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SHORT COMMUNICATION

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ESTIMATES OF GENE EFFECTS FOR SEED YIELD AND ITS COMPONENTS IN INDIAN X EXOTIC MUSTARD

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ABSTRACT

Analysis of generation means was carried out in four crosses involving one exotic strain of Polish origin with four Indian cultivars of brown mustard (*Brassica juncea*) for seed yield and its component characters. The data revealed considerable proportions of non-allelic interactions. All characters were found to be controlled by both additive and non-additive gene action, however, in the case of seed yield and its direct components, predominance of non-additive gene action was observed.

Key words : Indian mustard; Gene effects; Yield components; *Brassica juncea*.

INTRODUCTION

While taking up studies on the transfer of yellow seed coat colour from exotic to Indian cultivars in brown mustard (*Brassica juncea*) (Anand *et al.*, 1985), undersirably tall and poor yielding segregates were observed in the progeny of the crosses. As distant hybridization often accompany undesirable associations, it was felt necessary to understand the genetic architecture of seed yield and some of its component traits to speed up the breeding programme for improved productivity. It was with this view, that the present study was conducted.

MATERIALS AND METHODS

The study comprised of four Indian recommended cultivars, viz. Varuna, Pusa Bold, Prakash and RLM-198 and an exotic cultivar of Polish origin, and their crosses, viz. Polish 1 × Varuna, Polish-1 × Pusa Bold, Polish-1 × Prakash and Polish-1 × RLM-198. Each cross was considered as a genetic group and comprised of various segregating and non-segregating generations. The first two genetic groups (Set–I) comprised of parents, F_1, reciprocal F_1, F_2, F_3 and BC_1 generations, while in the remaining two (Set II) F_3 generation was lacking.

All four genetic groups with their parental and other generations were grown in a RBD with three replications during the *Rabi* of 1982—83. Each genetic group was considered as a single unit in the process of randomization. The parental, F_1, reciprocal F_1, F_2 and BC_1 plots consisted of 2, 1, 1, 5 and 1 row respectively. The respective number of families in F_3 generation were eight and nine in Polish-1 × Varuna and Polish-1 × Pusa Bold. Each F_3 family was grown in a plot size of five rows each. The three meter rows were spaced 60 cm apart with plant to plant distance within rows was maintained at 15 cm. Normal cultural and plant protection operations were followed during the crop season. Ten plants were chosen at random in each non-segregating and backcross generations, and 25 plants in F_2 and in each family of F_3 generation in all crosses for recording observations on 12 characters, namely, days to first flowering, days to maturity, number of primary branches, number of secondary branches, plant height

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(cm), length of main shoot (cm), number of siliqua on main shoot, pod index, grain formation period, number of seeds per siliqua, 1000-seed weight(g) and seed yield per plant(g). Pod index was derived from the ratio of number of pods on main axis divided by the length of the main axis while grain formation period was calculated in days, as the difference in the duration between date of first flowering and date of maturity. The statistical methods for estimating the various gene effects and non-allelic interactions for Set I were computed following Jinks and Jones (1958), after modifying the formula so as to incorporate F_3 in the place of BC_2 generation and for Set II (based on means of five generations), the three parameters (*m*, *d*, *h*) were estimated by weighed least square technique proposed by Cavalli (1952).

RESULTS AND DISCUSSION

The analysis of variance showed highly significant differences among various generations of all crosses for all the characters except number of secondary branches.

The different measures of the relative values of additive and non-additive gene effects (Table 1) showed that for days to first flowering days to maturity and 1000-seed weight both additive and dominance gene effects were equally predominant in controlling these traits. Among non-additive gene effects additive × dominance (*j*) gene effects were substantial and largely responsible for the inheritance of these traits. Additive gene effects were of greater magnitude in controlling the number of primary branches and seeds per siliqua. The contribution of additive × dominance interaction was significant for 1000-seed weight. Additive gene effects were substantial for plant height, however, non-additive gene effects were also important in controlling this trait. Non-additive gene effects made profound contribution to the inheritance of secondary branches, length of main shoot, number of siliquae on main shoot, pod index, grain formation period and seed yield per plant than additive gene effects. However, additive (d) and additive × additive (i) gene effects, were also significant and important for these traits. Among non-additive gene effects, dominance (h) contributed maximum of all towards the inheritance of these traits. Most of the characters were under the control of duplicate epistasis except days to maturity, plant height and 1000-seed weight in the cross Polish-I × Pusa Bold. A number of workers reported the importance of both additive and and non-additive genetic variances in the inheritance of yield and some of its component traits in Indian mustard (Singh, 1973; Yadava *et al.* 1974; Yadava and Kumar, 1981). But the preponderance of non-additive genetic variance was, reported by Labana *et al.* (1978) for seed yield, Lal and Singh (1974) for plant height, Labana *et al.* (1978) for primary and secondary branches and for seed size. A comparison of results of the present analysis with those of Singh *et al.* (1981) and Ram Dhari and Yadava (1983) in Indian mustard indicated that the genetic models assuming negligible epistasis may be biased to a greater extent. Since most of the yield attributing characters were under the control of both additive and non-additive gene action (though the latter predominated), further improvement should be based or simmultaneous exploitation of additive and non additive gene effects. The selection programme aiming to improve such characters in a population should accumulate the favourable additive genes and simultaneously maintain heterozygosity in the population for manifestation of the dominance and the epistatic

TABLE 1. Estimates of components of generation means for days to first flowering, days to maturity, number of primary branches

Cross	Gene effects ± standard error						X2	Epistasis
	m	d	h	i	j	l		
Days to first flowering								
Polish-I X Variuna	64.65**±0.99	28.82**±0.53	39.95**±4.69	23.07**±1.12	-89.87**+4.00	-38.67**±3.90	—	D
Polish-I X Pusa Bold	63.11**±1.10	31.92**±0.32	23.97**±5.17	21.11**±1.22	-70.61**+4.47	-22.05**±4.35	—	D
Polish-I X Prakash	91.92**±0.69	19.01**±0.70	-16.83**±1.17	—	—	—	89.29**	—
Polish-1 X RIM-198	93.63**±0.62	16.88**±0.64	-31.90**±0.96	—	—	—	419.22**	—
Days to maturity								
Polish-I X Varuna	144.41**±0.86	8.90**±0.45	9.52**±4.11	14.66**±0.97	-28.51**+3.45	- 5.70**+3.45	—	D
Polish-I X Pusa Bold	152.14**±1.21	10.33**±0.65	16.95**±5.77	5.95**±1.37	-18.43**+4.99	13.55**+4.81	—	C
Polish-I X Prakash	156.07**±0.60	9.97**±0.65	-13.06**±0.91	—	—	—	35.63**	—
Polish-I X RLM-198	157-92**±0.37	9.74**±0.38	-14.97**±0.82	—	—	—	125.00**	—
Number of primary branches								
Polish-I X Varuna	7.39**±0.56	1.61**±0.31	-4.10**±2.65	-0.34**±0.64	0.50**±2.34	2.84**±2.18	—	D
Polish-I X Pusa Bold	5.93**±0.54	1.87**±0.28	-0.50**±2.54	1.54**±0.60	-1.46**±2.19	1.47**±2.13	—	D
Polish-I X Prakash	6.84**±0.22	0.10**±0.23	-1.31**±0.42	—	—	—	16.18**	—
Polish-I X RLM-198	7.17**±0.20	0.91**±0.20	-0.45**±0.48	—	—	—	13.82**	—

* Significant at 5% level

** Significant at 1% level

C = complementary; D = duplicate.

Table 1 (Contd.)

	Gene effects ± standard error						X2	Epistasis
	m	d	h	i	j	l		
Number of secondary branches								
Polish-I X Varuna	15.18**±0.71	2.00**±0.38	15.05**±3.36	0.98±0.80	4.82±2.90	15.93**±2.80	—	C
Polish-I X Pusa Bold	13.55**±1.01	3.73**±0.54	-8.92±4.82	4.68**±1.14	4.78±4.11	11.23**±4.04	—	D
Polish-I X Prakash	12.92**±0.38	-1.81**±0.39	-1.56**±0. 66	—	—	—	46.94**	—
Polish-I X RLM-198	11.17**±0.35	1.32**±0.36	8.06**±0.60	—	—	—	8.57**	—
Plant height								
Polish-I X Varuna	188.82**±1.01	36.25**±0.51	62.97**±4.79	29.23**±1.13	-42.46**±4.07	-22.92**±4.05	—	D
Polish-I X Pusa Bold	209.31**±1.06	39.23**±0.58	17.03**±5.20	-0.68±1.23	0.64±4.54	0.52±4.35	—	C
Polish-I X Prakash	218.87**±0.55	20.13±0.58	-2.58**±0.94	—	—	—	600.62**	—
Polish-I X RLM-198	230.96**±0.72	11.31**±0.77	-6.94**±1.05	—	—	—	236.29**	—
Length of main shoot								
Polish-I X Varuna	24.62**±1.00	-25.25**±0.56	95.92**±4.73	24.46**±1.14	40.25**±4.04**	-45.21**±3.89	—	—
Polish-I X Pusa Bold	97.89**±1.46	-16.58**±0.49	-131.10**±7.02	-46.57**±1.62	125.52**±5.83	110.76**±6.03	—	D
Polish-I X Prakash	52 69**±0.61	-13.61**±0.65	11.23**±0.85	—	—	—	59.74**	—
Polish-I X RLM-198	52.72**±0.59	-12.72**±0.61	21.49**±1.01	—	—	—	252.33**	—

* *Significant at 5% level*

** Significant at 1% level

C = complementary; C = duplicate.

Table 1 (Contd.)

Cross	Gene effects + standard error						X2	Epistasis
	m	d	h	i	j	l		
Number of siliquae on main shoot								
Polish-I X Varuna	97.17**±1.01	-9.32**±0.50	-184.37**±4.82	-67.59**±1.12	142.89**±4.04	147.80**±4.09	—	D
Polish-I X Pusa Bold	82.63**±1.25	-10.63**±0.61	-123.56**±6.01	-51.36**±1.39	136.25**±4.01	105.01**±5.74	—	D
Polish-I X Prakash	39.33**±0.49	-12.12**±0.51	11.73**±0.93	—	—	—	230.61**	—
Polish-I X RLM-198	40.65**±0.57	- 8.02**±0.58	29.79**±1.08	—	—	—	452.06**	—
Pod index								
Polish-I X Varuna	8.54**±0.31	1.67**±0.48	-5.55**±1.46	-1.63**±0.90	4.89**±1.27	5.08**±1.23	—	D
Polish-I X Pusa Bold	8.24**±0.35	0.73**±0.21	-1.07**±1.66	-1.29**±0.41	3.40**±1.52	1.08**±1.33	—	D
Polish-I X Prakash	7.52**±0.15	-0.22**±0.16	0.99**±0.22	—	—	—	14.87**	—
Polish-I X RLM - 198	8.18**±0.13	1.15**±0.14	0.60**±0.20	—	—	—	63.78**	—
Grain formation period								
Polish-I X Varuna	79.78**±1.26	-19.92**±0.71	-30.56**±5.98	- 8.43**±1.45	61.39**±5.19	33.15**±4.91	—	D
Polish-I X Pusa Bold	89.03**±1.46	-21.58**±0.85	-40.93**±6.96	-15.15**±1.69	50.58**±6.14	35.60**±5.68	—	D
Polish-I X Prakash	64.76**±0.88	- 6.61**±0.93	0.80**±1.27	—	—	—	74.85**	—
Polish-I X RLM-198	64.09**±0.67	- 5.73**±0.70	18.52**±0.94	—	—	—	210.51**	—

* Significant at 5% level

** Significant at 1% level

D = duplicate.

Table 1 (Contd.)

Cross	Gene effects ± standard error						X2	Epistasis
	m	d	h	i	j	l		
Seeds per siliqua								
Polish-I X Varuna	11.89**±0.75	-1.12**±0.36	2.16±3.57	-1.54±0.83	7.02*±2.97	-1.92±3.05	—	D
Polish-I X Pusa Bold	10.47**±0.84	-1.67**±0.20	3.22±4.02	1.16±0.95	10.67**±3.43	-2.36±3.38	—	D
Polish-I X Prakash	11.52**±0.36	-1.04*±0.38	0.46±0.65	—	—	—	0.22	—
Poilsh-I X RLM-198	11.17**±0.40	-1.09**±0.40	1.34±0.80	—	—	—	8.45*	—
1000 - seed weight								
Polish-I X Varuna	3.93**±0.07	-1.82**±0.04	-4.56**±0.32	0.22**±0.08	1.25**+0.27	3.88**±0.27	—	D
Polish-I X Pusa Bold	2.99**±0.08	1.60**±0.04	0.17**±0.37	1.46**±0.09	-1.32**+0.31	0.84**±0.31	—	C
Polish-I X Prakash	2.77**±0.03	-0.31**±0.03	-0.46**±0.07	—	—	—	46.55**	—
Polish-I X RLM-198	2.57**±0.04	-0.30**±0.04	0.54**±0.07	—	—	—	100.14**	—
Seed yield per plant								
Polish-I X Varuna	16.50**±0.29	-3.92**±0.15	-36.53**±1.40	-6.53**±0.33	24.14**±1.18	28.39**±1.18	—	D
Polish-I X Pusa Bold	18.82**±0.31	-2.89**±0.14	-38.27**±1.49	-7.25**±0.34	22.36**±1.23	37.39**±1.30	—	D
Polish-I X Prakash	8.81**±0.39	-3.75**±0.40	2.12**±0.78	—	—	—	22.73**	—
Polish-I X RLM-198	9.50**±0.45	-2.18**±0.45	6.94**±0.88	—	—	—	43.44**	—

* Significant at 5% level

** Significant at 1% level

C = complementary; D = duplicate.

gene effects. Reciprocal recurrent selection proposed by Comstock, Robinson and Harvey (1949) appears to be the best available method to meet the requirement, provided natural means for easy recombination are available. The selects in early generations may be intermated in biparental fashion and the best families may be bulked to produce a phenotypically uniform but genetically buffered variety of brown mustard. The early generation intermating, besides accumulating the favourable genes and maintaining the heterozygosity in the population is likely to throw out desirable recombinants. Jensen's (1970) diallel selective mating system involving recurrent selection procedures would also serve the purpose for incorporating genes from various sources, while maintaining initial population means.

However, the above mentioned breeding programmes require extensive crossing work which is cumbersome in mustard, being a self-pollinating crop. The recent reports on cytoplasmic genetic male sterility in mustard with almost cent per cent seed setting under natural open pollinated conditions (Rawat and Anand, 1979) have raised the hope of utilising it in the crossing programme. This male sterility can also be efficiently utilised in exploiting the predominant dominance portion of gene action in the case of yield component characters by means of producing F_1 hybrids. On the other hand, the significant additive genetic component observed for the crosses suggested, that simple pedigree selection could also enhance yield but to a limited extent. For characters number of primary branches, seeds per siliqua and plant height that are under the control of mostly additive gene action and additive × additive interaction, simple pedigree or mass selection could be the best breeding procedure.

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INFLUENCE OF MOISTURE STRESS AT CRITICAL STAGES OF CROP GROWTH ON SEED QUALITY OF GROUNDNUT CULTIVARS

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ABSTRACT

The study indicated that the moisture stress at pod initiation, filling and maturation stages significantly reduced the kernel weight, germination potential and length of root and hypocotyl of the seedlings. However, the differences among these parameters were not significant due to cultivars.

Key words : Moisture stress; kernel weight; germination potential; seed vigour.

INTRODUCTION

Soil moisture plays an important role on seed quality (Austin, 1972). Information on the influence of moisture stress at critical stages of crop growth on yield, germination, vigour and storability of seed is very limited for seed crop. Hence, studies on this aspect will be of immense value to the seed industry, particularly when the seed crop is raised predominantly with lift irrigation mostly dependent on frequently failing electrical energy.

MATERIALS AND METHODS

Kernel of five cultivars of groundnut namely, CO 1, CO 2, TMV 2, JL 24 and Ah. 7284–101 obtained from the experiment carried out adopting strip-plot design replicated thrice, to the study influence of moisture stress on seed quality were utilized for this study. The details of the treatment are as follows :

Treatment	Irrigation on 'th day after sowing													
T_1	1	4	14	24	34	44	54	64	71	78	85	92	99	106
T_2	1	4	—	—	34	44	54	64	71	78	85	92	99	106
T_3	1	4	14	24	—	—	54	64	71	78	85	92	99	106
T_4	1	4	14	24	34	44	—	64	71	78	85	92	99	106
T_5	1	4	14	24	34	44	54	—	—	78	85	92	99	106
T_6	1	4	14	24	34	44	54	64	71	78	—	—	—	106

— Irrigation was withheld

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The kernels / seeds from each replication were pooled treatmentwise in each cultivar and mixed thoroughly. Then, the seed samples were drawn and divided further with the soil divider to the extent required for testing the seed quality characteristics. The mean weight of 8 × 100 kernels was recorded for each treatment. Using "sand medium" (ISTA, 1976) germination test was carried out at 25°C and 90 ± 3% RH with 4 × 100 seeds spaced uniformly and allowed to germinate for 10 days and percentage germination was calculated on the basis of number of normal seedlings. The growth of root and hypocotyl were measured on the tenth day after sowing.

RESULTS AND DISCUSSION

The weight of 100 kernels, germination potential and length of root and hypo cotyl differed significantly due to moisture stress treatments. However, the difference due to cultivars and the interaction between moisture stress treatment and cultivars wer not significant.

Irrespective of cultivars, the weight of kernels from the plants given moisture stress at pod initiation stage was the lowest which was on par with that of kernels from the plants given moisture stress at pcd filling and maturation stages. Kernel obtained from the control plots recorded more weight (Table 1). Yao *et al.* (1982) in groundnut reported a maximum reduction in 100 kernel weight due to drought treatment at the seed development stage followed by drought treatment at the flowering and pod ripening stages.

TABLE 1. Mean weight of hundred kernels as influenced by moisture stress in groundnut cultivars

	CO 1	CO 2	TMV 2	JL-24	Ah 7284-101
T_1	64.685	66.465	70.650	70.425	66.555
T_2	64.565	66.320	69.175	71.490	65.565
T_3	66.055	65.860	70.015	69.665	64.510
T_4	64.035	64.380	68.080	66.305	63.705
T_5	63.470	64.000	68.305	69.325	64.600
T_6	63.560	64.530	68.850	66.965	64.155
	Treatment	**Cultivar**	**Treatment x Cultivar**		
CD (P=0.05)	0.890**	NS	NS		

Moisture stress at initial stages of crop grcwth did not reduce the germination potential. However, stress at pod initiation, filing and maturation stages significantly reduced the germination potential. Kernels obtained from the plants given moisture stress at pod filling stage recorded the lowest germination which was on par with the germination of kernels obtained from the plants given moisture stress at pod initiation and maturation stages (Table 2). Reduced germination due to stress applied to mother plant during seed development and maturation phases has been reported in groundnut by Pallas *et al.* (1977) and Yao *et al.* (1982).

TABLE 2. Mean percentage of germination* as influenced by moisture stress in groundnut cultivars

	CO 1	CO 2	TMV 2	JL–24	Ah 7284–101
T_1	77	76	75	77	77
T_2	77	76	76	78	78
T_3	78	75	77	75	75
T_4	74	73	75	73	74
T_5	72	71	70	70	70
T_6	73	73	72	71	72
	Treatment	**Cultivar**	**Treatment x Cultivar**		
CD (P=0.05)	2**	NS	NS		

* Tested three months after harvest

Kernels harvested from plants receiving moisture stress at pod maturation stage recorded the minimum seed vigour, as evidenced from length of root and hypocotyl of the seedlings (Table 2 and 4). The length of root and hypocotyl of the seedling was maximum for the kernels collected from the control plants.

TABLE 3. Mean length of root as influenced by moisture stress in groundnut cultivars

	CO 1	CO 2	TMV 2	JL 24	Ah 7284-101
T_1	11.0	10.8	11.5	11.2	11.0
T_2	10.9	11.0	11.2	11.5	10.9
T_3	10.8	10.9	11.0	11.1	10.7
T_4	10.5	10.5	10.9	10.9	10.8
T_5	10.0	10.0	10.5	10.3	10.0
T_6	9.8	9.7	9.9	10.0	9.8
	Treatment	**Cultivar**	**Treatment x Cultivar**		
CD (P=0.05)	0.7**	NS	NS		

TABLE 4. Mean length of hypocotyl as influenced by moisture stress in groundnut cultivars

	CO 1	CO 2	TMV2	JL 24	Ah 7284-101
T_1	3.9	3.8	4.0	3.9	3.9
T_2	4.0	3.8	3.9	3.9	3.8
T_3	4.0	3.9	3.6	3.9	3.9
T_4	3.5	3.5	3.5	3.4	3.6
T_5	3.3	3.2	3.1	3.2	3.1
T_6	3.2	3.2	3.2	3.2	3.1
	Treatment	**Cultivar**	**Treatment x Cultivar**		
CD (P=0.05)	0.3**	NS	NS		

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BIOCHEMICAL CHANGES ACCOMPANYING KERNEL DEVELOMENT IN FOUR GROUNDNUT CULTIVARS

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ABSTRACT

Biochemical changes in kernels of four varieties of groundnut (*Arachis hypogaea* L.) during their developmental stages were studied. Soluble sugars, total diglycerides and free amino acids decreased, while total oil and triglycerides increased with maturity. Total oil and its triglyceride component was higher in virginia bunch than spanish bunch varieties at all stages, whereas proteins and ash content did not show much variation. Decrease in S.V. and I.V.'s of the oil observed during kernel development indicates formation of high molecular weight fatty acids with lesser unsaturation. TMV 10, with higher oil content, differed in that the S.V. and I.V.'s showed a marked decrease with maturity.

Key words : *Arachis hypogaea*; mono, di-and triglycerides; I.V.; S.V.; F.A.A; proteins; sugars.

INTRODUCTION

Seed and pod development in groundnut is accompanied by many biochemical changes. Oil and proteins accumulate during maturity at the expense of carbohydrates (Nagaraj and Kailash Kumar, 1984). Accumulation pattern of oil, protein, amino acids and other components during developmental stages depend on the final seed composition which is a characteristic of the genotype (Basha *et al.*, 1976, Sanders. 1980). In the following study we report the biochemical changes that accompany the kernel development and maturity in four groundnut varieties which belong to two different types namely spanish bunch and virginia bunch.

MATERIALS AND METHODS

The varieties GAUG 1 and JL 24 belonging to spanish bunch and TMV 10 and Kadiri 3 to virginia bunch group were sown in the NRCG farm at Timbawadi on 2.7.1982. The crop was grown as per recommended schedule of practices. Pod samples were collected by pulling out the plants on 60th day in the case of GAUG 1 and JL 24 and on the 80th day in the case of TMV 10 and Kadiri 3 (stage 1 or S_1). These dates were the earliest possible for these varieties from the point of view of kernal formation in the pods. Subsequent samples (S_2 S_3 S_4 and S_5) were collected at intervals of every 10 days till the varieties were finally harvested. Care was taken to collect more mature pods at every subsequent stage by avoiding freshly formed pods. The samples were dried in an ovan at 60°C for about 12 h. The kernels were separated from the pods and were powdered using a dry grinder. The powdered kernel samples were analysed for total oil (Soxhlet extraction with hexane), total soluble protein (Lowry *et al.* 1951), free amino acids FAA (Moore and Stain, 1948), total soluble sugars (Dubois *et al.*, 1956), glyceride composition and oil quality (A.O.A.C., 1980) and ash content (ashing at 550°C).

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Proteins, FAA, sugars and minerals were estimated from the defatted residues. but their values have been expressed on full fat kernel basis. As the oil samples available was very limited at the initial stages, iodine value (IV) ano saponification values (SV) were estimated from S_3 (stage 3) onwards for all the varieties. All the analyses were carried out in triplicate and the average values have been presented in the Tables 1, 2 and 3. All the values expressed are on dry weight basis.

RESULTS

Spanish bunch varieties

The oil content increased from about 17 per cent to 49.8 and 48.3 per cent in GAUG 1 and JL 24 varieties (Table 1). The oil per cent increased two fold in the first 10 days itself in the two varieties. Later on there was a gradual addition of oil in GAUG 1 till final harvest stage. In JL 24, however, the increase was substantial up to 80 days after which there was only a marginal increase of about 3.0 pe1 cent in the next twenty days. This could be due to the fact that JL 24 is a faster maturing variety (90 days maturity period).

Triglycerides, which constituted about 70-75 per cent of the oil at the initial stages, increased gradually to about 96-98 per cent at harvest. Diglycerides (23 per cent) decreased throughout the developmental stages and at final maturity it was about 2 per cent in both the varieties. Monoglycerides at all the stages formed on insignificant portion of the oil and the apparent minor reduction must be due to the dilution effect of triglycerides.

Protein content did not show any characteristic variation in GAUG I and was around 25 per cent at all the stages. In JL 24 there was a gradual reduction in protein from 60 days to 100 days of kernel development (30 to 25.9 per cent). The FAA content of JL 24 was higher (119.9 mg/100g.) than GAUG 1 (54.0 mg/100g.) at 60 days growth stage. In both the varieties, however, the FAA decreased with progressive maturity of the kernels.

The total soluble sugars decreased with maturity in both varieties frcm about 30 per cent at the initial stage to about 8 per cent. There was a larger proportion of decrease in the case of JL 24. The ash content did not show any characteristic variation at the different developmental stages.

Virginia bunch varieties

Oil content was higher in both the virginia varieties on 80th day (Table 2). There was proportionately higher oil accumulation during the first ten days (80-90 days) after which a gradual addition took place in both the varieties. TMV 10 variety had the highest oil content (54.3%) at maturity.

Triglyceride composition which was higher in the virginia bunch varieties than

TABLE 1 Biochemical changes in the developing kernels of two spanish bunch groundnut varieties

Constituents		GAUG 1					JL 24				
		S_1	S_2	S_3	S_4	S_5	S_1	S_2	S_3	S_4	S_5
Oil per cent		16.8	32.6	39.5	46.7	49.8	17.1	35.2	45.5	46.1	48.3
Triglycerides	As per cent of total oil	75.8	82.30	91.5	91.5	92.5	96.2	72.5	84 1	88.5	98.5
Diglycerides		23.2	12.4	5.6	5.8	2.1	23.8	15.0	12 0	3.6	1.9
Monoglycerides		0.3	0.7	0.6	0.5	0.3	1.1	0.5	0.4	0.3	00.2
Soluble protein per cent		24.6	26.3	25.1	26.1	25.3	30.1	27.3	27.3	26.9	25.9
FAA (mg/100g.)		54.0	34.0	38.9	23.2	18.1	119.8	72.8	34.9	24.2	16.6
Soluble sugars per cent		26.9	22.3	20.6	13.2	8.0	31.5	25.6	17.1	12.0	7.4
Total ash per cent		4.8	4.3	4.2	5.1	5.3	4.8	3.7	3.8	3.9	3.6

S_1, S_2, S_3, S_4 and S_5 refer to 60, 70, 80 ,90 and 100 days after sowing.

