH-2) to 11.53 (JL-24 x NCAC-343). Out of 18 crosses only four crosses viz. JL-24 x TAG-24 (Spanish x Spanish), JL-24 x MH-2, S.B.XI x MH-2 (Spanish x Valencia) and S.B.XI x NCAC-343 (Spanish x Virginia) showed negative significant useful heterosis over the standard check. It is interesting to note that in crosses Spanish x Spanish none of the hybrid showed significantly negative useful heterosis over standard check except JL-24 x TAG-24 (-5.76%). Basu *et al.*, (1986) recorded high desirable negative heterosis for this trait in Spanish x Spanish cross. In the present investigation also Spanish x Spanish or Spanish x Virginia showed negative heterosis. However the highest heterosis was obtained in Spanish x Valencia type.

Plant height (Height of main stem)

Fourteen crosses exhibited significantly positive heterosis over mid parent values. The highest values of both positive and negative heterosis were observed to be 122.25% (S.B.XI x TAG-24) and -60% (S.B.XI x NCAC-17500). Only five crosses gave significant positive heterobeltiosis for height of plant. Heterobeltiosis for plant height was found to range from -16.22% (ICGS-11 x NCAC-17500) to 35.60% (ICGS-11 x NRGS(F)-2). Out of 18 crosses only seven crosses viz. S.B.XI x TAG-24 (Spanish x Spanish), S.B.XI x NCAC- 343 (Spanish x Virginia), S.B.XI x UF-70103 (Spanish x Virginia), JL-24 x NCAC-17500 (Spanish x Virginia), S.B.XI x NCAC-17500 (Spanish x Virginia) and S.B.XI x NARGS (F)-2 (Spanish x Spanish) were found to show significantly positive useful heterosis for this trait. Basu *et al.*, (1986) reported a range of heterosis from -23.42 to 28.28%. High heterosis was indicated in Spanish x Spanish and Spanish x Valencia. Lin (1966) in Taiwan noted significant hybrid vigour for length of main stem (height) in Spanish x Virginia. In the present study also maximum heterosis was observed in Spanish x Virginia.

Number of main branches per plant

Six crosses showed positive significant heterosis over mid parent in respect of number of branches/plant whereas only three crosses viz. JL-24 x TAG-24 (Spanish x Spanish), JL-24 x NCAC-17500 (Spanish x Virginia) and ICGS-11 x NCAC-17500 (Spanish x Virginia) were positively significant for heterobeltiosis. The magnitude of useful heterosis for this trait was found to range from -8.69 to 141.31%. Most of the crosses showed positive significant heterosis over the best parent JL-24. Maximum hybrid vigour was observed in Spanish x Virginia crosses. This may be an indication of effects due to over dominance action. Lin (1966) in Taiwan noted significant hybrid vigour for number of branches in crosses of Spanish x Virginia and Basu *et al.*, (1986) also reported high heterosis in Spanish x Virginia crosses. Similar results were also obtained by Higgins (1940), Katayama and Nagatoma (1963) and Syakudo and Kawabata (1963).

Table 2. Heterosis (H_1), Heterobeltiosis (H_2) and useful heterosis (H_3) for different characters

Cross		Days to 50% flowering	Plant height (cm)	No. of branches/ plant	Yield/plant (g)	Days to maturity
JL - 24 x TAG - 24	H1	-2.00**	34.99**	7.52**	43.02**	-9.96**
	H2	2.08	0.93	6.38**	17.14**	-4.99
	H3	-5.76**	0.93	8.69**	17.14**	-4.97
S.B. XI x TAG - 24	H1	-8.05	122.25**	-1.96	40.00**	-14.14**
	H2	-	7.65	-9.09**	26.50	-12.82**
	H3	-7.69	17.67**	8.69**	-	-6.07*
ICGS - 11 x TAG - 24	H1	1.88*	21.64**	7.07**	69.04**	- 11.86**
	H2	12.5**	9.92	1.92	44.83**	-9.45**
	H3	3.84**	-24.18**	15.21**	29.52**	0.55
JL -24 x NCAC - 343	H1	5.45**	13.14**	17.94**	11.65**	-
	H2	11.53**	-7.90	-2.81	9.52**	6.62*
	H3	11.53**	-7.90	50.00**	9.52**	6.62*
S.B. XI x NCAC - 343	H1	-13.04**	31.35**	11.11**	29.34**	- 8.87**
	H2	-12.28**	3.40	-1.40	17.82**	-7.31**
	H3	-3.84**	13.02**	52.17**	13.33**	4.97
ICGS -11 x NCAC - 343	H1	-1.72	31.87**	-23.37**	22.11**	- 8.87**
	H2	-1.72	21.05	-33.80**	17.82**	-7.31**
	H3	9.61**	-9.06	2.17	13.33**	4.97
JL -24 x UF - 70103	H1	-6.30	9.19*	-14.63**	17.17**	-2.52
	H2	-	8.83	-40.67**	-10.47**	6.62**
	H3	-	8.83	52.17**	-10.47**	6.62**
S.B. XI x UF -70103	H1	-3.44**	28.75**	-22.54**	56.61**	- 7.31**
	H2	-1.75	3.82	43.22**	43.83**	-2.56
	H3	7.69**	13.48**	45.65**	31.42**	4.97
ICGS -11 x UF - 70103	H1	-4.27**	9.98*	-34.11**	8.13**	- 11.47**
	H2	-3.44	4.02	-52.54**	-7.56**	10.8**
	H3	7.69**	-21.86**	21.73**	-3.80**	4.41

Contd..

Table 2. contd...

Cross		Days to 50% flowering	Plant height (cm)	No. of branches/ plant	Yield/plant (g)	Days to maturity
JL -24 x NCAC -17500	H1	-0.88	5.62	52.20**	3.64*	4.23
	H2	7.69**	17.90**	25.20**	-1.98	-1.10
	H3	7.69**	17.90**	104.13**	-	-1.10
S.B. XI x NCAC - 17500	H1	-11.86**	-6.00	-1.53	55.85**	- 6.63**
	H2	-8.77**	-11.32**	-14.66**	47.47**	-6.15*
	H3	-	9.30**	39.13**	30.47**	1.10
ICGS -11 x NCAC - 17500	H1	-9.24**	-3.94	74.80**	49.89**	4.15
	H2	-6.89**	-16.22**	48.00	49.09**	-0.50
	H3	-3.84**	3.25	141.30**	33.33**	8.28**
JL - 24 x MH - 2	H1	-8.57**	52.05**	-0.22*	49.00	-0.54
	H2	-7.69**	20.23**	-4.25*	41.90**	1.10
	H3	-7.65**	20.23**	-2.17**	41.90**	1.10
S.B. XI x MH - 2	H1	-12.72**	29.44**	-17.64**	69.66**	4.18
	H2	-9.43**	-0.85	-23.63**	58.94*	-2.13
	H3	-7.69**	8.37	-8.69**	43.80**	1.10
ICGS - 11 x MH - 2	H1	-6.30**	52.33**	-5.05**	57.83**	-1.25
	H2	-1.88	35.29**	9.61**	56.84**	5.34*
	H3	-	1.62	2.17	41.90**	8.83**
JL - 24 x NARGS(F) - 2	H1	-3.44**	-0.93	-18.45**	12.04**	0.26
	H2	7.69**	16.39**	-38.13**	1.90	4.41
	H3	7.69**	-0.93	19.56**	1.90	4.41
S.B. XI x NARGS(F) - 2	H1	-10.74**	21.50**	-22.16**	63.31**	0.76
	H2	-5.26**	0.21	37.00**	60.45**	0.51
	H3	3.84	9.06*	21.73**	31.42**	7.18**
ICGS - 11 x NARGS(F) - 2	H1	-11.47**	40.16**	-33.28**	17.90**	-2.45
	H2	-6.89**	35.60**	-47.13**	12.88**	1.53
	H3	3.84**	1.86	2.17	0.92	9.94**
SE (diff)	H1	0.96	3.81	1.55	1.38	2.11
	H2 & H3	1.11	4.40	1.79	1.60	2.44

Pod yield per plant

Heterosis over mid-parent ranged from 3.64% to 69.66%. All crosses exhibited significant positive heterosis. The highest value of heterosis was observed in the hybrid S.B.XI x MH-2(69.66%) followed by ICGS-11 x TAG- 24 (69.04%), S.B.XI x NARGS(F)-2(63.31%), ICGS-11 x MH-2(57.83%) S.B.XI x UF-70103(56.61) and S.B.XI x NCAC-17500 (55.85%). The magnitude of heterobeltiosis for yield/plant was found to range from -10.47 (JL-24 x UF-70103) to 60.45% (S.B.XI x NARGS (F)-2).

Twelve crosses showed significant positive useful heterosis over check most of which either belonged to Spanish x Virginia and Spanish x Valencia combinations. *Fastigiata* generally have greater heterotic responses than parents of subspecies *Hypogaea*. Basu *et al.* (1986) reported significant positive heterosis in Spanish x Spanish and Spanish x Valencia crosses. Higgins (1940) observed marked heterosis for pod yield. Individual plant yields were highest for Spanish x Virginia, Valencia x Spanish combination exhibited high heterosis in the study of Jagannath Reddy and Raja Reddy (1987).

Days to maturity

Heterosis over mid parent ranged from -14.14% (S.B.XI x TAG-24) to 4.23% (JL-24 x NCAC-17500). Out of 18 crosses only 9 crosses showed desirable significant negative heterosis over mid parent. Five crosses S.B.XI x TAG- 24(-12.82%), ICGS-11 x TAG-24 (-9.45%) S.B.XI x NCAC-343 (-6.15%), ICGS-11 x NCAC-343(-7.31%) and S.B.XI x NCAC-17500 (-6.63%) gave significant negative heterobeltiosis for days to maturity. Only one cross S.B.XI x TAG- 24 (Spanish x Spanish) showed significant negative useful heterosis for this character. Basu *et al.,* (1986) reported the desirable significant negative heterosis over better parent for days to 50% flowering in Spanish x Spanish crosses which was not observed in present study. Regarding days to maturity in Spanish x Valencia crosses were promising in his study. However it was not reflected in the days to maturity. Spanish x Spanish also exhibited high heterotic effect for number of matured pods per plant over mid parent as well as better parent. The heterosis over mid parent for pod yield per plant ranged from 34.72 to 57.28% and the cross GAUGI x Chico (Spanish x Spanish) recorded the highest value. On this basis Basu et al., (1986) suggested usefulness of Spanish x Valencia crosses.

In the present investigation, the maximum significant useful heterosis was observed for days to 50% flowering in S.B.XI X MH-2 (Spanish x Valencia- 7.69%) Plant height in JL-24 x MH-2 (Spanish x Valencia 20.23%), number of branches/plant in ICGS-11 x NCAC-17500 (Spanish x Virginia 141.80%), yield/plant in S.B.XI x MH-2 (Spanish x Valencia 43.80%) and days to maturity in S.B.XI x TAG-24 (Spanish x Spanish -6.07%).

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EFFECT OF IRRIGATION AND STARCH POLYMER ON YIELD ATTRIBUTES, YIELD AND QUALITY OF MUSTARD (*BRASSICA JUNCEA* L.)

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ABSTRACT

The effect of irrigation and starch polymer (Jalshakti) levels was studied on yield, its attributes and quality of mustard under silty clay loam soils of Pantnagar. Seed yield of mustard var. *Krishna was significantly higher under two irrigations in comparison with unirrigated conditions* but remained at par with one irrigation. Seed yield increased by 8.1 and 21.8 percent during 1987-88 and 7.9 and 23.6 percent during 1988-89 under two irrigations as compared to one irrigation and unirrigated condition, respectively. Siliquae per plant and 1000 seed weight significantly increased with application of two irrigations. Seed coating @1.5% + soil application of Jalshakti @ 6 kg per ha. increased seed yield over control. Seed coating or soil application had no significant effect. Jalshakti treatment also increased oil content in seeds.

Key words : Irrigation; Mustard; Starch polymer.

INTRODUCTION

Crop yield is directly influenced by water stress at critical stages of growth. Not only the number of irrigations but also the stage affects the seed yield of mustard. Winter crops often suffer severely from water stress during critical stages of growth (Singh and Kumar, 1981). Besides, selecting the optimum stage of irrigation in irrigated areas, it is also desirable that the moisture is retained for a longer period in soil. Starch polymers (Jalshakti) have been reported to increase the water absorbing capacity of soil and extend irrigation intervals. Therefore, investigations were carried out to study the integrated effect of different levels of irrigation and starch polymer (Jalshakti) on yield, yield attributes and quality of mustard.

MATERIALS AND METHODS

The experiment was conducted at Crop Research Centre of G.B.Pant University of Agriculture and Technology, Pantnagar during winter seasons of 1987-88 and 1988-89 on silty clay loam soils having pH of 7.2 and 7.1 and organic carbon percent 1.04 and 1.02, respectively. Total rainfall received during the crop season was 60.3 mm and 80.4 mm, respectively. The experiment was laid out in split-plot design, taking irrigation levels as main-plots (unirrigated, one irrigation at rosette stage and two irrigations at rosette and siliquae formation stages) and Jalshakti levels in sub-plots (control, seed coating @1.5%, soil application @ 6 kg/ha and seed coating @ 1.5% + soil application of Jalshakti @ 6 kg/ha) with three replications. Variety 'Krishna' of Indian mustard was sown on 16 Oct. and 10 Nov. A basal application of 60 kg N, 40 kg P_2O_5 and 20 kg K_2O per hectare was made and 30 kg N/ha was topdressed at the flowering stage. The observations on various yield attributes were recorded from five randomly selected plants in each plot. The oil content was determined using soxhlet's extraction method and N percentage was determined by the micro Kjeldahl's method (Jackson, 1973). The amount of protein content was obtained by multiplying the N with a constant factor of 6.25.

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RESULTS AND DISCUSSION

Yield attributes

Significantly higher number of branches/plant, Siliquae/plant, 1000 seed weight and seed weight/plant were recorded in the treatment where two irrigations were applied (Table 1) However, during 1988-89, number of branches/plant as well as seed weight/plant remained at par with one irrigation. The treatments comprising one irrigation and unirrigated also did not differ significantly for number of siliquae/plant during 1988-89 and seed weight/plant during both the years. Bajpai and Singh (1981) also reported significant increase in branches and siliquae/plant with two irrigations. Sharma and Kumar (1989) reported significantly higher 1000 seed weight and seed weight/plant with two irrigations.

Table 1. Influence of irrigation and Jalshakti levels on yield attributes of mustard

Treatments	No. of branches/ plant		No. of siliquae/ plant		1000 seed weight (g)		Seed weight/ plant (g)	
	'87-88	'88-89	'87-88	'88-89	'87-88	'88-89	'87-88	'88-89
Irrigation levels								
Unirrigated	21.8	11.1	237.5	149.9	4.18	3.84	9.82	9.70
One irrigation	26.9	13.2	264.4	179.4	4.68	4.33	10.45	10.16
Two irrigations	31.1	14.8	300.6	218.9	5.05	4.55	13.04	13.31
SEm.±	0.66	0.56	3.93	8.49	0.09	0.07	0.32	0.45
CD at 5%	2.6	2.2	15.4	33.3	0.35	0.27	1.25	1.75
Jalshakti levels								
Control	24.6	11.8	252.1	165.6	4.23	3.93	10.03	10.00
Seed coating @1.5%	25.8	12.8	260.0	172.2	4.66	4.30	10.83	10.67
Soil application @ 6kg/ha	26.4	13.4	272.2	186.1	4.74	4.33	11.53	11.05
Seed coating 1.5% + Soil application @ 6kg/ha	29.6	14.3	285.6	201.3	4.85	4.40	12.02	11.43
SEm. ±	1.23	0.93	10.48	9.68	0.10	0.10	0.25	0.33
CD at 5%	NS	NS	NS	NS	0.30	0.29	0.74	NS

The number of branches and siliquae, though, did not differ significantly with respect to irrigation levels but Jalshakti levels had more value over control. Significantly higher 1000 seed weight and seed weight/plant was recorded where seed coating of Jalshakti was made along with soil application in comparison with control. However, during 1988-89, seed weight/plant did not differ significantly. Seed coating @ 1.5% or soil application of Jalshakti @ 6 kg/ha did not have significant difference for 1000 seed weight and both remained at par with the treatment where seed coating was done along with soil application of Jalshakti.

Seed Yield

Seed yield was significantly higher under two irrigations in comparison with unirrigated condition but remained at par with one irrigation during both the years (Table 2). Seed yield increased by 8.1 and 21.8 per cent during 1987-88 and 7.9 and 23.6 percent during 1988-89 under two irrigations as compared to one irrigation and unirrigated condition, respectively. Increase in yield attributes additively resulted in an increase in the seed yield of mustard. A significant increase in the seed yield of mustard with the application of one irrigation has been reported by different workers (Kumar, 1981; Sharma and Kumar, 1989).

Table 2. Influence of irrigation and jalshakti on yield, oil and protein contents in seeds of mustard

Treatments	Seed yield (q/ha)		Oil content (%)		Protein content (%)	
	'87-88	'88-89	'87-88	'88-89	'87-88	'88-89
Irrigation levels						
Unirrigated	11.43	10.47	37.10	36.93	19.99	20.22
One irrigation	12.89	11.99	38.79	38.61	19.00	19.99
Two irrigations	13.93	12.94	40.99	40.54	18.90	19.26
SEm.±	0.41	0.34	0.14	0.22	0.38	0.11
CD at 5%	1.60	1.33	0.55	0.86	NS	0.43
Jalshakti levels						
Control	11.79	10.82	38.41	38.07	20.60	20.03
Seed coating @1.5%	12.59	11.74	38.89	38.43	19.61	19.93
Soil application @ 6kg/ha	13.01	12.20	39.27	38.79	19.49	19.72
Seed coating 1.5% + Soil application @ 6kg/ha	13.60	12.61	39.84	39.48	19.28	19.60
SEm. ±	0.24	0.16	0.18	0.18	0.43	0.09
CD at 5%	0.72	0.47	0.55	0.53	NS	0.26

Significantly higher seed yield was recorded where seed coating of Jalshakti was done along with soil application in comparison with control. Although, seed coating @ 1.5% or soil application @ 6 kg/ha or seed coating as well as soil application had no significant differences, but, soil application had beneficial effect on seed yield.

Oil content

Significantly higher oil content was recorded when two irrigations were made during both the years, one irrigation also had significantly higher oil content over unirrigated conditions (Table 2). Sharma and Kumar (1988) reported that two irrigations significantly increased the oil content in mustard. Significantly higher oil content was recorded when seed coating of Jalshakti was done along with soil application during both the years. Seed coating @ 1.5% and soil application of Jalshakti @ 6 kg/ha alone also remained almost the same.

Protein content

Protein content in seeds was not-significant during 1987-88 and decreased with increase in irrigation levels during 1988-89. However, one irrigation and unirrigated conditions did not differ significantly. Higher protein content was recorded in control and lowest protein content was recorded under seed coating of Jalshakti along with soil application. However, during 1987-88 the protein content did not differ significantly due to Jalshakti levels.

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NUTRITION OF GROUNDNUT IN RELATION TO CALCIUM SATURATION OF SOIL*

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ABSTRACT

The results of the two years study on nutrition of groundnut in relation to calcium saturation of soil revealed that calcium oxide was more effective than calcium sulphate in enhancing the pod yield. Calcium saturation in soil upto 75 per cent can adequately cause for steep gradient of calcium concentration between pod and soil and also increase the availability of magnesium and sulphur resulting in higher pod yield of groundnut. Higher pod yield can also be realized in sandy loam type of soil as compared to sandy clay loam soil.

Key words : Groundnut; Calcium saturation; Calcium sources; Magnesium; Sulphur

INTRODUCTION

Adequate calcium is essential in the root zone and pod zone to produce high yield of good quality pods. Groundnut has the unique characteristic of uptake of calcium by the developing pegs and pods. As calcium is relatively immobile in the plant tissues and is not translocated in sufficient quantities from the roots to meet the needs of developing pods, calcium has to be made available in adequate quantities in the pod zone. It is thus recognized that calcium availability in podding zone is often a yield limiting factor for groundnut production. Presently, gypsum is recommended on adhoc basis without considering the native status and calcium saturation. Mehlich and Reed (1947) observed increase in pod filling with increasing degree of calcium saturation. Thus, this calls for a reintroduction of the concept of application of calcium to groundnut through a suitable source in order to establish a steep gradient in Ca concentration between pod and soil. Hence, the present investigation on uptake of Ca, Mg and S by groundnut in relation to calcium saturation of soil was undertaken.

MATERIALS AND METHODS

This study was carried out in pots for two years (kharif 1989 and summer 1990) at the Main Research Station, Hebbal, Bangalore. There were 16 treatment combinations consisting of two soil types (ARS, Chintamani soil and GKVK farm soil), two sources of calcium (CaO and $CaSO_4$) and four levels of calcium saturation (Control, 25%, 50% and 75% saturation) tried in completely randomized design with three replications. Burnt clay pots of 16 kg capacity were used for the study. In each pot 15.5 kg soil free from stones and stubbles was filled. Fresh soil was used for the study during the second year. The physical and chemical properties of the two soils used in the study are given in Table 1.

Required calcium to attain saturation level was worked out as :

$$Required\ calcium (meq/100\,g) = CEC\ \frac{Ca\ saturation\ required - Ca\ saturation\ present}{100}$$

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The soil was saturated as per the treatments ten days earlier to sowing and allowed for equilibration by stirring and watering. Nitrogen, phosphorus and potassium at 25:75:37.5 kg per ha were applied through DAP and muriate of potash. Calcium and Magnesium in the soil and plant parts (Jackson, 1973) and sulphur in the plant parts (Chenin and Yein, 1950) were analysed at different stages. Pod yield was recorded and expressed in g per plant.

Table 1. Physical and Chemical properties of soils of ARS Chintamani and GKVK farm

Particulars	ARS Chintamani soil	GKVK Farm soil
I Physical properties Mechanical analysis (%)		
Sand	50.9	33.23
Silt	25.7	33.62
Clay	23.4	33.13
Textural class	Red sandy loam	Sandy clay loam
II Chemical properties		
Soil reaction (pH)	5.8	5.3
CEC (meq/ 100 g)	9.6	9.8
Exchangeable Ca (meq/ 100 g)	1.38	1.30
Calcium Saturation (%)	13.26	14.37
Exchangeable Mg (meq/ 100 g)	0.70	0.60
Available sulphur (ppm)	32.0	16.0
Available nitrogen (kg/ ha)	571.2	280.0
Available P_2O_5 (kg/ ha)	45.02	21.88
Available K_2O (kg/ ha)	99.68	55.63

RESULTS AND DISCUSSION

Effect of soil types

The results of the study indicated that Chintamani soil registered significantly more pod yield (17.08 g/plant) than GKVK soil (11.64 g/plant) during 1989. Similar trend was also observed during 1990 but the differences were not significant (Table 2). Results on nutrient status of soil at different stages of crop growth revealed higher calcium status in the soil before sowing and also at 50 DAS in Chintamani soil as compared to GKVK soil (Table 1). Similarly Chintamani soil had higher magnesium content at 50 DAS but the differences were not significant (Table 2). These observations clearly indicate the increased availability of calcium and magnesium in Chintamani soil as compared to GKVK soil.

There was significant increase in the accumulation of calcium in the shoot and pod at 60 DAS and calcium and magnesium in kernel at harvest during 1989 in Chintamani soil (Tables 3 and 4). Thus, the efficiency of Chintamani soil in enhancing the pod yield of groundnut could be attributed to the increased availability of nitrogen and uptake of nutrients and better texture of the soil.