TABLE 2. Biochemical changes in the developing kernels of two bunch groundnut varieties

Constituents		TMV 10					Kadiri 3				
		S_1	S_2	S_3	S_4	S_5	S_1	S_2	S_3	S_4	S_5
Oil per cent		36.4	49.2	51.2	52.2	54.3	39.3	45.9	47.9	49.9	50.5
Triglycerides	As per cent	82.8	89.7	89.1	89.6	93.5	83.8	85.4	86.4	89.8	93.8
Diglycerides	of total	15.0	9.1	8.0	5.1	4.7	10.6	10.1	10.5	5.5	4.9
Monoglycerides	oil	1.1	0.5	0.4	0.3	0.2	0.4	00.6	0.6	0.5	0.5
Soluble protein per cent		22.1	22.9	24.2	24.2	22.8	28.3	29 0	25.1	26.4	25.0
FAA (mg/100).		71.7	25.4	28.0	18.4	14.3	52.0	26.1	23.7	16.6	14.6
Soluble sugars per cent		20.5	11.1	6.8	7.8	6.6	22.0	14.8	6.3	6.5	6.7
Total ash per cent		5.9	05.5	5.1	4.7	4.2	4.3	3.9	3.5	3.4	3.6

S_1, S_2, S_3, S_4 and S_5 refer to 80, 90, 100, 110 and 120 days after sowing.

spanish bunch varieties at the initial stage, increased gradually with maturity in both the former varieties. Diglycerides however, decreased with kernel maturity. Monoglycerides, as in the case of spanish bunch varieties, constituted only a minor proportion of the oil in these two varieties also.

Soluble protein content again did not show any characteristic variation with development and remained around 22-24 per cent and 24-29 per cent in TMV 10 and Kadiri 3 respectively. FAA content decreased with maturity in both the varieties. TMV 10 had higher FAA on 80th day than Kadiri 3.

Soluble sugars decreased with maturity in the virginia bunch varieties also. The ash content was slightly higher in TMV 10 particularly at the initial stage than that of Kadiri 3 as well as the other two spanish bunch varieties.

Oil quality characteristics

In all the varieties there was a decrease in trend of iodine value (which is a measure of unsaturation) with maturity (Table 3). The decrease was very nominal in

TABLE 3. *Oil quality in developing kernels of four Arachis hypogaea varieties*

Variety	Iodine value			Saponification value		
	S_3	S_4	S_5	S_3	S_4	S_5
GAUG 1	94.2	86.6	83.8	193.6	190.0	188.0
JL 24	96.9	93.3	89.6	198.3	194.0	188.0
TMV 10	95.0	86.0	86.0	232.0	192.0	186.0
Kadiri 3	98.0	93.9	95.1	202.0	189.0	184.0

JL 24 and Kadiri 3 whereas there was a marked decrease in the case of GAGU 1 and TMV 10. Saponification value, which provides an estimate of the average molecular weight, also decreased with maturity in all the varieties. Since saponification value is inversely related to the average molecular weight, it is evident from this study that the higher molecular weight fatty acids are getting accumulated with the kernel development. Least decrease was observed with JL 24 and the highest decrease was observed with TMV 10. This shows that TMV 10 had more of low molecular weight compounds at the initial stage which were converted to higher molecular weight compounds with maturity. Other varieties had relatively higher molecular weight compounds at the initial stages.

DISCUSSION

Soluble sugars decreased and oil increased with increasing maturity. It is thus evident that sugars (particularly sucrose and its products) are the major precursors in the formation of oil (Stumpf, 1976) and hence are being consumed in the bio-synthesis of lipids.

Diglycerides and amino acids decreased throughout the developmental stages of the kernel. These two are the metabolic intermediates in the biosynthetic sequence of lipid and protein formation. Hence, these two groups of components decreased with maturity.

Decrease of I.V. and S.V.'s took place with the kernel development. This indicates that high molecular weight fatty acids with lesser unsaturation and formed during fatty acid biosynthesis. It is quite likely that 18:2 or 18:3 fatty acids are getting converted to 18:1 acid in these varieties (Shibahara *et al.*, 1977). In TMV 10 variety, in addition to this type of change, some low molecular weight acids like 14:0 and 16:0 are getting converted to 18:1 and other higher molecular weight acids.

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YIELD VARIATIONS CAUSED BY CULTIVAR, SEASON AND POPULATION DENSITY OF *SESAMUM INDICUM* L.

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ABSTRACT

A field experiment was conducted to study the yield variations caused by six cultivars (Patan-64, Madhavi, Gowri, NP-6, T-12 and TMV-3) of sesame (*Sesamum indicum* L.) at three population densities (16, 33 and 66 plants m^{-2}) and in three seasons (post—monsoon, summer and monsoon) during 1979—1980. The main effects of yield variations were assessed by measuring the grain yield and its attributes. TMV-3 yielded maximum due to more branches and number of seeds per capsule. The capsules of Patan-64 and T-12 were considerably bigger in size due to the capsule wall rather than seed number and/or test weight. The contribution of yield in branches was compensated by the multi capsules per node in Patan—64. Madhavi had the maximum harvest index (HI) and test weight. The seed oil content of Patan-64 and TMV-3 was significantly more than that of other cultivars. The grain yield of sesame increased linearly from 16 to 66 plants m^{-2}. The increase in yield thus caused was mainly due to the number of plants per unit area rather than the branches. The yield contribution by main stem increased in oil content due to high population density. Grain yield in summer was maximum followed by post-monsoon and monsoon seasons. The capsule size was significantly bigger during summer season which was owing to the higher number of seeds per capsule. The HI was also higher during this season. The low temperature and short photoperiod of the post-monsoon season were the main factors for suppression of branches, number of seeds per capsule and test weight. he waterlogging due to heavy rain during the monsoon season had reduced the fruitTing length of axes consequently the grain yield. However, seasons did not influence the oil content of seeds.

Key words Sesame; yield analysis; population density; seasons.

INTRODUCTION

Yield variations in a crop are mostly brought about by genetic make up, growing seasons and population density. Although a number of cultivars had been released from various agricultural research stations of India from 1967 to 1980, the yield potential was shown to be less than a ton ha^{-1}. These cultivars are being grown in India during monsoon (beginning of July), post-monsoon (begining of November) and summer (end of February) seasons. Sesame, being a short day plant, the crop grown during post-monsoon seasons would be very much stunted in growth because of short photoperiod and low temperature. The crop puts forth more vegetative growth before entering reproductive phase during the other two seasons (Sen and Jain, 1948). Therefore the number of plants per unit area becomes an important management practice in order to get maximum yield. Also the architecture of the genotype is an important consideration for fixing the population density. In the case of sesame there are branching and non-branching genotypes which require different spacings (Mazzani and Cobo 1956). Although the optimum population density has been suggested for sesame by various workers (Weise, 1971, Narain and Srivastava, 1962) often the results are not very convincing because of the flexibility of this management practice to seasons and population density independently or in combination .

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Therefore, the present study was undertaken in order to investigate the effect of genotypes, seasons and population density on the yield and yield attributes of sesame. This report presents the main effects of these three factors.

MATERIALS AND METHODS

A field experiment was carried out at the Commercial Farm of College of Agriculture, Hyderabad, India (17° 19'N, 79° 23'E) from 1979 to 1980. Six cultivars of sesame, Patan-64, Madhavi Gowri, NP-6, T-12 and TMV-3 were sown in Alfisol in a R B D with four replications. The plot size was 5 m $\times$ 4 m. A basal application of 30 Kg N ha^{-1} in the form of urea and 13 kg P ha^{-1} as single super phosphate was given.

Three population densities of 16, 33 and 66 plants m^{-2} were tested by giving a row to row spacing of 30 cm. The experiment was conducted during the post-monsoon, summer and monsoon seasons and the planting dates were November 6, 1979, February 19, 1980 and 6 July 1980 respectively.

Large number of seeds were planted in rows and after two weeks the seedlings were thinned to obtain required population per unit area. In addition to the rainfall during monsoon season, supplemental irrigation was given. During the other two seasons the crops received regular irrigations. The crop was kept free of weeds and insect pests in order to provide better conditions for growth. The meteorological data for each growing season are given in Table 1.

The yield analysis was done using the method described by Narayanan and Reddy (1982). The number of capsules and grain yield were determined for main stem and branches separately and their percentage contribution was calculated. The number of seeds per capsule was arrived at from the relationship of 1000 seed weight to total seed weight from total number of capsules. The percentage of grain to capsule weight was determined and expressed as shelling percentage. The seeds of all treatments in duplicate were analysed for oil content in a Nuclear magnetic resonance spectrometer (NMR) as described by Tiwari *et al.* (1974).

The data were subjected to statistical analysis by adopting a split plot design taking seasons as main plot and cultivars and population densities as sub-plot treatments.

TABLE 1. Meteorological data (from November 5, 1979 to October 18, 1980)

Standard week	Temperature (oC)		Relative humidity(%) at 1414 h	Sunshine (h)	Rain-fall (mm)	Operations
	Max.	Min.				
45*	30.3	19.0	48	8.9	—	Sowing of post-monsoon crop
46	28.0	19.9	66	6.1	11.0	
47	30.6	18.3	45	9.2	—	
48	28.1	18.9	62	5.9	16.0	
49	28.6	15.0	41	9.9	1.0	
50	27.9	14.4	38	9.6	—	
51	29.3	16.3	46	8.6	—	
52	28.1	11.9	36	10.5	—	
1	29.7	16.3	43	10.2	—	
2	28.5	14.3	40	9.6	—	
3	29.1	12.6	27	10.8	—	
4	31.0	15.7	26	10.3	—	Harvest of post monsoon crop
5	31.0	17.1	28	10.6	—	
6	31.9	17.8	31	10.4	—	
7	32.6	18.1	30	10.3	—	
8	34.4	18.6	23	10.5	—	Sowing of summer crop
9	35.6	17.8	20	10.6	—	
10	35.1	20.5	25	8.5	—	
11	33.3	19.9	26	9.3	10.0	
12	37.0	20.8	18	9.4	—	
13	36.7	23.2	27	8.4	—	
14	35.4	22.1	27	8.3	5.5	
15	39.4	25.0	24	9.9	0.6	
16	38.7	24.9	24	9.1	2.4	
17	39.5	27.0	25	7.9	17.0	
18	38.9	25.8	26	9.6	0.2	
19	40.3	26.8	19	10.0	0.5	
20	40.0	26.2	30	9.9	8.5	Harvest of summer crop
21	41.2	27.2	19	11.3	—	
22	38.6	25.9	33	7.4	8.4	
23	33.7	24.1	49	6.4	27.0	
24	31.3	23.2	68	3.6	80.2	
25	32.7	24.3	51	6.1	—	
26	32.3	23.6	56	3.4	16.5	
27	30.6	23.0	58	5.5	17.4	
28	31.7	23.2	56	3.5	6.9	Sowing of monsoon crop
29	32.3	23.3	51	4.7	19.8	
30	28.4	22.1	74	2.1	45.9	
31	28.1	22.2	77	1.9	36.8	
32	28.8	22.2	67	2.3	6.8	
33	31.3	22.6	67	6.3	48.3	
34	28.1	21.8	70	3.3	8.7	
35	30.7	22.1	60	6.1	29.8	
36	28.3	21.7	68	3.9	21.6	
37	30.8	22.1	62	6.3	5.6	
38	31.3	21.9	62	4.7	17.5	
39	32.8	22.4	46	8.5	1.4	
40	34.0	18.3	30	8.8	—	Harvest of monsoon crop
41**	34.0	19.3	34	9.8	—	

* November 5, 1979 to november 11, 1979

** October 12, 1980 to October 18, 1980

RESULTS AND DISCUSSION

Yield variations due to cultivars :

The variations in yield and its attributes of the six cultivars are given in Table 2. The total grain yield of TMV-3 was significantly superior to all other cultivars which in turn was at par with each other. It indicates that most of the cultivars released by breeders for growing at various parts of India do not vary in their grain yield. TMV-3. was of a little longer duration type than others. The yield contribution in Patan-64 was entirely by the main stem because of its non-branching habitat. The yield contribution by the main stem of Madhavi, NP-6 and T-12 was substantial due to the less branching nature of these cvs. as compared with Gowri and TVM-3. Branches of TMV-3 contributed almost equally that of the main stem.

Number of capsules m^{-2} is an important yield component of sesame (Gupta, 1976). Cultivar TMV-3 yielded the maximum number of capsules per unit area followed by Gowri and both these two cultivars were relatively branching and late types. The other cultivars did not change in the number of capsules. Patan-64 however had the least number of capsules; still it was on par with other early cultivars. The number of nodes on Patan-64 was although lower than the less branching cultivars, it could equalize with other because of its multi capsules. The trend of main stem and branch contributions to the total number of capsules remained almost similar in all cultivars as in yield contributions. The contribution by branches for T-12 was increased considerably because of the big capsule size (191 mg $capsule^{-1}$) on the branches. The number of seeds per capsule was substantially more in Madhavi and TMV-3 which again explains the high yield of TMV-3 and to a lesser extent of Madhavi.

The test weight of Gowri and Madhavi was significantly higher than others. This again contributes to the total yield of Madhavi and not to Gowri.

The capsule size of Patan-64 and T-12 was significantly more than that of other cvs. Capsule size was positively associated with yield (Muhammed and Dorairaj, 1964). However in this study such an association was not found. It may be due to the fact that the capsule size would have been contributed by the capsule wall rather than the seeds within it. This is evident from the low shelling percentages for these two cultivars. In general in all cultivars the capsule size was significantly more in the main stem than in branches. The partitioning of phytomass to the grain indicated by harvest index was quite high in Madhavi as compared with others. Madhavi was already proved to be a good partitioner for yield (Narayanan and Reddy, 1982). The oil content for Patan-64 and TMV-3 was significantly higher than other cvs indicating that there is a genetic variation for oil content as observed by Pathak and Gangwar (1961).

Yield variations due to population density :

One of the methods of cultural manipulation in sesame used was to alter the population density in order to produce yield variations (Menon, 1967). However, the

TABLE 2. Yield and its attributes of six cultivars of sesame

Yield and its attributes	Cultivars						
	Patan-64	Madhavi	Gouri	NP-6	T-12	TMV-3	LSD(0.05)
Total grain yield (g m^{-2})	27.9	32.5	30.7	29.3	31.7	47.9	5.9
Percentage contribution from :							
Main stem	100	72	67	76	71	54	—
Branches	0	28	33	24	29	46	—
Number of branches $plant^{-1}$	0	2.29	2.45	1.91	2.12	3.40	0.30
Percentage contribution from :							
Main stem	100	66	60	66	60	48	—
Branches	0	34	40	34	40	52	—
Number of seeds $capsule^{-1}$	22	30	24	21	21	29	—
Test weight (mg 100 m^{-1})	60.5	61.7	61.8	60.4	60.5	60.6	0.8
Capsule size (mg $capsule^{-1}$)							
in Main stem	231	183	184	192	224	199	8.3
in Branches	-	146	167	169	191	179	8.0
Harvest Index (%)	24	27	25	24	24	23	2.0
Oil content (%)	52.90	50.30	50.35	50.45	50.20	50.85	0.55
Shelling percentage	29.7	43.9	38.9	35.3	30.1	45.0	—

levels of population density used earlier were far below those used in this investigation. Kinnan (1955) desired to have closer spacing to produce higher yield and to supress weed growth. The yield and its attributes as influenced by three levels of population density are shown in Table 3. The total grain yield of sesame linearly increased from 16 to 66 plants m^{-2}. Such a linear increase was brought about by the compensation of: branches by the number of plants per unit area which was evident from the contribution of main stem against that of branches. The yield contribution by the main stem increased with population density whereas that of branches decreased because of the decrease in number of branches with increase of population density. The number of capsules m^{-2} was also showing the same trend similar to the yield as it is the major yield component.

TABLE 3. Effect of population density on the yield and its attributes of sesame

Yield and its attributes	Population density (Plants m^{-2})			LSD(0.05)
	16	33	66	
Total grain yield (g m^{-2})	27.8	34.5	43.4	4.2
Percentage contribution from :				
main stem	56	67	75	—
Branches	44	33	25	—
Number of branches $plant^{-1}$	3.35	2.32	1.64	0.20
Number of capsules (m^{-2})	323	437	571	44
Percentage contribution from :				
Main stem	49	60	67	—
Branches	51	40	33	—
Number of seeds $capsule^{-1}$	28	26	25	—
Test weight (mg 100 ml^{-1})	60.7	61.1	60.9	NS
Capsule size (mg $capsule^{-1}$)				
in Main stem	214	202	190	6.0
in Branches	179	169	163	6.0
Harvest index (%)	25	25	24	NS
Oil content (%)	50.75	50.35	50.85	0.40
Shelling percentage	37.3	36.3	37.8	—

However Mazzani and Cobo (1956) growing branched sesame cultivars in nine densities varying from 4 to 20 plants m^{-2} found little variation in seed yield, number of branches and oil percentage which may be due to very low range of population density. On the other hand, Nadi and Lazin (1974) reported that increase in population density increased seed yield which was positively correlated with number of capsules per plant, number of seeds per capsule and 1000 seeds weight. Neither the number of seeds per capsule nor the test weight showed significant difference due to increase in population density. Harvest index and the shelling percentage also did not vary. The partitioning cf phytomass into the grains was compensated by more number of plants per unit area as in the case of total grain yield. There was a slight increase in oil content at the highest population density.

Yield variations due to growing seasons :

Although the growth and development cf sesame are influenced by photoperiod and temperature (Thomas, 1965; Thomar and Bhargava, 1980; Gopalakrishnan *et al.*, 1967) farmers grow tnis crop throughout the year whenever it fits into a cropping system. The yield variations produced in such cases are due to the environmental effects.

The yield and its attributes as influenced by postmonsoon, summer and monsoon seasons are given in Table 4. The yield of sesame was significantly higher during

TABLE 4. Effect of seasons on the yield and its attributes of sesame

Yield and its attributes	Post monsoon	Summer	Monsoon	LDS (0.05)
Total grain yield (g m^{-2})	31.1	16.2	13.4	7.4
Percentage contribution from :				
Main stem	58	74	58	—
Branches	42	26	42	—
Plant Height (cm)	43.0	53.3	53.9	4.9
Fruiting length of main stem (cm)	—	32.5	24.2	--
Number of branches plan^{-1}	2.5	2.0	2.9	0.4
Number of capsules (cm^{-2})	494	490	345	135
Precentage contribution from :				
Main stem	55	71	53	—
Branches	45	29	47	—
Number of seeds capsule^{-1}	20	41	13	—
Test weight (g 100 ml^{-1})	62.5	60.5	59.8	1.0
Capsule size (mg capsule^{-1})				
in Main stem	169	269	174	34
in Branches	142	229	140	6
Harvest Index (%)	25	30	17	2
Oil content (%)	50.45	50.75	50.80	NS
Shelling percentage	37.4	50.2	23.8	—

summer season followed by post-monsoon and monsoon seasons. Short photoperiods were known to reduce drastically the yield of sesame (Sen and Jain, 1948). The grain yield was contributed mostly by the mainstem which was obviously because of the less number of branches produced during this post-monsoon season. Moreover the plant height was considerably more during summer season but it was almost same as that of monsoon season. Inspite of more height and branches during monsoon season the yield was very poor which may be partly duc to the short fruiting length in the main stem which was caused by waterlogging as a result of high rain fall (Table 1) and fungal diseases. Nakhtore (1952) observed that the cultivated types of sesame are more susceptible to waterlogging. Sesame is easily affected by fungal diseases when the rainfall is high. This crop grows well when the rainfall is 500-700 mm. A temperature of 24°C was found (Smilde, 1960) to retard the growth of sesame but when the temperature was raised to 33°C, stem growth and leaf production were stimulated. A negative correlation between plant height and average soil and air temperatures were generally observed for sesame in Japan (Matsuoka *et al.*, 1953). The yield contribution by the main stem and branches was 58 and 42 per cent for both post-monsoon and monsoon seasons.

The number of capsules m^{-2} was same for post-monsoon and summer seasons but it was significantly lower during monsoon season and again the trend in contribution of main stem and branches was similar to the yield. Although the number of capsule per unit area was same as that of summer season, for post-monsoon season, the yield was lower because of the less number of seeds per capsule and test weight. Thus the main effect of post-monsoon season was not on the main yield component but on the seeds per capsule and test weight. The low temperature prevailed during especially reproductive growth (period) may be the reason for it (Table 1).

The capsule size was significantly bigger during summer season which must be due to the higher seed number per capsule. The partitioning of phytomass during summer season was very high probably due to the powerful reproductive sink size as evident from the number of capsules and number of seeds per capsule. Again the shelling percentage was 58 per cent for the crop grown in summer season. This percentage was almost half of it for the crop grown during monsoon season because of the less number of seeds per captsule. Seasons did not influence the oil content of seeds.

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VARIABILITY, CORRELATION AND PATH—COEFFICIENT ANALYSIS IN LINSEED

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ABSTRACT

Forty linseed strains of diverse eco-geographic and genetic origin were studied for yield and its components. All the eight characters showed significant amount of variability. Branches, capsules and yield per plant showed high heritability and high genetic advance indicating additive gene effects. High heritability and moderate genetic advance for 1000 seed weight indicated presence of both additive and non-additive gene-effect; while high heritability and low genetic advance for maturity was due to non-additive gene effect. Capsules/plant, seed/capsule and seed weight showed high positive correlation with yield both at phenotypic and genotypic levels. Both capsules/plant and seeds/capsule had high positive direct effect on yield and their indirect effect via. other characters was small. Seed weight and days to flowering had moderate positive direct effect on yield while days to maturity showed moderate negative direct effect on yield. Thus yield improvement can be achieved through selection for more capsules/plant, more seeds/capsule and moderate seed weight accompanied with synchronous flowering and early maturity.

Key words : Linseed; coefficients of variability; heritability; genetic advance; phenotypic and genotypic correlations; path-coefficient analysis; direct and indirect effects.

INTRODUCTION

The ultimate criterion of productivity in an oilseed crop is the oil yield, which depends on seed yield and oil content. Although improvement in oil content is possible, there appears to be much greater scope of increasing the seed yield potential. Yield, however, is a polygenically controlled complex character and is determined by a number of multiplicative character components, which are also quantitatively inherited. Though some studies on genetic parameters and character associations in linseed have been reported, most of them were based on few genotypes and/or limited number of characters. The present investigation on genetic parameters and character associations in linseed, based on a large array of diverse strains, would give a better understanding about the bearing of different characters on yield and the scope of yield improvement through selection for these characters.

MATERIALS AND METHODS

The material for the present study comprised forty promising varieties/cultures from research stations of different states (22 from Uttar Pradesh, 6 from Maharastra, 5 from Madhya Pradesh, 2 each from Bihar and Himachal Pradesh and 1 each from Haryana, Punjab and Gujarat) representing diverse eco-geographic and genetic origin. The experiment was conducted during *rabi* 1984-85 at the Central Research Station, OUAT, Bhubaneswar in RBD with 3 replications. Observations on days to flowering, maturity and 1000 seed weight were taken on plot basis, while observations on plant height,

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effective branches/plant, capsules/plant, seeds/capsule and seed yield/plant were recorded on ten random plants per plot. Variability, heritability and genetic advance (at 5% selection intensity) of characters were estimated following Al-Jibouri *et al.* (1958). Phenotypic and genotypic correlations were estimated after Robinson *et al.* (1951). The direct and indirect effects of characters on yield were computed by path-coefficient analysis following Dewey and Lu (1959) using both phenotypic and genotypic correlation, the later being more reliable.

RESULTS AND DISCUSSION

Variability, heritability and genetic advance :

The range of variation for different characters indicated wide differences among the strains (Table 1) and the analysis of variance showed that those difference were highly significant. The high phenotypic and genotypic variance estimates for the characters indicated that the genotypes under investigation possess very high potential differences, which might be due to their diverse genetic origin and differential adaptability. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) revealed similar pattern of variability, the former being little higher. The PCV and GCV estimates were high for branches/plant, capsules/plant and yield/plant, moderates for seeds/capsules and seed weight and low for rest of the characters. Badwal *et al.* (1970) reported the presence of tremendous variability for branches, capsules and yield per plant besides plant height and seed weight.

The heritability estimates were high for days to maturity, 1000 seed weight and yield/plant indicating that selection for these characters directly on phenotypic values would be effective. For other characters heritability was moderate. Similar high heritability estimates for maturity, seed weight and yield were observed by Vijaya Kumar and Rao (1975) and Gupta and Godawat (1981).

Genetic advance (GA) as percentage of mean was high for branches, capsules and yield per plant; moderate for seeds/capsule, seed weight and plant height and low for days to flowering and maturity. Vijaya Kumar and Rao (1975) and Gupta and Godawat (1981) reported high GA for branches/plant, capsules/plant, yield/plant and seed weight and low GA for plant height, which are in general conformity with this study.

Considering heritability and GA simultaneously, it is observed that branches, capsules and yield per plant had high heritability as well as high GA indicating presence of additive gene effect for these characters. Thus, these characters would respond to selection with greater efficiency. Similar results were reported by Vijaya Kumar and Rao (1975). 1000 seed weight showed high heritability with moderate GA indicating the presence of both additive and non-additive gene effects. The observed high heritability and low GA for days to maturity indicated non-additive gene effect for the trait. Rest of the characters showed moderate to low values for heritability and GA.

TABLE 1. Estimates of parameters of variability and genetic advance in linseed

Characters	Mean	Range	PCV	GCV	h^2 (%)	G.A.	G.A.**
Days to flowering	57.04	45.0 –65.5	9.47	8.49	80.4	8.94	15.67
Days to maturity	96.19	85.0–103.0	4.82	4.45	85.2	8.13	8.45
Plant height (cm)	45.22	29.2– 57.6	13.44	11.67	75.5	9.44	20.88
Effective branches/plant	6.04	2.50– 9.65	26.65	24.85	87.0	2.89	47.85
Capsules/plant	16.73	8.5– 29.1	30.91	28.68	86.1	9.17	54.81
Seed/capsule	5.66	3.24– 7.78	21.34	19.21	81.0	2.02	35.69
1000 seed wt. (g)	7.05	5.19– 8.84	12.87	12.00	86.9	1.62	22.98
Yield/plant (g)	0.66	0.23– 1.23	38.02	35.48	87.1	0.44	66.66

** Genetic advance as percentage of population mean

Phenotypic and genotypic correlations :

The phenotypic correlations (r_p) and genotypic correlaticns (r_g) amongst the characters followed almost similar trend of association, the later being little higher in most cases (Table 2); so are discussed together. Considering the correlation of the seven characters with yield, it was observed that capsules/plant and seeds/capsule showed highly significant positive association with yield. Similar results were reported by Patil *et al.* (1980), Rai (1981, 1984) and Chaudhury *et al.* (1984). The moderate positive association of 1000 seed weight with yield is in conformity with reports of Patil *et al.* (1980) and Chawla and Singh (1983). The observed moderate negative correlation of days to flowering and maturity with yield might be due to exposure of late maturing varieties to relatively high temperature during seed set and seed filling, there by resulting in less seeds/capsule and low 1000 seed weight. Similar negative correlations of flowering and maturity with yield were reported Vijaya Kumar *et al.* (1975), Gupta and Godawat (1981), Rai (1984) and Chaudhury *et al.* (1984). Thus the positive inherent association of capsules/plant, seeds/capsule and 1000 seed weight and moderate negative inherent association of flowing and maturity with yield indicates that there is enough scope of yield improvement through selection of genotyperes with higher capsules/plant, seeds/capsule and seed weight coupled with early maturity.

Days to flowering showed significant positive association with days to maturity and branches/plant and a moderate negative association with seeds/capsule. Similar results were reported by Chawla and Singh (1983). Days to maturity showed significant negative association with 1000 seed weight. Thus it showed that late flowering reduced seeds/capsule while late maturity reduced seed weight. So early synchronous flowering with early maturity would improve both seeds/capsule and seed weight without much affecting capsules/plant. Moreover the poor association of seeds/capsule with capsule/plant and seed weight and moderate negative association between capsule/plant and seed weight would indicate that there is scope of selection of genotypes with more genotypes with more capsules/plant, seeds/capsule and moderate seed weight.

Path-coefficient analysis :

The cause and effect relationship, as indicated by direct and indirect effects of component traits on yield were studied by path-coefficient analysis. The analysis based on phenotypic and genotypic correlations followed almost similar trend. As it is more precise and accurate to estimate path-coefficients based on genotypic correlations it is only presented (Table 3). The low residual effect in the analysis indicated that most of the important yield attributes were taken into consideration. Capsules/plant and seeds/capsules had high positive direct effect on yield and their indirect effects via other traits were very small. It is in confirmity with reports of Patil *et al.* (1980), Rai (1981) and Chaudhury *et al.* (1984). 1000 seed weight had a moderate positive direct effect on yield and its correlation with yield was much affected by indirect effects via. maturity, seeds/capsule and capsules/plant. Similar moderate positive direct effect of seed weight on yield were reported by Badwal *et al.* (1970), while Rai (1981) also reportad its high positive direct effect. Flowering had a moderate positive direct effect on yield while

TABLE 2. *Genotypic (upper triangle) and phenotypic (lower triangle) correlation among eight characters in linseed.*

Charaters	Days to flowering	Days to maturity	Plant height	Branches/ plant	Capsules/ plant	Seeds/ capsule	1000 seed wt	Yield/ plant
Days to flowering		0.404*	0.179	0.534*	-0.028	-0.264	0.010	-0.186
Days to maturity	0.383*		0.167	0.179	0.078	0.179	-0.443*	-0.217
Plant height	0.120	0.174		0.052	-0.027	-0.196	0.146	-0.129
Branches/plant	0.442*	0.181	0.051		0.051	0.026	-0.006	0.033
Capsules/plant	-0.074	0.074	0.024	0.104		0.048	-0.223	0.723*
Seeds/capsule	-0.267	0.131	-0.207	0.003	0.021		0.133	0.613*
1000 seed wt.	-0.007	-0.383*	0.124	0.051	-0.195	0.140		0.278
Yield/plant	-0.214	-0.204	-0.096	0.073	0.721*	0.597*	0.268	

* Significant at 5% level.

TABLE 3. Direct and indirect effects of component traits on seed yield of linseed

Charaters	Days to flowering	Days to maturity	(Plant height	Branches/ plant	Pods/ plant	Seeds/ pod	1000-seed wt.	Correlation with yield(r_g)
Days to flowering	0.205	-0.163	0.006	-0.033	-0.022	-0.182	0.002	-0.186
Days to maturity	0.083	-0.403	0.006	-0.011	-0.060	0.123	-0.076	-0.217
Plant height	0.037	-0.067	**0.035**	-0.003	0.021	0.135	0.025	-0.129
Branches/plant	0.109	-0.072	0.002	**-0.062**	0.040	0.018	-0.001	0.033
Capsules/plant	-0.006	-0.032	-0.001	-0.003	**0.770**	0.033	-0.038	0.723
Seed/capsule	-0.054	-0.072	-0.007	-0.002	0.037	**0.688**	0.023	**0.613**
1000-seed wt.	0.002	0.178	0.005	0.001	-0.171	0.091	0.172	**0.278**

Residual effect 0.262

Underlined figures denote direct effects.

maturity showed a negative direct effect, however, their corrrelation with yield were much influenced by indirect effects via other traits. The direct effects of plant height and branches on yield were low and their indirect effects via other traits were also low.

From the overall study there is indication that the yield could be improved upon through selection for more capsules/plant, more seeds/capsule and moderate seed weight with synchronous flowering and early maturity.

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BIOPRODUCTIVITY AND ITS RELATIONSHIP TO YIELD ATTRIBUTES AND SEED YIELD IN INBREDS, HYBRIDS AND POPULATIONS OF SUNFLOWER

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ABSTRACT

The relationship between some of the physiological parameters and productivity was assessed in parents, hybrids and populations of sunflower. Significant genotypic difference in leaf area, biological yield and economic yield was observed. Hybrids, in general, had higher source size and produced higher biological and economic yield. Studies made on correlation showed close association of harvest index, leaf area and total dry matter with seed yield. Path analysis study brought out the importance of leaf area ininfluencing the seed yield as it had high direct as well as indirect effect on productivity. The importance of source size for increasing the productivity is discussed.

Key words : Sunflower; biological yield; harvest index; correlation; path analysis.

INTRODUCTION

Productivity of a crop depends on the extent of interception of solar energy by foliage and photosynthetic rate per unit leaf area. The fraction of the available energy intercepted by the canopy depends on the rate of leaf area development and leaf area duration. Although photosynthetic rate per unit leaf area is an important determinant of productivity, in many crop plants increasing leaf area index was shown to increase canopy photosynthesis and crop growth rate as in sward grass (Robson, 1973), in maize (Williams *et al.*, 1965) and in rice (Bedhal *et al.*, 1972). Hence, selection of genotypes for enhanced canopy photosynthetic rate should form one of the approaches in sunflower breeding programmes for achieving higher crop growth rate and seed yield.

In this study genotypic variation in leaf area and productivity was assessed to know the relationship between source size, biological yield and economic yield in sunflower.

MATERIAL AND METHODS

The base material for the study consisted nineteen entries which included seven parents (inbreds), nine hybrids and three open pollinated varieties. The experiment was laidout in a RBD with four replications. The experiment was conducted during rainy season of 1983 under protective irrigated conditions, by following recommended package of practices. Each genotype was planted in five rows of 4.5 m length in each replication and a spacing of 60 × 30 cm was followed. Data on days to flowering, plant height, stem diameter, total dry matter, harvest index, number of leaves per plant and leaf area were collected on five random plants in each replication. Leaf area was measured at maximum leaf area stage (65 days after sowing). Since all the genotypes except, Morden variety, used in this study showed difference of only 6 to 7 days in flowering, only maximum leaf area data were collected. Mean values over four replications were used to carryout path coefficient analysis by following the method of Dewey and Lu (1959).

RESULTS

The mean performance of parents, hybrids and open pollinated varieties is presented in Table 1. Leaf area per plant was maximum in the parent CMS 307 follow-

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ed by CMS 302. The biological yield amongst athe parents ranged from 73.37 g (RHA 801) to 202.50 g/plant (CMS 89). The seed yield per plant showed wide variation amongst the parents - from 7.61 g (in RHA 274) to 59.61 g (in CMS 234)

In general, the hybrids/populations which had higher seed yield also showed higher leaf area and higher biological yield. For instance, the seed yield was high in cross combinations CMS 307 × RHA 274 and CMS 308 × RHA 801, the leaf area and biological yield was also high in these hybrids Amongst three populations tested, CGPI showed highest seed yield, leaf area and biological yield

The relationship between leaf area, biological yield and seed yield is graphically presented in Fig. 1.

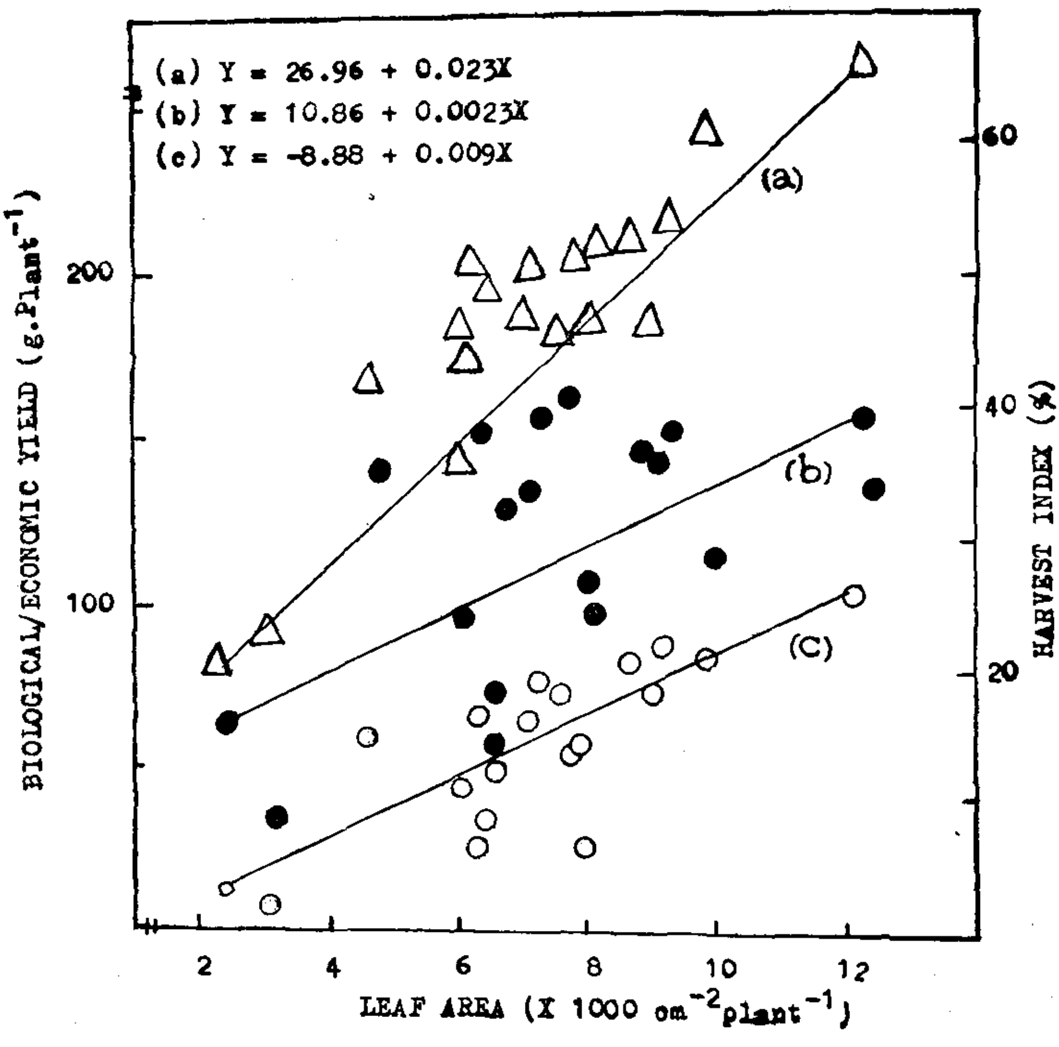

TABLE 1. Mean performance of parents, hybrids and open pollinated varieties for physiological characters and seed yield

Parents/Hybrids/ open-pollinated varieties	Days to 50 per cent flowering	Plant height (cm)	Stem diameter (cm)	Total dry matter/ plant (g)	Harvest index (%)	Leaf area per plant (sq. cm)	Leaf No./ plant	Seed yield/ plant (g)
RHA 274	56.75	125.40	2.11	95.08	8.06	3178.98	18.47	7.61
RHA 801	57.25	94.10	1.79	73.37	12.15	2476.33	15.33	8.80
CMS 89	66.25	134.30	3.08	202.50	13.18	6436.25	17.20	27.17
CMS 234	57.75	167.20	2.24	169.84	35.38	4848.76	24.07	59.61
CMS 302	65.25	142.55	2.80	194.98	18.00	6540.68	19.80	34.64
CMS 307	64.50	142.30	3.26	186.39	12.88	8108.36	20.00	23.85
CMS 308	61.75	129.60	2.44	184.09	24.48	6121.48	19.87	54.67
CMS 234 × RHA 274	55.00	188.00	2.59	200.57	38.83	7324.97	26.80	78.29
CMS 302 × RHA 274	55.00	168.05	2.51	171.78	37.62	6429.19	23.33	65.20
CMS 307 × RHA 274	58.73	169.80	3.42	323.22	33.53	12492.10	23.73	107.90
CMS 308 × RHA 274	59.25	178.25	2.77	206.34	35.32	9072.76	23.27	72.35
CMS 89 × RHA 801	64.75	173.75	2.97	228.05	24.31	8035.49	22.67	55.78
CMS 234 × RHA 801	52.25	167.75	2.42	183.98	39.83	7687.24	22.53	73.18
CMS 302 × RHA 801	57.50	141.90	2.51	185.86	33.78	7116.03	20.53	63.43
CMS 307 × RHA 801	55.00	156.15	2.73	221.31	36.28	8896.36	19.00	80.48
CMS 308 × RHA 801	58.00	168.05	2.67	231.53	38.01	9370.57	22.13	87.38
Morden	51.00	124.90	2.40	145.11	32.24	6772.01	17.13	47.83
EC 68415	62.75	207.20	2 55	207.99	26.08	7995.19	22.67	54.71
CGP—1	62.25	198.75	2.92	296 25	28.15	9503.97	25.73	84.90
CD P=0.05	1.45	10.45	0.29	50.49	5.14	2095.46	1.90	18.56

TABLE 2. Direct (diagonal) and indirect effects of seven physiological traits on seed yield

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	Correlation with seed yield
X_1	**−0.4806**	0.0027	0.0689	−0.0924	0.1386	0.0999	−0.0108	−0.2736
X_2	−0.0445	**0.0296**	0.0528	−0.2077	−0.1389	0.5546	0.4624	0.7083
X_3	−0.2510	0.0118	**0.1320**	−0.2453	−0.1019	0.7019	0.1631	0.4105
X_4	−0.1465	0.0203	0.1069	**−0.3030**	−0.0114	0.8039	0.3217	0.7917
X_5	0.2740	0.0169	0.0553	−0.0142	**−0.2431**	0.4471	0.3245	0.8606
X_6	−0.0550	0.0188	0.1061	−0.2788	−0.1244	**0.8736**	0.2756	0.8157
X_7	0.0099	0.0262	0.0412	−0.1867	−0.1511	0.4612	**0.5220**	0.7227

Residual factor = 0.3907

X_1 = Days to 50% flowering; X_2 = Plant height; X_3 = Stem diameter; X_4 = Total dry matter; X_5 = Harvest Index; X_6 = Leaf area; X_7 = Leaf numbers per plant.

All the characters studied except days to flowering were positively correlated with seed yield (Table 2). Considering the numerical values of correlation, harvest index, leaf area and total dry matter appear to be closely associated with seed yield. Path analysis, which measures direct and indirect effects of independent variables on the dependent variable (seed yield), revealed that leaf area, number of leaves per plant and stem diameter, in order, had maximum direct effect on seed yield. Besides, it was of interest to know that both leaf area and number of leaves per plant had also highest indirect effect in particular via total dry matter, harvest index, plant height and stem diameter.

DISCUSSION

Photosynthetic efficiency per unit leaf area and photosynthetic area are the two important factors which contribute for crop growth rate. Relationship between photosynthetic rate and dry matter accumulation was observed in several crop species (Janardhan and Murty, 1978; Devendra *et al.*, 1980; Sashidhar *et al.*, 1985). Bioproductivity in a crop canopy has been shown to be particularly dependent on canopy cover in many crop plants (Christy and Porter, 1982; Hesketh *et al.*, 1982) and enhancement of crop canopy photosynthesis with increasing leaf area is well established in several studies (Bedhal *et al.*, 1972; Robson, 1973).

In the present study, the genotypes showed wide variation for maximum leaf area, biological yield and seed yield. A positive correlation between photosynthetic area and biological yield (r = 0.92) and economic yield (r = 0.82) was observed and the relationship was highly significant (Fig.1). This suggests that in sunflower genotypes, bioproductivity is related to source size and rate of all aspects of bioproductivity seem to increase with increase in leaf area. There was significant positive relationship between harvest index and seed yield (r=0.8606) which also suggested that in these set of genotypes seed yield is contributed by more partitioning of dry matter to reproductive sinks.

A positive significant relationship between leaf area and seed yield suggests that increasing leaf area per plant under fertile environmental condition will result in substantial increase in crop yield. With increase in photosynthetic area although bioproductivity increased linearly (Fig. 1), the partitioning of dry matter to the seed yield decreased resulting in reduced correlation value between leaf area and harvest index (r = 0.37). This suggests that in effect increase in leaf area increased dry matter accumulation in the plant, but dry matter import into the seed caused a "backing up" after certain level. The factors which caused lower partitioning percentage of dry matter to the reproductive parts after a threshold level are yet to be identified.

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RESPONSE OF NITROGEN LEVELS ON LINSEED VARIETIES UNDER RAINFED AT LOW ALTITUDE HILL CONDITION OF NAGALAND

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ABSTRACT

A field experiment was conducted in *rabi* season of 1984 and 1985 at ICAR Research Farm, Jharnapani under rainfed low altitude condition of Nagaland to study the response of levels of nitrogon (0, 30, 60 and 90 kg/ha) to linseed varieties (LHCC-69), LHCK-21, LHCK-39, LHCK-172 and Neelam). The varieties, Neelam, LHCK-69 and LHCK-39 amongst varieties and 60 kg nitrogen per hectare amongst nitrogen levels gave significantly higher yields. The observations were recorded on plant height, average number of branches/ plant, number of capsule/ plant, number of grains/ capsule and number of grains/ plant and test weight g/1000 seeds. All these yield attributing characters viz., the grian yield per plant, average number of seeds per capsule, test weight g/1000 seeds showed possitive effects with application of nitrogen levels to linseed varieties.

Key words : Linseed ; nitrogen levels; ***Linum usitatissimum*** L.

INTRODUCTION

Linseed (*Linum usitatissimum* L.) has a considerable export value because its oil is used as a lubricant, paints, varnish and soap industry. Its fibre has also economic value. India with about 2 million hectares under linseed cultivation occupies 1/4th of area, fourth in production and eight in productivity. Its average yield is about 200 kg/ha. Linseed is, however, generally grown as pure crop in rabi season after paddy in foot hill, low and mid altitude areas of Nagaland. Its production in the state is low as compared to national average. The low productivity warrants the attention of research workers to find the causes of low yield in linseed and ways to improve it (Bhan, 1980; Rai, 1984). Hence, development of agrotechniques for linseed was considered essential as these information are not available for agroclimatic condition of Nagaland. The present study was, therefore, under taken to study the effects of various levels of nitrogen to linseed varieties.

MATERIAL AND METHODS

The experiment was carried out at the Research Farm of ICAR Research Complex for NEH Region, Nagaland Centre, Jharnapani, during the *rabi* seasons of 1984 and 1985. The soil texture of experimental plot was clay loam with pH 5.5. The available organic carbon was 63 percent, available P_2O_5 and K_2O were 42.0 and 180 kg/ha, respectively. The experiment was laid out in RBD replicated three times. The treatment comprises of five varieties (LHCK-69, LHCK-21, LHCK-39, LHCK-172 and Neelam). and four nitrogen levels (0, 30, 60 and 90 kg/ha). The crop was sown with spacing 20 cm apart row to row. Fertilizers applied as basal were 30 and 20 kg P_2O_5 and K_2O kg/ha respectively.

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The nitrogen doses were applied as per treatment. The crop was sown on 5th November and harvested on 10th April during both the years. The yield was calculated on the basis of net plot size 5×4 m. The growth and yield data on average plant height, average number of branches per plant, number of capsule per plant, number of grains per capsule, per plant and test weight/1000 seeds were recorded during both the years (Table 2).

RESULTS AND DISCUSSION

The data obtained on the yield and its attributes due to nitrogen levels on linseed varieties are presented in Table 1 and 2. Data revealed that differences in yield and yield attributes were found due to varieties and nitrogen levels in both the years as well as in pooled results.

TABLE 1. Yield (q/ha) of linseed as influenced by varieties and nitrogen levels during 1984 and 1985.

	Nitrogen levels (Kg/ha)				
	0	30	60	90	Pooled
			1984		
LHCK- 69	4.0	4.5	8.5	5.5	5.65
LHCK- 21	3.5	4.0	8.0	7.7	5.60
LHCK- 39	4.5	7.0	10.0	8.9	7.35
LHCK-172	3.2	4.2	7.5	5.5	5.10
Neelam	4.7	7.3	12.2	9.1	8.33
CD (P=0.05)	1.2	1.3	1.7	1.5	1.50
			1985		
LHCK- 69	5.6	7.4	10.0	8.8	8.47
LHCK- 21	4.0	5.4	8.6	6.5	5.77
LHCK- 39	4.2	5.6	8.0	6.0	5.97
LHCK-172	3.8	6.2	9.2	7.0	6.55
Neelam	4.8	7.2	14.5	9.5	8.75
CD (P=0.05)	1.3	1.0	1.8	1.6	1.45

Effect of varieties :

Pooled results (Table 1) indicated that Neelam recorded highest seed yield of 8.33 and 8.75 q/ha during 1984 and 1985 respectively which was significantly higher among the tested varieties except LHCK-69 which was at par statistically in second year. Other varieties in respect of seed yield followed the order LHCK-39 (7.35 q/ha), LHCK-69 (5.65 q/ha), LHCK-21 (5.60 q/ha) and LHCK-172 (5.10 q/ha) during the first year.

However, during the second year, LHCK-21 recorded lowest yield (5.57 q/ha) which may be attributed due tc poor plant stand and growth. The grain yield of other varieties in second year was in order of LHCK-69 (8.47 q/ha), LHCK-172 (6.55 q/ha) and LHCK-39 (5.97 q/ha) indicating that LHCK-21, LHCK-172 and LHCK-39 were at par statistically in respect of seed yield in second year.

Among the varieties the Neelam had higher yield during both years and it was mainly with more test weight of 1000 seeds, more number of grains per plant, number of grains/capsule and number of branches/ plant. Other worker recommended positive response of yield attributes on linseed is Patil *et. al.* (1980).

The higher yield of LHCK-69 at par with Neelam during second year was associated due to more number of grains/plant, number of grains/capsule and number of branches/ plant. So, Neelam and LHCK-69 performed well during both the years maintaining first and second position in respect of seed yield. Whereas LHCK-39 was second in respect of yield in first year. The more yield of LHCK-39 was due to higher plant height and good plant growth (Table 2).

Studies on yield attributes due to varieties showed that Neelam was superior among others. On pooled basis, the plant height (55.50) cm was maximum with Neelam followed by LHCK-39 (51.85 cm). The minimum plant height was in LHCK-172 (43.37 cm). Number of branches/plant, number of capsule/ plant, number of grains/ capsule and test weight (g/1000 seeds) was significantly higher (Table 2) in Neelam over rest of

TABLE 2. Yield attributes of linseed as influenced by nitrogen levels and varieties during two rabi season) 1984 and 1985 (Pooled).

Plant	No. of		No. of	No. of	Test	
Treatment	Plant height (cm)	No. of branches per plant	No. of capsule per plant	No. of grains per capsule	No. of grains perplant	Test weight (g/1000 seeds)
I. Nitrogen levels/ha						
0 kg	44.00	4.36	16.72	4.96	82.92	6.00
30 kg	47.40	5.16	19.32	5.18	100.27	7.50
60 kg	54.70	6.42	27.10	6.84	165.36	9.60
90 kg	56.40	6.43	26.60	5.34	142.04	8.56
C.D. (P=0.05	5.60	1.94	3.30	1.02	50.6	1.05
II. Varieties						
LHCK- 69	51.55	5.86	27.10	7.40	200.54	9.50
LHCK- 21	49.50	4.67	14.80	5.10	74.48	5.98
LHCK- 39	52.25	4.62	22.80	5.70	129.96	7.60
LHCK-172	43.37	4.92	18.51	4.40	81.44	6.00
Neelam	55.50	6.70	27.50	6.00	165.00	9.80
C.D. (P=0.05)	2.30	1.19	4.05	0.70	34.00	1.48

varieties. But LHCK-69 had more number of grains/ plant (200.54) which was highest followed by Neelam (165.0) and was minimum in LHCK-21 (74.48). Choudhury *et al.* (1984) and Bedwal *et al.* (1970) also studied the similar results of yield attributes on linseed

Effect of nitrogen :

Nitrogen application had a significant influence on yield and yield attributes of linseed (Table 1). The seed yield increased significantly with increasing levels of nitrogen from control (0 kg/ha) to 60 kg/ha during both the years and beyond 60 kg/ha, there was no increase in yield (Table 1). The differences between 60 kg and 90 kg N/ha on seed yield were significant which indicated that the response of increasing levels of nitrogen up to 60 kg N/ha was beneficial and 90 kg N/ha could not give further increase in yield but it was higher than 0 and 30 kg N/ha. Pooled analysis revealed that application of 60 kg N/ha gave highest seed yield (10.45 q/ha) which was significantly superior to rest of other levels of nitrogen (Table 1). The increase in yield due to 60kg N/ha was found to the extent of 57, 43 and 18 percent over 0, 30 and 90 kg N/ha respectively. Tomer *et al.* (1985) also studied that there was beneficial effect of increasing levels of fertilizer application on yield and yield attributes of linseed

Considering the results on yield attributes due to nitrogen application from 0 to 90 kg/ha which showed positive effect on yield attributes *viz.* plant height, number of branches and number of capsule/plant. The yield attributes *viz.* number grains/ capsule, number of grains/ plant and test weight (g/1000 seeds) could not increase beyond application of 60 kg N/ha. Hence it was observed that application of 60 kg N/ha was optimum for the yield as well as yield attributes of linseed varieties. The similar results were reported by Singh *et al.* (1982) and Chowla *et al.* (1983).

Interaction effect of varieties and nitrogen levels was significant on seed yield and yield attributes of linseed. Singh *et al.* (1974) also observed the similar results.