Table 2. Pod yield and calcium content in soil at different stages as influenced by calcium sources and saturation levels in two soils on groundnut

	Pod yield (g/plant)		Calcium content (meq/100 g) in soil					
			Before sowing		50 DAS		After harvest	
	1989	*1990*	*1989*	*1990*	1989	1990	1989	1990
Soils								
A : ARS, Chintamani soil	17.08	14.40	6.01	5.98	5.61	6.09	4.39	4.07
B : GKVK farm soil	11.64	14.05	5.56	5.45	5.36	5.72	4.37	4.93
SEm. ±	0.43	0.68	0.12	0.15	0.06	0.19	0.12	0.17
CD at 5%	1.20	NS	0.33	0.44	0.17	NS	NS	0.47
Calcium sources								
S1: Calcium oxide	*15.06*	*14.20*	*5.69*	*5.53*	*5.42*	*5.65*	*5.15*	*5.00*
S2: Calcium sulphate	13.66	14.24	5.88	5.90	5.55	6.16	3.61	4.01
SEm. ±	0.43	0.68	0.12	0.15	0.06	0.19	0.12	0.17
CD at 5%	1.20	NS	NS	NS	NS	NS	0.34	0.47
Calcium saturation levels								
L0: Control	10.82	10.54	1.35	1.47	1.40	1.40	1.43	1.50
L1: 25% saturation	14.52	14.88	3.85	3.84	3.37	4.17	3.40	3.85
L2: 50% saturation	15.28	15.54	7.38	7.58	6.77	7.95	5.59	5.60
L3: 75% saturation	16.80	15.92	10.56	9.97	10.40	10.11	7.10	7.07
SEm. ±	0.61	0.96	0.17	0.22	0.09	0.28	0.17	0.24
CD at 5%	1.70	2.67	0.47	0.62	0.25	0.77	0.49	0.67

NS = Not significant

Effect of calcium sources

Calcium sources which contain either only calcium or both calcium and sulphur are generally used in groundnut production. During 1989, calcium oxide produced significantly more pod yield (15.06 g) than calcium sulphate (13.66 g). Satyanarayana *et al.*, (1975) reported that in acid soils with pH 5.1 at Bangalore, application of lime at one tonne per ha increased the pod yield of groundnut from 0.66 tonnes in control to 1.32 tonnes per ha. The pH of the soil in the study was 5.8 in Chintamani soil and 5.3 in GKVK soil. Beneficial effect of calcium was due to increase in base saturation with concomitant increase in nutrient availability (Sudhir *et al.*, 19897). Further, in the present study calcium oxide application resulted significantly more calcium and magnesium accumulation in kernel as compared to calcium sulphate.

Effect of calcium saturation levels

Pod yield was significantly influenced by the calcium saturation during both the years. Twenty five per cent calcium saturation recorded significant increase in pod yield by 34.19 per cent in 1989 and 41.17 per cent in 1990 over control (Table 2). Increase in calcium saturation to 75 per cent caused significant increase in pod yield (55.25%) over control during 1989 while *there* was *no significant* effect during *1990*. Thus, indicating the great demand for calcium by groundnut crop. Calcium will effectively neutralise the acidity and calcium ions would be retained on exchange complex. McLean and Carbonell (1972) pointed out that at higher base saturation of acid soil, the calcium and magnesium ions are absorbed on sites of pH dependent charges which favour the hydrolysis reaction and increased calcium and magnesium activities.

The overall increase in yield of groundnut due to calcium saturation was due to increase in the availability of nutrients. This was evident from the positive and significant correlation between pod yield and calcium and magnesium status in the soil before sowing and 50 DAs, calcium, magnesium and sulphur concentration in shoot and pod at 60 DAS and in shoot at harvest. Calcium saturation significantly increased the calcium content in the soil before sowing, at 50 DAS and after harvest with successive increment in calcium saturation levels during both the years (Table 2). This may be attributed to higher solution concentration of calcium and absorption of calcium and concomitant released of magnesium to the soil solution phase (Bheemaiah and Ananthanarayana, 1984). The increase in charge density due to calcium saturation has greater affinity for higher valent ions (Bishngi *et al.*, 1988). Thus calcium being divalent ion, calcium saturation increased its concentration on exchange complex. This increased availability of calcium in the soil has greatly influenced the increased accumulation in different plant parts at 60 DAS and at harvest (Table 3).

Table 3. Magnesium content in soil and calcium in different plant parts as influenced by calcium sources and saturation levels in two soils on groundnut

	Magnesium content (meq/100g) in soil						Calcium per cent					
	Before sowing		50 DAS		After harvest		60 DAS Shoot + pod		At harvest			
									Haulm		Kernel	
	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990
Soils												
A : ARS, Chintamani soil	1.65	1.58	1.32	1.18	0.86	0.87	1.58	1.67	1.95	1.74	0.30	0.25
B : GKVK farm soil	1.70	1.63	1.08	1.11	0.77	0.70	1.33	1.60	1.99	1.65	0.16	0.25
SEm. ±	0.20	0.15	0.10	0.09	0.07	0.05	0.04	0.03	0.04	0.03	0.01	0.01
CD at 5%	NS	NS	NS	NS	NS	0.16	0.11	NS	NS	NS	0.04	NS
Calcium sources												
S1: Calcium oxide	1.62	1.54	1.20	1.17	0.86	0.81	1.48	1.60	1.97	1.68	0.25	0.26
S2: Calcium sulphate	1.73	1.67	1.20	1.12	0.77	0.75	1.43	1.66	1.97	1.71	0.21	0.23
SEm. ±	0.20	0.15	0.10	0.09	0.07	0.05	0.04	0.03	0.04	0.03	0.01	0.01
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.01
Calcium saturation levels												
L0: Control	0.68	0.60	0.66	0.65	0.65	0.56	1.37	1.47	1.68	1.36	0.18	0.21
L1: 25% saturation	1.60	1.58	0.96	1.04	0.95	0.95	1.35	1.63	2.06	1.69	0.26	0.26
L2: 50% saturation	1.95	1.84	1.70	1.60	0.90	0.86	1.64	1.64	1.94	1.75	0.27	0.25
L3: 75% saturation	2.49	2.40	1.48	1.30	0.78	0.75	1.46	1.80	2.21	1.98	0.23	0.27
SEm. ±	0.29	0.22	0.14	0.13	0.10	0.08	0.06	0.05	0.05	0.05	0.02	0.01
CD at 5%	0.81	0.61	0.40	0.35	NS	0.22	0.16	0.14	0.16	0.14	NS	0.02

NS = Not significant

Magnesium content in the soil increased with successive increment in calcium saturation upto 75 per cent before sowing during both the years and upto 50 per cent at 50 DAS and after harvest (Table 3). In different plant parts synergistic effect has been observed between calcium saturation at 25 per cent and magnesium indicating the release of magnesium from exchange complex into soil solution and subsequent uptake by the crop (Table 4).

Calcium saturation caused greater accumulation of sulphur in different parts of groundnut during both the years (Table 4). This may be explained due to the mechanism of desorption taking place consequent to an increase in pH dependent charge (Korentajer *et al.*, 1983). The neutralisation process further enhance the mineralisation of organic matter which will contribute to the release of sulphur and its accumulation in the plant.

Table 4. Magnesium and sulphur (%) in different parts at different stages as influenced by calcium sources and saturation levels in two soils on groundnut

	Magnesium (per cent)						Sulphur (per cent)					
	60 DAS Shoot + pod		At harvest				60 DAS Shoot + pod		At harvest			
			Haulm		Kernel				Haulm		Kernel	
	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990
Soils												
A : ARS, Chintamani soil	0.38	0.24	0.45	0.45	0.10	0.09	0.45	0.35	0.23	0.26	0.26	0.16
B : GKVK farm soil	0.36	0.29	0.54	0.53	0.08	0.11	0.36	0.46	0.27	0.21	0.26	0.20
SEm. ±	0.02	0.02	0.04	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
CD at 5%	NS	NS	NS	0.07	0.01	NS	0.05	0.04	0.02	0.03	NS	0.02
Calcium sources												
S1: Calcium oxide	0.34	0.27	0.41	0.48	0.11	0.09	0.39	0.41	0.25	0.22	0.27	0.17
S2: Calcium sulphate	0.40	0.25	0.59	0.50	0.08	0.10	0.42	0.40	0.24	0.24	0.25	0.19
SEm. ±	0.02	0.02	0.04	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
CD at 5%	NS	NS	0.11	NS	0.01	NS	NS	NS	NS	NS	NS	NS
Calcium saturation levels												
L0: Control	0.31	0.10	0.25	0.32	0.02	0.06	0.30	0.31	0.16	0.16	0.21	0.12
L1: 25% saturation	0.40	0.32	0.52	0.63	0.13	0.13	0.44	0.41	0.26	0.23	0.27	0.21
L2: 50% saturation	0.36	0.36	0.65	0.55	0.10	0.11	0.45	0.46	0.26	0.25	0.25	0.18
L3: 75% saturation	0.42	0.28	0.58	0.47	0.11	0.09	0.43	0.45	0.31	0.29	0.32	0.21
SEm. ±	0.04	0.03	0.05	0.03	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
CD at 5%	NS	0.08	0.15	0.09	0.02	0.02	0.08	0.06	0.03	0.04	0.03	0.03

NS = Not significant

Hence, it can be concluded that calcium saturation upto 75 per cent irrespective of soil types can adequately meet the greater demand of calcium in enhancing the pod yield of groundnut and also cause increased availability of magnesium and sulphur.

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MANAGEMENT OF AFLATOXIN CONTAMINATION OF GROUNDNUT*

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ABSTRACT

Aflatoxin contamination of groundnut is a serious problem in most groundnut-producing countries; in some regions the problem is largely preharvest while in other regions it is mainly postharvest. The most effective way to avoid aflatoxin contamination is to prevent seed infection by the aflatoxin-producing fungi, Aspergillus flavus, A. parasiticus, and A. nomius, at all stages in production, storage, and processing. All possible aflatoxin management systems including preventive measures (cultural practices, use of A. flavus-resistant cultivars, and provision of effective storage conditions) and curative practices (decontamination/segregation of contaminated groundnuts, and detoxification procedures) are discussed. Some possible future management strategies are suggested.

Key words : Groundnut; Arachis hypogaea; Aflatoxin; Aspergillus flavus; Aflatoxin management; Genetic resistance.

INTRODUCTION

Aflatoxin contamination of groundnut is a serious problem in most groundnut-producing countries. Infection of groundnut kernels by the aflatoxin-producing fungi, *Aspergillus flavus*, *A. nomius*, and *A. parasiticus*, and subsequent contamination with aflatoxins may occur before harvest, during postharvest curing and drying, or in storage (Dickens, 1977; Mehan, 1987). Aflatoxin contamination is largely a preharvest phenomenon in the semi-arid tropics, while in the more humid tropics it is predominantly a postharvest problem. Research in a number of countries has provided an understanding of the effects of cultural practices, crop produce handling, and storage conditions on aflatoxin contamination in groundnuts, and this has been used to formulate aflatoxin management practices to be used by producers and those concerned with purchase, storage and processing of groundnuts and groundnut products.

For management of infection by the aflatoxin-producing fungi and subsequent aflatoxin contamination of groundnut, both preventive and curative practices are important. Therefore, aflatoxin management should be initiated in the farmers' field and should continue through harvest, crop produce handling, marketing, storage and processing. Preventive options include cultural practices (e.g., soil application of gypsum, field drying of crop produce in inverted windrows), application of plant protection chemicals and provision of effective storage conditions and care during processing, while curative measures should include decontamination/segregation of contaminated pods and kernels and effective detoxification procedures. Genetic resistance is a desirable component of any integrated aflatoxin management system.

In this paper I discuss available aflatoxin management systems, and then provide some possible future management strategies.

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Management of aflatoxin contamination before harvest

Cropping groundnut continuously on the same land leads to high populations of the aflatoxin-producing fungi in the soil and this increases the probability of preharvest seed infection and aflatoxin contamination (Joffe and Lisker, 1970; Pettit and Taber, 1968). Crop rotation with cotton, tobacco and some cereals including wheat, rice, and millet can greatly reduce the build-up of inoculum of *A. flavus*/*A. parasiticus* (Pettit and Taber, 1968). Soil types influence build-up and survival of the aflatoxigenic fungi (Graham, 1982; Mehan *et al.*, 1991). Light sandy soils and Alfisols favour rapid proliferation of these fungi, particularly under dry conditions, and risks of preharvest aflatoxin contamination are high in these soils. There appears to be less risk of preharvest contamination of groundnut in Vertisols; high water-holding capacity may be partly responsible for this (Mehan *et al.*, 1991).

Drought stress favours both fungal infection and aflatoxin production in groundnut (Davidson *et al.*, 1983a; Cole *et al.*, 1984). Infection by the aflatoxigenic fungi and aflatoxin contamination before harvest can be either prevented or greatly reduced by avoiding drought stress, particularly during the latter stages of pod development (Wilson and Stansell, 1983; Cole *et al.*, 1984).

In order to prevent preharvest infection and aflatoxin contamination it is important to choose a cultivar that fits a particular growing season and matures at the end of the rains so that postharvest field drying can be done under dry conditions. If the rainy season is longer than the duration of the crop, sowing dates may be adjusted so that the crop matures at the end of the rainy season and postharvest conditions are congenial for rapid and effective curing and drying of the produce.

Excessive weed growth may deplete available soil moisture and contribute to drought stress, so effective weed control can reduce the risk of aflatoxin contamination.

Providing adequate soil moisture during the 4-6 weeks prior to harvest should be effective in prevention of seed infection by aflatoxigenic fungi and aflatoxin contamination (Wilson and Stansell, 1983; Cole *et al.*, 1984). Supplementary irrigation of the rainfed groundnut crop, especially during late season drought stress, prevents or greatly reduces preharvest aflatoxin contamination and may also reduce pod damage by soil-inhabiting insect pests. The beneficial effects of irrigation in alleviating preharvest contamination may be limited if part of the groundnut field is not irrigated. In irrigated fields the areas missed by the irrigation system may contain high levels of *A. flavus*-infected groundnuts. Pods from dry areas of the field should be handled and processed separately to remove *A. flavus*-contaminated groundnuts in the field. Close observation of the groundnut field prior to digging may reveal areas of plant stress, such as isolated pockets of severe drought stress, where fungal infection and aflatoxin contamination is commonly observed.

In some severe drought stress areas, where soil hardens at harvest, irrigation is given to facilitate lifting of the crop. In such cases lifting should be done immediately after irrigation; otherwise complete rotting of pods may occur.

Although it has not been proved that drought-tolerant cultivars have greater resistance to fungal infection of pods/seeds than drought-susceptible cultivars, it is a reasonable supposition and it is probably wise to use drought-tolerant cultivars in areas with frequent late season drought stress.

Application of gypsum to the soil at the time of pegging can reduce infection and aflatoxin contamination and contribute to improved crop quality (Davidson *et al.*, 1983b; Wilson and Walker, 1988).

Cultivation and crop protection practices that lower the incidence of soil- inhabiting pests should reduce aflatoxin contamination. Preharvest aflatoxin contamination can be substantially reduced by avoiding mechanical damage of pods during weeding. Individual plants that die from attack by pests and diseases should be lifted separately because of probable aflatoxin contamination.

Timely lifting of the crop at maturity can reduce infection and aflatoxin contamination.

Management of postharvest aflatoxin contamination

Where groundnuts are already infected by the aflatoxigenic fungi at harvest, there may be a serious build-up of aflatoxin contamination if environmental conditions during crop drying favour development of these fungi (McDonald and Harkness, 1964). Where preharvest conditions have not favoured fungal infection of seeds, there may still be infection of pods and with unfavourable postharvest drying conditions the aflatoxigenic fungi may invade the seed with subsequent aflatoxin contamination. Rain or humid weather during and after harvest contributes to unfavourable postharvest drying conditions.

Postharvest aflatoxin contamination can be either prevented or minimized by the following practices :

1. Avoiding mechanical damage to pods during harvesting and subsequent processing;

2. Rapid field drying of the produce can largely prevent postharvest invasion of seeds by aflatoxigenic fungi;

One of the most effective rapid curing and drying procedures for reducing aflatoxin contamination is to invert the groundnut plants in windrows. Pods are exposed to direct sunlight and air currents and they dry rapidly and effectively (Dickens and Khalsa, 1967). However, very rapid drying may cause testa slippage and production of seeds with off-flavors, and may reduce seed viability.

3. Preventing rewetting of the crop produce either during or after the drying process;

When groundnut plants with high moisture content are lifted and dried in windrows there may be a considerable amount of seed infection by aflatoxigenic fungi, particularly under unfavourable drying conditions (Jackson, 1967a, b). In warm, wet weather the drying time is extended and the risk of aflatoxin contamination is increased. Rain shortly after lifting is not harmful, but rain after the groundnuts are partially dried, followed by poor drying conditions, is likely to result in aflatoxin contamination. In areas where rains continue after harvest, if field drying of groundnuts is delayed then aflatoxin contamination is highly probable. During the rainy season and also in the case of unseasonal rains at harvest it may be difficult to rapidly dry the harvested produce. In these situations, construction of special drying yards at strategic points in villages, and the availability of cheap plastic/polyethylene material to cover the produce if rain occurs, should prevent mold growth on pods. Treating the crop produce with 5% common salt (sodium chloride) can reduce mold growth (Farah *et al.*, 1983).

4. Discarding moldy and damaged pods and drying the produce to a safe moisture level (8%) (Dickens, 1977) before storage of pods.

Management of aflatoxin contamination of groundnuts in storage/transit

Increased moisture from rewetting of pods in storage or from exposure of pods to high humidity for extended periods of time favours rapid invasion by aflatoxigenic fungi with subsequent aflatoxin contamination.

It is important that dried pods/seeds be protected from wetting and stored in well-ventilated warehouses or silos with protection from insect infestation.

Siting groundnut stores in high relative humidity areas should be avoided if possible. Providing dry, well-ventilated godowns with concrete floors should prevent contamination in storage. Aeration is essential for prevention of aflatoxin contamination during storage of groundnuts. Cool temperatures (12-20°C) and uniform moisture distribution reduce mold growth and insect activity.

In order to eliminate an insect infestation in either the warehouse or on/in the bag stacks, prophylactic spraying of the structure and the exposed bag surfaces with approved insecticide may be employed. Fumigation may be implemented with fumigants effective against insects and fungi. For large-scale fumigation, methyl bromide or mixtures of ethylene dibromide and methyl bromide (1:3) should be effective when applied under tropical temperature conditions (Agboola and Opadokin, 1982). Phosphine generating fumigant products are also effective for this purpose (Agboola and Opadokin, 1982).

Infested transport containers may provide sources for contamination of the stocks that are delivered by the transport system. Therefore, it is important to disinfest empty transport containers. If the transit is prolonged, fumigation of the full transport containers should be done at the final destination. During transit in humid weather and during ocean transportation, moisture from the air or water of condensation may be absorbed by the consignment. The moisture content of the shipment should be verified before warehousing. Tarpaulins or airtight containers effectively prevent moisture uptake during transportation. Packaging materials resistant to insect penetration, and ballooning of the bag stacks reduce the risk of aflatoxin contamination.

Decontamination/segregation of aflatoxin-contaminated groundnuts

Where groundnuts are intended for human consumption, a reduction in aflatoxin contamination may be achieved by selective processes such as hand-picking and electronic sorting to remove mold-damaged seeds. This is the basis for some decontamination/segregation procedures that have been developed and utilized by the groundnut industry in several countries (Dickens, 1977; Tiemstra, 1977; Read, 1989). Sorting raw kernels by visual examination is not effective when apparently healthy kernels have concealed mold damage. This does not apply when scanning blanched kernels and it is important that such examinations are carried out at this later stage in processing. The most effective way to remove off-colour kernels is with electronic colour sorting. Kernels that differ substantially in colour from the standard for the particular cultivar(s) being examined should be rejected. Blanching followed by photoelectric colour sorting and hand-picking effectively reduces aflatoxin contamination. In processes where sorting is done after roasting and blanching, the darker and nonblanched kernels should also be removed.

However, there are problems associated with intrinsic seed colour differences among cultivars and discolouration caused by factors other than fungal infection. The primary objective is to reduce aflatoxin contamination by removal of toxic kernels; however, methods for inspection, separation, and diversion should be designed so that contaminated kernels are removed and non-contaminated kernels are not removed from the sample. It is important to detect concealed mold damage in order to increase the effectiveness of the decontamination/ segregation of kernels.

In the USA and Australia, segregation of toxic groundnuts has been very successful. Contaminated lots are diverted for oil extraction and non-food uses (Dickens, 1977). While this approach is recommended for developed countries, safeguards are required if segregation of contaminated groundnut lots is to be used in less developed countries where the rejected groundnuts could be inadvertently distributed to local markets. It is important that those concerned with segregation should ensure that highly toxic material does not get back into the food chain. Where facilities exist, oil may be extracted from this material and detoxified, but the cake is not suitable for animal feed. Perhaps it could be used as a fertilizer.

Control of aflatoxin contamination with groundnut cultivars resistant to seed infection and colonization by aflatoxigenic fungi

The use of groundnut cultivars resistant to seed infection and colonization by the aflatoxigenic fungi is an effective and practical way of either preventing or greatly reducing aflatoxin contamination.

Much research on development of cultivars with high levels of resistance to seed invasion and colonization by *A. flavus*/*A. parasiticus* has been conducted. Resistance traits of the testa have been studied by scientists in several countries (Laprade and Bartz, 1972; Mixon and Rogers, 1973; Bartz *et al.*, 1978; Zambettakis *et al.*, 1977; Mixon, 1979; Zambettakis *et al.*, 1981; Mehan *et al.*, 1981; Mehan and McDonald, 1984; Tsai and Yeh, 1985; Mixon, 1986; Pua and Medalla, 1986; Rao *et al.*, 1989). Several genotypes and breeding lines with resistance to seed invasion and colonization in laboratory inoculation tests have been reported. This resistance will probably be of most value during postharvest field drying or in storage.

Genetic resistance of groundnuts to seed infection and aflatoxin contamination in the field has been extensively studied in the last decade (Davidson *et al.*, 1983b; Kisyombe *et al.*, 1985; Mehan *et al.*., 1986; Mehan *et al.*, 1987). This is important because it identified preharvest infection and aflatoxin contamination as a serious problem in rainfed groundnut production areas of the semi-arid tropics. Several genotypes with field resistance to seed infection by *A. flavus* have been reported (Kisyombe *et al.*, 1985; Mehan *et al.*, 1987). Some of these genotypes also possess resistance to seed colonization. These resistances in some cultivars (e.g., J 11 and 55-437) could reduce aflatoxin contamination in some environments.

Resistance to seed infection by aflatoxigenic fungi is also important for maintaining quality of seed used for planting because these fungi cause seed rots and aflaroot disease of seedlings.

Resistance based on genotypes with seeds that can be infected and colonized by aflatoxigenic fungi but prevent aflatoxin production would be useful. Immunity to aflatoxin production has not been reported, but there are marked genotypic differences in aflatoxin production.

Resistant cultivars should be part of an integrated aflatoxin management programme that includes cultural and crop handling procedures appropriate for different agroecological situations. The use of cultivars resistant to aflatoxigenic fungi in combination with crop management practices designed to minimize the risk of aflatoxin contamination could provide a solution to this serious problem.

Regulatory control measures

Aflatoxin regulatory programmes have been introduced in some countries (Van Egmond, 1989). Regulatory programmes in some developing countries are introduced primarily to protect the export market of agricultural commodities including groundnut and groundnut products. These regulations must be strictly enforced, otherwise the importing countries will reject the commodities resulting in a loss of foreign exchange. Many groundnut importing countries (e.g., Germany, Denmark, the Netherlands, and the U.K.) limit the amount of aflatoxins in groundnut and groundnut products. The tolerance level for aflatoxin in a commodity varies widely depending on the country and the foodstuff and also whether the foodstuff is designated for human or animal consumption (Van Egmond, 1989). Countries dependent on export of groundnuts are obliged to establish export limits that meet import requirements. This leads to economic loss if the requirements are unnecessarily strict. In many developing countries, domestic regulatory measures on aflatoxins have received little or no attention.

Aflatoxin detection is an essential component of an aflatoxin control programme. The use of ELISA kits to detect aflatoxins should expedite development of management/control programmes because the kits are easy to use in locations with limited laboratory facilities.

Other approaches/strategies to the groundnut aflatoxin problem

Soil solarization

Soil solarization may be effective in reducing preharvest infection and aflatoxin contamination. Solarization for disinfestation of soil involves mulching soil with transparent polyethylene sheets in the hot season before planting. This should reduce soil populations of the aflatoxigenic fungi, particularly in light sandy and sandy loam soils with a high population of aflatoxigenic fungi.

The use of biocompetitive agents

The use of microbes to reduce preharvest aflatoxin contamination has been suggested. This is possible with non-toxigenic strains of *A. flavus*/*A. parasiticus* (Cleaveland *et al.*, 1990).

It is important to use aggressive, stable, non-aflatoxigenic strains as biocompetitive agents. These strains should not have the potential to exchange genetic material through anastomosis and re-acquisition of the aflatoxigenic trait from soil- inhabiting aflatoxigenic strains. It should be possible to develop 'superior' (stable, aggressive) non-aflatoxigenic strains with existing genetic engineering technology.

Aflatoxin-resistant transgenic groundnuts

New molecular techniques for development of resistance to aflatoxigenic fungi/aflatoxin should be applied to groundnut. A gene conferring resistance to infection by aflatoxigenic fungi or to aflatoxin production should be introduced in groundnut with the microprojectile bombardment technique. *Aspergillus*-resistant or aflatoxin-resistant transgenic plants should be an effective genetic approach to management of aflatoxin production.

CONCLUDING REMARKS/RECOMMENDATIONS

There are good prospects for breeding groundnut cultivars with useful levels of resistance to seed infection and colonization by *A. flavus*/*A. parasiticus*. Efforts to combine resistances to preharvest seed infection and postharvest seed colonization or aflatoxin production should be initiated. Research should be intensified into elucidation of resistance mechanisms and their inheritance. Resistant cultivars will be essential for specific producer and user requirements (e.g., oil-type and confectionery-type). Resistant cultivars should be an important component of an integrated aflatoxin management system.

Education and extension form an integral part of any aflatoxin prevention and control programme. Emphasis should be given to regional and national level training programmes specifically aimed at prevention and control measures for the personnel involved in crop management, crop-produce handling and storage of groundnut.

Availability of popular extension literature on aflatoxin management strategies aimed at educating the farmers and extension workers would be helpful in the prevention and control of the groundnut aflatoxin problem. Involvement of voluntary groups such as trade associations, farmer groups, and consumer councils would help in the dissemination of information pertaining to action programmes on the prevention of aflatoxin contamination.

There is an obvious need to conduct systematic surveys in different seasons to determine the extent to which groundnuts are contaminated with aflatoxins (preharvest and postharvest) in different agroecological zones. This information could be used to formulate plans for effective control of aflatoxin contamination.

Novel approaches to solve the aflatoxin problem should be pursued. Development of biocontrol agents and aflatoxin-resistant transgenic groundnut cultivars are high priority research goals.

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SOME CROP PHYSIOLOGICAL APPROACHES FOR GROUNDNUT IMPROVEMENT*

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ABSTRACT

Groundnut is an important oilseed and cash crop in India, where it is primarily grown under rainfed conditions. Mean yields of groundnut are low and erratic under rainfed conditions with a national average of 750 kg/ha. These poor yields are attributed to various biotic and abiotic stresses. Yields under irrigated conditions in India are also lower than those in the developed countries.

This paper describes crop physiological factors influencing groundnut yields. An effort was made to analyze groundnut production in terms of crop physiological attributes and to indicate the scope of using these attributes as selection criteria for crop improvement.

Key words : Groundnut; Crop physiology; Yields.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed and cash crop in India, which ranks first in the world's groundnut production. The average yield of groundnut in India, however ranged between 700-900 kg/ha during the past decade (Fletcher *et al*., 1992). These yields are low compared to average yields of 2500 kg/ha in developing countries (Gibbons, 1979). The highest farm yield achieved (9.6 t/ha was reported from Zimbabwe (Hilderbrand, 1980) under high input conditions, indicating the crop's production potential.

In India, poor yields has been attributed to pests, diseases and the un- reliable rainfall. Yields are often subject to large temporal and spatial variation for reasons which are not always obvious (Shankara Reddy and Adivi Reddy, 1979). This failure to achieve the yield potential which is common, must have a physiological explanation. Thus a study of crop physiological factors influencing yields is basic to any improvement efforts.

Recent on-farm researcher managed trials conducted in India indicated that improved genotype contributed 25-28% to yield increases, while improved agronomy contributed about 30-32%. However, combining improved genotype and agronomy resulted in a synergistic yield improvement ranging from 50 to 150% (McDonald, Personal communication). Obviously, a logical approach to increasing yields calls for an appropriate combination of crop improvement (by genetics) and management (agronomy).

Various aspects of groundnut physiology were well described in papers (Williams and Nageswara Rao, 1984) and review articles (Boote *et al.*, 1982, Ketring *et al.*, 1982 Reddy, 1988).

The objective here is to analyze groundnut production in terms of crop physiological attributes, describe how they influence yields, and indicate how one can select for these attributes.

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Crop physiological basis for yield differences

The dry matter yield achieved by a crop at final harvest can be described as :

$Y = CGR \times d$ ....(1)

where, CGR is the crop growth rate (g m^{-2} day^{-1}) and 'd' is the crop duration in days. Pod yield achieved by the crop (Yp) can then be described as :

$Yp = CGR \times d \times p$ .....(2)

where, p is the proportion of the daily assimilate partitioned into pods during the pod filling phase. If one assumes that the duration of the crop is fixed, then CGR and p are the major crop parameters determining crop yield. In crop improvement point of view, it is important to understand all factors influencing these parameters.

It is well known that CO_2, radiation and water are fundamental for plant growth. Assuming that CO_2 is never limiting, then radiation and water availability become major factors influencing the crop yield.

Radiation interception and radiation-use efficiency

Using the radiation parameters, the dry matter produced (Y) by a given genotype can be described as :

$Y = R \times RUE$ ......(3)

where, R is the cumulative radiation intercepted by the canopy during a given period, and RUE is the radiation-use efficiency, i.e., amount of dry matter produced per unit of radiation intercepted.

Radiation interception (both in terms of space and time) is an important requirement for carbon assimilation. The major plant determinant of photosynthetic potential is the development and maintenance of photosynthetically active leaf area. Leaf area is the product of leaf initiation rate and individual leaflets size. Both processes are strongly influenced by genetic and environmental factors. It has been observed for groundnut that, complete ground cover in equidistant planting is achieved at a leaf area index (LAI) of approximately 3 (Fig.1) and once this has occurred, crop growth rate depends mainly on other factors such as availability of water and duration. The amount of radiation intercepted by the crop is influenced by factors affecting LAI, such as plant population/mortality during crop growth, canopy development, pests and disease incidence etc.

It is well documented that total dry matter production is linearly related to cumulative radiation intercepted. Mathews *et al.*, (1988b), reported that four genotypes when grown under water-deficit conditions, had intercepted same amount of solar radiation but produced different amounts of dry matter which resulted in significant differences in radiation-use efficiency between genotypes particularly during the later parts of the growing season (Fig 2.).

The rate of dry matter production depends not only on the leaf area index (LAI) but also on the leaf orientation with respect to the sun. We have examined the effect of canopy structure and geometry on groundnut productivity using genotypes with various leaf sizes and

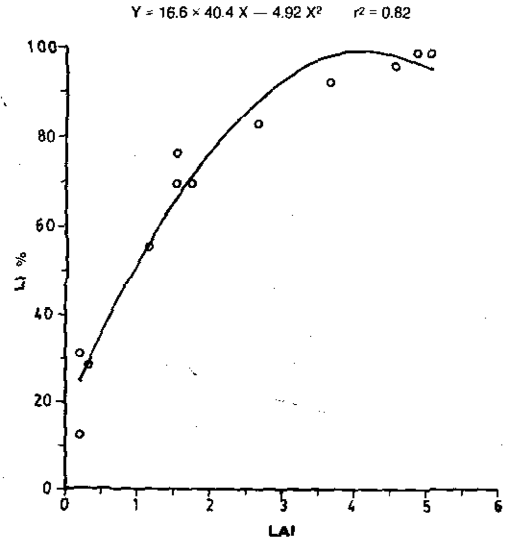

Fig. 1 The relationship between radiation absorbed (Li) and leaf area index (LAI) of groundnut at ICRISAT center, 1988-89 post rainy season

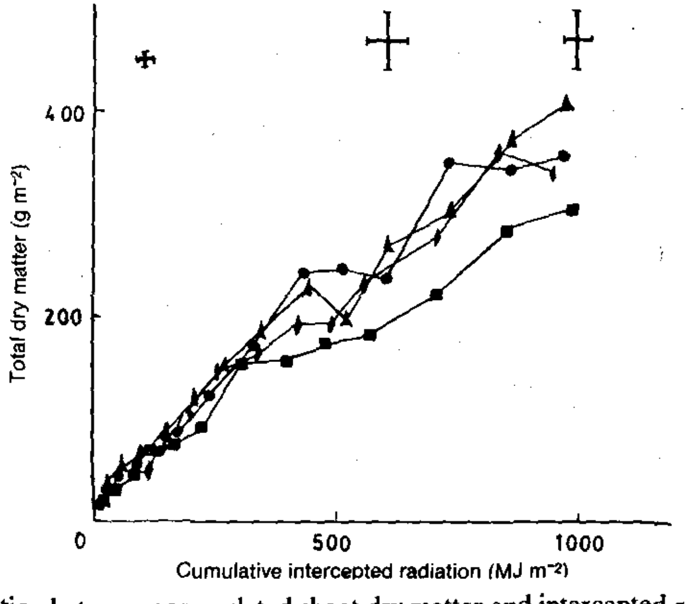

Fig. 2 Relation between accumulated *shoot dry matter* and *intercepted radiation* for four groundnut genotypes, (●) TMV 2, (▲) Kadiri 3, (◆) NC Ac 17090 and (■) EC 76446 (292). Typical standard errors are shown.
(Source : Mathews *et al.*, 1988b)

shapes grown under irrigated and water-deficit conditions. Results indicated that TMV 2-NLM (mutant of TMV 2) which has narrow-leaf, but more leaf number, produced more total dry matter compared to TMV 2 under irrigated and mid-season drought conditions. One physiological parameter which contributed to greater total yield in TMV 2-NLM was the increased radiation-use efficiency (Table 1).

Table 1. Total dry matter (TDM), pod dry matter (PDM) and radiation-use efficiency (RUE) of TMV 2 and narrow leaf mutant of TMV 2 (TMV 2-NLM) grown under *irrigated and water deficit conditions at ICRISAT Center.*

	1989-90 postrainy season			1990 rainy season					
	Irrigated			Irrigated			Mid-season drought		
Genotype	TDM (t/ha)	PDM (t/ha)	RUE g/MJ	TDM (t/ha)	PDM (t/ha)	RUE g/MJ	TDM (t/ha)	PDM (t/ha)	RUE g/MJ
TMV 2	11.1	3.3	0.95	6.14	1.3	ND	5.18	0.78	0.59
TMV 2-NLM	12.2	3.9	1.16	7.50	1.2	ND	7.20	0.89	0.75
SE	±0.76	0.31	0.06	±0.29	±0.04	-	±0.29	±0.04	±0.08
CV(%)	13.2	25.3	18.1	4.8	5.1	-	4.8	5.1	21.1

ND = not determined

Radiation-use efficiency was positively correlated with crop-growth rate in a set of groundnut genotypes grown under adequately irrigated conditions (Fig.3). The implication of genotypic variation in radiation-use efficiency is an important criteria for selection.

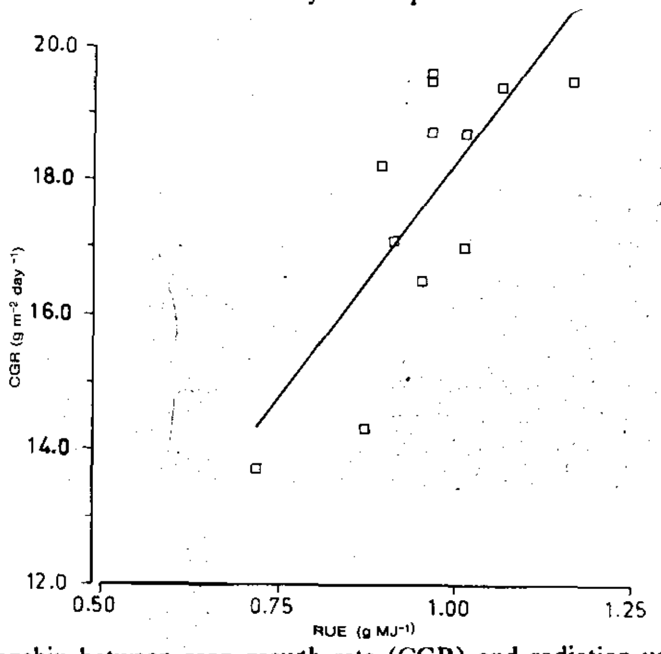

Fig. 3 Relationship between crop growth rate (CGR) and radiation use efficiency (RUE) in 12 groundnut genotypes grown under irrigated condition during the 1989-90 postrainy season at ICRISAT center

Another factor influencing radiation-use efficiency is the ability of a genotype to orient it's leaves to intercept or avoid incoming radiation (para heliotropism). Variability in stomatal closure and leaf movement may represent adaptative mechanisms for over a range of environmental conditions (Shackell and Hall, 1979, Ramesh babu *et al.*, 1983). Various reports have indicated that para heliotropism may help to reduce leaf temperature (Shackell and Hall, 1979). Genotypic differences exist in groundnut germplasm for para heliotropism. However, in one study, the observed variation in para heliotropism did not result in consistent differences in leaf temperature between genotypes (Mathews *et al.*, 1988b). These results may be because the small differences in leaf temperature as a result of leaf folding were over ridden by a strong upward sensible heat flux from the soil surface during drought condition. These results suggest that under severe drought conditions, where surface soil temperature increases, the role of para heliotropism in reducing canopy temperatures may be of little consequence. However, it has been reported that leaf folding helps to minimize damage to photosynthetic apparatus under high light intensities and high temperatures (Ludlow and Bjorkman, 1985). This phenomenon requires further investigation.

Water-use and water-use efficiency

The total dry matter produced (Y) can also be described as :

Y = T x WUE ....(4)

where T is the total amount of water loss through transpiration and WUE is the efficiency with which dry matter is produced per unit of water transpired.

Many studies have demonstrated that crops accumulate dry matter at a rate proportional to the amount of transpired water over a given period (Stewart *et al.*, 1975, Fisher and Turner, 1978, Ong *et al.*, 1987, Azam-Ali *et al.*, 1989). The slope value (b term) of the relationship between dry matter and transpiration indicates WUE. Azam-Ali *et al.*, (1989) reported that the regression co-efficient (r^2) between dry matter produced and transpiration was 0.84, when roots were excluded (Fig.4a), but the r^2 increased to 0.94 when roots weight was included in the dry matter estimation (Fig.4 b).

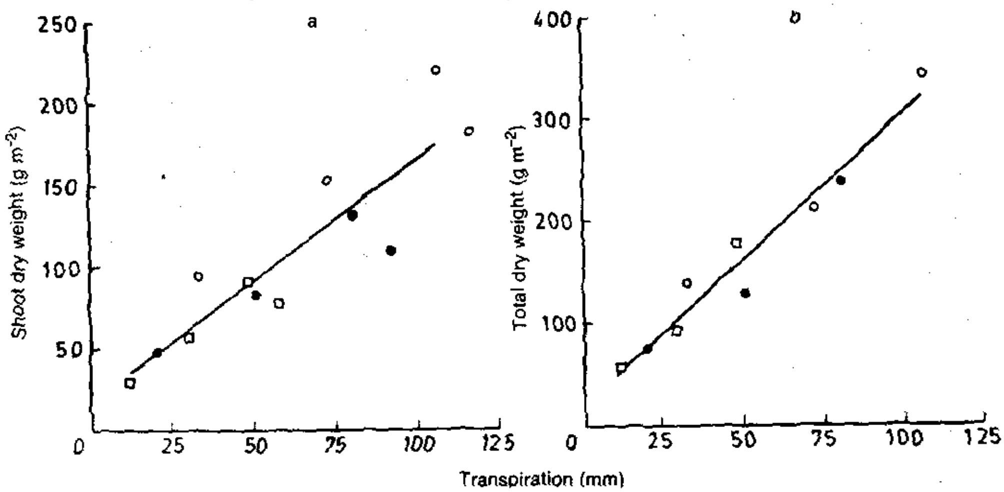

Fig. 4 · (a) The relation between shoot dry weight and transpiration of TMV 2 grown at 3 plant densities, slope = 1.57 (± 0.24), mg g^{-1} (r^2 = 0.83) (Source : Azam-Ali et al., 1989)

(b) The relation between total dry weight (including roots) and transpiration of TMV 2 grown at 3 plant densities, slope = 3.00 (± 0.27) mg g^{-1} ($r^2 \approx$ 0.94) (Source : Azam-Ali et al., 1989)

This close relationship between total dry matter production and transpiration for a given genotype implies that any genetic traits or managerial practices that enhance transpiration *in the total evapotranspiration (ET) would have positively effect the yield, and that yields* can not be increased by reducing transpiration.

There is little information on genotypic variation for transpiration and water-use *efficiency, mainly because of practical difficulties involved in measurement of transpiration* and root biomass in the field. In a field experiment, Mathews *et al.,* (1988a) observed little variation in transpiration among four groundnut genotypes under prolonged drought conditions during early crop growth (Table 2).

Table 2. Dry weight (DM), water use (T) and water-use efficiency (WUE) of four groundnut genotypes during prolonged water deficit conditions.

Genotype	DM (g m^{-2})	T *(mm)*	WUE (g kg^{-1})
TMV 2	424	219	1.94
Kadiri 3	493	227	2.17
NC Ac 17090	464	228	2.04
EC 76446 (292)	389	227	1.71
SE	± 21	± 6	± 0.03

(Source: Mathews *et al.*, 1988)

However, in another field experiment we observed substantial variation among genotypes for both transpiration and water uptake from various soil depths during a drought phase (Nageswara Rao *et al.* 1992, Table 3).

Table 3. Amount of water (mm) extracted from different soil horizons by 10 groundnut genotypes during the end-of season drought.

	Soil horizons (cm)			
Genotype	0-30	30-60	60-90	90-120
ICG 1697	14	11	17	20
ICG 2716	20	12	19	16
ICGV 86707	16	13	18	18
ICG 221	12	9	15	19
ICGV 86635	16	10	14	20
ICGV 86644	12	10	16	16
ICG 476	13	13	13	9
ICG 2738	18	10	20	21
ICG 5305	16	12	16	18
ICGV 86743	13	9	12	17
SE	± 2.2	± 1.6	+ 2.1	± 2.5

(Source: Nageswaea Rao *et al.,*)

For example, ICG 476 could extract 9 mm of water from 90-120 cm depth while ICG 1697, ICGV 86635 and ICG 2738 extracted about 20 mm indicating a significant variability among genotypes for water extraction from deeper soil profile. There is little information available on variation in root physical parameters and its relationship with water uptake in groundnut. This information will be of vital importance if T is to be improved.

Water-use efficiency is a genetic trait which can contribute to productivity when water resources are scarce. Variation in water-use efficiency between and within species, has been shown as early as 1914 (Briggs and Shanz, 1914). More recently, variation for water-use efficiency has been observed among genotypes in grass species (Bleak and Keller, 1973), Cotton (Hubick and Farquhar, 1987) and groundnut, (Hubick *et al.*, 1986, Wright *et al.*, 1988, ICRISAT, 1990). Recent experiments using selected groundnut genotypes have shown significant variation in water-use efficiency, ranging from 1.81-3.15 g kg/ha. Water-use efficiency accounted for about 80% of variation in dry matter produced under a given environmental conditions (Wright *et al.*, 1992, unpublished).

While potentially useful, water-use efficiency is not an easy trait to select for and exploit in a breeding programme because of practical difficulties involved in measurement of transpiration and root mass in the field experiments. Recently, it has been shown that the carbon isotope discrimination against ^{13}C during CO_2 assimilation (Δ) was negatively correlated with water-use efficiency in wheat (Farquhar and Richards, 1984). Subsequently, strong correlation between Δ and water-use efficiency has been observed in other crops including groundnut (Hubick *et al.*, 1986, Wright *et al.*, 1988, Wright *et al.*, 1992, unpublished data, Fig. 5a). These results imply that water-use efficiency is an important trait to select for and that carbon discrimination technology can be effectively used to identify groundnut

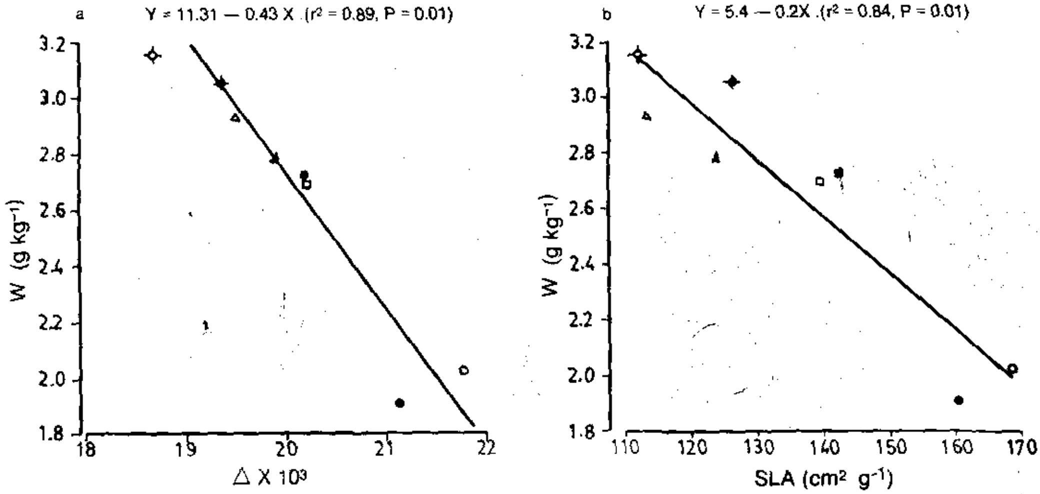

Fig. 5 Relationship of water-use efficiency (W) with carbon isotope discrimination (Δ) (5a), and specific leaf area (SLA) (5b) in Tifton-8 (◇), Shulamit (□), Mccubin (△) and Chico (○), grown under intermittent (closed symbols), and prolonged drought (open symbols) conditions
(Source : Wright and Nageswara Rao, 1992, unpublished data)

genotypes with greater water-use efficiency. However, determination of isotope discrimination requires expensive and sophisticated mass spectrometry facilities which are not easily available.

In a recent study, both WUE and Δ were shown to be strongly correlated to specific leaf area, SLA (defined as leaf area per unit dry wt, $cm^2 g^{-1}$) in groundnut genotypes (Wright *et al.,* 1992, unpublished data, Fig. 5b). It appears that environment and genotype can *significantly influence* Δ *and SLA but the G x E interaction for these parameters was not* significant (Nageswara Rao and Wright, 1992, unpublished data). This observation implies that SLA, which is a crude, but easily measurable parameter can be used as a rapid and inexpensive selection index for high water-use efficiency.

Further experimentation using this technique on a larger scale under varied environments is in progress at ICRISAT Center.

Partitioning of dry matter to pods

Dry matter accumulated in the pods (Yp) can be described using equations (3) and (4) as :

Yp : R x RUE x p .... using eq. (3) or,

Yp : T x WUE x p .... using eq. (4)

where, p is the fraction of that daily assimilates partitioned into pods.

Duncan *et al.*, (1978) evaluated physiological changes which resulted in higher yields in four groundnut cultivars released in the USA. This study concluded that three physiological attributes explained most of the yield variation were (1) partitioning of assimilate between vegetative and reproductive parts, (2) length of the seed filling period and (3) rate of fruit establishment. For example, estimates of daily partitioning to fruit (p) ranged from 41% for the first cultivar released in the USA (Dixie Runner) to 98% for the recently released cultivar, Early Bunch. In experiments conducted at ICRISAT Center, we found large variation for p among genotypes grown under irrigated or drought conditions (Mathews *et al.*, 1988a, ICRISAT, 1990). Genotypic variation for p was more predominant during recovery phase following release of mid-season drought conditions (Nageswara Rao, *et al.*, 1989). The physiological basis of genotypic variation in the recovery is not clear at present.