Hence the present study indicated that Neelam, LHCK-69 and LHCK-39 ranked first, second and third in respect of seed yield amongst the varieties and application of 60 kg N/ha was found to be optimum for obtaining higher yield of linseed under rainfed agroclimatic conditions of Nagaland.

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HETEROSIS AND COMBINING ABILITY ANALYSIS IN CASTOR

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ABSTRACT

A line × tester analysis using 4 pistillate lines and 8 pollen parents, was carried out to study the heterosis and combining ability for yield and its attributes. The crosses exhibted -13.30 to 88.57% heterosis over better parent for yield, 38.89 to 59.86% for spike length, 31.85 to 97.69% for number of capsules per plant and 27.27 to 9.26% for 100 seed weight. The hybrids VP-1 × JI-35 and SKP-4 × JI-35 are of commercial value. The estimated components of general and specific combining ability (gca and sca) variances showed pre-dominance of non-additive gene action for yield per plant, number of capsules per plant and effective branches per plant and additive for rest of the characters. The female SKP-4 was good general combiner for 100-seed weight, SKP-3 for length and effective length of main spike and number of capsules per main spike and VP-1 for effective branches. Among the males JI-35 was the best general combiner for yield and important yield components. The parents having high *per se* performance were also good general combiners for the respective traits.

Key words : Heterosis; combining ability, castor; line × tester analysis.

INTRODUCTION

Information on magnitude of heterosis, type of gene action involved and specific combining ability of different parents and crosses is helpful in planing of future breeding programmes. Since production of hybrid castor seed is feasible because of the availability of pistillate lines, hybrids are developed for extensive cultivation in Gujarat State. A number of new male and female lines are recently evolved to develop better yielding hybrids. The present investigation aims at assessing the extent of heterosis, relative importance of general and specific combining effects and type of gene action for yield and its components through line × tester analysis of some newly developed male and female lines of castor (*Ricinus communis* L.).

MATERIAL AND METHODS

Four pistillate lines (SKP-2, SKP-3, SKP-4 and VP-1) and eight pollen parents were selected on the basis of desirable agronomic characters and wide genetic bases (Table 3). The resulting 32 hybrids alongwith 12 parents were laid out in a RBD with two replications at Castor Research Scheme, Gujarat Agricultural University, Sardar Krushinagar in 1982-83. Each plot consisted of 15 plants having an inter and intra row spacing of 90 cm. × 60 cm. Observations were recorded on five randomly selected plants for ten characters viz. days to flowering, plant height up to main spike, length of main spike (cm), effective length of main spike (cm), node upto main spike, effective branches per plant, number of capsules per main spike, number of capsules per plant, 100 seed weight (g) and seed yield per plart (g). Heterosis, heterobeltiosis and heterosis over standard hybrid was calculated as usual, estimates of general and specific combining ability effects were computed as per the method suggested by Kempthorne (1957).

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RESULTS AND DISCUSSION

The analysis of variance (Table 1) revealed significant differences among the parents for all the characters, suggesting sufficient variability among parental lines. The parents *vs* crosses comparision was significant for majority of characters under study, indicating the presence of considerable mean heterosis. The magnitude of heterosis over better was 13.30 to 88.57 % for seed yield per plant, 27.27 to 9. 26% for 100 seed weight, 31.85 to 97.60 % for number of capsules per plant, 43.80 to 26.60 % for number of capsules per main spike, 59.72 to 83.18% for effective branches per plant 18.12 to 29.25% for nodes upto main spike 38.96 to 59.83 % for length of main spike and 10.9 to 12.5 % for days to flowering (Table 2). Theer crosses were superior then standard hybrid and better parent. In this contect crosses VP-1 × JI-35 with 32.84% hetero-beltiosis and 51.26 % heterosis over standard hybrid GAUCH-1 (VP-1 × VI-9) and SKP-4 × JI-35 with 58.67 % heterobeltiosis and 80.67 % heterosis over standard hybrid should be considered for commercial exploitation of hybrid vigour in castoı.

The male and female parents were significantly divergent for general combin-ing ability (gca) effects in most of the characters except number of capsules per plant and seed yield per plant (Table 1). Variance due to specific combining ability (sca) effects were significant for all the characters except for days to flower, length of main spike, effective length of main spike, nodes upto main spike and number of capsules in main spike.

The variance components due to males (6^2 gca males) were higher than those due to females (6^2 gca females) for all the characters except effective length of main spike The estimates of sca variances (5^2 sca) were considerably higher than gca variance (pool. ed) for effective branches per plant, number of capsules per plant and yield per plant-indicating preponderance of non-additive gene action in the inexitance of these traits., However, for the remaining characters gca variances were higher in magnitude suggest-ing additive gene action for the control of these, traits. Kandaswami (1977), Singh and Yadava (1981) and Singh and Srivastva (1982) also found the importance of non-additive gene action for yield and some of the related traits in castor. The preponderance of additive gene action for days to flower and nodes upto main spike was also observed by Hooks *et al.* (1971) and Patel *et al.* (1984) in castor.

Among the males JI-35 was the best general combnier for effective branches per plant (Table 3) SKI-6 and VI-9 for days to flower and nodes upto main spike OTC-30-18 and SKI-6 for plant height upto main spike, SPS-43-3 and SPS-59-10 for length and effective length of main spike, SPS-59-10 and OTC-30-18 for number of capsules per main spike and SPS-43-3 and SPS-59-10 for 100 seed weight. Among the females, SKP-2 was good general combiner for plant height upto main spike, SKP-3 for length of main spike, effective length of main spike and SKP-4 for 100 seed weight, number of capsules per main spike and effective length of main spike and VP-1 for effective branches per plant.

The estimates of sca effects for yield per plant (Table 4) was significant for eight

TABLE No. 1. **Analysis of variance for combining ability for various characters in castors.**

Source of variance	D.F.	Days to flowering	Plant height upto main spike (cm)	Length of main spike (cm)	Effective length of main spike (cm)	Nodes upto main spike	Effective branches per plant	No. of capsules per main spike	No. of capsules per plant	100-seed weight gms.	Seed yield per plant (g)
Treatments	43	122.41*	225.67**	133.22**	111.65**	14.28*	22.12**	330.29**	3199.19**	33.75**	2075.14**
Parents	11	253.53**	356.89**	168.73**	136.96**	26.46**	40.07**	457.71**	2353.84**	60.68**	920.19*
Crosses	31	63.40**	170.19**	118.03**	101.04**	9.71**	16.20**	294.75**	3181.98**	25.04**	2009.72**
Parents vs crosses	1	509.17**	502.13**	213.37*	162.15*	21.99**	8.08	30.26	13041.54**	7.40	16807.65**
Males effects (M)	7	125.09**	500.05**	253.98**	173.54**	24.98**	25.41*	563.01**	4564.22	79.37**	3180.17
Females effects (F)	3	186.52**	221.17*	421.58**	409.18**	24.09**	36.46*	853.97**	2443.85	32.31**	961.39
Females × Male (F × M) interaction	21	25.25	52.95*	29.35	32.85	2.56	10.24**	125.44	2826.68**	5.89*	1769.34**
Error	43	18.73	27.53	36.05	37.75	1.91	3.01	90.08	859.13	2.69	454.17
C.V. %		6.36	14.48	17.88	21.39	8.11	17.42	21.20	19.81	5.41	18.62
Variance components											
σ^2 gca (male)		12.48	55.89	28.08	17.59	2.80	1.89	54.70	217.19	9.18	176.35
σ^2 gca (females)		10.08	10.51	24.51	23.52	1.35	1.64	45.53	– 23.93	1.65	– 50.49
σ^2 gca (pooled)		10.88	25.64	25.70	21.54	1.83	1.73	48.59	56.45	4.16	25.12
σ^2 sca		3.26	12.71	–3.35	–2.45	0.32	3.62	17.68	983.77	1.60	657.58
σ^2 gca / σ^2 sca		9.29	0.49	–0.13	–0.11	0.17	2.09	0.36	17.43	0.38	26.18

* = Significant at P=0.05

** = Significant at P=0.01

TABLE 2. Range of per cent heterotic of 32 crosses for yield and yield components in castor

Particulars	Characters									
	Days to* flowering	Plant * height upto main spike (cm)	Length of main spike (cm)	Effective length of main spike (cm)	Nodes* upto main spike	Effective branches per plant	No. of capsules per main spike	No. of capsules per plant	100-seed weight (cm)	seed yield per plant (g)
Mild-parent heterosis	–19.51 – 5.96	–16.20 – 67.88	–21.17 – 61.21	–24.71 – 70.10	–20.23 – 9.97	–36.94 – 116.57	–30.54 – 51.22	–26.11 – 103.30	–13.85 – 15.00	– 8.92 – 122.80
Better parent heterosis	–10.9 – 12.5	– 6.90 – 175.18	–38.96 – 59.83	–46.29 – 57.72	–18.12 – 29.25	–59.72 – 83.18	–43.80 – 26.60	–31.85 – 97.50	–27.27 – 09.26	–13.30 – 88.57
Heterosis over standard hybrid	– 3.5 – 20.0	–43.63 – 54.39	–38.96 – 64.77	–37.83 – 71.16	–17.33 – 53.33	–39.31 – 133.33	–41.39 – 83.72	–45.02 – 70.37	–13.21 – 43.40	–45.80 – 80.67
No. of crosses significantly superior to mid-parent	9	0	7	4	7	8	3	8	4	11
No. of crosses significantly superior to better parent	1	0	2	3	1	2	0	3	0	8
No. of crosses significantly superior to standard hybrid	0	3	5	2	0	6	2	3	17	3

* Nagative heterosis was considered to be desirable and number of crosses significant in negative direction were considered superior.

TABLE 3. Estimates of g.c.a. effects with mean performance of twelve parent (8+4) for various

Parents	Days to flowering		Plant height upto main spike (cm)		Length of main spike (cm)		Effective length of main spike (cm)		Nodes main
	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect
Males									
SKI-6	-6 39**	61.00	-5.52**	28.00	-6.69**	17.90	-6.08**	11.40	-2.66**
VI-9	-3.89*	61.00	-3.69	31.00	-4.49**	20.90	-5.66*	18.60	-1.39**
J-1	-0 27	61.50	1.70	33.00	-2.93	23.40	-2.66	17.90	0.07
JI-35	4.11*	86.00	11.00**	59.90	1.02	34.20	1.62	28.10	1.39**
OTC-30-18	0 23	88 00	-13.49**	22.30	1.50	41.60	1.23	36.70	0.85
SPS-35-50	-1 39	69.50	-2.66	37.30	-1.87	29.20	-0.10	27.40	-1.53**
SPS-43-3	2.11	74.00	5.74*	46.60	7.31**	48.60	4.45*	39.40	0.49
SPS-59-10	5.48**	92.00	6.90**	48.30	8.16**	34.30	7.19**	24.60	2.76**
SE gca	3.07	-	3.73	-	4.28	-	4.38	-	0.99
SE (gi-gj)	4.13	-	4.99	-	5.72	-	5.85	-	1.32
Females									
SKP-2	-1.46	60.00	-5.01**	23.80	-5.62**	26.80	-5.37**	24.40	-1.29**
SKP-3	5.11**	72.00	2.86*	21.00	6.43**	34.10	5.28**	33.00	1.60**
SKP-4	-1.64	66.00	2.78*	19.20	1.31	23.00	3.20*	22.90	0.19
VP-1	-1.02	72.00	-0.64	17.30	-2.12	38.50	-3.13*	33.70	-0.51
SE gca	2.18	-	2.64	-	3.03	-	3.11	-	0.71
SE (gi-gj)	2.91	-	3.53	-	4.05	-	4.15	-	0.94

* = Significant at P = 0.05

** = Significant at P = 0.01

characters in castor

up to spike	Effective branches per plant		No. of capsule per main spike		No. of capsules per plant		100 seed weight (g)		Seed yield per plant (g)	
Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean
12.00	–0.35	7.70	–11.55**	16.30	–28.74	100.70	1.99**	35.50	–21.41	83.50
14.10	–1.10	6.60	–5.89	30.40	2.14	152.00	–2.89**	27.50	4.47	97.50
14.80	0.40	18.00	–8.38*	23.00	–11.79	166.40	–4.39**	22.00	–12.29	98.50
20.50**	3.27	10.70	1.65	60.50	52.05	194.10	–1.64**	25.00	40.84	125.50
22.70	–2.94**	5.60	7.47*	59.70	–15.94	123.20	–1.39*	32.00	–20.91	94.00
17.10	0.76	17.10	2.85	54.30	7.00	125.10	0.49	38.50	6.34	86.00
21.70	0.65	9.40	0.13	54.20	–3.45	129.40	4.99**	40.00	2.84	113.00
23.10	–0.63	12.30	13.70**	62.40	–1.24	92.10	2.86**	33.00	0.09	86.00
–	1.23	–	6.78	–	NS	–	1.17	–	NS	–
–	1.64	–	9.06	–	–	–	1.56	–	–	–
14.70	–0.30	9.55	–8.71*	37.40	–18.35	159.50	–1.58**	26.50	–11.60	109.00
19.30	–1.92**	3.90	6.61**	44.30	4.30	86.90	0.05	27.00	3.03	70 00
18.00	0.21	5.20	5.42*	42.60	5.59	86.40	1.86**	33.00	4.28	57.50
16.30	1.76**	7.40	–3.29	40.60	8.47	121.15	–0.33	29.50	4.28	90.00
–	0.87	–	4.78	–	NS	–	0.83	–	NS	–
–	1.16	–	6.39	–	–	–	–	–	–	–

TABLE 4. Mean, heterobeltiosis and specific combining ability of promising crosses in castor

Sr. No.	Cross		Days to flower	Plant height upto main spike (cm)	Length of main spike (cm)	Effective length of main spike (cm)	Node upto main spike	Effective branches per plant	No. of capsules per main spike	No. of capsules per plant	100-seed weight Pgm)	seed yield per plant (gm)
1.	SKP-2 × SPS-59-10	M	72.50	44.30	43.00	38 80	19 00	08.80	52.80	166.60	33.00	154.50
		H	20.83**	86.13**	11.68	15.13	29.25**	-28.45*	-15.38	4.45	0.00	41.74*
		SCA	1.96	4.71	5.93	7.42	0.79	-0.67	2.69	30.79	1.58	43.30**
2.	SKP-3 × VI-9	M	70.00	35.25	35.75	28 60	16.75	8.50	46.25	202.85	27.50	176.50
		H	14.75*	67.85**	4.84	-13.33	20.21	28.79	4.40	33.45	0.00	81.03**
		SCA	2.26	-1.62	1.28	-0.58	-0 28	1.39	0.40	41.01	0.20	46.09**
3.	SKP-3 × SPS-59-10	M	79.50	50.10	50.75	45.70	23.0	8.10	79.00	181.95	34.50	132.00
		H	10.41	138.57**	47.96**	38.48*	19.71*	-34.15*	26.60	97.56**	4.54	88.57**
		SCA	2.39	2.64	1.63	3.67	1.90	0.32	13.56	23.49	1.45	5.97
4.	SKP-4 × J-1	M	64.50	43.90	37.40	34.70	17.10	12.25	49.60	218.30	28.00	150.00
		H	4.87	128.64**	59.83*	51.53	14.86**	1.94**	16.43	31.19	-15.15**	52.28*
		SCA	-0.11	1.72	4.49	4.60	0.00	1.51	7.43	59.10**	0.39	35.09*
5.	SKP-4 × JI-35	M	71.50	49.10	39.30	36.80	17.90	3.70	47.20	251.55	31.50	215.00
		H	8.33	156.5**	15.59	30 96	-0.55	28.04	-21.98	29.60	-4.54	58.67**
		SAC	2.51	-2 38	2.33	2.42	-0.42	0.09	-5.00	38.52	1.14	46.97**
6.	VP-1 × JI-35	M	67.00	52.50	34.60	29.90	18.50	19.60	49.40	266.80	26.50	180.00
		H	-6.94	203.46*e	-10.13	-11.28	13.49	83.18**	-18.35	37.45*	-10.17	32.84*
		SCA	-1.61	4.44	1.17	1.84	0.88	4.44**	5.95	50.89*	-1.67	11.97
7.	VP-1 × SPS-35-50	M	63.40	39.90	31.80	28.20	14.80	13.10	51.20	161.40	30.00	158.00
		H	-9.35	119.67**	-17.40	-16.32	-9.20	-23.39*	-4.05	31.00	-22.08**	75.56**
		SCA	-0.11	3.00	1.26	1.86	0.10	0.45	6.55	-9.47	-0.30	24.47
8.	VP-1 × SPA-59-10	M	66.00	31.40	32.10	25.50	17.20	12.70	43.00	162.00	32.50	141.00
		H	-8.33	81.50**	-16.62	-24.33	-15.52	3.25	-31.09**	50.23*	-1.52	56.67**
		SCA	-3.98	-12.56**	-8.47	-8.13	-1.79	1.44	-12.50	19.37	-0.17	13.72

M = Mean, H = Hetrobeltiosis and SCA = Specific combining ability

* = Significant at P=0.05

** = Significant at P=0.01

hybrids, of which crosses SKP-4 × JI-35 and VP-1 × JI-35 recorded the highest mean performance alongwtih 58.67 % and 32.84% respective heterobeltiosis, are of commercial value. The female SKP-4 in NES type pistillate line which develops few interspersed male flowers under high temperature (above 30°C) and remains 100 % pistillate under low temperature (below 30°C) during flowering phase. Maintenance of SKP-4 can be done by advancing sowing date and hybrid seed can be produced from delayed sowing by planting 3:1 rows of female and males lines. VP-1 is an established 'S' type pistillate line which can be maintained by selfing of late reverted plants of sibbing with heterozygous segregant. The hybrid seed production can be achieved by planting the female line with double seed rate along with male line in a ratio of 3:1 rows and removing 30 to 50% monoecious plants, after emergence of main spike before anthesis from the rows of VP-1.

Gca effects of the parents were found in accordance to mean performance of the sane parents for yield attributes, suggesting that *per se* performance of the parents could be effectively used as a selection criterion far other than yield, while selecting parents for evolvement of productive hybrids in castor.

The results revealed that for yield and its main attributes, non-additive gene action was more important indicating hybrid breeding programme will be more usefull for improving the yield in castor.

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COMBINING ABILITY FOR SEED CHARACTERS IN CASTOR.

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ABSTRACT

A line × tester analysis of combining ability was carried out using four pistillate lines and eight pollen parents in castor for seed length, seed width, thickness of seed, 100 seed weight, endosperm percentage and oil content. The variances for gca sca showed pre-dominance of additive gene action for all the characters barring oil content. Female SKP-3 was good general combiners for seed width, seed length and oil content and SKP-4 was good general combiner for seed width, 100 seed weight and thickness of seed. Among males SPS-43-3 was the best general combiner for seed length thickness of seed and 100 seed weight. A parent showing higher mean performance generally proved to be good general combiner. Seed size can be improved through direct selection.

Key words : Combining ability; castor; seed size, oil content, endosperm%: line × tester analysis.

INTRODUCTION

Gross yield of oil per hectare, which is largely determined by seed weight and oil content in the seed determines the superior of castor genotype. While efforts are being made to increase seed yield, little attention has been paid for oil content and other seed characters. Information on nature of genetic control of seed traits is lacking in castor. Such information if gathered from the comparative study of parents and crosse may be helpful in genetic manipulation-of seed traits. Keeping this in view the present study was conducted.

MATERIAL AND METHODS

The material consisted of four pistillate lines and eight pollen parents (Table 2) and their 32 crosses. These were grown in 1982-83 at the Castor Research Station, Gujarat Agricultural University, Sardar Krushinagar under Castor Research Project. The experiment was laid out in a RBD replicated twice. Each treatment consisted of single row of 6 m having 15 plants, 90 cm apart. From the seed yield of five randomly selected plants, 100 seeds were counted and weighted for the test weight. Out of which 25 seeds were selected randomly for the measurement of length, width, thickness and endosperm percentage. The remaining seeds were subjected to analysis of oil content. Mean values were used for the statistical analysis as suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance (Table 1) revealed significant differences among the parents for all the characters barring oil content. differences among the crosses were also highly significant for all the traits except endosperm percentage, indicating presence of genetic variability in the material selected for study. Significant differences for parents

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TABLE 1. Analysis of variance for combining ability for various characters in castor

Source of variance	D.F.	Seed length (cm	Seed width (cm)	Thickness of seed (cm)	100 seed weight (g)	Endosperm percentage	Oil content (%)
Treatments	43	0.0072**	0.0046**	0.0020**	33.7460**	5.3688**	5.5779**
Parents	11	0.0150**	0.0073**	0.0035**	60.6780**	13.2911**	2.0955
Crosses	31	0.0045**	0.0037**	0.0015**	25.0400**	2.3158	6.3167**
Parents vs Crosses	1	0.0042**	0.0024**	0.0007	7.3990	24.4756**	20.9361**
Males M)	7	0.0125**	0.0136**	0.0052**	79.3730**	6.1641**	6.4657
Females (F)	3	0.0076**	0.0043**	0.0011**	32.0370**	1.4102	15.4966*
Female × **Male** (F × M)	21	0.0014	0.0004	0.0003	5.8910*	1.1625	4.9557**
Error	43	0.0008	0.0006	0.0006	2.6880	2.4111	1.9908
C.V. %		**2.42**	**3.04**	4.22	5.41	2.11	2.89
Variance components							
σ^2 gca (male)		0.0014	0.0016	0.0006	9.1800	0.6252	0.1888
σ^2 gca (female)		0.0004	0.0003	0.0001	1.6500	0.0155	0.6588
σ^2 gca (pooled)		0.0007	0.0007	0.0002	4.1600	0.2187	0.5021
σ^2 sca		0.0003	0.0001	0.0002	1.6000	-0.6243	1.4825
σ^2 gca / σ^2 sca		0.3611	0.1549	0.7083	0.3846	-2.8546	2.9526

* = Significant at P=0.05

** = Significant at P=0.01

TABLE 2. Estimates of gca effects and mean performance of twelve parents for various characters in castor

Parents	Seed length (cm)		Seed width (cm)		Thickness of seed (cm)		100 seed weigtht (g)		Endosperm percentage		Oil content (%)	
	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean	gca effect	Mean
Females												
SKP-2	–0.0238**	1.14	–0.0211**	0.77	–0.0117	0.56	–1.5800**	26.50	–0.3719	73.29	–0.9668**	49.64
SKP-3	0.0206**	1.12	0.0121**	0.78	0.0083	0.55	0.0500	27.00	–0.0775	74.69	1.1850**	50.10
SKP-4	0.0162*	1.16	0.0139*	0.81	0.0033	0.59	1.8600**	33.00	0.3225	74.52	–0.6300	49.03
VP-1	–0.0131	1.12	–0.0048	0.79	0.0002	0.57	–0.3300	29.50	0.1268	73.32	0.4119	47.12
SE (gi)	0.0072	–	0.0060	–	0.0061	–	0.4100	–	N.S.	–	0.3527	–
SE (gi – gj)	0.0102	–	0.0086	–	0.7008	–	0.5800	–	N.S.	–	0.4988	–
Males												
SKI-6	0.0356**	1.29	0.0133	0.87	0.0152	0.61	1.9900**	35.50	0.5062	74.66	0.2907	50.65
VI-9	–0.0356**	1.14	–0.0317**	0.75	–0.0198**	0.55	–2.8900**	27.50	0.7537	73.31	–0.3918	48.69
J-1	–0.0506**	1.04	–0.0642**	0.71	–0.0435**	0.53	–4.3900**	22.00	–1.6675*	66.14	–1.4268	49.09
JI-35	–0.0281**	1.14	–0.0242**	0.75	–0.0198*	0.54	–1.6400**	25.00	–0.5938	71.30	1.4832	50.47
OTC-30-18	–0.0269*	1.26	–0.0129	0.86	0.0077	0.63	–1.3900*	32.00	–0.6913	70.19	–0.3468	48.55
SPS-35-50	0.0156	1.27	0.0146	0.87	0.0177*	0.66	0.4900	38.50	0.5437	75.01	–0.1556	49.27
SPS-43-3	0.0456**	1.29	0.0583**	0.88	0.0340**	0.62	4.9900**	40.00	0.5375	74.63	–0.3931	50.33
SPS-59-10	0.0444**	1.29	0.0471**	0.88	0.0090	0.62	2.8600**	33.00	0.6112	71.93	0.9407	48.45
SE (gi)	0.0102	–	0.0086	–	0.0087	–	0.5800	–	0.5489	–	N.S.	–
SE (gi - gj)	0.0145	–	0.0121	–	0.0122	–	0.8200	–	0.7764	–	N.S.	–

* = Significant at P=0.05

** = Significant at P=0.01

TABLE 3. Specific combining ability and mean performance of selected crosses in castor

Crosses	100-seed weight (gm)		Oil content	
	sca	Mean	sca	Mean
SKP-3 × SPS-43-3	–1.6800	33.5	0.8925	52.06
SKP-3 × SPS-59-10	1.4500	34.5	0.5987	53.10
SKP-4 × SKI-6	1.0100	35.0	2.9637**	53.00
SKP-4 × SPS-43-3	1.0100	38.0	1.1575	50.51
VP-1 × J-1	3.5800**	29.0	1.6893	51.05
VP-1 × SPS-43-3	1.2000	36.0	–1.7194	48.68
SE (sca)	1.1600	—	0.9977	—
SE (Sij – Ski)	1.6400	—	1.4109	—

** Significant at P=0.01

vs. crosses for all the traits barring seed width and 100 seed weight revealed a substantial amount of hybrid vigour in the crosses. The variance due to males and females were significant for all the traits except oil content in males and endosperm percentage in females. While, females × males variance was significant only for 100 seed weight and suggested that additive gene actions were important and pre-dominant for the expression of all the traits except oil content and endosperm percentage. Both the types of gene action were important and non-additive type of gene action was pre-dominant for the expression of oil content. Giriraj *et al.* (1974) observed pre-domancy of additive components for test weight and importance of additive × dominance components for oil content which is in agreement with the present findings.

The gca effect (Table 2) indicated that female SKP-3 was good general combiner for seed length and seed width and SKP-4 was good general combiner for 100 seed weight, seed width and seed length. Female VP-1 was average general combiner for all the characters. Thus SKP-3 and SKP-4 can be used for developing bold seeded hybrids. Among the males, SPS-43-3 and SPS-59-10 were good general combiners for seed length, seed width, thickness of seed and 100 seed weight. Similarly, SKI-6 showed general combining ability for seed length and 100 seed weight, J-1 was found to be poor general combnier for all the characters.

Though the sca effect with regards to 100 seed weight (Table 3) was highly significant for the combination VP-1 × J-1 ,its mean performance was not very high. The highest mean performance for 100 seed weight was observed for SKP-4 × SPS-43-3. The combination SKP-4 × SKI-6 showed highly significant sca effect along with higher mean performance for oil content and fairly higher mean seed weight. This combination can be exploited for the development of bold seeded hybrid with high oil content.

A parent showing higher mean performance generally proved to be good general combiner for the respective traits, indicating the *per se* performance of the parents could be effectively used as a selection criterion while selecting the parents for developing bold seeded hybrids in castor.

It may be concluded from the present investigation that direct selection for high oil could not be very effective as the non-additive type of gene actions were predominant in the population. On the other hand hybridization and selection would be effective for the improvement of seed size in castor.

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AGRICULTURAL DROUGHTS AND GROUNDNUT PRODUCTIVITY IN ANANTAPUR DISTRICT OF ANDHRA PRADESH

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ABSTRACT

Groundnut is extensively grown under rainfed conditions in Anantapur district with an average productivity of 676 kg/ha. The productivity was observed to be below average during the years when the mean ratio of the actual evapotranspiration and the potential evapotranspiration during the growing season was less than 0.41. It was brought out that the risk of drought for groundnut is least during the years when the growing season commences during July 16 to August 5. The drought conditions leading to below average productivity occurred for a maximum of five consecutive years from 1922 to 1926 during the last 75 years.

Key words : Groundnut; actual evapotran; piration; agricultural drought.

INTRODUCTION

Groundnut (*Arachis hypogae* L.) is generally grown under rainfed conditions in the arid and semi-arid regions receiving an average annual rainfall of 500 to 1000 mm. Krishnan and Ramana Rao (1980) studied the productivity of groundnut in Kolar and Bijapur districts of Karnataka State using systems analysis approach and observed that the year to year variations in productivity depend upon the water availability conditions during the growing season and identified the optimum sowing periods for reducing the risk of mositure stress to the crop. Groundnut is extensively grown in Anantapur district under rainfed conditions. There is considerable variation in the productivity of the district from year to year due to recurring droughts. Therefore, the present investigation was taken up (i) to identify the conditions leading to drought and below average productivity of the crop (ii) to determine the influence of commencement of the growing season on the frequencies of occurrence of droughts and the probable period during which the crop is likely to be subjected to severe dry spells and (iii) to assess the possibility of the crop being subjected to drought conditions during consecutive years. The information generated can be used for judicious planning of groundnut crop in the district depending upon the date of commencement fo the growing season.

MATERIAL AND METHODS

The area under groundnut in Andhra Pradesh and Anantapur district and its productivity in the district for the years 1970 to 1982 were taken from the season and crop reports published by the Bureau of Economics and Statistics, Government of Andhra Pradesh, Hyderabad. The daily rainfall data recorded at Anantapur for the years 1911 to 1985 were utilized in the present study. The weekly totals of rainfall were computed according to the standard meteorological weeks. The soils in Anantapur district are predominantly red and very shallow soils with the depth ranging from 10 to 30 cm. The field capacity and wilting point of these soils at the Agricultural Research Station, Anantapur are 13.6 and 3.6 per cent respectively (Anonymous, 1986). Therefore, the available

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water holding capacity of these soils was taken as 25 mm. The weekly water balance computations were made using the book-keeping procedure of Thornthwaite and Mather (1955) to estimate the water available to the crop for actual evapotranspiration (AE). The normal monthly potential evapotranspiration values calculated by Rao *et al.* (1971) using modified Penman's formula were utilized and the weekly values were graphically interpolated as all the data required for calculating the potential evapotranspiration were not available. Further, the variations in potential evapotranspiration are very less when compared to the variability of rainfall. As the ratio of actual evapotranspiration to the potential evapotranspiration (AE/PE) indicates the rate at which water is available to the crop compared to the evaporative demand, these ratios were calculated weekwise. Krishnan and Ramana Rao (1980) considered that the growing season for groundnut commences from a week when AE/PE is equal to or greater than 0.50 and the same assumption was also used in the present study considering the first spell of rains were used for land preparation. As bunch type groundnut of 100 to 110 days duration are mostly grown in the district, the mean seasonal values of AE/PE were calculated for a period of 15 weeks from the week of commencement of the growing season. The minimum required seasonal value of AE/PE in respect of groundnut for getting average yield was obtained by graphical interpolation technique proposed by Azzi (1956) and similar method was also used by Sastri *et al* (1981, 1984) in respect of pearlmillet and short duration pulses in Western Rajasthan. As the productivity of groundnut was below average during the years with mean seasonal value of AE/PE less than 0.41 (Fig.1), the years

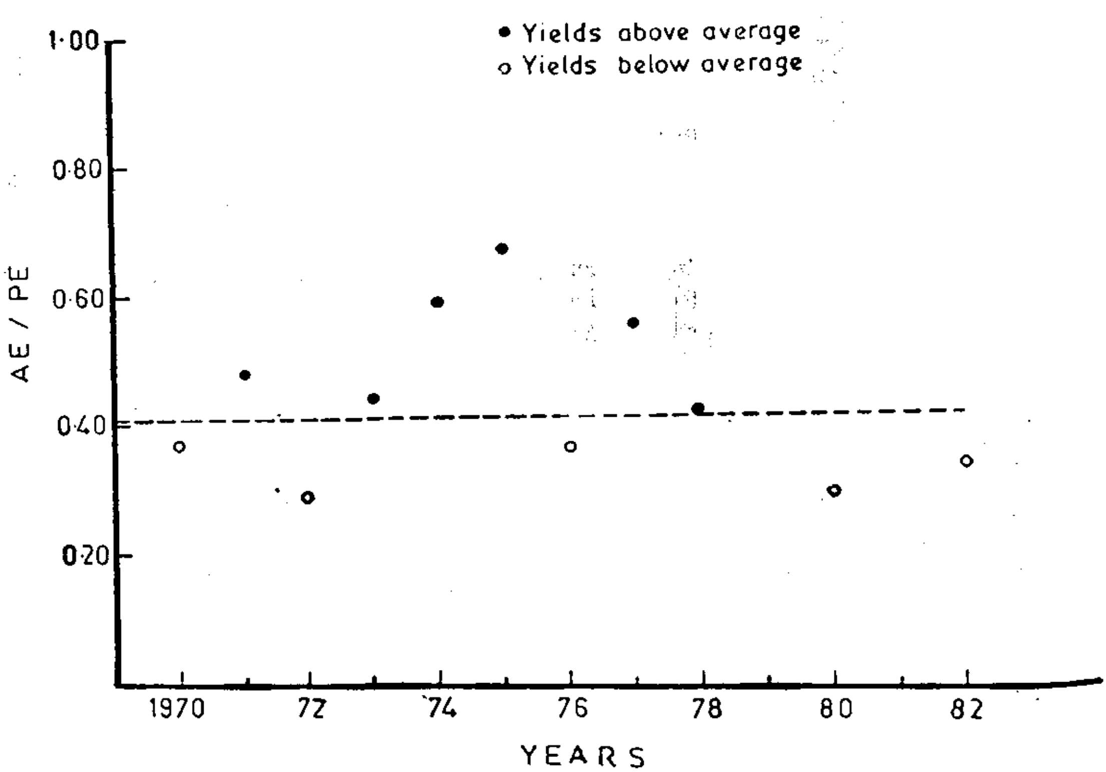

Fig 1. Seasonal value of AE/PE in different years

with mean seasonal value of AE/PE less than 0.41 were considered as drought years for the crop in the district. It is also assumed that the crop will be subjected to severe moisture stress and drought whenever AE/PE is less than 0.25 for four consecutive weeks and the periods of occurrence of severe dry spells depending upon the week of commencement of growing season were identified.

TABLE 1. Area under groundnut and its productivity in Anantapur District of Andhra Pradesh

Year	Area under groundnut (ha)		percentage of area in the district	productivity in the district (kg/ha)
	Andhra Pradesh	Anantapur District		
1970	13,35,903	2,59,666	19.4	491
1971	14,22,344	2,47,664	17.4	707
1972	12,41,124	2,02,530	16.3	571
1973	11,51,031	2,56,845	22.3	821
1974	12,38,189	2,80,950	22.7	811
1975	11,61,619	3,13,891	27.0	720
1976	9,28,945	2,65,868	28.6	308
1977	9,15,883	2,83,299	30.9	930
1978	10,58,519	3,24,779	30.7	775
1979	11,01,590	3,50,283	31.8	714
1980	10,80,376	3,16,981	29.3	369
1981	11,76,926	3,72,776	31.7	924
1982	12,19,917	3,79,124	31.1	557
Mean	11,56,336	2,96,512	25.6	676.4

RESULTS AND DISCUSSION

The area under groundnut in Andhra Pradesh and Anantapur district and the productivity in the distirict during the years 1970 to 1982 are given in Table 1. According to Vishnumurty (1985), the area under groundnut in the country is 6376 thousand hactares. Therefore, 18.5 per cent of the area under groundnut is in Andhra Pradesh itself. During the recent years, there is considerable increase in the area under groundnut in Anantapur district. During the year 1982, about 31.1 per cent of the area under groundnut crop in Andhra Pradesh is in Anantapur district compared to only 19.1 per cent during the year 1970. The average productivity of groundnut in the district is 676.4 kg/ha compared to the national productivity of 875 kg/ha (Vishnumurty, 1985) and it is about 77.3 percent only.

The mean weekly rainfall during different weeks of the rainy season is given in Table 2 and it is greater than 10 mm continuously from 29th to 45th week. As the crop has to be harvested when there is sufficient moisture in the soil, bunch type groundnut of 100 to 110 days duration can be sown upto 31st week only.

The frequencies of occurrence of droughts in the years with commencement of growing season during 25th to 32nd week and 33rd week onwards were determined and given in Table 3. The drought conditions occurred only in three out of twenty six years

TABLE 2. Mean and coefficient of variation of weekly rainfall during different weeks at Anantapur (1911—1985)

Standard week	Date		Mean weekly rainfall (mm)	coefficient of variation
24	June	11–17	9.0	181.1
25		18–24	6.7	163.7
26		25–1	12.1	160.5
27	July	2–8	7.5	152.2
28		9–15	9.9	171.2
29		16–22	16.9	161.6
30		23–29	14.5	160.1
31		30–5	12.7	160.2
32	August	6–12	11.0	216.2
33		13–19	16.0	182.1
34		20–26	24.4	173.7
35		27–2	19.8	174.2
36	September	3–9	15.6	143.6
37		10–16	33.0	131.4
38		17–23	50.5	105.8
39		24–30	39.2	134.4
40	October	1–7	33.3	128.6
41		8–14	33.2	170.2
42		15–21	15.2	137.4
43		20–28	20.9	164.9
44		29–4	14.4	189.6
45	November	5–11	17.6	215.1
46		12–18	9.5	211.2

TABLE 3. Frequencies of occurrence of droughts for *groundnut* as related to the commencement of growing season at Anantapur (1911-85)

Commencement of growing season (standard weeks)	Frequency of occurrence	frequency of occurrence of of drought years	standard weeks during which severe dry-spells occurred
25	10	7	26–34
26	15	6	28–35
27	5	3	29–33
28	5	3	30–36
29	16	1	31–41
30	6	2	31–38
31	4	–	—
32	3	2	38–43
33 onwards	11	6	35–49

when the growing season commenced from 29th to 31st week. During the years with early commencement of growing season from 25th to 28th week; the drought conditions existed in 19 out of 35 years and severe dry spells are likely within the first eight weeks of the growing season thereby effecting vegetative growth and flowering, The risk of drought was higher in 8 out of 14 years when the growing season commenced from 32nd week onwards. Therefore, farmers can take advantage of the years when the growing season commences from 29th to 31st week by increasing the area under the crop due to least risk of drought.

TABLE 4. Decadal frequencies of occurrence of droughts for groundnut in Anantapur District (1911-85)

Decade	Frequency of drought years
1911–20	3
1921–30	6
1931–40	3
1941–50	5
1951–60	3
1961–70	3
1971–80	5
1981–85	2
TOTAL	30

The decade wise frequencies of occurrence of droughts in respect of groundnut are given in Table 4. The number of droughts per decade varied from 3 to 6 and drought conditions have already existed in two years during the first half of the current decade. The sequences of occurrence of droughts for consecutive years were given in Table 5 and it is observed that drought conditions prevailed for a maximum of five consecutive years from 1922 to 1926 during the last 75 years.

TABLE 5. Sequences of occurrence of drought years for groundnut at Anantapur (1911-85)

Number of consecutive years during which droughts occurred	Frequency of occurrence	Year of occurrence
1	19	1911, 13, 18, 29, 31, 35, 36, 49, 54, 61, 65, 69, 72, 74, 76, 78, 80, 82, 84
2	2	1935–36; 1971–72
3	1	1942–44
4	–	—
5	1	1922–26

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EFFECTS OF TWO FORMS OF INBREEDING (SELFING AND SIB—MATING) ON THE VIGOUR AND PERFORMANCE IN TORIA

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ABSTRACT

An experiment was conducted during *rabi*, 1968-69 with toria (*Brassica campestris* var *toria*) to sutdy the effects of two forms of inbreeding (1) Selfing in the form of bud pollination, geitonogamical pollination, bagging to self; and (2) Sibmating.

Bud pollination in comparison to other forms caused more reduction in the per cent seed setting, plant in all the varieties. However, it was significantly different in one variety only. Sibmating was found to be similar to the open pollination. Hence sibmating is recommended as an useful method for maintaining the toria germplasm without any deterimental effects on performance.

Key words: Toria; *Brassica campestris* var. *toria*; **inbreeding.**

INTRODUCTION

The consequences of inbreeding in self incompatable cross pollinated crops are usually the loss of vigour, seed producing capability and the poor yield performance (Williams, 1931; Melton, 1970). However, in such crops, it has been reported that the reduction in above mentioned attributes could be lessened by the slower froms of inbreeding (Lantican, 1961; Posher *et al.*, 1972) and it would be helpful in the proper maintenance of the cultures. Quantitative data with respect to the effects of various forms of inbreeding on the vigour and the performance of the self incompatible oil yielding *Brassica* varieties, though important are however, lacking. The present investigation aims to study the effects of the forms of inbreeding (1) selfing in terms (a) bud pollination (b) Geitonogamical pollination, (c) bagging to self and (2) Sibmating so as also to compare the effects of the forms with that of the open pollination on the vigour and performance of five promising varieties of toria.

MATERIAL AND METHODS

Five genetically diverse varieties of toria (*Brassica campestris* var. *toria*) M 27 from Assam, B-54 from West Bengal, T-9 from U.P., ITSA, Syn. A. from Punjab and Haryana) provided the source material for the present investigation. These were grown at Crop Research Centre, G.P. Pant Univesity of Agriculture & Technology, Pantnagar during 1968-69 in a 9 row plots and were replicated 3 times. Length of the row was kept at 5 m and were spaced 30 cm apart. Plant to plant distance was maintained at 7.5 cm. Ten randomly selected plants were tagged in each replication. Fifteen buds were selected on the plants and were bagged. Out of these (i) 5 were bud pollinated; (ii) 5 were pollinated from the previously bagged open flowers of the same plant and

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(ii) 5 were sibmated. Besides bagging to self, bud pollination was also done in 5 unopened buds on each of the above mentioned plants. At the time of harvest, 5 open pollinated pods were also collected from each of the plants. The amount of seed set under the various types of inbreeding machenism were recorded to note their immediate effect on the seed fertility of the cultures. The success of pollination in the cultures usually was about 50%. However, it varied from 44.0 to 94.0% The average success of crossing under bud possing under bud pollination, geitonogamical pollination and sibmating has been given in Table 1. The seeds obtained from the individual typest or inbreeding mechanism were kept separately. During 1969-70, each of the entries were grown in a replicated randomized block design with three replications. Each of

TABLE 1. Success of crossing under the two forms of inbreeding (selfing and sibmating) in 5 varieties of toria.

Varieties	SELFING		SIBMATING
	Bud pollination	Geitonogamical pollination	
M 27	48	62	70
B 54	47	44	78
T_9	51	60	94
ITSA	50	56	57
Syn A	41	88	46
Average	47.4	60.0	69.0
SE ±	2.5	4.4	8.7

the entries were grown in a three row plot. Row length was kept at 3 m and they were spaced 30 cm apart. Ten plants were randomly selected for data. The characters recorded were the plant vigour in terms of plant height (cm) and the yield per plant (g).

Bagging to self either did not produce any seeds or if at all any seeds were produced, they were highly under developed, shrunken, and later failed to germinate. This indicated that the varieties under investigation were highly self incompatible.

RESULTS AND DISCUSSION

Seed setting under the three inbreeding systems namely the bud pollination geitonogamical pollination i.e. the pollination of the flowers of one plant with the flowers of the same plant, and sibmating with respect to 5 varieties of toria is given in Table 2. It is clear from the Table 2, that the overall average seed setting is more or less similar in both bud and geitonogamical pollinations. It varied from 0.51 to 4.30 seeds per pollinations. The average seed setting under the sibmating was 4.46 which was 74.9% more than the bud pollinated and 107.4% more than the geitonogamical pollination. Such

TABLE 2. Seed setting under three systems of inbreeding in 5 varieties of toria

Varieties	Systems of Inbreeding								
	Bud pollination			Geitonogamical Pollination			Sibmating		
	Total No. of Polli- nation made	Total No. seeds obtain- ed	Seeds per pod per polli- nation made	Total No. of Polli- nation	Total No. of seeds obtained	Seeds per pod per polli- nation	Total No. of polli- nation made	Total No. of seeds obtained	Seeds per pod poli- nation
M27	100	205	2.05	100	419	4.19	100	381	3.81
B54	100	480	4.80	100	104	1.04	146	880	6.03
T9	100	51	0.51	100	254	2.54	100	335	3.35
I.T.S.A.	109	320	2.93	100	150	1.50	113	302	2.67
Syn .A	77	193	2.50	50	76	1.50	132	828	5.27
Average per pollination			2.55			2.15			4.46
SE ±	0.43								

a behaviour of inbreeding in toria, which is a self incompatible and a highly cross pollinated crop, is perhaps expected. In alfalfa, another self incompatible and a highly cross pollinated crop, it has been reported that inbreeding is injurious to the frequency of fertilization seed development and the total production per plot. It was also observed that a large number (34.4%) of ovules collapse under inbteeding while their collapse is very less (7.1%) under cross pollination (Brink and Cooper, 1938; Cooper and Brink, 1940). The sibmating provides relatively more chances of mating of dissimilar self incompatibility alleles in a population than that of the bud pollination, geitonogamical pollination and thus theoretically, the chances of seed settingcould be better in this form of inbreeding. The mean performance of the progenies obtained under various types of inbreeding with respect to yield per plot and the plant height is given in Table 3. Data could not be recorded with respect to these characters in varieties T_9. ITSA and Syn. A. as some of the replicates were poor in germination and had patchy plant populations and, therefore, the competitive plants for observation could not be obtained for these varieties. The differences between the bud pollination with respect to yield per plant were statistically significant in T_9. Bud pollination reduced the per plot yield by 43.6% than the sibmating and 19.4% than the open pollination. The difference between the various forms of inbreeding with respect to other varieties, however, were statistically not significant. It was generally observed that the relative numerical values were generally higher under sibmating and open pollination as compared to bud pollination. On an average sibmating gave 10.3% and open pollination gave 19.8% better performance than the bud pollination.

TABLE 3. Mean performance for yield per plant (gms) and plant height (cms) of the progenies derived from various systems of inbreeding

Varieties	Characters							
	Yield per plant (gs)				Plant height (cm)			
	Bud pollination	Geitonogemical pollination	Sib mating	Open pollination	Bud pollination	Geitonogamical pollination	Sib mating	Open pollination
M27	7.01	6.17	6.18	7.33	67.8	46.9	61.3	67.8
B54	6.22	6.82	6.00	6.62	59.0	69.9	70.5	73.0
T9	5.36	*	7.70	6.40	55.3	*	70.7	78.9
I.T.S.A.	6.00	*	7.16	7.52	85.8	*	102.5	80.8
Syn. A.	7.16	*	8.01	7.43	80.0	*	93.4	86.8
Average	6.35	—	7.01	7.60	69.58	—	79.68	77.4
SE ±			0.83				10.58	

More or less similar pattern was observed with respect to the character, plant height. Significant different values were observed in variety T_9. Bud pollination reduced the plant height by 42.6% than the open pollination and 27.8% than the sibmating.

From the above observations, it appears that as compared to the various forms of selfing, sibmating gives the better performance of the varieties and it would be better for the maintenance of their performance and vigour. In some of the cases it approaches more or less equal to the values obtained under open pollination.

As a consequence of sibmating the reduction in these attributes may be lesser. Sibmating is a slower form of inbreeding and delays rapid gene fixation. The present study reveals that to maintain relatively high level of perfoımnace and phenotypic expression, inbreeding should be minimum. Maintenance of the cultures by full sibmating, therefore, appears to be desirable. From the practical point of view, in toria, it could be accomplished either by use of honey bee in insect proof cages, or by bagging together 4 to 5 inflorescences or 4 to 5 plants about 6 to 7 times in a culture and gently shaking them 4 to 5 days so that the pollination take place within the bag or by growing individual culture in long distance isolations (400 m) by allowing natural cross pollination. Such a scheme would maintain the vigour and performance of the cultures and would be operationally lot convenient to handle in the maintenance of germplasm in the toria breeding programme.

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CHARACTER ASSOCIATION AND COMPONENT ANALYSIS IN NIGER

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ABSTRACT

Twenty eight genotypes of niger (*Guizotia abyssinica* Cass) representing diverse indigenous meterial were used to study the character association among yield and its components. Genotypic differences were significant for yield and its important components, thereby indicating the possibility of improving yield through varietal selection in the existing collection.

The achenes yield per plant showed significant positive association with number of capitula per plant, number of achenes per capitulum, 1000 achene weight, number of effective nodes per plant and plant height. Inter-correlation among different character pairs showing significant positive association were discussued in light of their magnitude at phenotypic and environmental levels and it was inferred that for achieving higher yield, selection should be practiced in two cycles.

Key words: Niger; association analysis; yield **components.**

INTRODUCTION

Inspite of its ancient culture in India, niger (*Guizotia abyssinica* Cass) remained as an unexploited crop in respect of genetic understanding and improvement. As a result niger cultivation continues to be confined to isolated pockets comprising marginal and sub-marginal lands. The present study was taken up to understand the nature of character association which in turn helps in formulating the selection criterion.

MATERIAL AND METHODS

Twenty eight genotypes of niger representing five geographical groups, viz., Bihar, Orissa, Karnataka, M.P. and Maharastra were evaluated in a RCBD with three replications at Jabalpur during *Kharif*, 1980. Each genotype was grown in the plot size of 2.5 $\times$ 9 m^2, with 30 cm row to row and 15 cm plant to plant distance. Recommended cultural practices were followed to maintain uniform crop. Data on ten randomly selected plants were recorded inrespect of days to maturity, plant height, number of capitula per plant, number of achenes per capitulum, weight of 1000 achenes (g) and yield per plant. Variability parameters were computed following the standard procedures and correlation of coefficient analysis was corried out following the methcd of Miller *et al.* (1958).

RESULTS AND DISCUSSION

Highly significant differences were observed among genotypes for all the characters studied. The source of variation due to genotypes was further partitioned between

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and within groups components. The between group variation was highly significant for yield and its components. Similarly the genotypes within each group also showed significant differences for yield and its principal components, like number of capitula per plant, number of achenes per capitulum and weight of 1000 achenes except the latter from Karnataka group. It clearly revealed that there are possibilities of improving yield through genotypic selection both within and across the states. Bagri (1973) also reported highly significant differences among indigenous varieties of niger for most of the characters except number of achenes per capitulum.

The variability parameters are presented in Table 1. High value of G.C.V. were observed for achenes yield per plant and number of capitulum per plant, indicating the possibilities of improving these characters through selection. Achene yield per plant and number of capitula per plant were coupled with high heritability and high genetic advance susggesting the role of additive gene action in their control. Thus, it may be inferred that these two traits are most reliable for selection. High heritability was associated with low genetic advance for days to maturity, which revealed the non-additive gene action in their expression. The remaining characters *viz.* weight of 1000 achene, number of achenes per capitulum, plant heights, number of effective nodes per plant and number of branches per plant showed medium value of genetic advance associated with high heritability estimates; it suggested some promise for improvement of the traits through selection. The present findings were in conformation to those of Nema (1965) and Nema and Singh (1965).

The genotypic, phenotypic and environmental correlation coefficients of different characters pairs are presented in Table 2. The achene yield per plant showed highest significant positive association with number of capitula per plant followed by number of achenes per capitulum, weight of 1000 achenes, number of effective nodes per plant and plant height. The correlation coefficients among these important yield components, namely the number of capitula per plant, number of achenes per capitulum and weight of 1000 achene were significantly positive. The remaining three characters *viz.*, plant height, number of branches per plant and number of effective nodes per plant relating to the vegetative growth showed significantly positive association among themselves. These results are in agreement with the findings of Kandaswami (1973).

The characters, plant height, number of effective nodes per plant and number of capitula per plant showing significant positive phenotypic correlation with achenes yield per plant. Though the number of capitula per plant had highest positive association with achene yield, higher value of environmental correlation reduces the efficiency of selection. The magnitude of correlation of achene yield with number of achenes per capitulum and weight of 1000 achene was next in order thus, it may be concluded that in the first cycle of selection, emphasis be given for more number of capitula per plant while final selection from there selected types be made on the basis of more number of achenes per capitulum and 1000 achene weight or improving achene yield in niger.