Although there is large genetic variation in p, conventional methods of determining p are laborious and cumbersome and limit number of entries that can be assessed for this trait. However, simple methodologies are now available to identify genotypes with partitioning attributes needed to maximize yield in a given environment using simple non-determinative measurements (Williams and Saxena, 1991).

Interactions between RUE, WUE and p

Although the genetic traits like canopy geometry, RUE, root parameters, WUE and p are important, it is also necessary to understand their effects on final yield before one recommends screening for such traits for a breeding programme. At present, very little is known about interaction amongst these traits and their effect on yield, even though each of them contribute to dry matter production either directly or indirectly.

From the limited studies conducted in groundnut, the simple linear correlation between dry matter production and radiation interception breaks down once water is in short supply (Azam-Ali *et al.,* 1989). We observed a linear relationship between WUE and RUE under two different drought patterns (Wright, Nageswara Rao, and Farquhar, 1992 unpublished data). It was noted that although RUE declined under severe drought conditions, ranking of genotypes for WUE and RUE was consistent under both drought treatments, suggesting that selection for WUE may concurrently improve RUE, which is an important trait for high biomass-production under non-limiting conditions.

From the limited data available, it appears that WUE is negatively correlated to partitioning of dry matter to pods (p) (r = -0.65) implying that selection for greater WUE might result in greater total dry matter production but not necessarily increased pod yields (Nageswara Rao and Wright, 1992, unpublished data). However, the genotypes involved in these studies are limited in number and it is possible that there may be exceptions to this negative relationship when more genotypes are tested in future studies. If this negative linkage persists even in wider germplasm, then alternate methods for combining these desirable traits are to be sought.

CONCLUSIONS

Groundnut yields are influenced by important physiological traits i.e., partitioning of dry matter to pods, ability to extract water from deeper soil layers, water-use efficiency and radiation-use efficiency. Recent research revealed genotypic variability in groundnut genotypes for the above traits. It is however necessary to develop rapid screening techniques to identify genotypes with these desirable traits. Recently, it has been shown that carbon isotope discrimination in leaves was strongly correlated with water-use efficiency and that it can be used as a rapid screening tool to identify water-use efficient genotypes.

At present, little is known about interaction amongst these traits, even though each of them contribute directly or indirectly, to the yields. For example, water-use efficiency seem to be negatively associated with the partitioning of dry matter to pods.

Further studies are required to understand the interaction of these traits among themselves with the environment and their effect on the final yield.

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DIFFERENTIAL GENOTYPIC RESPONSE TO PROGRESSIVE DEVELOPMENT OF WILTS IN SAFFLOWER

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ABSTRACT

Genotypic differences in relation to the manifestation of the wilt disease symptoms at pre-determined crop growth stages were enumerated in a screening programme involving fifty one promising germplasm accessions and advanced breeding lines of safflower. Studies revealed the influence of crop growth stage on differential response of the safflower genotypes to wilt incidence. It is necessary to screen the genotypes at different crop growth stages right from seedling to post flowering. Screening at one stage viz., seedling or adult plant may not be complete and often lines showing susceptibility or resistance at one stage may show varied responses at another stage. The pattern of disease development in relation to inoculum load (x) and apparent rate of infection ("r") in genotypes belonging to all groups i.e., immune/tolerant, moderately resistant, moderately susceptible and susceptible categories were calculated in representative genotypes. The results are of immense use in selection of parents for hybridization programme aimed at evolving stable and durable sources of resistance in combination with high yield.

Key words : Wilt; Fusarium oxysporum; Genotypic differences; Safflower.

INTRODUCTION

Safflower wilt caused by *Fusarium oxysporum* f.sp. *carthami* Kliesiewicz and Houston, 1962) has assumed economic importance in recent years with increasing incidence being reported from different safflower growing areas (Chakrabarti and Basuchaudhary, 1978; AICROPO, 1990). The disease has become endemic in areas such as Marathwada and Buldana districts of Maharashtra where the crop is grown under intensive management conditions (Nirmal *et al.*, 1989; Pedogaonkar *et al.*, 1990). The yield losses are so high in these areas that the crop can hardly compete with other *rabi* oilseed crops of the region. The continuation of safflower cultivation in irrigated areas largely depends on the identification and development of wilt resistant varieties.

Against this background, an attempt had been made to unravel the genotypic differences in relation to the manifestation of the disease symptoms at pre-determined crop growth stages which help in the identification of stable and durable sources of resistance for wilt. The results of a comprehensive screening programme taken up during the last two *rabi* seasons are presented in this paper.

MATERIALS AND METHODS

With a view to provide ideal disease conditions for testing the reaction of advanced breeding lines and promising germplasm accessions to wilt, a disease sick plot measuring 40 x 25 sq.m was developed at the Research Farm, Directorate of Oilseeds Research, Hyderabad. The field represented a low lying and typical medium to deep loam with alkaline reaction (8.0 pH). Effervescence was high and organic carbon moderate. The perpetuation of causal organism (*Fusarium oxysporum*) in the plot was ascertained by the incorporation of chopped pieces of diseased plants and addition of adequate quantity of inoculum multiplied on autoclaved sorghum seed.

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The test materials comprising 51 (*rabi* 1990-91) and 60 (*rabi*, 1991-92) diverse advanced breeding lines and selected germplasm accessions including five check varieties (Bhima, HUS-305, Tara, A.1 and APRR-3) were sown in Randomized Block Design with two replications in disease sick plot. A single row of 5.0 m length spaced at 45 cm between rows and 20 cm within the row represented the plot size. Two susceptible genotypes (Tara and Manjira) placed after every four rows within the replication served as infector rows. These were sown 15 days prior to the sowing of test materials. The crop was grown as per recommended cultural practices under irrigation. The affected plants were identified and disease counts recorded from seedling stage (= 35 days after sowing) to complete maturity at 15 days interval as per the manifestation and expression of well marked symptoms. The incidence of wilt at each stage was confirmed by isolation and identification of causal organism from randomly selected diseased plant in all genotypes.

In accordance with the scale proposed by Mayee and Datar (1986) the genotypes were grouped into five categories : immune (DI = 0-1%), tolerant (DI = 1-10%), moderately tolerant (DI = 11-20%), moderately susceptible (DI = 20-50%) and susceptible (DI = 51% or more), based on plant mortality due to wilt. The per cent disease was transformed to proportion of infection 'x' and its logarithmic conversion in representative genotypes of various disease categories. Apparent rate of infection 'r' was calculated by the formula of Van der Planck, (1963).

RESULTS AND DISCUSSION

Typical wilt symptoms charactersied by the appearance of small, brownish spots measuring 0.5 to 1.0 mm at collar region were observed within 25 to 30 days after seeding. These spots developed into elongated lesions, thereby killing the affected seedlings within 3-4 days after the appearance of initial symptoms. Thereafter, the genotypes exhibited characteristic wilt symptoms leading to death of plant which formed the basis for recording the number of affected plants at 15 days interval starting from 35 days after seeding.

The effectivness of wilt sick plot in providing an ideal environment for disease development was evident from seedling mortality which varied from 0 to 48 percent in both seasons. The disease spread was gradual with maximum incidence at maturity (Per cent incidence ≥ 80%) in susceptible types like HUS-3169 and HUS-3165 and also in the checks like Manjira and Tara. Highly significant genotypic differences in per cent wilt incidence were observed at all stages of scoring except 35 days old seedling stage in the crop season of 1991-92. As the crop growth progressed the genotypic differences for the expression of disease symptoms became more and more conspicuous (Table 1).

Among the check varieties, HUS-305 showed 19.9% disease incidence at 50 days crop growth stage which remained unaltered till maturity indicating the seedling susceptibility and adult plant resistance to wilt. In contrast, Tara, an early maturing variety of Maharashtra recorded highest incidence of 48.9% at seedling stage itself and attained highest (= 72.5%) by maturity in first year. The apparent rate of infection rose steadily from 0.00026 to 0.0201 (Fig.1). The same trend was observed in second season with final infection raising to 90%. Other standard check varieties like A.1 and Bhima followed a similar trend as that of Tara. However, there was a sudden spurt in disease development (r = 0.00057 and 0.0008 from

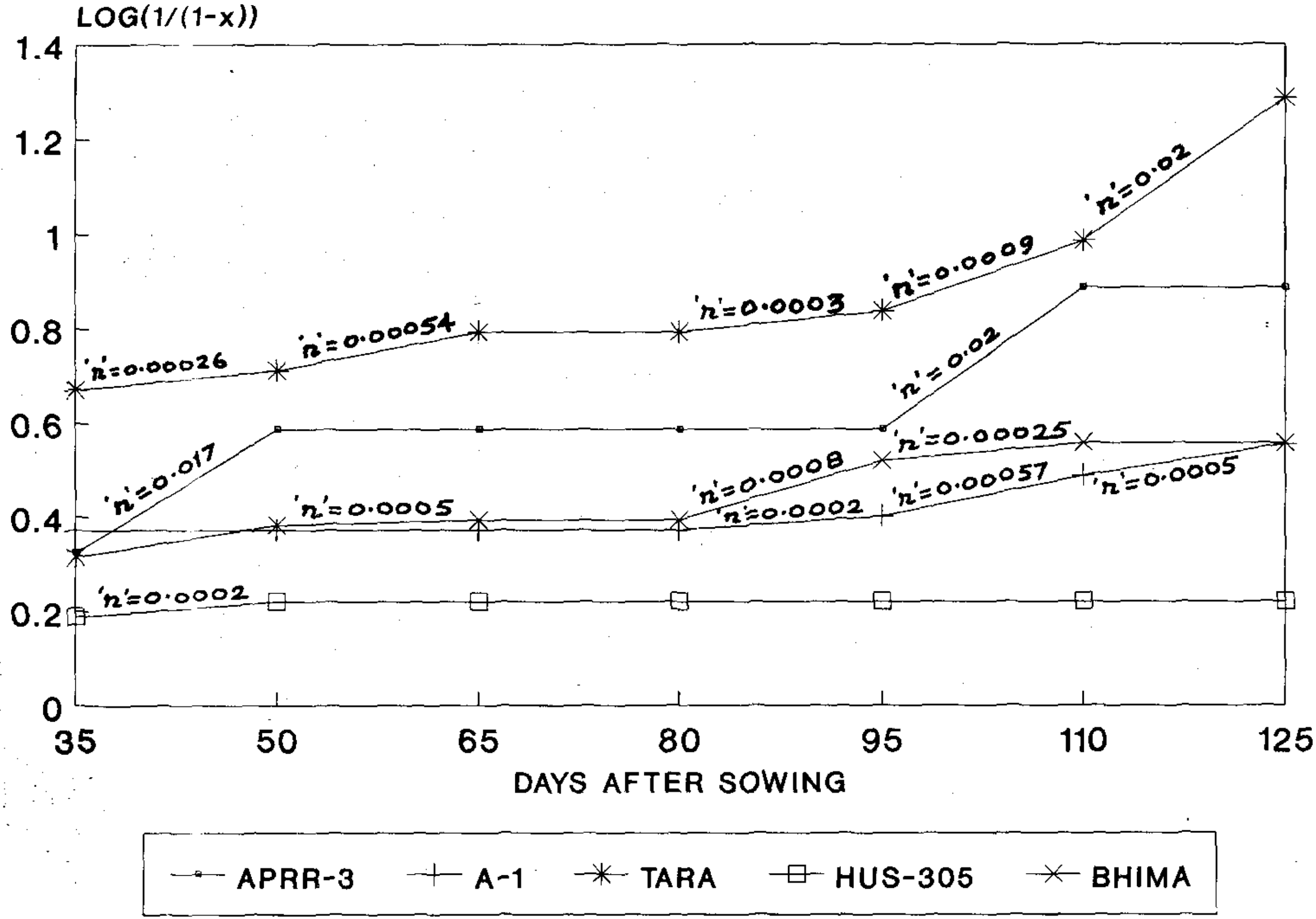

Fig.1 Progression of wilt incidence in some selected safflower varieties in disease sick plot

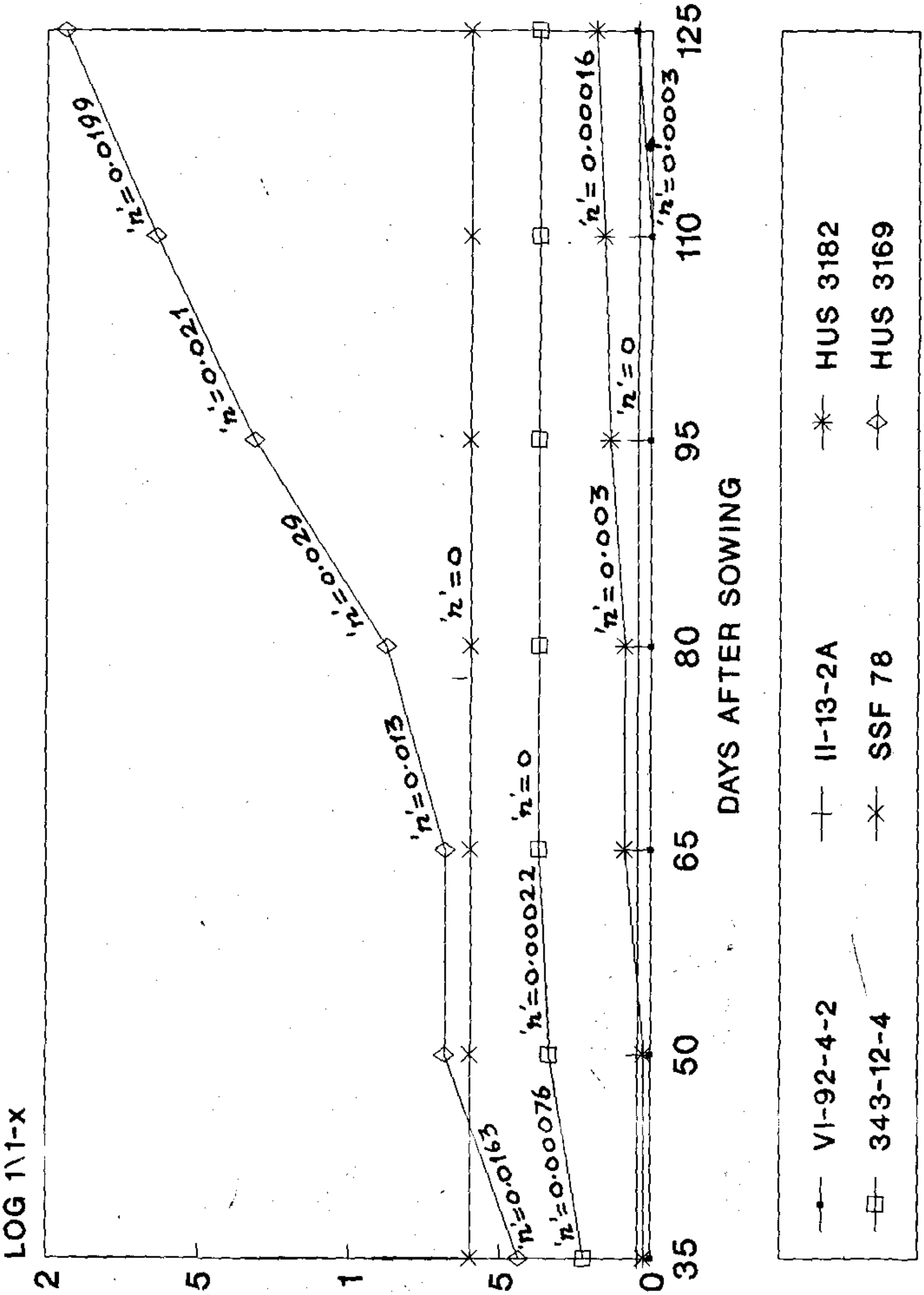

Fig. 2 Progressive development of wilt in some representative genotypes of different groups

0.0002 and 0.00005 respectively) during the period from 80 to 110 days after seeding suggesting their vulnerability to disease at and after flowering.

Fig.2 shows the differential disease development of selected genotypes each representing immune/tolerant, moderately resistant, moderately susceptible and susceptible groups. A more resistant entry like II-13-2A exhibited negligible disease incidence (= 4.25%) at seedling stage but remained totally free from wilt symptoms thereafter. On the other hand, another advanced breeding line VI-92-4-2 did not express wilt symptoms upto 110 days after planting but registered 5.0% disease incidence at maturity.

In moderately susceptible group, the representative entry namely SSF-78 had 45% wilt incidence at seedling stage without any increase in 'r' afterwards. The disease in HUS-3169 rose gradually with r = 0.0199 from 35.0% at seedling stage to 85% by complete maturity.

Differential growth responses of safflower genotypes to wilt have been reported by Thomas and Hill (1977) in pot culture studies. From this point of view, the present report is based on a wide range of genotypes derived from diverse genetic background which were assessed for their differential reaction to wilt at pre-determined growth stages under field conditions. These results unequivocally demonstrate the influence of crop growth stage on the differential response of safflower genotypes to wilt. Hence, the screening of safflower genotypes against wilt at any one particular crop growth stage (either seedling or adult plant) will not be complete and many a times misleading. Foolproof and durable sources of field resistance to wilt can only be identified from comprehensive field screening at different crop growth stages right from seedling.

In accordance with the scale proposed by Mayee and Datar (1986) the tested materials for two consecutive seasons have been grouped into immune/resistant/tolerant, moderately resistant, moderately susceptible and susceptible (Table 1) and their differential growth responses given hereunder :

i) **Immune/tolerant** : Five entries representing highly resistant/tolerant grade exhibited low/no disease at one or more crop growth stages. Within this group, 86-69-36A showed completely resistance to wilt at seedling as well as at maturity. Other entries like VI-92-4-2 and 86-93-20A were totally free from wilt at seedling stage but tended to express the wilt symptoms in less than 10% plants at maturity. The reverse was seen in II-13-2A and 86-93-16A where total resistance was seen at maturity rather than seedling stage.

ii) **Moderately resistance** : Represented by three genotypes, (Table 1) the moderately resistant group expressed similar growth response to wilt as that of immune or tolerant category. The genotypes namely HUS-305 and HUS- 3128 showed fairly high level of susceptibility (18 to 20%) before flowering but there was no further spread thereafter upto complete maturity. Contrary to this trend, HUS-3182 offered considerably resistant reaction upto 50 DAS crop growth stage and the disease spread gradually increased after flowering. However, at maturity all three representative genotypes recorded comparable disease score.

iii) **Moderately susceptible** : The differential growth responses to wilt were more in this category which comprised as many as twenty five genotypes and thirteen in second season including popular varieties like Bhima and A.1. Ten out of twenty five genotypes had less than

Table 1. Performance of genotypes against wilts for two successive *rabi* seasons

Genotype/ Entry	DAYS AFTER SOWING													
	35		50		65		80		95		110		125	
	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A) IMMUNE/TOLERANT														
1. 86-69-36A	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. VI-92-4-2	0	0	0	0	0	0	0	0	0	0	0	0	5.00	0
3. 86-93-16A	4.50	0	4.5	2.74	4.5	2.74	4.5	2.74	4.5	2.74	4.5	2.74	4.50	2.74
4. II-13-2A	4..25	6.33	4.25	6.33	4.25	6.33	4.25	6.33	4.25	6.33	4.25	6.33	4.25	6.33
5. 86-93-20A	1..67	0	1.67	5.00	1.67	5.00	1.67	7.78	1.67	7.78	1.67	7.78	1.67	7.78
B) MODERATELY RESISTANT														
6. HUS-3128	8.06	0	8.06	0	8.06	3.57	8.06	3.57	9.32	3.57	11.81	9.31	16.36	16.45
7. HUS-305	17.11	2.78	19.89	5.54	19.89	7.67	19.89	7.67	19.89	16..06	19.89	21.41	19.89	21.41
8. HUS-3182	2.05	13.54	2.05	17.70	8.34	20.83	8.34	28.13	12.50	28.13	14.67	28.13	16.75	32.29

Contd..

Table 1. contd...

Genotype/ Entry	DAYS AFTER SOWING													
	35		50		65		80		95		110		125	
	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92	'90-91	'91-92
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C) MODERATELY SUSCEPTIBLE														
9. A.1	31.11	7.29	31.11	13.54	31.11	13.54	31.11	13.54	31.11	13.54	38.67	13.54	42.67	21.38
10. Bhima	27.25	6.16	31.88	16.50	32.60	16.50	32.60	25.00	40.58	25.00	42.72	30.00	42.75	36.00
11. HUS-3159	15.96	0	18.90	23.85	21.28	23.85	26.00	23.85	28.99	23.85	34.34	23.85	42.57	23.85
12. HUS-3179	18.06	0	29.87	0	29.87	4.55	29.87	22.73	41.32	27.27	41.32	36.36	41.32	40.89
13. 398-9	17.47	0	17.47	10.30	17.47	27. 69	17.47	27.69	29.69	27.69	29.67	32.69	29.69	32.69
14. Manjira	2.87	0	6.77	8.33	11.70	12.90	11.70	12.90	19.80	21.25	19.90	32.75	34.75	32.75
15. II - 14-1A	0	0	0	0	0	0	21.35	14.35	21.35	15.60	25.00	33.60	27.00	35.00
D) MODERATELY SUSCEPTIBLE														
16. HUS-3165	16.75	18.75	20.32	20.83	25.42	30.83	26.49	30.83	44.99	30.83	55.68	49.30	62.21	56.88
17. APRR-3	27.78	0	44.44	13.83	44.44	13.83	44.44	13.83	44.44	27.78	58.88	31.68	58.88	31.68
18. Tara	48.92	12.50	50.92	38.75	54.76	62.50	54.76	62.50	54.76	70.00	62.72	90.00	72.46	91.28
CD (0.05%)	-	12.58	35.13	22.25	38.61	28.85	39.90	26.09	43.72	22.98	43.39	29.91	49.24	26.10

20% disease incidence indicating moderate resistant reaction upto 50 days crop growth stage in *rabi* 1991. Thereafter, the rates of infection was low in genotypes like GMU-624 (r = 0.0001) but very high in HUS-3165-2 (r = 0.007). With moderate amount of disease (x) at the seedling stage, the rate of infection 'r' was high in genotypes namely GMU-995-1, 425-6, Bhima and HUS-3179. In addition, there were genotypes like SSF-78 and JLSF-118 which exhibited high disease incidence (40%)right at 35 days crop growth stage. Considering the high production potentials of most genotypes in this group, selective crossing between genotypes possessing low initial inoculum load (x) and genotypes characterized by the low rate of disease spread (r) within the group is suggested to combine reasonably high level of disease resistance with high seed yield. Table 1 shows comparative consistent performance of selective genotypes like Bhima, A.1 which showed progressive susceptibility as the crop growth advanced. The frequency of partial wilts was also more in such genotypes (to the extent of 45% in Manjira, 40% in Bhima, 36% in A.1).

iv) **Susceptible:** Before flowering, eleven out of sixteen (*rabi* 1990-91) and three out of nine genotypes (*rabi*, 1991-92) in this group were moderately susceptible with less than 50% disease incidence. The disease incidence before flowering (62 days after seeding) was highest (= 66.7%) in JLSF-228 followed by GMU-163 (= 56.2%). Similarly, GMU-163, HUS-3165- 3, HUS-1187-8, GMU-187 and HUS-3169 registered steady and high rate of disease development in the first season. Similar trend was seen in the succeeding season. Three entries HUS-3165, APRR-3 and Tara showed susceptibility in both the years. The genetic improvement of genotypes in this group for disease resistance largely depends on careful selection of at least two parents, one for low 'x' and other for low 'r' from immune/tolerant group or moderately resistant group. Either a three way cross or double cross mating system involving one or two susceptible low 'x' and low 'r' is suggested to bring in durable sources of field resistance to wilt in susceptible but high yielding genotypes of this group.