TABLE 1. Genetic parameters of variation for yield and its components in niger

	Genetic Parameters	Days to Maturity	Plant Height	No. of Branches/ Plant	No. of Effective Nodes/ Plant	No. of Capitula/ Pianf	No. of Achenes/ Capitulum	1000 Achenes Weight (g)	Achenes Yield/ Plant (g)
1.	Mean	105.25	46.25	10.23	3.88	40.13	30.93	4.09	5.54
2.	Range								
	Minimum	85.00	34.80	8.52	3.07	27.40	22.16	2.80	3.18
	Maximum	121.00	62.95	13.94	5.40	63.35	48.99	5.33	8.33
3.	P.C.V.	9.23	18.09	14.81	15.21	26.49	19.13	19.09	27.98
4.	G.C.V.	9.19	17.60	14.62	15.04	26.19	18.71	19.05	27.94
5.	Heritability	99.22	94.65	97.45	97.73	97.71	95.69	99.59	99.68
6.	Genetic advance	19.86	16.31	3.22	1.18	21.40	11.66	1.60	3.18
7.	G.A. as % of mean	18.87	35.27	29.74	30.63	53.32	37.71	39.16	57.47

TABLE 2. Genotypic, phenotypic and environmental correlation coefficients of different character pairs in niger

Characters		Plant height	No. of branches/ Plant	No. of effective nodes/Plant	No. of capitula/ Plant	No. of Achenes/ Capitulum	1000 Achenes Weight	Yield/ Plant
Days to maturity	G	0.6058	0.4531*	0.1787	0.2151	–0.1123	0.1932	–0.0128
	P	0.5889**	0.4470	0.1775	0.2132	–0.1086	0.1929	–0.0121
	E	0.0870	0.0992	0.1199	0.1044	–0.0466	0.1570	–0.1334
Plant height	G		0.6919	0.4283	0.6330	0.0770	0.5282	0.3817
	P		0.6907**	0.4160*	0 6328**	0.0766	0.5161**	0.3786*
	E		0.8180	0.6914	0.7447	0.1099	0.2172	0.6054
No. of branches/ plant	G			0.6080	0.5201	0.0920	0.2902	0.3326
	P			0.6052**	0.5200**	0.0903	0.2864	0.3322
	E			0.4862	0.6409	0.1943	0.5340	0.5964
No. of effective nodes/plant	G				0.6163	0.5457	0.3650	0.5537
	P				0.6159**	0.5311**	0.3647	0.5508**
	E				0.5971	0.1055	0.4796	0.5130
No. of capitula/plant	G					0.6030	0.8181	0.8540
	P					0.5897**	0.8086**	0.8478**
	E					0.2085	0.1529	0.5827
No. of achenes/ capitulum	G						0.4377	0.6947
	P						0.4270*	0.6819**
	E						0.0264	0.2950
1000 achenes weight	G							0.6231
	P							0.6217**
	E							0.2283

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GENETIC BEHAVIOUR OF YIELD, YIELD COMPONENTS AND OIL CONTENT IN LINSEED

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ABSTRACT

A 8 × 8 diallel set excluding reciprocals was studied. Both additive and non-additive gene actions for all the characters studied appeared important. However, *predominance of additive gene action for days to maturity*, 1000 seed weight and oil content, and non-additive gene action for days to flowering, plant height, number of tillers per plant, number of branches per plant, number of capsules per plant and yield per plant were apparent. Among parents LC 216 was the best general combiner for yield and oil content along with other four important traits. The crosses R 158 × A 7-1-1 followed by LS × A 7-1-1 and R 158 × Hira for yield per plant and LS 4 × LC 216 for oil content were good specific combiners.

Key words : Linseed; diallel analysis; combining ability.

INTRODUCTION

Linseed being a crop of poverty striken areas needs immediate attention of the breeders for improving the lot of peasantry. The poor productivity of seed and non-usage of straw resulting in low income to the grower is largely attributed to a number of factors like low yielding varieties and susceptible to a number of common diseases. This necessitated to undertake this study for incorporating high yield, high oil content, disease resistance and other economic characters by involving a number of indigenous and exotic biotypes in a diallel crossing programme.

MATERIAL AND METHODS

Eight diverse strains of linseed were used to develop a diallel cross, excluding reciprocals. The parents and F_1s were grown in a randomized complete block design with three replications during *Rabi* 1980 at C.S. Azad University of Agriculture and Technology, Kanpur. Each treatment in each replication was sown in a single row of 3.0 m length spaced 40 cm apart. The plant to plant distance was kept at about 15 cm apart. Ten randomly selected plants were used for recording observations on days to flowering, days to maturity, plant height, number of tillers per plant, number of branches per plant. Number of capsules per plant, 1000 seed weight, yield per plant and oil content. The combining ability analysis was carried out by the procedure suggested by Griffing (1956) method 2 and model 1.

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant variances among genotypes, parents and crosses for all the characters studied. Variances due to parents *vs* hybrids were also highly significant for all the characters except days to maturity and number of tillers per plant.

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TABLE 1. Analysis of variance for combining ability in linseed

Source	d.f.	Mean squares								
		Days to flowering	Days to maturity	Plant height	No. of tillers/ plant	No. of branches/ plant	No. of capsules/ plant	1000 seed weight	Yield/ plant	Oil content
gca	7	42.89**	15.52**	206.44**	6.70**	234.64**	2737.49**	8.42**	13.40**	59.38**
sca	28	12.91**	1.78**	21.93**	1.21**	118.30**	2331.79**	0.45**	13.97**	3.01**
Error	70	0.43	0.80	2.36	0.17	4.39	96.26	0.06	0.06	0.09
Estimated components of variance										
6^2 gca		2.99	1.27	18.45	0.54	11.63	40.57	0.79	@	5.63
6^2 sca		12.48	0.97	19.57	1.03	103.90	2235.53	0.39	13.90	2.92
6^2 gca /6^2 sca		0.24	1.30	0.94	0.52	0.11	0.01	2.03	@@	1.93
6^2 sac/6^2 (gca) 0.5		2.04	0.87	1.03	1.37	2.98	7.42	0.69	@@@	0.72

* Significant at 5 per cent level ** Significant at 1 per cent leve

@ Estimate of variance component was negative

@@ Numerator was negative,

@@@ Denominator was negative.

Highly significant variances for both general and specific combining ability for all the characters (Table 1) indicated the importance of both additive and non-additive gene effects. However, the estimates of components of genetic variances (6^2 gca and 6^2 sca) indicated predominant role of additive gene action alongwith partial dominance for days to maturity, 1000 seed weight and oil content. These results are in conformity with those of Shehata and Comstock (1971) and Patil and Chopde (1981). The higher estimates of 6^2 sca than 6^2 gca for days to flowering, plant height, number of tillers per plant, number of branches per plant, number of capsules per plant and yield per plant reflected the predominance of non-additive gene action in the inheritance of these characters. The estimates of average degree of dominance also indicated over oomccnani for the characters. Singh and Singh (1979) reported similar results for most of the characters.

On the basis of general combining ability effects, parent 5/1 for plant height, 1000 seed weight and yield per plant; DPL 20 for days to maturity and oil content; R 158 for days to flowering, days to maturity, plant height, number of branches per plant and number of capsules per plant; Hira for plant height and 1000 seed weight; LS 4 for days to maturity; number of tillers per plant, number of branches per plant and oil content; A 7-1-1 for days to flowering, number of capsules per plant and yield per plant; FR 4 for days to flowering and number of tillers per plant and LC 216 for number of tillers per plant, number of branches per plant, number of capsules per plant, 1000 seed weight, yield per plant and oil content were good general combiners. A multiple crossing programme or an intermating population involving all possible crosses among these strains subject to biparental mating may be expected to offer the maximum promise in breeding for high seed yield. To facilitate the comparison, three best parents were considered for their gca effects and *perse* performance (Table 2). A perusal of the result revealed that all the three top parents were common for days to flowering, days to to maturity and 1000 seed weight, two for plant height, number of tillers per plant, number of branches per plant, yield per plant and oil content, and one for number of capsules per plant under both the criteria. This suggested that *per se* per formance of parents would provide an indication of their general combining ability for utilizing them in hybridization programme.

Estimates of specific combining ability effects revealed a wide range of variation for all the characters (Table 3). The crosses R 158 × A 7-1-1, LS 4 × A 7-1-1 and R 158 × Hira were superior specific combiners for yield per plant. Besides yield, LS 4 × A 7-1-1 for days to flowering, plant height and number of capsules per plant, R 158 × A 7-1-1 for number of branches and number of capsules per plant and R 158 × Hira for days to flowering and number of branches per plant were also good specific combiner. LS 4 × LC 216 was the best specific combiner for oil content. LS 4 × A 7-1-1 for days to flowering and number of capsules per plant, R 158 × A 7-1-1 for number of capsules and yield per plant, R 158 × Hira for number of branches per plant and LS 4 × LC 216 for oil content were also superior with respect to their *per se* performance.

On the basis of postulated gene action it is suggested that breeding procedure like pedigree method can be used to expoit additive and additive × additive portion of

TABLE 2. Estimates of general combining ability (gca) effects and mean values of parents (in parentheses) in linseed

Parent	Days to flowering	Days to maturity	Plant height	No. of tillers/ plant	No. of branches/plant	No. of capsules/plant	1000 seed weight	Yield/ plant	Oil content
5 / 1	1.87** (64.4)	1.06** (146.4)	7.11** (75.6)	-1.06** (7.67)	-4.52** (54.4)	-12.75** (140.7)	1.71** (13.2)	0.98** (12.4)	-0.72** (39.7)
DPL 20	0.63** (59.5)	-1.25** (139.9)	-2.24** (66.3)	0.38** (9.60)	-4.07** (50.7)	3.69 (214.1)	-0.72** (7.9)	-1.11** (10.1)	0.36** (42.2)
R 158	-1.27** (54.7)	1.24** (139.3)	1.93** (69.1)	0.62** (8.60)	-2.10** (48.7)	28.66** (178.5)	-0.58** (8.0)	-0.43** (7.4)	-0.69** (41.0)
Hira	2.19** (64.7)	0.34 (140.6)	3.47** (73.7)	0.68** (7.27)	2.44** (58.9)	-23.16** (146.7)	0.90** (11.4)	-0.50** (11.4)	0.04 (41.0)
LS 4	-0.14 (61.4)	-1.13** (139.5)	-7.98** (45.5)	0.69** (9.87)	4.44** (69.9)	-1.70 (193.5)	-1.15** (6.8)	-1.33** (8.7)	0.53** (41.8)
A 7-1-1	-0.94** (56.8)	-0.56** (140.1)	0.22 (65.5)	0.35** (7.87)	1.27** (49.5)	8.14** (135.1)	-0.39** (8.8)	0.48** (9.4)	-0.54** (41.5)
FR 4	-4.00** (47.5)	1.85** (143.1)	-3.03** (57.8)	0.78** (5.73)	-5.10** (37.3)	-13.87** (120.9)	0.01 (9.1)	-0.25** (8.5)	-0.45** (44.3)
LC 216	1.68** (65.6)	0.91** (143.4)	0.52 (71.3)	1.18** (11.80)	8.34** (77.0)	10.99** (201.7)	0.22** (10.2)	2.16** (16.7)	1.51** (40.6)
SE (gi) ±	0.19	0.27	0.45	0.12	0.62	2.90	0.08	0.08	0.09
SE (gi-gi) ±	0.29	0.40	0.69	0.19	0.94	4.39	0.11	0.11	0.14

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

TABLE 3. Estimates of specific combining ability (sca) effects in linseed

Crosses		Days to flowering	Days to maturity	Plant height	No. of tillers/plant	No. of branches/plant	No. of capsules/plant	1000 seed weight	Yield /plant	Oil content
5/1	× DPL 20	−1.31*	−2.16**	2.17	−2.71**	−3.09	20.66**	0.23	−0.17	−0.45
	× R 158	−0.81	−0.57	3.80**	1.71**	8.24**	17.47*	0.44**	1.26**	−0.60*
	× Hira	−1.67**	−1.85*	1.26	−0.19	−5.72**	16.29*	−0.22	0.76**	0.91**
	× LS 4	3.36**	−1.58*	10.41**	0.31	8.10**	44.43**	0.44**	3.97**	0.65**
	× A 7–1–1	1.06*	−0.85	0.31	−1.46**	−12.03**	−20.67**	0.02	−1.71**	0.18
	× FR 4	4.82**	1.74*	1.76	0.08	3.12	22.60**	0.76**	3.76**	−0.04
	× L C 216	−1.76**	−0.02	−3.99**	−0.28	−5.10**	−9.86	−0.82**	−0.51*	−0.49*
DPL20	× R 158	6.33**	−0.26	1.85	1.31**	−0.71	−14.47	−0.06	−2.13**	−1.58**
	× *Hira*	−1.63**	0.36	−3.89**	0.01	−3.37*	19.25*	0.01	2.90**	−0.13
	× LS 4	2.10**	0.43	−6.64**	−0.96**	−9.45**	−47.91**	0.01	−2.79**	−0.14
	× A 7–1–1	−0.40	0 56	2.26	0.78*	−10.92**	−17.75*	0.42*	0.84**	−1.13**
	× FR 4	0.76	−0.15	2.21	1.50**	−6.19**	36.96**	0.48*	3.50**	−0.51*
	× LC 216	−3.32**	−0.21	−1.04	−0.02	2.95	14.20	0.62**	1.53**	1.34**
R 158	× Hira	−4.49**	−0.35	5.44**	1.13**	17.96**	33.18**	0.34	4.14**	−1.13**
	× LS 4	1.50**	−0.68	−0.81	−0.08	−4.02*	−34.18**	0.03	−0.34	−1.28**
	× A 7–1–1	3.20**	1.05	0.29	0.93**	26.45**	173.08**	0.42*	10.93**	−0.89**
	× FR 4	−1.04*	1.34	1.84	−1.42**	−13.08**	−33.61**	0.39	−0.61**	−0.16
	× LC 216	−0.52	−0.72	−4.41**	−0.70*	−2.72	−1.71	0.45**	−1.40**	1.33**
Hira	× LS 4	−0.46	1.94**	4.85**	−1.04**	−18.78**	−64.96**	1.64**	−3.62**	0.02

(Table Contd)

TABLE 3. contd.

Crosses	Days to flowering	Days to maturity	Plant height	No. of tillers/plant	No. of branches/plant	No. of capsules/plant	1000 seed weight	Yield/ plant	Oil content
Hira × A 7–1–1	0.44	–0.23	0.15	–1.24**	–3.21**	–14.70	–0.22	–1.71**	0.55**
× FR 4	7.30**	2.76**	–2.70*	0.65	6.46**	14.81	–0.55**	0.233	–3.01**
× LC 216	–1.48**	0.80	–0.15	0.03	0.22	–7.85	0.18	0.85**	1.67**
LS 4 × A 7–1–1	–8.63**	0.44	6.30**	0.99**	8.41**	54.34**	0.11	4.70**	–0.36
× FR 4	–4.77**	–1.37	2.85*	1.42**	16.68**	32.15**	0.17	2.00**	–1.48**
× LC 216	2.55**	0.57	–1.40	–0.06	–1.86	4.39	–0.13	1.28**	2.61**
A 7-1-1-× FR 4	3.93**	0.16	–2.55*	–0.01	–2.15	–20.29*	0.31	–1.24**	–2.47**
× LC 216	2.05**	–0.30	1.60	–0.53	–1.19	–9.65	0.03	–0.42*	1.92**
FR 4 × LC 216	–2.99**	–0.01	7.35**	0.27	8.18**	33.16**	0.59**	2.31**	–2.21**
SE (sij) ±	0.52	0.71	1.21	0.33	1.65	7.74	0.20	0.20	0.24
SE (sij–sik) ±	0.88	1.20	2.06	0.56	2.81	13.16	0.34	0.34	0.41

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

genetic variances in the improvement of characters. The characters showing predominance of non-additive gene action can be improved through recurrent selection programme. Because of tediousness in making sufficient seed by hand emasculation, low rate of natural out crossing and depending on insects for transmitting pollens, such an approach would be rather difficult to employ in linseed crop. In such situation reported cytoplasmic male sterility (Dubey and Singh, 1966; Thompson, 1977) may be helpful in the recurrent selection programme to accumulate favourable genes and facilitate breaking of linkages. Rao and Singh (1984) also advocated the use of recurrent selection for the improvement of yield in linseed. Population improvement procedure as suggested by Redden and Jensen (1974) may be another breeding strategy for the improvement of this crop.

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IDENTIFICATION OF PARENTS FOR HYBRIDIZATION THROUGH COMBINING ABILITY ANALYSIS IN TARAMIRA UNDER RAINFED CONDITIONS

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ABSTRACT

In the present study on 10 × 10 diallel cross (excluding reciprocals) of taramira (*Eruca sativa* (L.)) both GCA and SCA variances were significant for all the traits except siliqua length and 1000 seed weight. GCA/SCA ratio however indicated the preponderance of non-additive genetic variace for all the traits excepting number of primary branches/plant, seeds/siliqua and seed yield/plant in which additive variance was high. Parents Ldh. Comp.-1 (for seed yield, main shoot length and number of siliquae on main shoot), TMC-13 (for primary and secondary branches/ plant) and RTM-2 (for siliqua length) were the best general combiners. The best specific combinations for seed yield and other important components like primary and secondary branches per plant, siliqua length and seeds/siliqua were T-27 × TMC-13 and RTM-2 × Ldh. Comp-1.

Key words: Combining ability; Taramira; *Eruca sativa* L.

INTRODUCTION

Taramira (*Eruca sativa* L.) is an important oilseed crop adapted to rainfed, waste and marginal lands and late sown conditions. Selection of parents for successful hybridization programme is of prime importance to enhance the yield potential of a crop. Breeders, therefore, need information on the nature and extent of gene action controlling the traits of economic importance. This study was, therefore, undertaken to determine the gene action and combining ability for yield and yield components in taramira under rainfed conditions.

MATERIAL AND METHODS

Ten inbreds viz., TMC-25, TMC-74, TMC-82, TMC-84, TMC-86, TMC-13, TMC-50, T-27, RTM-2 and Ludhiana Comp.-1 of taramira representing morphological variability and geographical diversity were crossed in all possible combinations exluding reciprocals. The 45 F_1's and their 10 parents were grown in a RBD with 3 replications during the winter of 1982-83. Each treatment was represented by 5 m long single row spaced 30 cm apart. The plants were spaced 15 cm within the row. Ten competetive plants from each row were used to record observations on plant height (cm), main shoot length (cm), number of primary and secondary branches/plant, number of siliquae on main shoot, siliqua length (cm), number of seeds/siliqua, 1000 seed weight (g) and seed yield/plant (g). Combining ability analysis was done following Griffing (1956) Model-1, Method-2.

RESULTS AND DISCUSSION

Mean squares due to general and specific combining ability (GCA and SCA) were

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significant for all the traits except plant height (GCA only), siliqua length and 1000 sede weight, indicating involvement of both additive and non-additive type of gene actions in the inheritance of these traits. Higher proportion of SCA component and GCA: SCA ratio was observed lower than 1 for plant height, main shoot length, number of secondary branches/plant and number of siliquae on main shoot (Table 1). This indicated the role of non-additive gene action in the expression of these traits. Results reported by Lal and Singh (1979) in Indian mustard and Rishi Pal and Singh (1980) in rapeseed agree with the results that non-additive type of gene actions were involved in the inheritance of plant height and number of secondary branches/plant. Additive type of gene action was important in the inheritance of number of primary branches/plant., number of seed/siliqua and seed yield/plant.

General Combining Ability

The GCA effects of parents for different traits are given in Table 2. Parent TMC-13 was the best general combiner for number of primary and secondary branches/plant, however, none of the parents showed significant GCA effects for plant height. For siliqua length, RTM-2 was the best general combiner whereas TMC-84 and TMC-86 gave the highest and significant positive GCA effects for number of seeds/siliqua and 1000 seed weight, respectively. Out of four parents which gave significant positive GCA for seed yield, Ludhiana Comp-1 and T-27 were found to be the best general combiners. The former was also a best general combiner for main shoot length and number of siliquae on main shoot. There was no close agreement between the mean performance and the general combining ability, yet Ludhianna Comp - 1 alongwith the highest combining ability for seed yield, main shoot length and number of siliquae on main shoot also had maximum mean performance for these traits.

Specific Combining Ability

Out of 15 cross combinations exhibiting significant positive SCA effects for seed yield, T-27 × TMC-13 followed by RTM-2 × Ludhiana Comp. 1, TMC-82 × TMC-52, RMC-84 × TMC-25 and TMC-13×TMC-25 gave maximum SCA effects (Table 3). The first cross also had significant positive SCA effects for main shoot length, number of primary and secondary branches/plant, siliqua length and number of seeds/siliqua whereas the second cross had significant SCA effects for all the traits except main shoot length and 1000 seed weight. Estimates of SCA effects were highest for plant height (Ludhiana Comp-1 × TMC-25) for main shoot length (TMC-84 × TMC-25) for primary branches and seeds/siliqua (TMC-13 × TMC-25) for secondary branches (TMC-82 × T-27) for siliqua length (RTM-2 × Ludhiana Comp.-1) for 1000 seed weight (TMC-74 × TMC-84). This reflected marked contribution of non-additive genes in the expression of these traits.

The cross T-27×TMC-13 with highest SCA effects for seed yield involved both the parents with high GCA effects whereas RTM-2×Ldh. Comp.-1 involved only one parent with high GCA effect. The crosses with high SCA effect for seed yield like TMC-82×RTM-2 and TMC-84×TMC-25 involved both the parents with no GCA effects.

TABLE 1. Mean squares for general and specific combining ability for nine quantitative traits in taramira

Source	d.f.	Plant height	Main shoot length	No. of primary branches/plant	No. of secondary branches/plant	No. of siliquae on main shoot	Siliquae length	No. of seeds/siliquae	1000 seed weight	Seed yield/plant
GCA	9	4.32	41.25**	13.75**	38.26**	30.13**	0.37	32.14**	0.10	23.07**
SCA	45	20.38**	49.25**	13.36**	58.79**	47.40**	0.23	30.39**	0.11	19.46**
Error	108	6.13	10.37	2.08	9.73	3.23	0.02	3.64	0.02	1.74
GCA/SCA	—	0.21	0.84	1.03	0.65	0.64	1.64	1.66	0.96	1.19

**P ≈ 0.01

TABLE 3. Specific combining ability effects for nine quantitative traits in tramira

Cross	Plant height	Main shoot length	No. of primary branches/ plant	No. of secondary branches/ plants	No. of siliquae on main shoot	Siliqua length	No. of seeds/ siliqua	1000-seed weight	Seed/ yield plant
1 × 2	-4.83**	0.74	2.09	-24.35**	-7.70**	-0.15	-7.59**	-0.28*	-2.68*
1 × 3	1.39	-4.27	3.90*	2.14	2.04	0.07	4.29*	.071**	4.70**
1 × 4	2.95	2.72**	-0.36	-2.51	-1.03	0.00	3.71*	-0.16	0.36
1 × 5	0.85	6.67*	1.64	2.43	1.42	0.18	0.79	-0.30*	1.18
1 × 6	0.83	7.66**	0.83	-5.89*	3.98*	0.66**	3.50*	0.22	-2.48*
1 × 7	1.13	1.65	2.22	0.64	4.73**	0.03	3.34	-0.01	4.18*
1 × 8	1.46	1.05	-1.62	-3.14	3.46*	0.00	-2.92	0.40**	1.94
1 × 9	0.87	1.73	-0.12	2.33	0.77	-0.17	0.00	0.29*	1.82
1 × 10	2.46	-4.69	-2.00	-3.65	2.76	-0.03	1.17	-0.01	-0.02
2 × 3	2.10	4.42	-0.37	-4.48	3.91*	0.04	5.04**	0.32**	1.08
2 × 4	3.74*	3.30	2.40	-3.36	5.47**	-0.02	8.88**	0.22	2.10
2 × 5	1.73	-3.81	2.28	-3.03	-1.35	0.13	-2.79	-0.34**	-1.78
2 × 6	-1.25	9.38**	-0.25	-2.32	4.83**	1.10	5.59**	0.29*	2.82*
2 × 7	1.35	2.01	2.48	0.42	2.66	-0.07	3.19	0.27*	3.64**
2 × 8	5.10*	11.35**	-0.28	-5.05	4.89**	0.12	4.82**	0.26*	4.54**
2 × 9	-0.45	5.35	-1.16	-2.42	0.01	0.12	-1.30	-0.02	-1.44
2 × 10	-1.49	-4.40	-0.99	15.89**	-5.61**	-0.38**	-3.17	0.55**	1.92
3 × 4	-1.62	0.03	1.71	4.10	2.89	0.24	1.31	0.05	1.15
3 × 5	1.84	1.27	-0.39	-2.73	0.08	0.00	1.44	0.62**	-1.76
3 × 6	-3.27	-5.83*	-1.46	7.24*	-4.09*	-0.93**	-1.40	-0.30*	-1.29
3 × 7	-0.41	-5.23	0.19	2.05	-3.20	0.36**	7.61**	-0.60**	1.47
3 × 8	-0.92	0.43	1.58	1.65	-5.40**	0.34*	8.12**	-0.75**	0.49
3 × 9	1.58	-9.22**	-3.84*	1.94**	-5.27**	0.61*	-9.48**	-0.64**	1.76
3 × 10	4.19*	10.67**	1.95	-0.64	2.50	-0.28*	-2.66	0.19	5.23*
4 × 5	1.10	1.21	1.23	14.00**	21.15**	0.30*	-2.66	0.01	0.28
4 × 6	4.82*	-4.87	1.41	6.76**	-4.67**	-0.45**	-6.07**	-0.23	5.50**
4 × 7	0.06	2.84	-1.02	1.90	-6.04**	-0.15	-0.30	0.01	2.04
4 × 8	3.93*	-12.38	2.30	3.87	-4.93**	0.46**	-4.26*	-0.04	3.22**
4 × 9	-0.26	2.02	-0.31	-2.87	-2.52	0.12	2.25	-0.28*	2.71*
4 × 10	1.84	-13.72**	-1.54	-10.50*	-6.66**	0.00	-5.24**	0.38**	-4.15**

TABLE 2. Contd.

5 × 6	3.62**	0.99	-2.10	3.52	-4.99**	-1.01	0.82	0.20	3.47**
5 × 7	1.89	-6.39*	-1.71	-6.27*	-1.74	-0.01	-0.12	0.06	2.18
5 × 8	-0.66	2.88	-0.72	-2.03	5.21**	-0.03	3.94*	0.15	2.80**
5 × 9	1.55	9.51**	6.99**	6.55*	0.28	0.61**	8.30**	-0.16	7.72**
5 × 10	3.82*	0.37	3.45*	0.68	-2.22	0.05	2.35	0.07	1.10
6 × 7	4.53*	4.40	7.32**	5.88*	20.78**	1.04**	4.19*	0.22	7.49**
6 × 8	-0.67	-7.45*	0.66	2.37	-2.37	-3.37*	-0.93**	-8.34**	-1.83
6 × 9	3.80*	-12.32**	6.03**	3.14	-2.57	-0.22	-0.63	-0.01	-0.01
6 × 10	2.36	5.58	0.13	7.02*	0.45	-0.21	6.53**	-0.13	3.60**
7 × 8	3.50	-8.27**	1.57	2.89	-8.95**	0.36**	3.42	0.03	1.06
7 × 9	-3.02	1.22	-1.33	6.10*	-2.85	-0.20*	-2.93	0.09	-3.55**
7 × 10	6.01*	5.26	-2.45	-0.12	3.48*	0.31*	-7.26**	-0.05	-1.10
8 × 9	3.77*	7.92**	0.67	8.88**	11.39**	0.41**	2.28	0.19	0.14
9 × 10	0.44	9.09**	5.02**	6.97*	6.43**	0.14	3.25	-0.23	0.97
9 × 10	6.20	-0.04	8.82**	0.85	11.89**	0.36**	13.49	0.59**	5.17**
SE (sij) ±	2.28	2.96	1.32	2.87	1.65	0.14	1.75	0.13	1.21
SE (sij) (sik) ±	3.55	4.36	1.95	4.22	2.43	0.20	2.58	0.20	1.78

1, TMC—74; 2, TC—86; 3, TMC—84; 4, TMC—83; 5, T—27; 6, RTM—2; 7, Ludh. Comp; 8, TC—50; 9, TV—13; 10, TMC—25.

GCA of parents, therefore, did not necessarily reflect the SCA in cross-combinations. Usually the higher SCA effects were obtained from crosses which involved diverse parents.

Two crosses for seed yield and primary branches/plant with highest SCA effects, which involved both the parents with additive components, might throw desirable and fixable segregants, confirming findings of Paul *et al.* (1976) in mustard.

Maximum genetic improvement for primary and secondary branches, main shoot length, number of siliquae on main shoot, seed yield and siliqua length is expected to be attained by growing best general combiners viz., TMC-13, Ldh. Comp-1 and RTM-2 in isolation to allow inter se mating for the development of synthetics.

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EFFECT OF WATER STRESS ON PARTITIONING OF DRY MATTER AND CROP GROWTH RATE IN RELATION TO PRODUCTIVITY IN GROUNDNUT CULTIVARS

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ABSTRACT

An attempt has been made to assess the partitioning of dry matter and Crop Growth Rate (CGR) of five high yielding groundnut cultivars under stress and stress free environments. The crop growth rate of the groundnut cultivars n relation to total dry matter and pod yield was considered along with dry matter partitioning under stress and stress free environments. The results showed that the Crop Growth Rate was maximum under stress free environments as against under stress environments. CGR reaches highest between 45 and 60 days and declines thereafter till harvest. Leaf and stem dry weights reached maximum between 60 and 75 days. The decrease in the dry weight of leaf and stem is reflected in pod weight which showed a steady increase from 60th day onwards till harvest. Root dry weight increased upto 45 days. A rapid decrease in CGR is observed between 60 and 75 days after sowing. Under both the environments CGR upto 60 DAS exhibited a high positive association with total dry matter production (TDMP) and pod yield. However, highly significant association has been observed between CGR and TDMP and pod yield at 30 45 DAS under both the conditions. A negative association was exhibited between these components after 75 days of crop growth.

Key words : Crop growth rate; dry matter production; pod yield stress and stress free environments.

INTRODUCTION

The Crop Growth Rate (CGR) in general is dependent on the amount and intensity of energy intercepted and the photosynthetic efficiency of the leaf or crop canopy. The major plant determinant of photosynthetic potential is the development and maintenance of photosynthetically active leaf area. The leaf area developed is the product of the leaf initiation rate and the size of the individual leaflets. These processes are influenced by both genetic and environmental factors. Temperature and water stress play a major role in the leaf area development. Williams (1975) reported that the differences in crop responses to temperature in a given genotype are relatively large compared to small differences in crop growth rate in non-stressed circumstances. Duncan *et al.* (1978) has observed that potential growth rates were showr to be fairly constant whereas the yield differences between high yielding cultivars were attributeo largely to differences in partitioning and duration. Stresses may operate to modify growth and development in two direction depending on time, type and severity of the stresses. Stresses which are known to influence development are generaly traced to water and diseases. Early water stress generally suspends development of the crop.

MATERIAL AND METHODS

The experiments were carried out during 1984-85 at Regional Research Station, Vridhachalam. The object of the investigations was primarily directed towards

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the study of partitioning of dry matter under stress and non-stress environments in high yielding groundnut cultivars, (*Arachis hypogaea* L.) in relation to pod yield. For stress environments only two irrigations were given for the whole crop period. The cultivars chosen, varied in yield but had a duration of 105-110 days. In the present study, an attempt has been made to make a comparative evaluation of five cultivars of groundnut classified as high yielders viz; Co 1, TMV 2, TMV 7, TMV 9 and TMV 12 under stress (Irrigation withheld after life irrigation) and stress free (Irrigation were given as and when the crop exhibits wilting symptoms) environments during *Kharif* 1984. The experiment was conducted in Factorial Randomised Block Design with four replications. Plant samples were taken at five stages of crop growth namely peak flowering, peg formation, pod formation, pod maturity and harvest corresponding to 30th 45th, 60th 75th and 96th day after sowing when partitioning of assimilates are effective. A total of 40 plants per cultivar (10 from each replication) was taken for sample. The plants were pooled and seperated into root, stem, leaf and pods and oven dried. These independent parts were weighed and crop growth rate was estimated by using the formula of Watson (1958). Pod yield was recorded at harvest for both stress and stress free environments. Correlation coefficients were determined using the methods enunciated by Snedecor and Cochran (1967).

RESULTS

In a comparative assessment of the cultivars, tested, the quantitative values based on the quantitative status of assimilate and partitioning of the assimilates from the plant to the seed is of significance in the present study. In the Tables 1 and 2, the dry matter partitioning between vegetative and reproductive parts and the crop growth rate during stress and stress free conditions have been given.

Dry matter partitioning

It is clear that the yield is strongly influenced by that proportion of the total growth which is used for reproductive purposes. The leaf dry matter reached maximum on 75th day and decreased towards harvest in all the cultivars under stress and stress freed environments. The stem dry matter reached maximum on the 60th day and decreased towards harvest. The decrease in the dry weight of leaf and stem reflected in steady increase in pod dry weight. The root dry matter shewed increase in weight upto 45 days with subsequent decrease towards harvest. The dry matter production of vegetative as well as reproductive parts were lower under stress as against stress free conditions. It was also observed that the rate of assimilate partitioning from vegetative parts to reproductive parts ranged from 31 to 35 per cent. The partitioning rates were higher in Co 1 and TMV 7 irrespective of the treatments. (Fig. 1). Irrespective of the treatments or varieties the dry matter production of plant components showed a significant sequential improvement from 30 DAS to 75 DAS. It was also evident that both the varieties and treatments showed a significant variation between them in respect of leaf, stress and root and pod biomass production. The drymatter partitioning was significantly superior in stress free environment than the stress environment Among

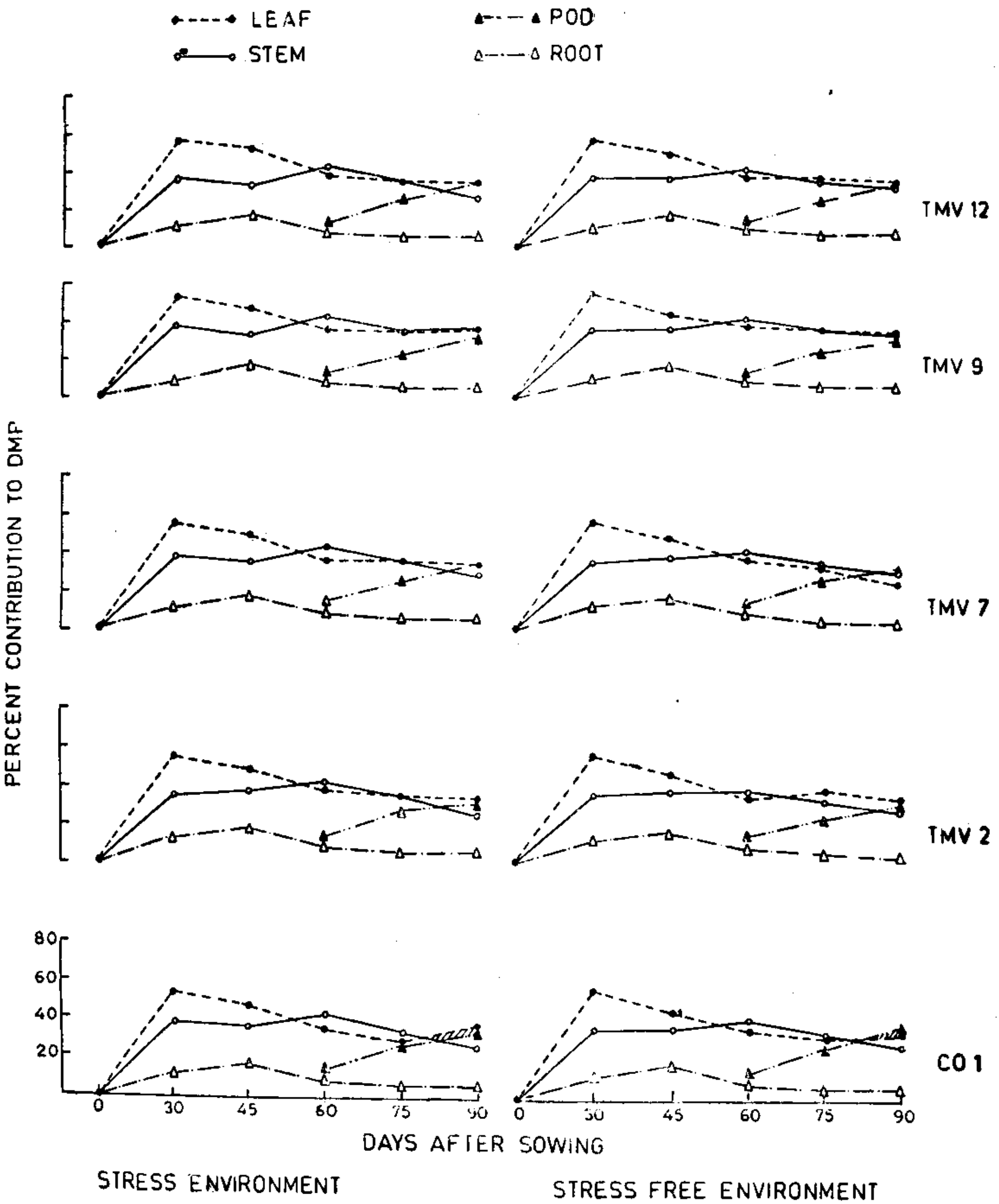

Fig. 1. Contribution to dry matter production under stress and stress free enviornments.

TABLE 1. Dry matter partitioning (g.plant^{-1}) in groundnut

Culti vars	30					45					Stress	
	Stem	Leaf	Root	Pods	Total	Stem	Leaf	Root	Pods	Total	Stem	Leaf
Co 1	1.210	1.720	0.360	—	3.290	3.840	5.050	1.700	—	10.590	7.050	6.210
TMV 2	1.150	1.750	0.350	—	3.250	3.550	4.860	1.520	—	9.009	6.100	5.930
TMV 7	1.170	1.680	0.370	—	3.220	3.690	5.020	1.710	—	10.420	6.990	5.980
TMV 9	1.100	1.510	0.290	—	2.900	2.980	4.340	1.480	—	8.800	5.970	5.220
TMV 12	1.120	1.330	0.300	—	3.150	3.050	4.740	1.370	—	9.160	6.000	5.460
											Stress free	
Co 1	1.250	1.880	0.350	—	3.480	4.170	5.110	1.980	—	11.260	7.250	6.500
TMV 2	1.170	1.710	0.340	—	3.220	3.900	4.870	1.610	—	10.380	6.110	6.020
TMV 7	1.150	1.850	0.350	—	3.350	3.980	5.240	1.840	—	11.060	7.100	6.480
TMV 9	1.120	1.660	0.300	—	3.080	3.540	4.600	1.610	—	9.750	6.540	5.960
TMV 12	1.140	1.720	0.310	—	3.170	3.610	4.830	1.530	—	9.970	6.340	5.980

Leaves : Varieties : SE : 0.2208
CD (P=0.05) : 0.6618
Treatments: SE : 0.1396
CD (P=0.05) : 0.4186

TABLE 2. Growth rate (g^{-2} day^{-1}) of groundnut cultivars under stress and tress free rop environments

Cultivars	Stress environment			Stress free environment			
	30–45	45–60	60–75	30–45	45–60	60–75	76–96
Co 1	14.84	13.58	5.89	15.82	13.64	5.43	0.89
TMV 2	13.52	11.04	5.96	14.55	11.32	3.46	1.68
TMV 7	14.63	13.11	4.90	15.67	13.60	4.55	1.10
TMV 9	11.99	11.34	5.06	13.55	12.24	2.99	1.71
TMV 12	12.22	10.89	5.00	13.82	11.75	3.50	1.42

cultivars under stress and stress free environments

environment

60					75					96		
Root	Pods	Total	Stem	Leaf	Root	Pods	Total	Stem	Leaf	Root	Pods	Total
1.510	2.500	17.270	6.880	6.870	1.010	5.410	20.170	5.170	4.690	0.920	6.990	19.950
1.280	2.020	15.330	5.960	6.660	0.970	4.670	18.260	4.380	4.540	0.880	5.870	17.790
1.500	2.400	16.870	6.600	6.740	0.990	4.890	19.280	5.050	4.480	0.900	6.860	19.550
1.190	2.000	14.380	5.720	5.910	0.870	4.380	16.870	4.440	4.010	0.810	5.740	16.900
1.110	1.950	14.520	5.840	5.940	0.960	4.240	16.980	4.320	5.000	0.830	5.710	16.800
environment												
1.600	2.620	19.970	6.990	6.910	1.430	5.310	20.640	6.210	4.870	1.030	7.100	21.250
1.420	2.400	15.950	5.750	6.810	1.050	4.040	17.650	5.380	4.010	0.940	5.680	18.810
1.590	2.580	17.750	6.830	6.890	1.390	4.880	19.990	5.980	4.860	0.990	6.890	20.750
1.380	1.890	15.770	6.240	6.130	1.000	3.870	17.740	5.890	4.040	0.960	5.440	18.420
1.410	2.020	15.750	6.100	6.280	1.070	4.020	17.470	5.570	5.090	0.880	5.720	18.450

Stem : Varieties : SE : 0.0269
CD(P=0.05) : 0.08066

Treatments : SE : 0.01702
CD(P=0.05) : 0.05101

PODS : Varieties : : 0.1568
CD(P=0.05) : 0.47007
Treatments : NS

Roots: Varieties : SE : 0.1871
CD (P=0.05) : 0.0508

Treatments : SE : 0.01183
CD(P=0.05 : 0.03547

the varieties, Co 1 recorded higher leaf, stems and root dry matter distribution over other varieties both under stress free and stress environments (Table 1).

Crop Growth Rate

CGR was high under stress free condition. The CGR was maximum between 30-45 days sowingN Among the cultivars, CO 1 registered a maximum CGR of 15.82 $g.^{-2}$ day^{-1} and 14.84 under stress free and stress conditions and 14.63 g^{-2} day^{-1} under stress conditions in TMV 7 (Table 2). This shows that cultivars possess considerable differences in their crop growth rate as well as yield. Results *per se* lend an indication that a high significant association has been observed between CGR and total dry matter production and pod yield. The crop growth rate from 30 to 60 days after sowing contributed positively to TDMP and pod yield. The correlation coefficient among the characters indicated high significant and positive association among these attributes at 30 to 60 days of crop growth under both the environments.

Pod yield

The pod yield was high under stress free condition. The differences in pod yield between cultivars and between treatments were highly significant. Under stress free condition, the cultivar Co 1 recorded high pod yield (Table 3).

TABLE 3. Pod yield of groundnut cultivars (g^{-2}) under stress and stress free environments

Cultivar	Stress environment	Stress free environment
	Mean pod yield	Mean pod yield
Co 1	102.50	122.75
TMV 2	91.75	102.75
TMV 7	99.25	119.25
TMV 9	88.25	93.25
TMV 12	89.25	102.00

Cultivar : SED : 4.96 Treatments : SED : 3-14

CD ($P=0.05$) : 10.18** CD ($P=0.05$) : 6.44**

C × T : NS

** Highly significant

RANKING

Cultivars : CO1, TMV 7, TMV 2, TMV 12. TMV 9

Treatments : Stress free environment, stress environment

The study indicated that the crop growth rate between 30 to 45 days after sowing could decide the production potential of groundnut cultivars. This was obvious from the fact that the cultivars which had high rates of crop growth did appear to be high yielders. The reasons advanced for this phenomenon are two fold viz: (1) the developmental stage at which the crop growth rate is measured (ii) the crop growth rate may vary due to change in the environment. It had been brought out by Williams and Nageswara Rao (1983) that the reproductive efficiency is influenced by the supply of carbohydrate. Aslo the proportion of growth available for reproductive growth can be influenced by the reporoductive sink. Duncan *et al.* (1973) observed that the proportion of total growth which was used for pod growth was constant for a variety and that varietal yield differences were due to differences in this partition factor rather than differences in total growth. In the present study a highly significant association has been observed between CGR and TDMP and pod yield between 30 and 45 days after sowing under both the environments viz., (r. 0.9597; $P < 0.05$ (Pod yield); 0.9929; $P < 0.05$ (TDMP) under stress and r. 0.9717; $P < 0.05$ (Pod yield); 0.9979 $P < 0.05$ (TDMP) in stress free environment (Table 4).

TABLE 4. Correlation coefficients between Crop Growth Rate (CGR) at different growth stages and pod yield and total dry matter yield under stress and stress free environments

CGR• at		Stress environment		Stress free environment	
		Pod yield	Total dry matter production	Pod yield	Total dry matter production
30–45	DAS (Flowering)	0.9597**	0.9929**	0.9717**	0.9979**
45–60	DAS (Pod formation)	0.9595**	0.9427**	0.8213**	0.9314**
60–70	DAS (Physiological maturity)	0.2941	0.5177*	0.9713**	0.9884**
75–96	DAS (Harvest)	—	—	–0.9489**	–0.9273**

** Highly significant (P=0.05)

High dry matter production is one of the pre-requisites for greater produtivityc of the crop plants. In addition developmental factors affecting the accumulation of dry matter and subsequent partitioning of assimilates are of great importance in determining the final yield in crops (Watson, 1971; Wareing and Patrick, 1975). Further it was observed by Srinivasan *et al.* (1984) that the leaf photosynthetic rate at the early pod development phase *versus* total dry matter could be considered as a critical developmental phase for assimilate synthesis, accumulation and subsequent translocation to the pods. Presumably, high dry matter at this growth phase gets diverted in a large measure to developing pods and thus contributing to increased yield potential of the plant. The reason for the greater diversion of photosynthetics at this phase is mainly due to the increased sink strength reflected through its larger demand for assimilates (Neales: and Incoll, 1968; Wareing and Patrici, 1975).

Summarising the results the study indicated that the crop growth rate by itself did not lend any advantage to the crop for increasing its productivity. However, the high crop growth rate between 30 and 45 days after sowing and the effective partitioning to reproductive sink could increase the pod yield in groundnut cultivars. These parameters being inter dependent on each other appear to act complementarily and the resultant high yield might be the outcome of increased translocation of photosynthetics in response to the greater sink demands.

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GENETIC AND MORPHOLOGICAL VARIABILITY FOR QUANTITATIVE CHARACTERS IN SUNFLOWER

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ABSTRACT

A study of thrity exotic collections of sunflower (*Helianthus annuus* L.) over three seasons, *Kharif*, *rabi* and spring, for 14 different quantitative characters revealed considerable amount of variability for all the characters except for seedling dry matter weight in *kharif*. Variations at genotypic level were also quite high for most of the traits indicating sufficient scope for selection. The spring grown crop was observed to have the highest variability for most of the characters including head diameter and seed yield. The heritability was high for days to heading, days to flowering, number of leaves, plant height at flowering and maturity, oil content and protein content in all the seasons, while for other characters heritability varied with the season. The genetic advance was consistently high for seed yield in all the three seasons. In general, the characters with higher genetic advance exhibited higher genetic variability suggesting the possibility of crop improvement through effective selection pressure.

Key words : Sunflower variability; heritability; genetic advance.

INTRODUCTION

A knowledge of variability in yield and other important traits is essential for crop improvement. In sunflower most of the studies (Oka and Campos, 1974; Fick, 1975; Singh *et al.* 1977) are restricted to a particular environment. Studies based on several environments (seasons) would be more meaningful in making effective selections and also provide information regarding the genetic advance expected from selection. A study was, therefore, undertaken to find out the extent of variability among 14 quantitative characters in 30 exotic sunflower cultivars grown over three seasons.

MATERIAL AND METHODS

Thirty exotic collections of sunflower were multiplied during *rabi*, 1975 througq sib-mating and trials were laid out in three different seasons, *kharif* (1976), *rabi* (1976-77) and spring (1977). In each season these collections were grown in a randomised block design with three replications. There were 4 rows of 3 m length in a plot, having row to row distance of 60 cm and plant to plant distance of 30 cm. From each plot 10 plants were randomly chosen to record 14 characters such as seedling height, seedling fresh and matter weight, days to heading and flowering, number of leaves, plant height both at flowering and maturity, stem diameter, head diameter, seed yield, 1000 seed weight, oil and protein content. The seedling characters were recorded after 30 days of sowing. Oil content was estimated by the Pulsed Nuclear Magnetic Resonance Spectrometer (NMR) technique (Tiwari *et al.*, 1974) and protein content was determined on the dehulled and defatted seeds with the help of Technicon Auto-analyser.

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The phenotypic and genotypic coefficients of variation were calculated according to Burton (1952). Heritability and expected genetic advance were estimated according to Hanson *et al.* (1956) and Johnson *et al.* (1955), respectively.

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the cultivars for all the characters except for seedling drymatter weight in *kharif* (Table 1) which indicated the presence of considerable amount of diversity in the material selected for the study. Ten characters, seedling height, seedling fresh and dry matter weight, number of leaves, plant height at flowering and maturity, stem and head diameter, seed yield and oil content showed maximum range of variation in spring, while only three characters, days to heading, days to flowering and protein content, exhibited highest range of variation in *rabi*. The remaining one character, 1000 seed weight indicated highest degree of variation in *kharif*. Considering the individual performance of genotypes, EC 42462 was earliest in flowering in *kharif*. EC 97409 took maximum days to flower in *rabi*. EC 98349A possessed maximum number of leaves as well as plant height at flowering and maturity in spring. In *kharif* season, EC 113790 was found to have shortest plant height both at flowering and maturity. The head diameter was maximum in *rabi* in case of EC 1037B. EC 98307 gave maximum seed yield in spring, while 1000 seed weight was maximum in IS 360 in *rabi* crop. Percent oil content was maximum in IS 356 in spring and protein content was highest in EC 97919 in *kharif*. The overall mean values indicated that kharif crop was earliest in flowering followed by spring and *rabi*. *Kharif* crop also produced shorter plants than *rabi* and spring. However, spring crop was best for higher number of leaves and seed yield as compared to the other seasons. Both head size and stem thickness attained maximum mean values in *rabi* season. Only oil and protein content were the two characters where very little variation in mean performance over seasons was noticed. Thus it was observed that, in general, variations were not only large among the collections in each season but also within collection between seasons. The estimates of both phenotypic and genotypic coefficient of variation were high for six characters in spring, for 5 characters in *rabi* and for two characters in *kharif* (Table 2). For seed yield phenotypic coefficient of variation was larger in spring, while the genotypic coefficient of variation was highest in *kharif*. This suggested that for making selection for any of these characters choice of season for raising of crop should also be taken into account.

The estimates of heritability in broad sense and genetic advance are presented in Table 3. Comparatively high estimates of heritability were recorded for 7 characters in *rabi* and for 5 characters in spring. Remaining two characters, head diameter and seed yield showed maximum heritability during *kharif* season. Values of heritability were quite consistent from season to season for seedling height, seedling fresh weight, plant height at flowering and maturity, oil and protein content. For rest of the characters heritability varied frequently with seasons. High estimates of heritability have also been found for oil and protein content by Fick (1975) and for days to heading and flowering, number of leaves, plant height at flowering and maturity by Oka and Campos (1974) which confirmed the findings reported here. The results on genetic advance

TABLE 1. Range,mean and variance ratio for 14 characters in sunflower

		Seedling height (cm)	Seed ling weight (g)	Seedling dry metter weight(g)	Days to heading	Days to flowering	Number of leaves	Plant heigt at flowering (cm)	Plant height at maturity (cm)	Stem diameter (mm)	Head diameter (cm)	Seed yield (g)	1000-seed weight (g)	Oil content (%)	Protein content (%)
Range	K	17.7+ 37.5	28.6+ 113.1	2.8+ 9.0	36.7+ 48.5	53.3+ 67.9	17.9+ 28.8	80.9+ 166.7	86.2+ 172.1	10.9+ 18.1	10.0+ 17.4	9.2+ 51.3	27.1+ 95.3	27.2 42.2	52.4 76.7
	R	12.3+ 24.8	20.3+ 36.8	1.9+ 3.5	65.0+ 95.0	93.5+ 127.7	28.6+ 46.3	110.3+ 236.8	123.4+ 244.1	21.5+ 28.3	23.9+ 29.7	29.9+ 74.9	68.2+ 120.8	25.9+ 42.7	50.0+ 75.4
	S	16.5+ 38.8	59.1+ 196.4	5.2+ 16.3	43.5+ 60.2	62.3+ 84.4	29.3+ 56.3	140.5+ 269.4	158.1+ 280.1	18.9+ 29.8	16.3+ 24.1	14.6+ 89.9	49.5+ 107.9	22.2+ 47.8	45.5+ 59.2
Mean	K	29.3	66.3	5.9	43.3	59.1	22.0	129.9	138.4	16.1	15.6	35.9	62.2	35.2	63.9
	R	20.5	29.7	2.9	79.6	110.6	35.3	157.3	168.4	25.1	26.7	50.9	95.5	34.5	60.9
	S	24.0	97.3	8.7	51.3	71.9	39.0	194.5	206.7	24.1	21.0	60.0	35.2	70.2	51.9
Variance ratio	K	3.79**	2.25**	1.47	5.60**	7.64**	6.83**	9.92**	12.14**	3.27**	7.11**	8.04**	6.51**	22.01**	33.84**
	R	4.10**	2.15**	2.16**	16.42**	13.17**	14.19**	24.15**	25.08**	2.17**	2.29**	3.82**	2.50**	24.90**	72.37**
	S	3.95**	2.50**	2.44**	6.67**	9.58**	10.93**	11.55**	11.66**	6.89**	3.01**	4.67**	5.36**	59.30**	16.31**

+ Estimated from dehulled and defated seed; ** indicate significant at P=0.01.

K=*kharif*, R=*rabi* and S=spring.