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SHORT COMMUNICATIONS

MANAGEMENT OF SESAMUM LEAF SPOT (*Cercospora sesami* Zimm.) WITH FUNGICIDES

Leaf spot of sesamum (*Sesamum indicum* L.) caused by *Cercospora sesami* Zimm is a serious disease in Saurashtra region of Gujarat State and reduces the yield considerably. With a view to check the losses due to the disease some systemic and non systemic fungicides were tested for their field performance. Variety Gujarat Til-1 was sown in Randomized Block Design with four replications during *kharif* 1984, 1986 and 1988 using different fungicides mentioned in Table 1. Two sprays one immediately after appearance of the disease and second fifteen days after first spray using 750 l. water/ha were given. Observations on disease intensity was recorded from 10 plants randomly selected from each of the treatments on 0-5 scale. Seed yield was recorded and analysed statistically.

From the pooled data presented in Table 1, it is concluded that mancozeb (0.2%) was significantly superior in controlling the disease followed by carbendazim (0.025%). Maximum seed yield was obtained in mancozeb treated plots followed by carbendazim. Efficacy of mancozeb and carbendazim have been reported by Rao and Shanmugham (1983) and Kurozawa *et al*., (1985).

The cost benefit ratios of the two fungicides, viz., carbendazim (1:9.99) and mancozeb (1:8.20) are better and hence recommended for the control of leaf spot of sesamum.

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Table 1. Disease intensity and economics of chemical control of sesame leaf spot (*Cercospora sesami*) (Pooled analysis)

Sl. No.	Treatment	Conc. (%)	Per cent disease intensity (pooled data)	Total Cost of spray	Average seed yield (kg/ha)	Total income	Profit over control	ICBR
1.	Mancozeb (Dithane -M-45)	0.2	24.26(29.37)	414	596	7152	3396	1:8.20
2.	Carbendazim(Bavistin 50 WP)	0.025	32.63(34.90)	292	556	6672	2916	1:9.99
3.	Wett. sulpher(Wet.Sulf.40 WP)	0.3	41.43(41.50)	368	430	5160	1404	1:3.82
4.	Zineb (Dithane-Z-78 WP)	0.2	31.13(39.20)	414	441	5292	1536	1:3.71
5.	Copp. oxychloride(Blitox 50 WP)	0.2	47.2(43.5)	540	430	5160	1404	1:2.60
6.	Biteranol(Baycor 25 WP)	0.03	38.7(39.33)	NA	487	5844	2088	-
7.	Chlorothalonil (Daconil 75 WP)	0.2	39.93(40.26)	510	414	4328	1572	1:3.08
8.	Thiophanate methyl(Topsin M 75 WP)	0.04	40.73(40.48)	350	434	5218	1452	1:4.15
9.	Captafol (Foltaf 80 WP)	0.2	42.00(39.59)	611	426	5112	1355	1:2.22
10.	Control	-	59.93(50.20)	-	313	3756	-	-
	SEm.±		2.24		37.5			
	CD at 5%		6.65		111.58			

Figures in parenthesis are transformed values; Sesame price Rs.12/kg
NA indicates not available.

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PRODUCTION OF PECTINOLYTIC AND CELLULOLYTIC ENZYMES BY CASTOR FUSARIUM *IN VIVO*

Castor plants of cultivars GCH-3, T-4, JI-41, 26006 and T-3 infected with *F. oxysporum* f. *ricini* were taken for assaying the enzymatic activity *in vivo*. Assay of PGTE activity was estimated by the method of Ayres *et al.*, (1966), P.G. activity was carried out by determining loss in viscosity of sodium polypectate at specific time intervals (Bateman, 1964), P.M.E. activity was estimated as described by Matta and Dimond (1963) and cellulose activity was estimated by measuring viscosity loss of carboxy methyl cellulose (Koti Reddy and Mahadevan, 1967).

The data presented in Table 1 revealed that the highest enzymatic activity for PGTE, PTE, P.G., and cellulose was observed in GCH-3 variety followed by T-4, JI-41, 26006 and T-3.

Table 1. Production of pectinolytic and cellulolytic enzymes *in vivo* by castor *Fusarium* (expressed in terms of per cent loss in viscosity)

Enzymes	Susceptible varieties	Resistant varieties			
	Guj. Hybrid-3	T-4	JI-41	26006	T-3
PGTE	70.11	37.51	37.50	25.80	19.32
PTE	68.80	44.32	38.40	38.40	25.76
PG	65.75	45.40	34.20	27.70	23.20
Cellulose	73.14	39.12	31.56	27.71	20.28
PME	+	-	-	-	-

PME activity was also observed in GCH-3, while there was no PME activity detected in rest of the cultivars. In screening of castor varieties against wilt of castor it was observed that the varieties T-4, JI-41, 26006 and T-3 were tolerant while GCH-3 was susceptible to *Fusarium* wilt (Nanda, 1975).

Mussell and Green (1970) while working with *F. oxysporum* f. *lycopersici*, observed higher rate of PG activity in susceptible host than resistant. Deese and Stahman (1960, 1962) reported higher pectic enzyme activity in the susceptible tomato plants following infection with *F. oxysporum* f. *lycopersici* than those of resistant varieties.

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EVALUATION OF FEW CHEMICALS USED TO BREAK SEED DORMANCY IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

Sunflower (*Helianthus annuus* L.) is one of the important oilseed crops which has been grown extensively in northern Karnataka. The crop is grown through out the year as it is a photo- insensitive crop. As a result, there is an increased demand for the seeds. The seeds are usually dormant for a period of 6-7 weeks from maturity (Sindagi and Virupakshappa, 1986) with an after ripening period of 11 days followed by the coat imposed dormancy (UAS, 1990). Udayakumar and Sastry (1975) have reported the use of ethrel, Cytokinin (CK) and Gibberellic acid (GA) to break dormancy of sunflower seeds. However, the present study is undertaken with an objective of evaluating few growth promoters and also chemicals to overcome the seed dormancy so that they can be utilised for sowing immediately after maturity.

A popular and ruling genotype of sunflower, Morden, was used for this laboratory study. The seeds were collected soon after maturity and subjected to various chemical treatments. The chemical treatments were : GA 50 ppm, CK 5 ppm, ethrel 40 ppm, calcium chloride ($CaCl_2$) 0.02M, cobalt nitrate ($Co(NO_3)_2$) 0.02M and distilled water. The seeds were treated with 50 ml of respective solutions of the above chemicals for six and twelve hours separately and replicated thrice. Whereas direct incubation in distilled water served as control. The treated seeds (20 Nos) were transferred on to a filter paper in a petriplate and watered with ten ml of distilled water before incubation. After two days of incubation, an additional five ml of distilled water was added to each petriplate. The effect of the chemical treatments on seed dormancy was studied by recording the germination at weekly interval till the germination in control reached 80 per cent.

The effect of various chemical treatments on the seed dormancy is discussed here (Table 1). The observations on germination of seeds incubated at maturity (0 day) revealed that ethrel treatment both for six and twelve hours was superior in over- coming the dormancy compared to all the other treatments. The other chemical treatments except CK at 5 ppm, $Co(NO_3)_2$ at 0.02 M and water treatment for six hours were also found to be significantly superior in breaking the seed dormancy over control. In general, the germination was found to be very low even in the chemical treatments at zero day after maturation. The observation on germination of seven day old seed revealed that there was a marked improvement in the over all germination. The chemical treatment of seeds with ethrel and $CaCl_2$ for six and twelve hours improved the germination significantly over other treatments (both were 80 and 90 per cent with 6 and 12 hours treatment respectively). The other chemical treatments were also found to be effective in breaking the seed dormancy except GA, CK, $Co(NO_3)_2$ and water when treated for six hours. The impact of chemical treatments on 14 days old seeds revealed no significant influence of the various chemical treatments on germination as the differences remained statistically insignificant, with the mean germination per cent of 92.9. This indicated the possible natural break down of dormancy in two week old seeds.

The present study confirms the fact that ethrel is useful in breaking the dormancy of sunflower seeds as reported by Udayakumar and Sastry (1975). And also it can be finally concluded in the light of the findings $CaCl_2$ at 0.2M is also equally useful in breaking the dormancy of sunflower seeds.

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Table 1. Evaluation of few chemicals used to break seed dormancy in sunflower

Chemical	Solution concentration	Seeking period (Hours)	Germination per cent Days after maturity 0	7	14
GA	50 ppm	6	15.0	62.5	90.0
GA	50 ppm	12	20.0	75.0	100.0
CK	5 ppm	6	7.5	60.8	90.0
CK	5 ppm	12	27.5	72.5	95.0
Ethrel	40 ppm	6	52.5	80.0	95.0
Ethrel	40 ppm	12	62.5	90.0	95.0
$CaCl_2$	0.02M	6	12.5	80.0	90.0
$CaCl_2$	0.02M	12	22.5	90.0	95.0
$Co(NO_3)_2$	0.02M	6	10.0	60.0	35.0
$Co(NO_3)_2$	0.02M	12	15.0	75.0	90.0
Water		6	7.5	60.0	92.5
Water		12	25.0	70.0	100.0
Control			7.5	60.0	90.0
Mean			21.9	72.0	92.9
CV%			10.69	7.27	5.75
SEm±			1.35	3.02	3.09
CD 5%			3.95	8.82	9.51

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"NRC 2" - A PROMISING SOYBEAN MUTANT

Poor seed viability resulting in sub-optimum plant population is the prime problem in soybean limiting realization of its yield potential. Owing to this reason, several cultivars need a high seed rate to maintain a required population of 4 to 4.5 lakh plants per hectare. Mutation breeding in soybean was resorted to for rectifying the defect of poor seed germinability in otherwise suitable cultivars like "Bragg" (Bhatnagar and Tiwari, 1991 ; Bhatnagar *et al.,* 1989). Subsequent evaluation of the mutants under varied agro-climatic conditions brought out the superiority of a mutant of "Bragg" over its parent for several characters which is being reported here under.

M_2 generation, raised from the seed treatment of the variety "Bragg" (Jackson x D 49-2491) with 25 kR gamma rays followed with an exposure of UV (two hours of 260 nm), was screened and a high yielding mutant "T2-14" with relatively smaller-sized seeds was isolated and evaluated further for five years. The evaluation was carried out through laboratory tests, field trials, and comprehensive multi-locational testing under the All India Co-ordinated Research Project on Soybean (AICRPS) of ICAR. The mutant was named "NRC 2". Salient characteristics of the mutant as compared with its parent and other check varieties are presented below.

1. Yield and maturity duration : In northern hill zone, based on seven trials conducted over three years, the "NRC 2" on an average yielded 2347 kg/ha which was 33% higher than its parent "Bragg" (1871 kg/ha) and 11 % higher than "VLS 21" (2115 kg/ha), a qualifying variety for the zone. In the Malwa plateau, based on data obtained from three trials over three years, the "NRC 2" gave a mean yield of 2911 kg/ha which was 30% higher than that of "MACS 58" (2229 kg/ha) and about 4 % higher than that of "PK 472" (2807 kg/ha). The maturity duration of "NRC 2" was at par with checks in the northern hill zone. In Malwa plateau, "NRC 2" matured in about 98 to 104 days in different trials which was 6 to 8 days earlier than "PK 472" and "JS 80-21", the prominent varieties of the zone.

2. Distinguishing morphological characters : "NRC 2" is characterised by white flowers, green hypocotyl, tawny pubescence, seeds of light yellow colour with grey to black hilum, and determinate growth habit.

3. Seed-weight and seed-viability/germinability : High seed-weight in soybean is generally associated with low seed viability/germinability (Paschal and Ellis, 1978; Tiwari and Joshi, 1989). The "NRC 2" exhibited high seed germinability/storability (Table 1) compared to its parent "Bragg" and other bold-seeded varieties. Further, after a storage of seven months at ambient temperature, its germinability was comparable with that of "JS 80-21" which is claimed to possess the highest germinability among the recent yellow-seeded soybean varieties. As is evident from Table 1 "NRC 2 " had lower seed weight than its parent and other bold-seeded varieties. In the present sample of seven varieties also, a significant negative correlation ('r' = -0.98) was obtained between seed weight and seed germinability. Relatively smaller seed size of "NRC 2" is amply compensated by its capacity to produce more fruiting sites or pods, resulting in significantly higher yield than its parent.

The results presented clearly indicate the superiority of the mutant "NRC 2 " for agronomic and quality characters especially for northern hill zone and Malwa plateau of

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Madhya Pradesh. Besides, the mutant has a promise as a substitute for "Bragg" throughout the country.

Table 1. Seed germinability in the mutant "NRC 2" and other soybean cultivars after seven months' storage under ambient temperature

Sl.No.	Variety	Germinability (%)	100-seed weight (g)
1.	Bragg	42.0	16.8
2.	VLS 2	41.3	17.6
3.	Shivalik	77.3	12.7
4.	PK 472	66.0	13.3
5.	MACS 58	77.6	11.9
6.	JS 80-21	90.3	11.1
7.	NRC 2	89.3	11.6

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COMBINING ABILITY FOR ACHENE YIELD AND ITS ATTRIBUTES IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

Genetic architecture of the parents involved basically governs the nature of gene action. Thus it necessitates the assessment of the potentialities of the parents in hybrid combination through systematic genetic studies on the parents for general and specific combining ability effects. Hence, present investigation was undertaken to determine the combining ability of 20 inbred lines using three broad testers for various economic traits in sunflower.

The experimental material consisted of 20 inbred lines and three open pollinated testers of sunflower. The lines were derived by inbreeding elite open pollinated varieties (Morden and EC-68415) at Project Coordinating unit, (Sunflower), University of Agricultural Sciences, Bangalore. The testers were S-55 Morden, and EC-68415. The 20 female lines were crossed with three testers in a line x tester design during *rabi-summer* 1983-84. The inbred lines were treated with GA3 (125 ppm Con) at star bud stage for three days continuously to induce male sterility. The pollen from male parents (testers) were transferred manually to female (MS types) lines to produce crossed seeds. The resulting 60 F_1 hybrids along with 23 parents were grown in a Randomized Block Design with four replications at the University of Agricultural Sciences, Hebbal, Bangalore during *Kharif* 1984. Each entry was grown in two row plot of 3.5 metre length with a uniform spacing of 60cm x 20cm. The observations were recorded on ten random plants in each plot for yield and its component characters, viz., days to 50 per cent flowering, number of leaves per plant, leaf area index, days to maturity, plant height, capitulum diameter, stem girth, capitulum weight, number of filled achenes per capitulum, achene yield, test weight, volume weight (100 ml) and oil content. Data thus recorded were subjected to line x tester analysis (Kempthrone, 1957).

The analysis of variance revealed that substantial variability exists in the material for achene yield and other yield contributing characters. The estimates of $\frac{\sigma^2 gca}{\sigma^2 sca}$ revealed that the nature of gene action was predominantly non-additive for days to 50 per cent flowering, maturity (1:54.7), number of leaves, plant height, (1:102.3), number of filled achenes per capitulum (1:1946.8) achene yield (1:249.4), volume weight, whereas it was additive for leaf area index, (1:0.04), capitulum diameter, stem girth (1:0.03), test weight (1:0:02) and oil content (1:0.24). Putt (1966), Setty and Singh (1977) also reported predominant role of non-additive component for achene yield.

The estimates of gca effects of males and females (Table 1) revealed that EC-68415 was a good combiner for yield, test weight, volume weight and oil content. Morden and S.55 were desirable combiners for earliness and dwarfness. Among the females, IC.19, IC.43 and IC.49 for seed yield, IC.4, IC.19, IC.49 and IC.37 for test weight and IC.1, IC.49 and IC.43 for volume weight, IC.4, IC.1, IC.43 and IC.37 for oil content, IC.8, IC.49, IC.10, IC.28 and IC.9 for earliness and IC.33, IC.39, IC.1, IC.31, IC.11 and IC.28 for dwarfness were found to be good general combiners. It was observed in most cases the mean performance of the parent was not associated with the gca effects.

Specific combining ability effects were significant for few of the crosses. Ten crosses with high specific combining ability for achene yield are listed in Table 2 along with sca effects

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Table 1. Estimates of general combining ability (gca) effects in respect of parental lines for 13 characters of sunflower

Genotype	Number of days to 50 per cent flowering	Number of leaves per plant	Leaf area index	Days to maturity	Plant height	Capitulum diameter	Stem girth	Capitulum weight	No. of filled achene per capitulum	Achene yield per plant	Test weight	Volume weight	Oil content
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Males													
S-55	-0.55 **	-1.06 **	-0.11 **	-0.67 **	-5.43 **	0.11 *	-0.01	-0.36 **	-4.48	-1.19 **	-0.17 **	-0.29 **	-0.16
Morden	-0.62 **	0.27	0.05	-1.19 **	-1.46 **	-0.01	0.03 **	0.11	14.38 **	-0.27 **	-0.18 **	-0.05	-0.16
EC. 68415	1.17 **	0.80 **	0.05	1.86 **	6.89 **	-0.10	-0.12	0.25 **	-9.90 **	1.46 **	0.34 **	0.34 **	0.32 **
SE(GCA) T	0.15	0.14	0.03	0.22	0.39	0.05	0.01	0.06	3.63	0.02	0.09	0.10	1.79
SE (GI-GJ) T	0.21	0.19	0.04	0.30	0.55	0.08	0.02	0.09	5.13	0.12	0.03	0.13	0.14
Females													
IC.1	-0.17	-1.30 **	-0.23 **	-0.52	-4.41	0.10	-0.06 *	-0.33 *	-52.69 **	-1.57 **	0.07	1.71 **	0.72 **
IC. 4	1.16 **	-0.38	-0.21 **	1.15 **	-0.58	0.68 **	-0.07 *	0.65 **	-7.91	-0.21	0.42 **	-1.39 **	1.36 **
IC .8	-2.50 **	-0.16	-0.21 **	-2.85 **	-1.41	0.71 **	-0.07 *	-0.44 **	-6.26	-0.97 **	-0.01	-0.72 *	-0.71 **
IC .9	-1.25 **	-1.49 **	0.25 **	-1.27 **	6.98 **	0.08	0.01	0.60 **	-26.12 **	1.20 **	-0.13 **	-0.26	-0.61 *
IC .10	-1.67 **	1.72 **	0.44 **	-1.69 **	4.60 **	-0.25	0.18 **	-1.48 **	-36.65 **	-2.37 **	-0.12 *	-0.94 *	-0.30
IC.11	-0.84 **	-0.48 *	-0.11	-0.85	-4.30 **	-0.41 **	-0.08 **	-0.21	27.84 **	-0.80 **	-0.57 **	-0.14	0.19
IC. 13	1.41 **	-1.23 **	-0.09	1.98 **	-2.07 *	-0.44 **	-0.01	0.21	-10.90	-2.64 **	-0.19 **	-0.42	-1.08 **

Contd...

Table 1 contd...

Genotype	Number of days to 50 per cent flowering	Number of leaves per plant	Leaf area index	Days to maturity	Plant height	Capitulum diameter	Stem girth	Capitulum weight	No. of filled achene per capitulum	Achene yield per plant	Test weight	Volume weight	Oil content
1	2	3	4	5	6	7	8	9	10	11	12	13	14
IC. 16	0.16	0.57	0.31 **	0.23	4.66 **	0.68 **	0.20 **	0.53 **	34.97 **	1.17 **	-0.01	0.79 **	0.24
IC. 19	0.58	0.60	0.03	0.65	-0.85	-0.11	-0.05	0.60 **	36.51 **	3.27 **	0.29 **	0.31	0.12
IC. 22	-1.00 **	-0.94 **	-0.16 *	-0.85	6.17 **	0.75 **	0.10 **	-0.25	7.77	0.79	0.11 *	0.33	-0.87 **
IC. 25	1.75 **	1.28 **	0.05	0.48	2.55 *	0.33 *	0.02	0.09	3.62	0.58	0.12 *	-0.24	-0.46
IC. 28	-1.34 **	-0.78 *	-0.21 **	-0.77	-4.18 **	-0.55 **	-0.15 **	0.30	3.04	0.44	-0.04	-2.10 **	-0.09
IC. 31	1.75 **	0.78 *	0.16 *	2.23 **	-4.34 **	-0.50**	0.02	-0.16	-35.40 **	-2.32 **	-0.09	0.83 **	0.23
IC. 33	1.83 **	-0.52	-0.37 **	1.90 **	-6.65 **	-0.08	-0.02	-0.73 **	-20.47 *	-1.36 **	-0.02	0.73 **	-0.33
IC. 37	-0.17	0.18	0.06	0.15	-2.62 **	-0.36 *	-0.04	0.43 **	18.50 *	0.30	0.13 **	0.47 *	0.70
IC. 38	3.75 **	0.95 **	-0.11	3.73 **	7.95 **	0.42 **	-0.00	0.13	-8.92	0.69 **	0.11 *	-0.53 *	-0.33
IC. 39	-0.84 *	-0.03	-0.04	-1.02	-5.43 **	0.27	-00.02	-0.42 **	57.90 **	1.27 **	0.00	-1.38 **	0.10
IC. 43	-0.17	2.60 **	0.37**	-0.44	0.99	0.08	0.08 **	0.70 **	46.71 **	3.10 **	0.09	1.17 **	0.71 **
IC. 48	-0.59	-0.09	-0.13	-0.27	3.65 **	-0.35 *	-0.01	1.25 **	-27.94 **	-2.86 **	-0.32 **	0.43	0.27
IC. 49	-1.84 **	-1.27 **	-0.13	-1.94 **	1.25	0.18	-0.03	1.04 **	33.39 **	2.89 **	0.15 **	1.33 **	0.14
SE(GCA) L	0.39	0.35	0.08	0.56	1.00	0.14	0.03	0.16	9.36	0.23	0.05	0.23	0.26
SE (GI - GJ) L	0.91	0.50	0.11	0.79	1.41	0.20	0.04	0.22	13.24	0.32	0.07	0.33	0.37

* Significant at 5 per cent;. ** Significant at 1 per cent.

Table 2. Specific combining ability of top 10 hybrids and mean values (in parenthesis) for 13 characters

Characters	Number of days to 50 % flowering	Number of leaves per plant	Leaf area index	Days to maturity	Plant height	Capitulum diameter
1	2	3	4	5	6	7
IC. 11 x Morden	-0.21 (56.00)	-1.42* (21.09)	0.13 (2.75)	0.19 (86.00)	0.92 (121.40)	0.92*(13.22)
IC. 33 X Morden	-0.63 (58.25)	0.75 (23.32)	0.39** (2.74)	0.56 (88.00)	3.22 (121.15)	0.65**(13.29)
IC. 28 x EC- 68415	0.50 (57.00)	1.10 (23.84)	0.77** (3.28)	-0.19 (88.75)	11.90** (140.84)	1.20**(13.28)
IC. 19 x Morden	1.37 * (59.00)	0.81 (24.40)	0.26 (3.02)	2.19 (89.50)	7.65** (131.58)	1.77**(14.37)
IC. 31 x Morden	-2.30 ** (56.50)	-1.78* (21.99)	0.18 (2.71)	-1.89 (87.00)	3.24 (123.68)	0.53(11.69)
IC. 25 x S. 55	-0.87 (58.00)	-1.85** (21.09)	0.54** (2.07)	0.83 (88.50)	-7.44** (115.92)	0.49*(13.65)
IC. 38 x S. 55	4.13** (65.00)	1.97** (24.59)	0.44** (2.91)	4.08** (95.00)	16.03** (144.79)	1.23**(14.48)
IC. 9 x S. 55	-2.37** (53.50)	0.40 (19.77)	0.08 (2.40)	-2.42* (83.50)	-3.93* (123.86)	-0.05(12.86)
IC. 4 x EC- 68415	0.00 (60.00)	-2.22** (20.93)	-0.62** (2.32)	0.14 (91.00)	8.32** (124.39)	-0.91** (12.39)
IC. 16 x S.55	1.71*(59.00)	0.91 (23.14)	0.61**(3.49)	2.08** (89.50)	1.79 (127.26)	1.90* (14.70)
SE (SCA)	**0.67**	**0.61**	0.14	0.97	1.73	0.25
SE (sij-skl)	**0.95**	**0.86**	0.19	1.37	2.45	0.35

Contd..

Table 2 contd...

Characters	Stem girth	Capitulum weight	No. of filled achene per capitulum	Achene yield per plant	Test weight	Volume weight	Oil content
1	8	9	10	11	12	13	14
IC. 11 x Morden	0.27** (2.40)	2.41**(17.45)	95.08** (868.87)	4.59** (43.65)	0.38** (5.30)	1.44** (44.08)	0.02 (40.03)
IC. 33 X Morden	0.06 (2.26)	1.50**(16.03)	45.13** (770.61)	4.27** (42.78)	0.18 (5.58)	0.09 (43.59)	-0.59 (38.90)
IC. 28 x EC- 68415	0.19** (2.21)	2.02** (17.71)	40.74** (765.46)	4.13** (46.16)	0.26** (6.22)	0.01 (41.08)	-0.33 (39.88)
IC. 19 x Morden	0.23** (2.39)	1.20** (17.05)	49.25** (831.72)	3.74** (46.84)	0.23** (6.00)	0.62 (43.70)	0.24 (40.17)
IC. 31 x Morden	0.02 (2.26)	1.04** (16.13)	22.33 (732.89)	3.59** (41.14)	0.22** (5.61)	0.72 (44.31)	0.24 (40.27)
IC. 25 x S. 55	0.04 (2.23)	0.83** (15.70)	32.25* (762.97)	2.97** (42.49)	0.18* (5.79)	0.68 (42.97)	0.34 (39.70)
IC. 38 x S. 55	0.04 (2.21)	-0.14 (14.78)	-10.50 (709.68)	2.64** (42.28)	0.29** (5.89)	-1.22** (40.78)	0.06 (39.50)
IC. 9 x S. 55	-0.14** (2.05)	1.13** (16.52)	72.20** (773.18)	2.58** (42.71)	0.15 (5.52)	-0.72 (41.56)	0.61 (38.60)
IC. 4 x EC- 68415	-0.22** (1.88)	2.38 (18.43)	43.00** (756.77)	2.56** (43.94)	0.11 (6.53)	1.08** (42.86)	0.24 (41.89)
IC. 16 x S. 55	0.25** (2.62)	0.03 (15.35)	45.07* (807.14)	2.41** (42.53)	0.05 (5.53)	0.62 (43.94)	-1.27** (38.81)
SE (SCA)	0.05	0.27	16.22	0.39	0.08	0.40	0.45
SE (sij-skl)	0.07	0.39	22.93	0.55	0.12	0.57	0.64

* Significant at 5 per cent; ** Significant at 1 per cent

of these crosses for other characters and their respective mean values. The crosses IC.11 x Morden, IC.33 x Morden and IC.28 x EC-68415 were the best combiners, since they exhibited significant positive sca effects and had higher mean values for achene yield, capitulum weight, number of filled achenes per capitulum and test weight. The cross IC.9 x S.55 was the best combiner for oil content and the cross IC.25 x S.55 for dwarfness. The results indicate the involvement of non-additive gene effects in the inheritance of these characters. Similar results of non-additive gene action for different traits in sunflower were reported earlier by Putt (1966), Setty and Singh (1977) and Sindagi *et al*., (1979). Based on the gca effects and *per se* performance IC.22, IC.19, IC.43 and IC.48 have been suggested for utilization in the sunflower breeding programme.

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EFFECT OF NITROGEN ON SEED YIELD, ECONOMICS, NUTRIENT UPTAKE AND OIL CONTENT OF TARAMIRA GENOTYPES

Taramira (*Eruca sativa* L.) is a hardy winter season oilseed crop, preferably grown on residual soil moisture. There is a dearth of information on the economic dose of nitrogen and its effect on oil quality of different taramira genotypes. Therefore, a field experiment was conducted at SKN College of Agriculture, Jobner during 1987-88 to study the effect of nitrogen on economics and quality of taramira varieties grown under semi-arid conditions.

The soil of the experimental plot was loamy sand, low in organic carbon (0.21%), available N (75 kg/ha) and available P (17 kg P_2O_5/ha) and medium in available K (150 kg K_2O/ha). The treatments comprising four levels of nitrogen and four varieties were replicated four times in a Randomized Block Design. A basal dose of 20 kg P_2O_5/ha and nitrogen as per treatment was drilled at the time of sowing. The crop was sown on 10 November, 1987 in rows 30 cm apart with a seed rate of 5.0 kg/ha. In addition to pre-sowing irrigation, one life saving irrigation was applied on 10 January, 1988. The economics of the treatments was computed as per prevailing market rates.

Application of nitrogen significantly affected the content and uptake of nitrogen and phosphorus. By and large with the increase in the dose of nitrogen, there was a discernable enhancement in the content and uptake of nitrogen and phosphorus. Application of nitrogen at 30 kg, remaining *at par* with 45 kg/ha, offered significantly higher seed and oil yield than control, reflecting similarity in the obtainable net returns (Table 1). These results confirm the findings of Jat *et al.*, (1987) who reported 30 kg N/ha as an optimum dose of nitrogen for taramira. The positive response of taramira in terms of yield, uptake and economic returns to application of nitrogen was due to the low available nitrogen. This contention was further reinforced by the linear inter-relationships existed between seed yield and nitrogen uptake ($r = 0.93^*$; $y = 2.73 + 0.23x$), phosphorus uptake ($r = 0.84^*$; $y = 2.41 + 1.20x$) and oil yield ($r = 0.99^*$; $y = 0.04 + 0.03x$).

Taramira variety Job-TC 2 registered a significant increase of 12.1 and 14.3 per cent in seed yield, and 11.6 and 13.1 per cent in oil yield, respectively over T 27 and Job-TC 1, besides providing the highest net profit of Rs 2385/- as against the lowest of Rs. 1840/- under variety Job-TC 1. Differential behaviour of taramira varieties was also observed by Maliwal (1985).

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Table 1. Seed yield, uptake of nutrients and oil content of taramira genotypes as influenced by nitrogen application

Treat-ments	N-Content (%)		N-uptake (kg/ha)	P-Content (%)		P-uptake (kg/ha)	protein content (%)	Oil content in seed (%)	Oil yield (kg/ha)	Seed yield (kg/ha)	Cost of producti-on (Rs/ha)	Net Return (Rs/ha)
	Seed	Straw		Seed	Straw							
Nitrogen (kg/ha)												
0	2.53	0.31	24.3	0.57	0.15	7.1	15.8	38.1	279	714	1840	1730
15	2.69	0.46	32.1	0.54	0.16	8.2	16.8	39.2	308	786	1921	2011
30	3.02	0.60	39.7	0.61	0.17	8.9	18.9	39.5	330	834	2003	2171
45	3.13	0.69	47.8	0.60	0.17	10.5	19.6	39.3	344	876	2084	2295
CD 5%	0.16	0.03	1.1	0.05	NS	0.7	1.1	NS	27	64	-	-
Varieties												
T 27	2.79	0.47	34.3	0.58	0.15	8.6	17.5	39.3	304	775	1962	1915
RTM 2	2.82	0.50	35.3	0.54	0.16	8.2	17.6	38.8	313	806	1962	2067
Job-TC 1	2.83	0.53	35.5	0.60	0.17	9.1	17.7	39.4	299	760	1962	1840
Job-TC 2	2.93	0.56	38.8	0.59	0.17	8.7	18.3	39.6	344	869	1962	2385
CD 5%	NS	0.03	1.1	NS	NS	NS	NS	NS	27	64	-	-

Cost of taramira seed (Rs/q) = 500
General cost of cultivation (excluding treatment cost) = Rs 1840/ha

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STUDIES ON WEED MANAGEMENT IN BUNCH GROUNDNUT (*ARACHIS HYPOGAEA* L.) *

Groundnut grown during kharif season encounters several weeds, including grasses and seasonal broad leaf weeds which grow luxuriantly as compared to *rabi*/summer. The weed competition at early stages of *groundnut* is maximum because of slow initial growth of the crop. Critical period of crop weed competition was reported to be up to 45 days after sowing (Singh *et al.*, 1987). The Crop-weed competition is relatively low at the end of expansion phenophase when complete ground cover is attained by groundnut canopy.

The average loss of yield owing to crop-weed competition under normal management conditions had been found to be 34 per cent, while under poor management the yield loss was as high as 60 per cent. Once the weeds are established in row it is difficult to remove them because of the growth habit of groundnut and ultimately they interfere with harvesting resulting of pod loss in the soil. Although substantial information on use of herbicides such as alachlor (Doub *et al.*, 1988) pendimethalin (Kondap *et al.*, 1989) is available, the information on the effect of some new herbicides in combination with cultural practices is lacking for the transitional tract of Dharwad. Hence the present investigation was under taken to evaluate different weed management practices on growth, yield and yield components of groundnut.

An experiment was conducted during the *kharif* season of 1990-91 with *groundnut* cv. Dh-3-30 on medium black soils under rainfed conditions. The treatments (Table 1) were tested in a Randomized Block Design with three replications. Fluchloralin was sprayed and incorporated into the soil before sowing on 22 June, 1990. The other pre-emergence herbicides alachlor, pendimethalin and metalachlor were sprayed on 28 June 1990. The post emergence herbicides fluazifop-p-butyl was sprayed 15 days after sowing. The crop received a well distributed total rainfall of 496.6 mm during growth period. Observations on different growth characters were recorded at 30, 60 and 90 days and at harvest and yield components on 5 randomly selected plants per plot.

Seed germination

Application of pre-emergence herbicides has no undesirable effect on seed germination of groundnut while post emergence herbicide fluazifop-p-butyl has *substantially* reduced germination indicating its non-selectivity for groundnut crop. Some plants have shown the stunted growth at seedling stage but later the plants recovered. This has resulted in significant reduction in final plant stand and the crop was also suppressed by weeds as this herbicide failed to control dicot weeds (Table 1). Reduction in crop stand in groundnut by severe competition from weeds was noticed by Bhan *et al.*, (1971).

Growth

Leaf area index presented in Table 2 indicated that hand weeding + intercultivation recorded significantly higher leaf area index at all the stages of crop growth. Where as significantly lower leaf area index was observed in unweeded control at all the stages of crop growth. The higher leaf area index was due to higher leaf area per plant recorded in these treatments. Frayer and Makepeace (1977) reported that higher leaf area index in weed control treatments was due to *minimum* weed competition.

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Table 1. Effect of weed control on germination, crop stand at harvest, leaf area index and dry matter accumulation of groundnut

Treatments	Dose (kg) a.i/ha	Germination count at 15 DAS m^2	plant Stand at harvest m^2	Leaf area Index				Dry matter accumulation (g/plant)			
				30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Hand weeding + Intercultivation	15, 30 DAS 15, 30, 45, DAS	33.23	33.12	1.62	3.07	2.73	1.02	3.95	11.44	20.04	40.74
Alachlor	2.00	33.82	33.58	1.17	2.82	2.44	0.89	3.60	9.50	17.82	28.05
Fluchloralin	1.00	33.69	33.48	1.17	2.87	2.50	0.93	3.47	10.40	19.23	29.43
Pendimethalin	1.00	33.48	33.45	1.27	2.85	2.42	0.89	3.22	9.84	16.65	25.99
Fluzifop-p-butyl	0.25	30.05	28.00	1.20	2.84	2.47	0.96	3.13	4.27	14.00	24.35
Metalachlor	1.00	33.74	33.70	1.16	2.81	2.45	0.93	3.59	9.32	14.73	27.23
Alachlor + Intercultivation	2.0 + 15, 30, 45 DAS	33.42	33.40	1.39	2.97	2.52	0.91	3.74	9.95	18.16	28.17
Fluchloralin + Intercultivation	1.0 + 15, 30, 45 DAS	33.49	33.45	1.41	2.97	2.54	0.94	3.62	11.40	19.65	39.64
Pendimethalin + Intercultivation	1.0 + 15, 30 45 DAS	33.47	33.46	1.29	2.86	2.43	0.92	3.36	10.08	17.00	37.23
Fluzifop-p-butyl + Intercultivation	0.25 + 15, 30, 45 DAS	28.85	28.00	1.32	2.96	2.51	0.97	3.42	9.63	14.93	34.62
Metalachlor + Intercultivation	1.0 + 15, 30, 45 DAS	33.02	33.51	1.18	2.83	2.46	0.95	3.62	10.26	15.36	30.62
Intercultivation	15, 30, 45 DAS	33.66	33.00	1.15	2.76	2.42	0.80	3.62	10.01	12.16	32.22
Unweeded check		33.76	30.15	0.99	2.55	2.20	0.63	1.52	8.46	9.52	16.21
SEm±		0.21	0.35	0.01	0.02	0.01	0.01	0.32	0.31	0.53	3.28
CD 5%		0.65	1.07	0.03	0.08	0.02	0.05	0.93	0.90	1.54	9.56

DAS: Days after sowing; Intercultivation at 15, 30, 45 DAS

Hand weeding twice followed by 3 intercultivations remaining comparable to pre-emergence application of fluchloralin at 1 kg a.i./ha followed by 3 intercultivations substantially enhanced dry matter accumulation over the rest of the treatments (Table 1). Plants from unweeded check plots and fluazifop-p-butyl 0.25 kg a.i./ha. registered comparable dry matter yields.

Table 2. Effect of weed control on yield and yield components of groundnut

Treatments	Dose kg a.i/ha	No. of pods/plant	Pod weight plnat (g)	100-pod weight (g)	100 Kernal weight (g)	Pod yield (q/ha)
Hand weeding + Intercultivation	15, 30 DAS 15, 30, 45 DAS	17.83	18.79	126.83	49.33	28.90
Alachlor	2.00	11.75	12.13	124.63	47.45	17.79
Fluchloralin	1.00	18.75	18.28	124.82	47.72	20.13
Pendamethalin	1.00	13.06	11.62	125.33	46.13	15.01
Fluzifop-p-butyl	0.25	10.86	10.83	123.68	46.38	10.12
Metalachlor	1.00	11.53	11.90	120.39	46.58	14.00
Alachlor + Intercultivation	2.00 + 15, 30, 45 DAS	14.73	14.51	124.42	49.51	24.30
Fluchloralin + Intercultivation	1.0 + 15, 30, 45 DAS	20.99	21.14	127.10	50.36	28.79
Pendamethalin + Intercultivation	1.0 + 15, 30, 45 DAS	15.33	14.31	124.95	48.45	23.29
Metalachlor + Intercultivation	1.0 + 15, 30, 45 DAS	14.93	16.35	117.84	47.63	25.55
Intercultivation	15, 30, 45 DAS	14.80	14.33	120.09	47.76	14.12
Unweeded check	-	9.62	9.81	116.42	43.37	9.37
SEm±		1.49	1.33	0.36	0.28	1.23
CD at 5%		4.35	3.89	1.05	0.82	3.58

DAS: Days after sowing : Intercultivation at 15, 30, 45 DAS

Yield and yield components

Hand weeding twice followed by 3 intercultivations and pre- emergence application of fluchloralin at 1 kg a.i./ha followed by 3 intercultivations recorded significantly higher yield (28.90 and 28.79 q/ha, respectively) than the rest of the treatments (Table 2). The increase in yield was 208 and 207 per cent, respectively over unweeded control. Yield reduction due to weeds was reported by Diwakar (1981).

Increase in pod yield with these treatments can be attributed to the significant enhancement in yield components like number of pods per plant, pod weight per plant and 100 pod weight (Table 2). Association of groundnut yield with pod weight per plant (Bhan and Singh, 1971) and pod number per plant (Kulandaivelu and Sankaran 1986) was also reported.

From the foregoing account, it can be inferred that pre-sowing incorporation of fluchloralin @ 1.0 a.i./ha supplimented with three intercultivations was found to be more effective in controlling weeds and offered higher pod yield of groundnut.

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FEASIBILITIES OF RAISING CEREAL FODDERS AS INTERCROPS IN SUMMER GROUNDNUT (*ARACHIS HYPOGAEA* L.)

Groundnut plays an important role in Indian economy as an oilseed crop. Yet, its productivity is only 750 and 1500 kg per ha in *kharif* and *rabi*/summer seasons respectively (Basu and Reddy, 1989). One of the thrusts to augment its productivity has been extending its area in summer as a light irrigated crop replacing paddy. Since fodder availability in summer is scarce, it was thought to examine the feasibility of raising a few fodder crops as intercrops in groundnut and to assess the effect of these on growth, yield and net income.

The field experiment was therefore carried out at the Regional Research Station, Tiptur of the U.A.S., Bangalore, during 1991 . The study comprised ten treatments (Table 1) laid out in Randomized Block Design with four replications in 3.0m x 2.4m net plots . The soil was sandy loam, acidic in reaction (pH 5.7), medium in organic carbon, available nitrogen (301.1 kg/ha)and potash (119.8kg/ha) and low in phosphorus (8.9 kg/ha). Groundnut was sown at 30 x 10 cm spacing. Fertilizer doses given for each crop were 25:75:37.5, 150:50:50, 100:50:37.5 and 100:50:25 kg N, P_2O_5 and K_2O per ha for groundnut, African maize, sorghum and bajra respectively. Groundnut also received 500 kg per ha of gypsum at 30 DAS. The intercrops were fertilized as per area occupied by them. Sorghum, bajra, African maize and groundnut were harvested at 60, 67, 75 and 128 DAS respectively for fodder and pod yields.

The pod yield of groundnut in the sole crop was 3056 kg per ha and with intercropping, its yield got reduced and ranged from 2278 kg with African maize in 4:1 to 2645 kg with sorghum in 4:1 row proportions (Table 1). Such reductions were also observed by Koli (1975) and Rao and Rana (1980). The African maize was harvested at 75 DAS but later than bajra and sorghum (75 and 65 days), thus causing severe competition with groundnut. While, sorghum established poorly and its competition was withdrawn a fortnight earlier than maize. Similarly, reduction in leaf area index and total dry matter production at 120 DAS was observed due to intercropping of African maize and Bajra as compared to sorghum. Hence the yield of intercropped groundnut with sorghum was the highest. Earlier harvesting of sorghum component also improved shelling percentage (77.0%). In case of bajra, competition was more because of greater tiller production.

This investigation indicates that when the individual yield of intercropped groundnut is considered, groundnut with sorghum is advantageous but when the net monetary value is considered, groundnut with African maize in 4:1 row proportions is remunerative with the highest net income of Rs. 30,888 per ha. This was because African maize produced more tonnage of green fodder which fetched higher market rate (Rs. 325/t) than other fodder. However, the pod yield was more in groundnut sole crop and in groundnut + sorghum intercropping than in groundnut + African maize in both 8:2 and 4:1 row proportions. Therefore, if more groundnut pods are desired sorghum could be the choice for intercropping as it would not be affecting its production greatly but at the same time giving some fodder. The best choice, however is groundnut and African maize in 4:1 row proportions for getting high monetary returns as well as to get high value fodder during normal or scarcity situations for fodder during summer.

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Table 1. Leaf area index, total dry matter production, pod yield, shelling per cent and net income as influenced by intercropping in groundnut

Treatments	Leaf area index (DAS) 30	60	90	Total dry-matter(g/pl) 120 days	Pod yield (kg/ha)	Shelling per cent	Net income (Rs./ha)
Groundnut (sole crop)	0.22	2.15	4.70	79.25	3055.6	71.5	27907.50
Groundnut + African maize (8:2)	0.30	1.63	4.00	67.45	2277.8	74.0	28722.75
Groundnut + African maize (4:1)	0.21	2.01	3.49	75.90	2388.9	72.0	30887.75
Groundnut + Sorghum (8:2)	0.29	1.98	4.47	77.00	2538.2	75.5	25058.00
Groundnut + Sorghum (4:1)	0.26	1.98	4.39	82.20	2645.8	77.0	27334.25
Groundnut + Bajra (8:2)	0.26	1.38	4.05	78.90	2319.5	72.0	25336.25
Groundnut + Bajra (4:1)	0.26	1.43	3.64	76.00	2468.8	72.3	26901.75
African maize (sole crop)							23748.25
Sorghum (sole crop)							7476.00
Bajra (sole crop)							19258.25
SEm ±	0.01	0.04	0.15	1.00	36.9	0.52	406.64
CD at 5%	0.02	0.12	0.45	2.98	111.4	1.53	1180.06

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OCCURRENCE OF MIXED INFECTIONS OF GV AND NPV IN CASTOR SEMILOOPER *Achaea janata* LINN (LEPIDOPTERA:NOCTUIDAE)

Larve of *Achaea janata*, collected from castor (*Ricinus communis*) crop at the Research Farm, DOR, Hyderabad during Sept.1990, when reared in the laboratory, exhibited symptoms of viral infection and the same was confirmed by observation under phase optics. The symptoms were of a latent infection as the larvae looked healthy in the field. The polyhedral occlusion bodies (POB) were extracted and partially purified and fed to healthy castor semilooper larvae (7-8 days old). The feeding was normal for 3-4 days and then onwards, the feeding was reduced. The infected larvae became long and slender. The cuticle became thin and light in colouration, shiny and slimy. The larvae died after 6-7 days. There was no oozing out of contents.

Small pieces of infected larvae, gut of infected larvae, as well as POBs pelleted after purifying on a 30-65% sucrose gradient at 50,000 RPM in an ultracentrifuge, were fixed in glutaraldehyde for ultrastructural investigations.

The ultrastructural investigations revealed the presence of mixed infection (Fig.1) of Granulosus virus (GV) and Nuclear polyhedrosis virus (NPV) . The NPV (Fig .2) were tetrahedral in shape and contained 3-4 bundles of nucleocapsids with each bundle containing 2-3 nucleocapsids. The GV (Fig . 3) showed a single nucleocapsid but many of them were larger in size than that normal for GV i.e,. greater than 0.5um. The size of NPV was $1.66 \pm 0.31 \times 1.98 \pm 0.33$um. The size of GV was $0.671 \pm 0.12 \times 0.457 \pm 0.09$um.

Similar reports of occurrence of Baculovirus in castor semilooper has been reported earlier by Battu(1986) from Punjab and Vyas *et al.*, (1989) from Gujarat. However this is the first report on the occurrence of similar infection in and around Hyderabad.

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Fig. 1 Mixed infection of GV and NPV. Magnification - x 10,000

Fig. 2 Nuclear Polyhedrosis virus of *A. Janata*
Magnification - x 16,000; N - Nucleocapsids

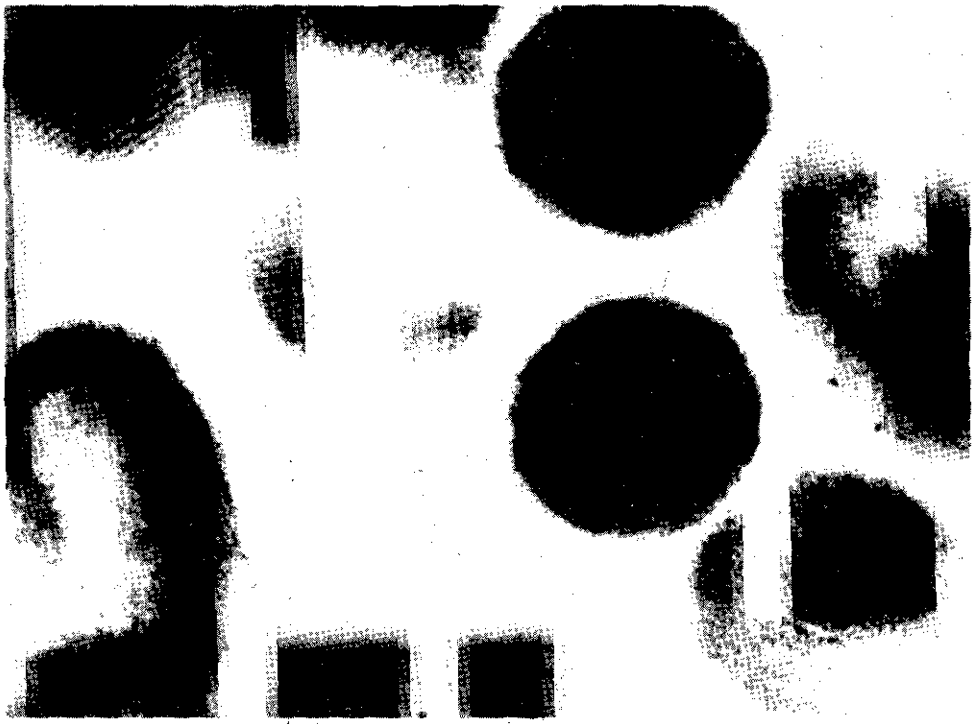

Fig. 3 Granulosus virus with a single central Nucleocapsid
Magnification - x 28,000

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SELECTION CRITERIA IN SOYBEAN (*GLYCINE MAX* (L.) *MERRILL*)

Success in any breeding programme mainly depends upon the choice of parents. Since yield is a complex quantitative character and determined by number of component characters, it is not merely possible for a breeder to select a high yielding genotype by considering a single character. Hence, a selection model for making selection on several characters simultaneously will be much useful. The present study was programmed to fix selection criteria based on simultaneous selection in many traits in soybean, an important leguminous crop which was a recent introduction for cultivation in India. Mishra *et al.*, (1988) has already fixed selection indices for different genotypes in soybean.

Sixty four geographically diverse genotypes of soybean were raised in a Randomized Block Design with three replications during *kharif* 1989 at Agricultural College and Research Institute, Madurai. Each genotype was accomodated in a single row of 6 m length with a spacing of 45 x 10 cm. Observations on 11 traits were recorded from 20 randomly selected plants from each genotype per replication. Three criteria viz., mean values of the genotypes for different traits, combined scores covering all the characters for different genotypes and discriminant function as suggested by smith (1936) were used for evaluation of genotypes.

The mean performance of the 64 genotypes revealed that certain genotypes showed their superiority over others for different traits. In a collection of genotypes, if certain types have superior performance than others for different traits, it is better to choose such of those superior performers for further breeding work. In the present study none of the types showed superior performance for all the 11 traits. However, among the 64 types studied, the genotype EC 100776 was significantly superior than grand mean for eight traits viz., days to 50% flowering , plant height, pods per plant, pod length, seed yield per plant, 100 seed weight, harvest index and protein content. Similarly, three other genotypes viz., EC 95287, IC 16990 and EC 94038 were also superior than others. While EC 95287 was significantly better for seven traits viz., plant height, pods per plant, harvest index and oil content, the type IC 16990 was superior for days to 50% flowering, plant height, primary branches per plant, pods per plant, pod length, protein content and oil content. The genotype EC 94039 recorded superior performance for plant height, primary branches per plant, pods per plant, pod length, seeds per pod, single plant yield and protein content. Apart from the four genotypes mentioned above, secondary order of importance may be given for selection of nine more types viz., SDP (L), KB, 80, KB 93, EC 14434, EC 62384, EC 14426, 37656 AMSS 52 and JS 81-303. These genotypes have superior performance for six characters each.

Since the aforesaid method of evaluation of genotypes takes into account only significantly superior mean values for different traits, a slightly modified method (combined score method) was also followed, which takes into account of significantly inferior mean values of different traits also. In this method, considering 'm' as the grand mean of all the genotypes and 'CD' as critical difference based on the analysis of variance for different traits, three kinds of scores viz., score -1 (mean of genotype below m-CD), score 0 (mean of genotype between m-CD and m + CD) score +1 (mean of genotype above m + CD) were given for all the genotypes. A combined score covering all the characters was worked out for each genotype. The combined scores revealed that the genotypes EC 95287 (+7), EC 100776 (+6), EC 14434 (+5), IC 16990 (+5), ACC NO 2004 (+5), EC 62384 (+5), EC 94038 (+5), 37656 (+4),

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AMSS 52(+4), SDP (L) (+3), EC 26691 (+3) and KB 78 (+3) were superior over other genotypes in an overall assessment of all the traits.

Smith (1936) proposed a selection model for making effective selection of superior from a collection of many genotypes considering several characters simultaneously using discriminant function. This method was also adopted in the present study to evaluate genotypes using reciprocal of concerned mean as weightage for different characters. In this context, the genotypes EC 94038, AMSS 52, SDP (L), EC 50084, EC 3294, EC 50082, EC 14434, ACC NO 2004, IC 16990, EC 95287 and EC 62384 (Selection index above 11.00) were adjudged as better than other genotypes.

While comparing all the three methods of evaluation viz., based on (1)mean, (2) combined scores and (3) selection index, it was clear that there were broad similarities in the ranking of genotypes between different methods of evaluation (Table 1). Therefore, selection of genotypes based on superior mean performance for as many characters as possible will be an ideal selection criteria.

Table 1. Comparison of three methods of evaluation

Superior mean		Combined scores		Selection index	
Rank	Genotype	Rank	Genotype	Rank	Genotype
1	EC 100776	1	EC 95287	1	EC 94038
2	EC 95287	2	100776	2	AMSS 52
3	IC 16990	3	IC 16990	3	SDP (L)
4	EC 94038	4	EC 94038	4	EC 50084
5	SDP (L)	5	EC 14434	5	EC 3294
6	EC 14434	6	EC 62384	6	EC 50082
7	EC 62384	7	ACC NO 2004	7	EC 14434
8	AMSS 52	8	AMSS 52	8	ACC NO 2004
9	37656	9	37656	9	IC 16990
10	EC 14426	10	SDP (L)	10	EC 95287
11	KB 80	11	EC 26691	11	EC 62384
12	KB 93	12	KB 78		
13	JS 81-303				

Considering all the three methods of evaluation of genotypes in toto, ten genotypes viz., EC 95287, IC 16990, EC 94038, SDP (L), EC 14434, EC 62384, AMSS 52, EC 100776, 37656 and ACC No. 2004 were found to be better than others. Therefore, these ten genotypes may be used directly for multilocational tests and selecting any one of them as improved variety or may be used as potential parents in any future breeding programme to combine the desirable attributes in the improvement of soybean.

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EFFECT OF NITROGEN, PHOSPHORUS AND SULPHUR ON SEED YIELD AND QUALITY OF MUSTARD

Soils of North Gujarat are deficient in available nitrogen and sulphui and medium in available phosphorus. The information available on the response and uptake pattern for these nutrients on mustard in this region is meagre and the present study is an attempt in this direction.

An experiment was conducted at Sardar Krushinagar, Gujarat Agricultural University during *rabi* 1990 on a loamy soil with pH 8.1, organic carbon 0.21%, alkaline $KMnO_4$ oxidizable nitrogen 144 kg N/ha, 0.5 M $NaHCO_3$ (pH 8.5) extractable phosphorus 48 kg P_2O_5/ha, 1N NH OAC (pH 7.0) extractable potassium 214 kg K_2O/ha and heat soluble sulphur 9.0 ppm. The treatment (Table 1) were replicated three times in a Randomised Block Design. Urea, DAP and gypsum were used as sources for N, P and S respectively. Full dose of P, S and 50 per cent of N as per treatment were applied below the seed at the sowing time. Remaininig 50 per cent N was top dressed after 45 days of sowing. The crop (Gujarat Mustard) was sown 45 cm apart, at a seed rate of 4 kg per hectare.

The appraisal of data (Table 1) reveal that increasing levels of nitrogen recorded significantly higher seed, straw and oil yields. The highest yield in all respects were with the application of 75 kg N/ha. Similarly, the uptake of nitrogen and phosphorus in grain and straw increased significantly with increasing levels of N upto 75 kg/ha. The increase in nitrogen with increasing nitrogen levels upto 120 kg/ha was also reported by Antil *et al.*, (1986), in a sandy loam soil at Hissar. The application of nitrogen significantly affected the uptake of sulphur. The maximum uptake of sulphur by grain and straw (9.48 and 13.27 kg/ha) were recorded with 75 kg N/ha.

Similarly, the response to phosphorus application was also observed. Application of 50 kg P_2O_5/ha produced signficantly higher grains (1039.44 kg/ha), straw (2606.31 kg/ha) and oil yield (377.83 kg/ha). Signficantly higher uptake of P, N and S by grain and straw was also obtained under this P treatment.

Application of sulphur at 40 kg S/ha significantly increased grain, straw and oil yields as well as the uptake of S, N and P by grain and straw. The higher level of S application to the crop resulted into profused vegetative and root growth and might have activated the absorption of S, N and P from the soil. Similar results have also been reported by Aulakh and Pasricha (1983).

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Table 1 Effect of different treatments on yield, quality and uptake of N, P and S by mustard

Nutrient (kg/ha) (N P S)	Seed yield (kg/ha)	Straw yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Nutrient uptake (kg/ha)					
					N		P		K	
					Seed	Straw	Seed	Straw	Seed	Straw
Nitrogen										
25	823	2179	37	305	24.6	21.5	6.2	5.4	7.9	11.1
50	1013	2571	36	366	29.8	23.9	8.2	7.1	8.7	12.2
75	1141	2725	36	409	33.6	26.2	9.2	8.0	9.5	13.3
Phosphorus										
25	949	2394	36	341	27.4	21.7	7.2	6.3	8.3	11.6
50	1039	2606	36	378	32.1	26.1	8.8	7.6	9.5	13.2
75	988	2476	36	360	28.5	23.8	7.7	6.7	8.4	11.7
Sulphur										
0	941	2421	36	337	27.1	21.7	6.6	5.7	7.6	10.6
20	968	2466	36	350	28.5	23.8	8.1	7.1	8.5	11.8
40	1068	2589	37	392	32.4	26.1	8.9	7.8	10.1	14.1
CD (0.05) for N, P and S	62	112	NS	28	2.6	2.0	0.9	0.7	1.0	1.3

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GENETICS OF MATURITY DURATION IN SOYBEAN UNDER TROPICAL CONDITIONS

At present, the major objective in breeding of soybeans is the development of early maturing varieties as it could increase the crop intensity and total production, especially in the tropics/sub-tropics. So, it was considered desirable to obtain information on the genetics of maturity duration in soybean.

Eight diverse parental lines were crossed to generate 5 F_1's [Bragg (early) x Kalitur (Late); Kalitur x UPSM 534 (early); PK 327 (early) x Jupiter (Late); PK 317 (early) x T 49 (Late) and PK 472 (Late) x UPSM 534 (early)]; 5F_2's and 5F_3's. F_1's (about 10 seeds/cross) and F_2's (approx. 500-800 seeds/cross) were made available from the soybean breeding project (AICRPS). These F_1's (one row, 4m long/cross) and F_2's (25-40 rows) were sown on July 12, 1986 along with parents (4 rows). Individual plants in F_2 generations of five soybean crosses and their parents were space- planted 20cm apart in rows, 4 metre long and 60 cm wide. Out of five, 4 F_1's did not germinate in 1986. Hence, fresh F_1 seeds of these crosses were again produced during *kharif* 1986. In 1987, parents (4 rows) F_1's (one row/cross), and F_3's (80 lines/cross, derived from 80 random F_2 plants) were planted on July 21. Frequency data were used to classify genotype into distinct groups and the Chi-Square test was conducted to ascertain the goodness of fit of various genetic ratios. The genotypes of each randomly selected F_2 plants was ascertained by classifying F_3 progeny row.

Parental and F_1 behaviour

Maturity duration, in the F_1 plants of four crosses viz., Bragg x Kalitur, Kalitur x UPSM 534, PK 317 x T 49 and PK 472 x UPSM 534 was lower than the mid parental values (more towards early parent mean) indicating partial dominance of early maturity over late maturity (Table 1) whereas in one cross PK 327 x Jupiter, maturity duration of F_1 plants was lower than

Table 1. Range and mean days for maturity duration in parents and F1's of different crosses of soybean

Cross	Year	Generation	Maturity duration	
			Range	Mean
Bragg x Kalitur	1987	P_1	95-103	101.0
		P_2	109-116	112.0
		F_1	104-109	105.0
Kalitur x UPSM 534	1987	P_1	109-116	112.0
		P_2	95-103	99.0
		F_1	102-0	102.0
PK 327 x Jupiter	1987	P_1	92-104	97.0
		P_2	111-118	114.0
		F_1	92-100	95.0
PK 317 x T 49	1986	P_1	101-105	101.9
		P_2	114-128	123.8
		F_1	111-0	111.0
PK 472 x UPSM 534	1987	P_1	102-108	107.0
		P_2	95-103	99.0
		F_1	102-0	102.0

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the mean of early parent indicating complete dominance for earliness. Bernard (1971) and McBlain and Bernard (1987) reported partial dominance of late maturity over early maturity whereas in the present study, partial/complete dominance of early maturity over late maturity was observed.

Frequency distribution and segregation pattern

1. Bragg x Kalitur

In this cross both the parents showed non-overlapping distributions (Table 2). A trimodal frequency distribution for early (101-109 days), segregating (110-113 days) and late maturing (114-118 days) type F_2 plants was observed. A fit to 1 (early) : 2 (segregating) : 1 (Late) ratio was shown. F_2 plants falling in their parental ranges were classified as true breeding early and late types. Transgressive segregation was also observed in F_2 but only for early date of maturity. This may result from inter-plant competition. The F_3 lines gave a satisfactory fit to 1 (early) : 2 (segregating): 1 (late) genetic ratio (Table 3). Thus confirming the single gene model as observed in F_2.

2. Kalitur x UPSM 534

The parents showed non-overlapping distributions. In this cross, if the 115 F_2 plants of intermediate classes were equally divided (57.5 and 57.5) and added to the early and late classes, a fit to 9 (early) : 7 (late) ratio was obtained. But if we accept a few misclassifications in 112 and 113 day category (Table 2) it could fit to 1 (early) : 2 (segregating) : 1 (late). F_3 segregation pattern (Table 3) supported the single gene model instead of two gene model for the expression of maturity duration. McBlain and Bernard (1987) and McBlain *et al.*, (1987) in soybean also reported a single locus for maturity (1 early : 3 late) but with the degree of dominance being different than that of ours.

Table 3. Segregation ratios for days to maturity in five crosses of soybean

Cross	Generation	Observed segregation			Total	Expected	$\chi 2$	P
		Early	segre-gating	Late				
Bragg x kalitur	F2 plants	51	82	59	192	1:2:1	4.750	0.10-0.05
	F3 lines	15	49	14	78	1:2:1	5.153	0.10-0.05
Kalitur x UPSM 534	F2 plants	109.5	-	91.5	201	9:7	0.256	0.90-0.80
	F3 lines	23	37	18	78	1:2:1	0.845	0.70-0.50
PK 327 x Jupiter	F2 plants	171	-	17	188	15:1	2.502	0.30-0.20
	F3 lines	38	39	2	79	7:8:1	2.095	0.50-0.30
PK 317 x T 49	F2 plants	270	-	88	358	3:1	0.034	0.99-0.98
	F3 lines	16	42	15	73	1:2:1	1.686	0.50-0.30
PK472 x UPSM 534	F2 plants	214.5	-	157.5	372	9:7	0.301	0.90-0.80
	F3 lines	7	29	19	55	1:8:7	4.839	0.10-0.05

3. PK 327 x Jupiter

The parental cultivars had non-overlapping distributions. When 30 F_2 plants of intervening classes were equally divided and added to the early and late classes (Table 2), a reasonable profit to the ratio of 15 (early) : 1 (late) was obtained. In this case, classical genetic ratio of 9:3:3:1 was modified to 15:1. Two dominant alleles of both the loci were producing the same phenotype without cumulative effect (either together or alone). This digenic ratio was further substantiated by F_3 progeny test (7 early : 8 segregation : 1 late) and confirmed the involvement of two dominant genes (Table 3).

4. PK 317 x T-49

A bimodal distribution for early (101-111 days), and late (112- 128 days) maturing type plants was obtained in F_2 generation of this cross (Table 2). F_2 plants were classified into early types on the basis of F_1 plant maturity. The frequency of 3 (early) : 1 (late) types gave a good fit to the monogenic segregation. This was confirmed by observing F_3 segregation pattern having a good fit to the expected 1 (early) : 2 (segregating) : 1 (late), indicating involvement of a single gene pair for maturity duration (Table 3). This result is not in conformity with those of McBlain and Bernard (1987) and McBlain *et al.*, (1987) with respect to nature of dominance as they reported a segregation pattern of 1 early : 3 late instead of 3 early : 1 late.

5. PK 472 x UPSM 534

Parents were separated by one class interval. In this case, the 3 individuals which fell in the intervening class were equally divided (1.5 and 1.5) to the early and late classes (Table 2). F_2 segregation gave a fit to the genetic ratio of 9 (early) : 7 (late), indicating the involvement of two gene pairs which were acting in a complementary manner to give early maturity. Any individual in the F_2, which possesses either one or non-dominant gene, would be a late type. The F_3 generation of this cross supported the involvement of two complementary factors by showing a fit to 1 early : 8 segregating : 7 late ratio (Table 3). Bernard (1971) also reported two gene pairs (E_1 and E_2) that affected time of maturity. Rai and Richharia (1948) in Vigna unguiculata also reported that the inheritance of maturity was controlled by two complementary factors. Bernard and Weiss (1973) reported that maturity was a quantitative trait hence several factors may influence the separation of phenotypic classes in populations segregating for maturity genes (McBlain *et al.,* 1987).

Summary on genetics of maturity in soybean

Genetic control of maturity time had been reported to be governed by five gene pairs ($E_1 e_1$, $E_2 e_2$, $E_3 e_3$, $E_4 e_4$ and $E_5 e_5$) in temperate environments (Bernard, 1971; Buzzel, 1971; Buzzel and Voldeng, 1980; Kilen and Hartwig, 1971 and McBlain and Bernard, 1987). The dominant alleles at all the five loci confer late maturity (McBlain *et al.*, 1987) whereas in the present findings either one or two dominant alleles were shown to confer early maturity.

Table 2. Frequency distribution of number of plants (parents and F_2 generation) for days to maturity in five crosses

Population	Days to maturity																	
	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Bragg										10		5						
kalitur																	10	39
UPSM 534				10		10		7	3									
PK 327				3	1	14			2									
Jupiter																4	2	11
PK 317				9		2		2										
T 49																	1	2
PK 472												28	3	14				
Bragg x Kalitur				2		8		3		21		17	18	19	33	12	12	35
Kalitur x UPSM 534		1				10		15		26	1	14	4	15	80	1	3	22
PK 327 x Jupiter				4		45		45	3	59	3	19	2	3	3	1		
PK 317 x T 49				15		19		37	8	81	6	68	17	19	18	4		
PK 472 x UPSM 534	1		1	29		22		28	9	123	3	110	1	7	34	2	1	1

Contd..

Table 2 contd...

Population	Days to maturity																
	116	117	118	119	120	121	122	123	124	125	126	127	128	129	N	$\bar{x}$*	SD
	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Bragg															15	108	0.94
kalitur		15	5												69	115	1.19
UPSM 534															30	103	1.96
PK 327															20	103	1.50
Jupiter		4	6	2											29	116	1.86
PK 317															13	102	1.49
T 49	1	1		1			6		4	4	1	3	6	2	32	124	4.33
PK 472															45	110	0.91
Bragg x Kalitur	2	4	6												192	111	3.57
Kalitur x UPSM 534	5	3		1											201	111	3.55
PK 327 x Jupiter				1											188	106	2.55
PK 317 x T 49	2	6		17		2					2		2		358	109	4.73
PK 472 x UPSM 534															372	107	2.94

N = Total number of plants; $\bar{x}$ = General mean; SD = Standard deviation

* Mean values rounded off to complete figures.

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ACCUMULATION OF STORAGE COMPONENTS IN DEVELOPING MUSTARD (*BRASSICA JUNCEA*) SEEDS

Oilseeds accumulate storage compounds during embryogenesis which serve as nitrogen and carbon sources during germination. The onset of deposition of storage component is controlled by the developmental stage of embryo. Some information is available on the accumulation of storage components during embryogenesis of rapeseed (Crouch and Sussex, 1981). However not much information is available on the accumulation of storage components in the developing Indian mustard seeds. Accordingly, the compositional changes in mustard (*B. juncea* cv. Prakash) seeds were studied.

Mustard crop (*B. juncea* cv. Prakash) was raised in the field of HAU farm following standard agronomic practices. Buds of equal size were tagged on a single day and the siliquae were collected from 10 DAF (days after flowering) upto maturity (45 DAF) at three days interval. Seeds were removed from the siliqua and weighed. Dry weight was determined by drying the seeds to a constant weight at 80°C. Oil was estimated by using NMR, MK III A Newport Analyser equipped with 2ml sample coil assembly (Gupta *et al.*,1985). Nitrogen content of seeds, determined by the conventional micro- Kjeldahl method (AOAC, 1970). Free amino acids were estimated by the method of Yemm and Cocking (1955) using glycine as a standard.

In the siliqua, the earliest stage at which visible seed formation could be seen was 10 DAF. However, at this stage the development of seed in terms of dry matter was only 0.7 per cent. The period for the initiation of accumulation of dry matter, oil and nitrogen in the present investigation was between two and three weeks after flowering. In *B. napus* also, the dry matter, oil and protein accumulation was reported to begin between two and three weeks after flowering (Crouch and Sussex, 1981). Fresh weight of seeds decreased, while dry weight continued to increase until 42 DAF stage (Fig. 1). Maximum rate of dry matter accumulation (0.14 mg/seed/day) was observed between 36 and 39 DAF stage. The mature seeds weighed 3.42 mg/seed. Nitrogen content of a seed is a relative indicator of protein content. The earliest stage at which nitrogen could be detected in the seeds was at 10 DAF stage, while the oil could be detected at 18 DAF stage (Fig. 2). The rate of accumulation of nitrogen was found maximum (7.33 μg/ seed/day) between 39 and 42 DAF stage. The amount of nitrogen found in mature seed was 131 μg/seed. The maximum rate of oil accumulation (83 μg/seed/day) was observed during 24 and 27 DAF stage while oil accumulation continued upto 42 DAF stage. In mature seeds the oil content was 1.462 mg/seed. Murphy and Cummins (1989) also observed rapid oil deposition in *B. napus* between four and six weeks after anthesis. In the present studies oil accumulated maximally earlier than accumulation of dry matter and nitrogen. Accumulation of dry matter, oil and nitrogen followed a sigmoidal pattern (Fig. 2). Such sigmoidal pattern of dry matter and oil accumulation has also been reported in *B. napus* (Murphy and Cummins, 1989). Free amino acid content increased during seed development and it reached to a maximum (12.38 μg/seed) at 24 DAF stage (Fig. 2). A sharp decline in free amino acid content was observed between three and four weeks after anthesis. Thereafter, it decreased gradually to a level of 4.54 μg amino acid/seed in the mature seeds. Such changes in amino acid content have also been reported in developing *B. napus* and peanut seeds (Finlayson and Christ, 1971; Basha *et al.*, 1976). The decrease in free amino acid content after 24 DAF was perhaps indicative of their rapid utilization for protein synthesis.

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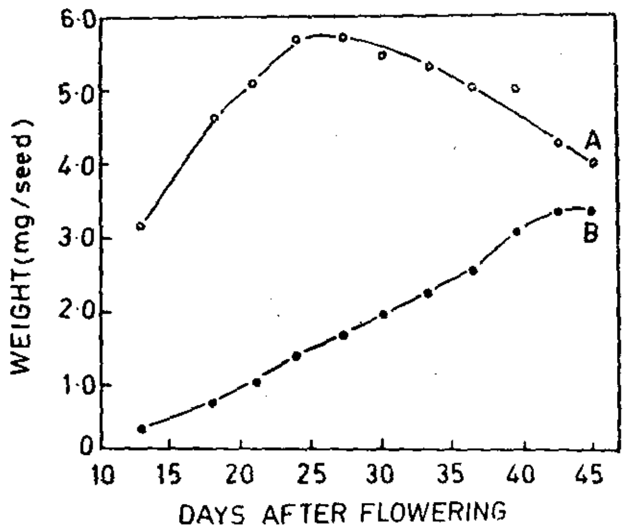

Fig. 1 Weight changes during development of *B. juncea* cv. Prakash seeds A. Fresh weight; B. Dry weight

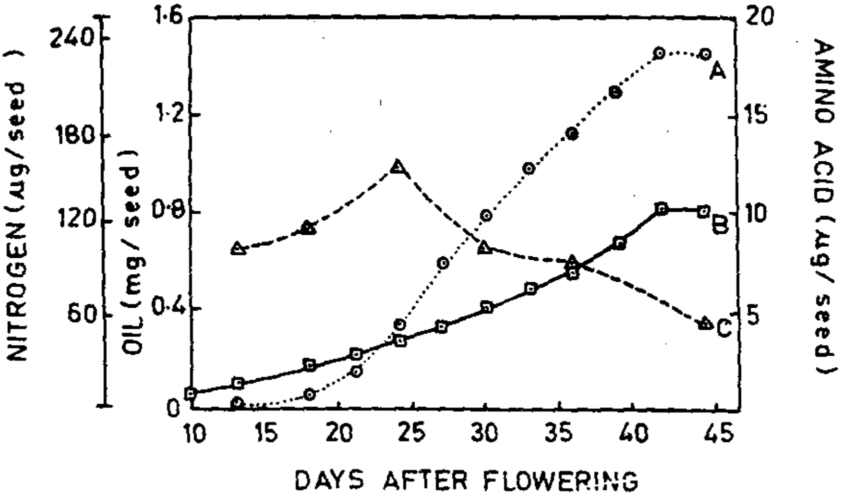

Fig. 2 Compositional changes during development of *B. juncea* cv. Prakash seeds A. Oil; B. Nitrogen; C. Free Amino acid

Results reported here suggest that in *Brassica juncea cv*. Prakash, the expression of genes responsible for contribution towards dry matter accumulation was maximum at 36 DAF stage. Thus the maturing seeds at 36 DAF stage are the most appropriate material for investigating gene products responsible for oil and protein deposition.

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EFFECT OF AMBIENT TEMPERATURE ON OIL ACCUMULATION IN BRASSICA SPECIES*

A field experiment was conducted on the farm of Indian Agricultural Research Institute, New Delhi during *rabi* 1987-88 and 1988-89 to study the effect of ambient temperature on oil accumulation in three cultivars of Brassica species viz., *Brassica napus* var. B.O. 54, *Brassica juncea* var. Pusa Bold and *Brassica campestris* var. Toria-T9, with different maturity periods. B.O. 54 is a late maturing variety, Pusa Bold has medium maturity and Toria-T9 is the one which matures early. The sowing was done on 7th, 10th October and 4th November during 1987-88 and 5th, 22nd October and 5th November during 1988-89 seasons. The crop was raised under no nutrient stress (60 Kg N, 92 kg P_2O_5 and 48 kg K_2O ha^{-1}) and under "no short of water" conditions. The experiment was laid out in RBD. The treatments included, three varieties and three sowing dates.

Study on seed oil content accumulation was made by using the procedure suggested by Kartha *et al.,* (1954), *Brassica* seed weighing 0.5g was taken and ground with 2.0 g of Pyrex glass powder and 2.5 g of anhydrous sodium sulphate (Na_2SO_4). The mixture was put in tappering glass tubes and extracted with 20 to 22 ml of petroleum benzene (boiling range 40-60°C) into the conical flasks. The aliquot was heated on water bath till it completely evaporated off, leaving behind oil in the conical flasks. The per cent oil content was calculated as :

$$Oilcontent\ (\%) = \frac{weight\ of\ oil\ in\ the\ seeds}{Dry\ weight\ of\ seeds} \times 100$$

The sampling for oil content was started after seed formation and continued at periodic intervals 24th Jan, 2nd, 15th, 28th Feb, 11th, 19th and 31st March. The per cent oil content values were measured and shown in Table 1. Relatively higher values of oil content were attained by the early maturity stage. These values were recorded when the pods were yellow in colour. The highest values of per cent oil content in the different treatments ranged from 39.5 to 42.5 in variety B.O. 54, 35.5 to 39.9 in Pusa Bold and 36.61 to 42.7% in Toria-T9. It may be mentioned that Gambhir *et al.*, (1983), using nuclear magnetic resonance (NMR) technique reported the highest per cent of oil content at yellow pod stage in Pusa Bold, in the Delhi region.

Oil content values at harvest obtained with the help of NMR and the accumulated growing degree days (GDD) during the oil accumulation period are given in the Table 2. The oil content in Brassica species under study ranged from 39.3 to 47.45% in the different sowings. During 1988-89 *rabi* season, it took more GDD for oil accumulation which resulted in higher oil content. This is more attributable to the prolonged growing season, relatively with cooler temperatures in 1988-89 season during the oil accumulation period. Oil content at harvest in variety B.O. 54 ranged between 39.7 to 45.0%. Whereas in Pusa Bold it ranged from 39.3 to 43.9%. First sowing in both the varieties B.O. 54 and Pusa Bold gave higher percentage of oil content. In Toria- T9, oil content ranged from 44.9 to 47.45%. The higher percentage of oil content (46.8 and 47.45%) was found in the third sowing, respectively in both the seasons. The

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Table 1. Oil content (%) in *Brassica* spp. in post pod formation stage during *rabi* 1988-89

Treatment	Sample	Jan.24	Feb.2	Feb.15	Feb.28	Mar.11	Mar.19	Mar.31
V1P1	1	30.95	29.5	36.9	38.2	34.2	38.4	-
	2	-	27.4	42.4	38.1	36.6	42.5	-
V1P2	1	-	8.7	16.1	40.6	30.3	34.7	-
	2	-	8.4	17.6	40.2	36.0	37.9	-
V1P3	1	-	-	11.3	19.2	39.5	36.7	31.7
	2	-	-	14.7	23.5	38.1	38.6	33.0
V2P1	1	35.75	35.4	33.7	31.9	37.9	-	-
	2	34.86	35.9	32.6	30.9	36.7	-	-
V2P2	1	-	24.2	34.7	33.3	36.7	36.5	-
	2	-	25.9	36.8	32.4	35.5	32.3	-
V2P3	1	-	4.9	18.1	30.9	39.9	32.5	30.3
	2	-	4.2	18.3	31.0	39.2	29.3	32.5
V3P1	1	36.61	31.5	33.0	-	-	-	-
	2	38.62	33.7	37.3		Crop harvested		
V3P2	1	40.36	41.8	42.8	38.9	-	-	-
	2	42.15	42.3	41.4	38.3	-	-	-
V3P3	1	-	22.5	39.2	42.7	35.6	-	-
	2	-	21.6	31.1	42.1	40.1	-	-

V1,V2 and V3 are vareities; B.O. 54, Pusa Bold and Toria-T9 respectively; P1, P2 and P3 are sowing dates 1, 2, 3 respectively. Underlined values indicate accumulation of maximum oil content.

Table 2. Oil content (%) and accumulated growing degree days (GDD) during oil accumulation period in *Brassica* spp.

Variety	Season	Oil content			GDD		
		P1	P2	P3	P1	P2	P3
B.O.54	I	42.50	42.26	39.70	1300 (16.4)	1324 (17.1)	1296 (18.4)
	II	45.00	43.75	43.75	1452 (16.1)	1371 (16.4)	1209 (16.6)
Pusa Bold	I	41.66	39.30	40.80	1337 (16.3)	1186 (16.1)	1226 (17.3)
	II	43.90	42.70	43.20	1452 (16.1)	1385 (16.2)	1186 (16.5)
Toria-T9	I	45.80	45.15	46.80	1087 (16.0)	1017 (15.6)	975 (15.8)
	II	45.40	44.90	47.45	1137 (15.8)	1102 (15.2)	884 (15.0)

P1,P2 and P3 are sowing dates 1, 2 and 3 respectively.

I = 1987-88; II = 1988-89.

Values in parenthesis are the mean temperatures during seed filling period.

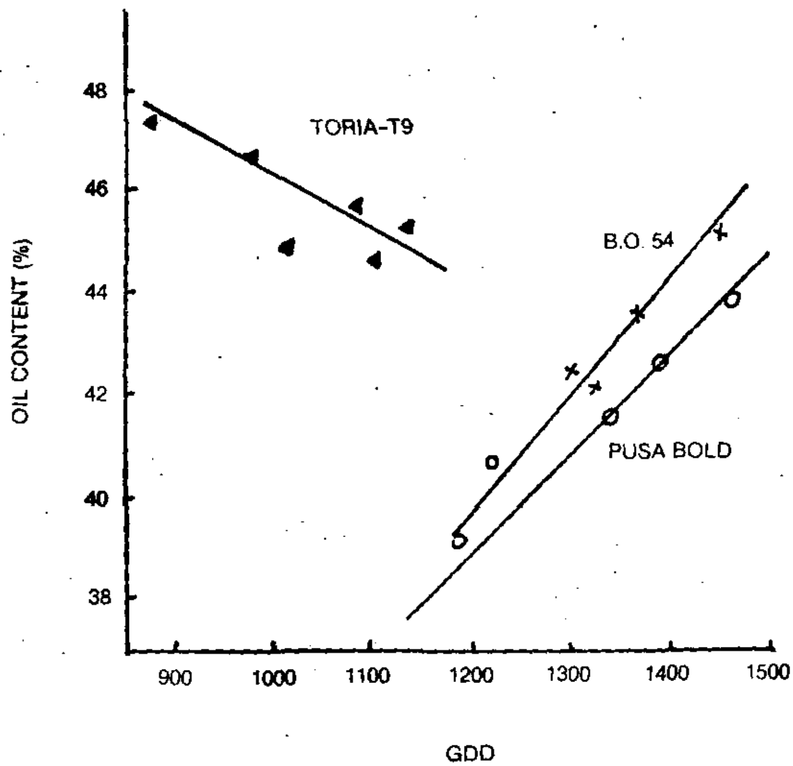

Fig. 1 Relationship between oil content (%) and accumulated growing degree days (GDD)

optimum temperature conditions for oil accumulation appear to correspond to the thermal environment that prevailed during pod filling stage of variety Toria-T9 with accumulation of 1033 GDD. The relationship between per cent oil content at harvest and accumulated heat unit system in Brassica species is shown in Fig.1. These lines were drawn using eye estimation which shows a linear trend in the relationship. In case of variety B.O. 54 and Pusa Bold, the per cent oil content showed an increase with increasing GDD. The short duration variety Toria-T9 on the other hand, gave an inverse relationship showing a decrease in oil content with increase in GDD.

Hodgson (1979) reported that oil content was inversely related to mean daily temperature during seed filling period. Shastry and Kumar (1981), Vasi *et al.*, (1986) observed that maximum temperature at vegetative stage was positively correlated with per cent oil content in Brassica. Results in the present investigation showed a direct relationship in long duration varieties (B.O. 54 and Pusa Bold). This type of behaviour is probably attributable to the differing thermal regimes encountered by the short and long duration varieties and needs further study.

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STUDIES ON THE COMPATIBILITY OF ANTAGONISTS WITH *RHIZOBIUM* IN GROUNDNUT.

Groundnut is an important oilseed crop. In India it is grown in an area of 7.6 million ha with a total production of 7.5 million tonnes with an average yield of 987 kg/ha. Mathur *et al*., (1967) reported that in the bunch varieties the mortality due to root rot was 65-75 per cent. The yield loss due to this was estimated to be 30 per cent. Seed bacterization with *Bacillus subtilis* has been found to be effective against soil borne pathogens. This treatment has also considerably improved the yield and dry matter of plants (Chang and Kommedahil, 1968). Application of *Trichoderma viride* reduced the root rot incidence in groundnut (Muthamilan, 1989). Biofertilizer *Rhizobium* is being recommended for groundnut for nitrogen nutrition. A pot culture study was conducted to find out the compatibility of Rhizobium with antagonists viz., *Trichoderma viride* and *Bacillus subtilis* in groundnut.

The antagonism of *T. viride* (T.V. 6), and *B. subtilis* (B.S. 9) against root rot fungus *Macrophomina phaseolina* under *in vitro* conditions has been proved in TNAU laboratory. These antagonists were used in the present investigation. *Rhizobium* strain TNAU 14 was used for seed treatment for nitrogen nutrition. Pot culture experiment was laid out with pathogen *M. phaseolina* alone in one treatment (control), pathogen with antagonists individually, pathogen with *Rhizobium* and pathogen in combination with individual antagonist and *Rhizobium*. The details of treatments are given in Table 1.

Sterilized soil was used for the studies at 2.5 kg/pot. The treatments were replicated thrice. In each treatment 30 plants were maintained. Seeds were treated with *T. viride* powder formulation at 4g/kg of seed. *B. subtilis* and *Rhizobium* were used at 600 g peat based inoculum for seeds required for one hectare. The sclerotia of *M. phaseolina* was incorporated a 500 mg/kg of soil (Elad *et al*., 1980). Nodulation, nodule dry weight were recorded on 30 and 50 DAS. Root rot incidence was recorded on 50th day.

Nodulation and nodule dry weight in the pot culture studies as influenced by various treatments is shown in the Table 1.

Table 1. Interaction of antagonists and *Rhizobium* on nodulation and nodule dry weight of groundnut

Treatments	Nodules/plant (days)		Nodule dry weight (mg)/plant (days)	
	30	50	30	50
T.viride + M.phaseolina	--	--	--	--
B.subtilis + M.phaseolina	--	--	--	--
Rhizobium + M.phaseolina	18.5	37.7	49.1	102.3
T.viride + Rhizobium + M.phaseolina	18.5	44.3	50.4	109.7
B.subtilis + Rhizobium + M.phaseolina	20.1	45.7	56.7	110.9
M.phaseolina alone (control)	--	--	--	--
CD	NS	0.8	1.2	0.9

The results clearly showed that either *T. viride* or *B. subtilis* when combined with *Rhizobium* did not inhibit nodulation, but increased significantly on 50th day. The nodule dry

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weight has also increased significantly on 30th and 50th day when *T. viride* or *B. subtilis* combined with *Rhizobium* (Table 1).

The incidence of root rot disease as influenced by various treatments is given in the Table 2.

Table 2. Interaction of antagonists and *Rhizobium* on the root rot incidence of groundnut

Treatments	% Root rot incidence
T.viride + M.phaseolina	18.7(26.2)
B.subtilis + M.phaseolina	25.3(30.8)
Rhizobium + M.phaseolina	54.7(48.3)
T.viride + Rhizobium + M.phaseolina	13.3(22.1)
B.subtilis + Rhizobium + M.phaseolina	17.3(25.2)
M.phaseolina alone (control)	57.3(49.8)
CD	7.2

Figures in parenthesis are transformed values

T. viride + Rhizobium and *B. subtilis + Rhizobium* treated crop registered 13.3% and 17.3% root rot which is significantly lesser to control (57.3%) (Table 2).

Haral and Konde (1983) reported that *B. subtilis + Rhizobium* treatment increased the nodulation over *Rhizobium* treatment alone in chickpea. In the present investigation also similar results were obtained (Table 1). Turner and Backman (1991) reported that treatment of groundnut seeds with *B. subtilis* was associated with increased nodulation. The present experimental results are also in conformity with the above findings.

Turner and Backman (1991) reported that treatment of peanut seed with *B. subtilis* reduced the root rot incidence. Jeyarajan and Ramakrishnan (1991) reported that urd bean root rot was effectively controlled by *T. viride*. Jeyarajan *et al.* (1991) found that *T. viride* registered 28.3% root rot against control (58.7%) in urd bean. Seed treatment with *Trichoderma* spp. has been reported to control root rot incidence in groundnut (Elad *et al.*, 1986). In the present experiment also with groundnut as test crop it was observed that *B. subtilis* and *T. viride* reduced the root rot incidence when they are treated individually or in combination with *Rhizobium* (Table 2).

Uma Maheswari (1991) reported increased nodulation and reduction in root rot incidence when groundnut seeds are treated with both *Trichoderma* and *Rhizobium*. Beneficial association of antagonists with *Rhizobium* spp. has been reported by Haral and Konde (1983). In this study also beneficial association of antagonists with *Rhizobium* was observed (Table 1 and Table 2). Thus by combined seed treatment with antagonists and *Rhizobium* increased nodulation and reduced root rot incidence can be achieved in groundnut.

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COMPETITIVE ABILITY OF *TRICHOGRAMMA CHILONIS* ISHII AND *TELENOMUS PRODITOR* NIXON IN PARASITIZING THE EGGS OF CASTOR SEMILOOPER (*ACHAEA JANATA* L.)

Among the insect pests of castor, castor semilooper (*Achaea janata*) holds pre-eminent position. Egg parasitoids namely *Telenomus proditor* and *Trichogramma chilonis* are known to keep the semilooper under check. Considering the efficacy of parasitization (Thobbi and Srihari, 1968) and easy mass multiplication under laboratory conditions (Kulshreshtha *et al*., 1967) the former was imported from New Guinea. Since then, *Telenomus proditor* is being multiplied in specifically established biological control stations of Department of Agriculture, Andhra Pradesh, located at Shadnagar, Mahabubnagar, Atchampet, and Kalvakurty and released in respective areas. There are little or no efforts to verify what exactly is happening to the parasitoid after release in the field. The present report is an attempt in that direction.

Extensive field survey of castor fields wherein *Telenomus* was released as well as not released were undertaken during 1987-90. Interestingly, it was the native egg parasitoid, *Trichogramma chilonis* found predominantly parasitising the eggs of semilooper to the extent of 50% in almost all the surveyed fields. It in fact prompted to study the competitive ability of native (*Trichogramma chilonis*) and exotic (*Telenomus proditor*) parasitoids under controlled (laboratory) and field conditions.

Laboratory Studies

Laboratory reared cultures of *Trichogramma* and *Telenomus* were released individually and in pre-determined proportions in separate parasitization glass tubes. A total of 60 parasitoids were released for each ratio on the egg card glued with 600 freshly laid semilooper eggs. The subsequent adult parasitoid emergence from the parasitized eggs recorded 10 days after release (Table 1) revealed that in the absence of competition *Trichogramma* parasitized 87.7 per cent and *Telenomus* 91.4 per cent host eggs. With the increased proportions of *Telenomus* per cent parasitization was reduced indicating poor competitive ability of the exotic parasitoid. Further *Trichogramma* alone emerged from the parasitized host eggs in all the treatments.

Table 1. Combined parasitization of *Trichogramma* and *Telenomus* in different proportions

S.No.	Ratio (*Trichogramma*:*Telenomus*)	Number of parasitized eggs*	per cent parasitization
1.	1:1	325	54.2
2.	1:2	262	43.7
3.	1:3	236	39.3
4.	1:4	173	28.8
5.	1:5	143	23.8
6.	*Trichogramma* alone	526	87.7
7.	*Telenomus* alone	548	91.3

* Constant number of 600 semilooper eggs were used in all the treatments

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Field Studies

Regular field releases of *Trichogramma* and *Telenomus* were effected at weekly intervals on the farmers' fields in a block of 10 acres each well isolated by 1 km distance from one another in collaboration with State Dept. of Agric., A.P. during 1990-91. The observations on the extent of parasitization in both the fields indicated that *Trichogramma* parasitized upto 91% semilooper eggs in the field where it was released and upto 56% in the field where *Telenomus* was released. The exotic parasitoid, *Telenomus* could not be recovered from the eggs where it was released.

Both the laboratory and field studies clearly suggested highly competitive nature and dominance of *Trichogramma chilonis* over *Telenomus* proditor in parasitizing the semilooper eggs. It is not surprising that the former being an indigenous one, possesses wide adaptability. Because of its shorter life cycles (7-9 days) it could be reared and produced in large numbers on *Corcyra cephalonica* in the laboratory unlike *Telenomus*. Field releases of this parasitoid at suitable intervals supplementing the natural populations could effectively check the castor semilooper, *Achaea janata*.

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DIFFERENTIAL REACTION OF FEMALE AND MALE PARENTS OF GCH-4 CASTOR HYBRID TO SEASONAL INCIDENCE OF INSECT PESTS IN GUNTUR DISTRICT OF ANDHRA PRADESH

The cultivation of castor (*Ricinus communis* Linn.) in Andhra Pradesh is largely confined to three Southern Telangana districts: Nalgonda, Mahabubnagar and Ranga Reddy. The crop has very limited area in coastal districts particularly Guntur. Considering the encouraging production potentials of the crop and easy accessibility of requisite isolation, hybrid seed production through laying out large scale demonstrations was attempted in and around Guntur during 1990-91 crop season represented an entirely new situation. In that context, the seasonal incidence of insect pests on male and female parents assumes importance.

Besides visual observations on the incidence of different known insect pests, population counts were recorded on 20 random plants each for female (VP-1) and male (48-1) parents at fortnightly intervals right from seedling stage. The results presented in Table 1 indicated the seasonal incidence of various insect pests on the crop and differential reaction of female and male parents to them.

Seasonal incidence and succession of insect pests.

The egg masses of *Spodoptera litura* were noticed on 45 days old crop during second fortnight of September, 1990. The incidence continued upto the end of November with the peak during second fortnight of October. By November second fortnight, the gram pod borer (*Helicoverpa armigera*) took over, infestation of which was highest in December, 1990. The population of *Helicoverpa* showed declining trend by the end of December, 1990 and disappeared by the end of January, 1991. Contrary to usual incidence during July to September in traditional castor areas, semilooper (*Achaea janata*) was found in hybrid plots during January and February, 1991. Among the sucking pests, jassid (*Empoasca flavescens*) was the first to infest castor in second fortnight of January, 1991 followed by white fly (*Trialeurodes ricini*) a month later. Subsequently, very low and negligible population of mite (*Tetranychus telarius*) was noticed.

Comparative reaction of male and female to insect pests

The parents of GCH-4 hybrid namely VP-1 and 48-1 exhibited interesting differential reaction to both defoliators and sucking pests. In general, VP-1 harboured distinctly more larval populations of *Spodoptera*, *Helicoverpa*, *semilooper* than 48-1. In case of *Spodoptera*, 16.9 larvae per plant on VP-1 compared to 5.5 on 48-1 were recorded at peak incidence. Besides extensive defoliation, the larvae bored into the stems of VP-1 thereby killing the plants partially or totally in about 5% plant population. As many as 5-15 larvae per plant along with mass of excreta were found in the affected stem. Comparatively more succulent leaves and stems of VP-1 appeared to have contributed for the preference. Similarly, castor semilooper showed remarkable preference to VP-1 (12.5 larvae per plant) which in general caused upto 40% defoliation compared to less than 10% in 48-1 (2.7 larvae per plant). None of the known larval parasitoids of semilooper was found at any phase of infestation. In case of jassids, 48-1 not only had higher mean population (10.5 nymphs/leaf) than VP-1 (5.5/leaf) but also expressed jassid burn symptoms. The preference was exactly reversed for the incidence of white

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Table 1. ***Comparative incidence of seasonal insect pests in castor hybrid seed production fields in Guntur district of Andhra Pradesh (1990-91)***

S.No	Observation period	Mean number of larvae per plant									
		Spodoptera		Helicovera		Semilooper		Jassid nymphs/leaf		White fly/leaf	
		48-1	VP-1	48-1	VP-1	48-1	VP-1	48-1	VP-1	48-1	VP-1
1.	Sept. II	Egg masses		-	-	-	-	-	-	-	-
2.	Oct. I	3.6	5.8	-	-	-	-	-	-	-	-
3.	Oct. II	5.5	16.9	-	-	-	-	-	-	-	-
4.	Nov. I	2.8	5.6	0.5	2.5	-	-	-	-	-	-
5.	Nov. II	1.4	3.2	0.9	4.2	-	-	-	-	-	-
6.	Dec. I	-	-	2.7	7.5	-	-	-	-	-	-
7.	Dec. II	-	-	2.1	7.0	0.5	0.8	-	-	-	-
8.	Jan. I	-	-	0.4	2.2	2.1	5.9	-	-	-	-
9.	Jan. II	-	-	0.5	1.8	2.7	12.5	1.0	0.4	-	-
10.	Feb. I	-	-	-	-	0.6	3.4	6.3	2.7	-	-
11.	Feb. II	-	-	-	-	-	-	10.5	5.5	2.1	3.6
12.	Mar. I	-	-	-	-	-	-	5.0	3.1	3.0	8.3
13.	Mar. II	-	-	-	-	-	-	1.4	0.2	4.7	13.5
14.	April. I	-	-	-	-	-	-	-	-	4.2	12.4

I & II = First and second fortnights

fly wherein VP-1 harboured more populations than 48-1 apart from exhibiting marked symptoms. The parents of GCH-4 did not show any perceptible differences for their reaction to mites. Among the morphological characters, the differences in bloom (VP-1 = triple and 48-1 = double) are reported for differential preference of jassid, white flies and mites (AICORPO,1988 ; Chandrasekaran *et al*., 1964; David and Radha, 1964; Jayaraj, 1968).

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