TABLE 2. Phenotypic variance, genotypic variance, phenotypic coefficient of variation and genotypic coefficient of variation for 14 characters in sunflower

Character		Seedling height	Seedling fresh weight	Seedling dry-matter weight	Days to heading	Days to flowering	Number of leaves	Plant height at flwoering	Plant height at maturity	Stem diameter	Head diameter	Seed yield	1000 seed weight	Oil content	Protein content
Phenotypic variance	K	32.0	893.0	4.9	11.6	17.6	9.7	395.7	324.3	3.1	3.5	117.6	164.9	20.9	32.7
	R	9.6	37.6	0.3	87.1	102.3	26.2	1127.5	1137.3	6.4	4.6	192.8	217.7	25.6	60.1
	S	36.7	1747.2	11.8	28.6	39.2	63.8	1369.1	1194.8	11.3	5.5	398.9	193.1	38.2	13.2
Genotypic variance	K	15.4	262.6	0.7	7.0	12.1	6.4	295.3	255.5	1.3	2.4	82.4	106.8	18.3	29.9
	R	4.9	10.4	0.1	72.9	82.1	21.4	998.1	1029.1	1.8	1.4	93.3	56.4	22.8	57.6
	S	18.2	582.9	3.8	18.7	29.1	49.0	1066.0	932.3	7.5	2.2	219.6	174.4	36.4	11.0
Phenotypic coefficient of variation	K	19.3	45.1	37.5	7.9	7.1	14.2	15.3	13.0	11.0	12.1	30.2	20.7	13.0	9.0
	R	15.1	20.7	20.2	11.7	9.2	14.5	21.4	20.2	10.1	8.1	27.3	15.4	14.7	12.7
	S	25.2	43.0	39.5	10.4	8.7	20.5	19.0	16.7	13.9	11.1	33.3	19.8	17.6	7.0
Genotypic coefficient of variation	K	13.4	24.4	13.8	6.1	5.9	11.5	13.2	11.6	7.2	9.9	25.3	16.6	12.1	8.6
	R	10.8	10.9	10.7	10.7	8.2	13.1	20.1	19.1	5.3	4.4	19.0	7.9	13.8	12.5
	S	17.8	24.8	22.5	8.4	7.5	18.0	16.8	14.8	11.3	7.1	24.7	15.2	17.1	6.4

K = *kharif*, R = *rabi*, and S = spring.

TABLE 3. **Heritability and genetic advance for 14 characters in sunflower**

Character		Seedling heignt	Seedling fresh weight	Seedding dry-matter weight	Days to heading	Days to flowering	Number of leaves	Plant height at flowering	Plant height at maturity	Stem diameter	Head dia meter	Seed yield	1000 seeb weight	Oil content	Protein content
Heritability	K	48.2	29.p	13.5	60.5	68.9	66.0	74.8	78.8	43.1	67.1	70.1	64.8	87.5	91.6
	R	50.8	27.8	27.8	83.6	80.2	81.5	88 5	88.9	28.0	30.1	48.4	25.9	88.9	96.0
	S	49.6	33.4	32.4	65.4	74.1	76.8	77.9	78.0	66.3	40.1	55.1	59.2	95.1	83.6
Genetic advance	K	5.6	18.1	0.6	4.3	5.9	4.2	30.6	29.2	1.6	2.6	15.7	17.1	8.2	10.8
	R	3.2	3.5	0.3	16.1	16.7	8.6	61.8	61.8	1.5	1.3	13.8	7.9	9.3	15.3
	S	6.2	28.8	2.3	7.1	9.6	12.6	59.4	55.5	4.6	1.9	22.7	16.9	12.1	633
Genetic advance per cextage of population mean	K	19.1	27.3	10.2	9.9	10.0	19.1	23.6	21.1	9.9	16.7	43.7	27.5	23.3	16.9
	R	15.6	11.8	11.3	20.2	15.1	24.4	38.9	36.7	6.0	4.9	27.1	8.3	27.0	25.1
	S	25.8	29.6	26.4	14.0	13.4	32.3	30.5	26.9	19.1	9.0	37.8	24.1	34.4	12.1

K = *kharif*, R = *rabi* and S = spring

revealed that the seed yield was the only character which showed highest genetic advance and maturity. The genetic advance was least for days to heading and stem diameter in *kharif* and for head diamter in *rabi* and spring, which suggested that such characters have lesser amount of additive genetic variance and that the rate of progress through selection is likely to be low. On the other hand, seed yield, oil and protein content with high heritability and genetic advance indicated that additive gene action might be operating predominantly in the inheritance of these characters. Thus the results suggested that significant improvement can be made by individual plant selection in early generation, as the higher the heritability, the faster the progress of selection. The characters with higher genetic advance such a seed yield had more genotypic variability suggesting that considerable improvement can be made by applying selection pressure in the subsequent generations.

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D^2 AND METEROGLYPH ANALYSIS IN SOYBEAN

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ABSTRACT

A comparative study of D^2 and meteroglyph analysis was carried out in 75 genotypes of soybean. D^2 analysis studies indicated the formation of five clusters. Cluster I had the maximum number of genotypes. Meteroglyph and index score method also showed similar types of clustering pattern as observed in D^2 analysis.

Key words : D^2 and Meteroglyph analysis; *Glycine max* L; quantitative traits.

INTRODUCTION

Genetic divergence is dependent on geographical as well as phenotypic components of cultivars and its quantitative assessment could provide a rational basis for selection of parents for hybridization programme for obtaining high yielding progenies (Griffing and Lindstrom, 1954) but very few attempts have been made to measure the genetic diversity in the soybean genetic improvement programme. Several biometrical methods such as D^2, line $\times$ tester, diallel cross, partial diallel cross and meteroglyph analyses have been shown to be useful in selecting parents for hybridization. Mahalanobis' D^2 statistics was found to be successful in the selection of parents (Chandra, 1977). Suitability of the meteroglyph analysis technique given by Anderson (1957) to measure the genetic diversity has not been adequately tested in different crop plants. Hence, an attempt was made in this investigation to compare the findings of D^2 analysis and meteroglyph analysis in soybean.

MATERIAL AND METHODS

The experimental material comprised of 75 genotypes of soybean evaluated in 1984-85 . The genotypes were sown in a randomized complete block design with three replications. Each plot consisted of two rows of 5 m length and spacing between rows was 45 cm. 10 cm plant to plant distance was maintained. Five competitive plants were selected from each genotype of each replication to record the observations; (i) days to 50% flowering, (ii) days to maturity, (iii) plant height, (iv) number of primary branches per plant, (v) number of pod bearing nodes per plant, vi)) number of pods per plant, (vii) average number of seeds per plant, (viii) number of seeds per plant, (ix) hundred seed weight (g), (x) biological yield per plant (g), (xi) seed yield per plant (g), and (xii) harvest index.

Mahalanobis (1936) D^2 analysis was used for assessing the genetic divergence between the populations. The genotypes were grouped into a number of clusters by Tocher's method as described by Rao (1952).

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TABLE 1. Inter and Intra-cluster distances D^2 and D values in soybean genotypes

Cultures	I	II	III	IV	V
I	346.56 (18.62)	417.99 (20.44)	562.07 (73.71)	1343.46 (36.65)	730.28 (27.02)
II		0.00 (0.00)	551.61 (23.49)	1407.80 (37.52)	960.10 (30.99)
III			214.53 (14.65)	452.20 (21.27)	936.46 (30.60)
IV				0.00 (0.00)	1515.50 (38.93)
V					0.00 (0.00)

Values given in parenthesis are $\sqrt{D^2}$ values i.e. D

Meteroglyph and index score analysis were carried out to study the morphological variation for different characters in genetic stock of soybean as per method proposed by Anderson (1957).

RESULTS AND DISCUSSION

Wlks test revealed highly significant differences among 75 genotypes for all the twelve characters taken in soybean.

The 75 genotypes were grouped into five clusters using the D^2 values in such a way that the genotypes within a cluster had smaller D^2 values than those in other clusters. The inter and intra D^2 and D values are given in Table 1. The highest inter cluster distance was between IV and V (38.93) followed by II and IV (37.52), I and IV (36.65), II and V (30.99), while the lowest inter-cluster distance was between III and IV (21.27). The composition of cluster and cluster means for different characters has been presented in Table 2 and 3 respectively. Varieties grouped in clusters V, IV and III were high yielding, and late maturing, and had comparatively low harvest index and more number of pods per plant. The genotypes grouped in cluster I and II were low yielding, early maturing having high harvest index and comparatively less number of pods per plant. It could be concluded that the high yielding genotypes coupled with resistance should be selected as parents for hybridization programme from cluster V, IV and III. However only one genotype from each cluster should be used in diallel crossing programme in order to know the combining ability of these genotypes for yield and its components. Similar studies were also conducted by Murty and Arunachalam (1966) in linseed.

Meteroglyph analysis and index score method was also carried out in order to know the morphological variability in 75 genotypes of soybean. The index score of two top high poding lines are MACS 101 and Sepaya. These were depicted on metero-

TABLE 2. Cluster means for different clusters

Cluster No.	No. of populations	Characters											
		Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of pod bearing nodes	No. of pods/ plant	No. of seeds/ pod	No. of seeds/ plant	100 seed weight (g)	Biological yield (g)	Seed yield (g)	Harvest index
	64	44.09I	100.67	32.01	2.73	15.17	29.11	1.97	56.93	12.31	13.59	6.78	49.98
Ii	1	43.00	97.33	53.36	0.94	12.27	19.08	2.90	55.48	8.78	9.18	4.56	49.80
III	8	51.96	107.33	56.87	4.20	22.56	50.56	2.40	102.77	7.29	18.04	**7.75**	**42.97**
IV	1	55.67	109.67	53.36	5.93	31.87	86.53	1.93	164.53	6.88	27.25	11.24	41.22
Vi	1	45.67	103.33	61.04	3.47	20.80	53.87	1.46	78.38	11.50	29.67	8.84	29.76

TABLE 3. Composition of clusters

Cluster	Name of the variety	Source
I	JS 2, JS 79-291, JS 79-308, JS 71-45 JS 75-46, JS 76-205,JS 75-19, JS 79-80, JS 78-80, JS 72-44, JS 79-53, JS 76-259, JS 80-21, JS 79-265, JS 79-41, JS 72-280	Jabalpur
	MACS 58. MACS 75, MACS 13, MACS 92, MACS 64, MACS 111	Maharashtra
	PK 755, PK 660, PK 654, PK 406, PK 633, PK 472, PK 766, PS 73-1	Pantnagar
	Hark, Rokushum, Bragg, Cocker Stuart, Ankur, BB 288-24-6-3, Cocker 240, Seminole, Bonus, Shelby	U . S. A .
	Himso 1531, Himso 1520	Palampur
	DS 61, DS 74-57-2, DS 76-1-29, DS 23, DS 11-2	Delhi
	VLS 12	Almora
	J 280, J 88, J 591, J 75-20-3, S 20	Junagarh
	SL 88, SL 4, SL 78	Ludhiana
	Khsb-2, Khsb-3	Bangalore
	PBN 101, PBN 102	Parbhani
	BR 12, N 19	Ranchi
	AKSS 63	Akola
	Pb 1	Punjab
II	JS 78-72	Jabalpur
III	MACS 10(a), MACS 105, MACS 100, MACS 107, MACS 101	Maharashtra
	Khsb 7	Bangalore
	Jawa 16	Exotic (S. Asia)
	Kalitur	M.P.
IV	Sepaya	Bihar
V	DS 143	Delhi

glph by taking lightly varible characters i.e. number of pods per plant and number of seeds per plant. It is interesting to note that genotypes with high index score were also high yielder. This suggests that the scoring procedure could be utilized in the preliminary screening of a large number of genotypes for the selection of the lines with desirable combination of various variables influencing the seed yield in soybean.

An overall observation of D^2 analysis and metroglyph analysis studies revealed that these two methods of analysis were found to be alternative in giving the information about the nature of divergence of genotypes of soybean. Similar comparison of D^2 analysis and meteroglyph analysis was also carried out by Chandra (1977) in linseed. In this study, D^2 analysis and meteroglyph analysis have shown similar type of clustering pattern of the genotypes for majority of the cluster.

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SHORT COMMUNICATION

PHENOTYPIC STABILITY OF POD YIELD IN SUMMER GROUNDNUT

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Area under summer groundnut is increasing year after year. Thus it is imperative to breed the stable varieties of groundnut possessing high level of pod yield. Therefore, a set of promising varieties of groundnut, namely R 33-1, G-201, UF 70-103, EC-21130, J1, TG-17, J2 and S.B.XI, were tested in a RBD with four replications at seven locations, Kolhapur, Karad, Digraj, Pandharpur, Pune, Dhule and Rahuri during summer season of 1983 to test the phenotypic stability. The plot size 4.95 × 1.60 m with 30× 15 cm spacing was used. Nutrients application (20 Kg N, 40 kg P_2O_5 per hectare) and other package of practices were kept constant for all locations. Data on dry pod yield in kg were recorded on plot basis. Statistical analysis were done as per the method proposed by Eberhart and Russell (1966).

TABLE 1. Pooled analysis of variance for dry pod yield (kg)

Source of variation	Dt.	Sum of squares	Mean sum of square
Genotypes	7	1.70	0.24*
Environments	6	7.23	1.20*
Genotype x environment	42	7.14	0.17*
Environment (g × e)	48	14.37	0.30*
Environment (Linear)	1	7.23	7.23**
Genotypes × environment (Linear)	7	0.64	0.09
Pooled deviation (Non-linear)	40	6.49	0.16*
Pooled error	147	17.08	0.11

* Significant at P=0.05
** Significant at P=0.01

Pooled analysis of variance for pod yield (Table 1) showed that there were significant differences amongst environments and genotypes. Significant mean squares due to environment plus genotype - environment interactions revealed that the genotypes interacted with environmental conditions that existed at different locations. Preponderance of non-linear component (g × e) was not significant against the pooled deviation revealing thereby the fact that the prediction of performance in different enviroments was not possible for pod yield. However, Singh *et al.* (1975) reported that the differences in stability were mainly due to the linear regression. Moreover Patel *et al.* (1983) observed that both linear regression and deviations from linearity were responsible for the differences in stability for seed yield among varieties.

Breese (1969) and Paroda and Hayes (1971) advocated to use linear regression as a measure of response of particular genotype, whereas the deviation around regression

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TABLE 2. Varietal performance under different environments and stability parameters

Cultivars	Kolhapur	Karad	Digraj	Pandharpur	Pune	Dhule	Rahuri	$\bar{x}$	pi	bi	-SE	S^2d
1. R—33—1	1.07	1.18	2.79	0.82	2.35	1.48	2.44	1.73	0.16	1.36	0.66	0.37**
2. G 201	1.82	1.13	2.67	0.88	1.08	1.51	1.81	1.57	0.00	1.42	0.30	0.06
3. UF 70—103	1.20	1.93	2.82	1.35	2.07	1.75	2.45	1.94	0.37	1.14	0.43	0.14
4. EC 21130	1.62	1.58	1.74	1.75	0.79	1.18	1.71	1.48	-0.09	0.51	0.35	0.08
5. J—2	1.20	1.38	2.45	1.54	1.00	1.37	0.87	1.55	-0.02	1.11	0.25	0.03
6. TG—17	1.67	0.92	2.09	1.30	0.79	1.40	1.69	1.41	-0.16	0.95	0.30	0.05
7. J—1	1.92	1.97	2.10	1.08	1.19	0.87	1.55	1.53	-0.04	0.81	0.43	0.14
8. SB XI	1.65	1.57	2.27	1.15	0.50	1.23	2.18	1.36	-0.21	0.68	0.51	0.21
Environment	1.52	1.46	2.24	1.23	1.22	1.35	1.96	1.57				
Mean	-0.049	-0.111	0.673	-0.337	-0.347	-0.221	0.392					

S.E.- 0.16

C.D. (P=0.05) =0.46

line could be considered as a measure of stability, the genotypes with lowest deviations being the most stable. Ram *et al.* (1968) suggested in addition to the above criteria to give a weightage to phenotypic index. Accordingly, it should be possible to judge the stability of dry pod yield of different varieties of groundnut by giving due consideration to three parameters, phenotypic index (Pi), the linear regression (bi) and the deviations from regression function (S^2d) (Table 2). The phenotypic index which reflects the mean performance of genotypes over environments was positive i.e. mean greater than grand mean in three varieties, R33-1, UF 70-103 and G-201 and these were grouped as highly responsible to the change in the environmental conditions because the regression co-efficient values exceed unity. This fact is established considering the environmental index due to favourable environment at Digraj and Rahuri. For these varieties, the magnitude of non-linear component was also high hence prediction of performance across environments particularly of R33-1, the value of S^2d being significant, was not possible. The four cultivars, SB-XI, TG-17, EC 21130 and J1 with low regression values, had negative phenotypic index values indicating response to variables of environmental growth conditions. Amongst the cultivars, TG 17 and EC 21103 had comparatively stable performance as the values of deviation around the regression line (S^2d) were low. The variety, J 2 had more or less the average performance, its regression value approaching to the unity and the least mean square deviation from regression (S^2d = 0.05) indicated that J2 was the most stable for pod yield and was medium in response to environmental conditions. The present studies showed that the cultivars, UF 70-103 and J2 can be considered as the most desirable varieties for summer cultivation under favourable and medium environmental conditions respectively.

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GENETICS OF GRAIN YIELD AND OIL CONTENT IN LINSEED

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In order to know the genetics of grain yield and oil content, a line × tester analysis was undertaken to assess the combining ability of some exotic and indigenous lines of linseed (*Linum usitatissimum* Linn). Keeping the objective in view, 30 female lines were crossed with 3 male testers (Neelum, NP Hyb 57, NP (RR) 236) to develop 90 hybrids. The resulting 90 F_1s and their 90 F_2s alongwith 33 parents were grown in a RCBD with three replications at Research Farm of C.S.Azad University of Agriculture and Technology, Kanpur, during *rabi*, 1974. Parents and F_1s were accomodated in single row and F_2s in two rows each of 3.0 m long and 40 cm apart. Plant to plant distance was maintained at 15 cm. The observations were recorded on five randomly selected plants in each parent and F_1 and ten plants in F_2 for days to flowering, plant height, number of tillers per plant, number of branches per plant, days to maturity, number of capsules per plant, number of seeds per capsules, 1000 seed weight, grain yield per plant and oil content. The data were analysed for combining ability according to the procedure suggested by Kempthorne (1957).

Analysis of variance showed significant differences among genotypes for all the characters studied. Among parents differences were, however, not significant in rgards to capsules per plant and yield per plant. Variances due to crosses and parents *vs* crosses (F_1s + F_2s) were also significant for all the characters except plant height and oil content in case of parents *vs* crosses.

Analysis of variance for combining ability (Table 1) revealed that general combining ability (gca) for male and female genotypes was significant for all the characters in both the generations except for number of capsules per plant and yield per plant for females in F_1. Specific combining ability (sca) for males × females was also significant for all the traits in both the generations except for number of branches per plant and days to maturity in both the generations and for number of capsules per plant and yield for plant in F_1.

The estimates of combining ability variances were translated into genetic variances to understand the nature and magnitude of gene action. High magnitude of gca variance (pooled) and partial dominance in F_1 and sca variance along with over dominance in F_2 for days to flowering indicated predominance of additive and non-additive gene actions in F_1 hybrids and F_2 families, respectively. The different estimates obtained in F_1 and F_2 generations may be attributed to change in the distribution of genes in F_2 population or may be due to linkage disequilibrium. Robinson *et al.* (1960) stated that if there was predominance of repulsion phase linkage, additive genetic variance could

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TABLE 1. Analysis of variance for combining ability in F_1 and F_2 generations

Source	d.f.	Mean squares									
		Days to flowering		Plant height		No. of tillers/ plant		No. of branches/ plant		Days to maturity	
		F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Replications	2	14.75	8.35	548.86**	419 99**	41.64**	22.73**	1168.17**	423.42**	32.30**	47.75**
Males	2	253.70**	130.70**	5599.15**	3523.72**	171.71**	201.60**	9037.89**	749.23**	23.40**	29.15**
Females	29	1 77 86**	167.35**	478.85**	402.04**	13.36**	7.00**	273.68**	139.66**	35.52**	49.40**
Males × Females	28	12.98**	14.23**	28.51**	34.14**	4.42*	2.89*	107.00	76.19	5.14	4.31
Error	178	6.84	5.88	16.29	23.08	3.05	2.07	86.77	69.41	5.04	3.96
Estimates of components of variance, ratio (6^2 gca/6^2 ca) and degree of dominance (6^2 sca/6^2 gca)0.5											
6^2 gca (males)		2.67	1.29	39.67	38.77	1.85	2.20	10.34	7.47	0.20	0.27
6^2 gca (females)		18.32	17.01	50.03	40.87	0.99	0.45	18.52	7.05	3.37	5.02
6^2 gca (pooled)		4.09	2.72	40.61	38.96	1.78	2.40	11.08	7.43	0.49	0.70
6^2 sca		2.04	2.78	4.07	3.68	0.45	0.27	6.74	2.25	0.03	0.11
6^2 gca/6^2 sca		2.00	0.97	9.97	10.57	3.89	7.50	1.64	3.29	15.34	6.04
(6^2 sca/6^2 gca)		0.70	1.01	0.31	0.30	0.50	0.36	0.78	0.55	0.25	0.40

** Significant at P=0.01

TABLE 1. Contd.

Source	d.f.	Mean squares									
		No. of capsules/ plant		No. of seeds/ capsule		1000 seed weight		yield/plant		Oil content	
		F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Replications	2	35315.00**	16513.80**	0.24	0.15	2.18**	1.06**	125.50**	65.05**	1.56	13.18*
Males	2	13045.45**	7534.85**	49.37**	3.86**	79.04**	81.05**	49.56**	23.39**	55.79**	42.20**
Females	29	2918.23	2016.35**	3.76**	0.77**	6.60**	5.72**	7.32	5.70*	13.45**	14.78**
Males × Females	58	1703.38	1540.23**	3.06**	0.51*	0.94**	0.34**	5.22	5.16**	5.81**	5.78**
Error	78	1950.92	980.41	0.44	0.37	0.25	0.14	6.45	3.22	3.45	3.92
Estimates of components of variance,ratio (6^2 gca/6^2 sca) axd degree of dominance (6^2 sca/6^2 gca) 0.05											
6^2 gca(males)		126.02	66.60	0.51	0.03	0.86	0.89	0.49	0.20	0.55	0.40
6^2gca(females)		134.98	52.90	0.07	0.02	0.62	0.59	0.23	0.06	0.84	1.00
6^2 gca(pooled)		126.83	65.36	0.47	0.03	0.84	0.86	0.46	0.18	0.58	0.45
6^2 sca		@	186.60	0.87	0.04	0.23	0.06	@	0.64	0.78	0.62
6^2 gca/6^2 sca		@	0.35	0.54	0.78	3.67	13.16	@@	0.29	0.74	0.73
(6^2sca/6^2gca)0.5		@@@	1.68	1.35	1.13	0.52	0.27	@@@	1.85	1.16	1.16

* Significant at P=0.05
** Significant at P=0.01

@ Estimate of variance component was negative
@@ Denominator was negative
@@@ Numerator was negative

increase as the generations were advanced, and if the linkage was predominantly in coupling phase, additive genetic variance could decrease. For plant height, number of tillers per plant, number of branches per plant, days to maturity and 1000 seed weight additive gene action alongwith partial dominance played an important role in both the generations. These results are in conformity with those of Chandra (1978), Singh and Singh (1979) and Rao and Singh (1984). To exploit the additive genetic variance in the improvement of such characters, pedigree method can be used. Generally, it has been observed in self-pollinated crops that additive genetic variance gets fixed rapidly after the F_2 generation, resulting in restricted recombinations. The breeding procedure based on intermating F_2 population, as usggested by Hanson (1959) and Joshi (1979) would appear more appropriate.

Number of capsules per plant, number of seeds per capsules, yield per plant and oil content were found to be largely controlled by non-additive effects alongwith overdominance in one or both the generations. Singh and Singh (1979) observed similar trend for these traits in linseed. The presence of predominantly large amount of non-additive gene action would necessitate the maintenance of heterozygosity in the population. Since this type of gene action is not fixable, therefore, breeding method such as biparental mating followed by recurrent selection may hasten the rate of genetic improvement for these characters. Reported cytoplasmic male sterility (Dubey and Singh, 1966; Thompson, 1977) may be utilize in the recurrent selection programme to accumulate favourable genes and facilitate breaking of undesirable linkages. Rao and Singh (1984) also suggested similar methodology for population improvement in this crop.

Estimates of gca effects revelaed that among female lines, EC 1462 (b), Sabour T 6 and NP 6, besides being good combiner for early flowering, were also good combiners for early maturity, oil content and 1000 seed weight, respectively. EC 22604 for number of tillers per plant and number of seeds per plant, EC 41678 for number of branches per plant and FRW 9 for 1000 seed weight and oil content were good general combiners in both F_1 and F_2 generations. It is interesting to note that besides being good combiner for yield, EC 13251 was also good combiner for plant height and 1000 seed weight; EC 1433 for number of capsules per plant and CP 43 for 1000 seed weight which are the important yield components. Among males, Neelum for yield per plant, plant height and 1000 seed weight, NP (RR) 236 for oil content and NP Hyb 57 for rest of the characters were good general combiners. A multiple crossing programme for intermating population involving all possible crosses among these strains subjects to biparental mating may be expected to offer the maximum promise in breeding for high seed yield and oil content.

Cross combinations NC 9-1 × Neelum, EC 12350 × NP (RR) 236, FRW 9 × NP (RR) 236, NP (RR) 151 × Neelum and NP 45 × Neelum were good specific combiners for yield per plant. Besides yield, cross NC 9-1 × Neelum also exhibited high sca effects for number of tillers and number of branches per plant and FRW 9 × NP (RR) 236 for number of branches per plant. All these superior specific combiners involved high × high, high × low or low × low general combiners. It appeard that the desirable sca effects of any cross combination need not necessarily depend on the level of gca effects of the parents involved.

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SEED SIZE IN RELATION TO FLOWERING PATTERN AND TOTAL FLOWER PRODUCTION IN GROUNDNUT

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Several investigators have studied the relationship between seed size and crop growth parameters like field emergence in wheat (Rogler, 1954), plant height in soybean (Singh *et al.* 1972) and yield in groundnut (Dharmalingam and Ramakrishnan, 1981), but the work on flowering pattern and total flower production in groundnut (*Arachis hypogaea* L) was limited. The present study was taken up with two popular bunch type groundnut varieties namely POL 1 and TMV 2, to assess the inter-relationship of seed size with pattern of flowering and total flower production.

The kernels of the two groundnut varieties were graded for size using metal sieves possessing 21/64", 20/64", 18/64" and 16/64" diamter round perforation, respectively. A field trial was laid out in a RBD with three replications. On 20th day of sowing five plants were selected at random from the middle ten rows of each plot and labelled. The daily flower production on the labelled five plants was recorded from the data of first flower opening to the cessation of flowering. Finally, the mean total flower production per plant in each treatment was calculated. To study the pattern of flower production in each treatment, the flowers produced were grouped into mean flower production/plant i) upto 30th day (F_1); ii) from 31st to 40th day (F_2); iii) from 41st to 50th day (F_3); iv) from 51st to 60th day (F_4); v) from 61st to 70th day (F_5).

The results of flower production (Table 1) revealed that except in plants in 20/64" retained seed of POL 1 and ungraded in TMV 2, in all those from other treatments of both the varieties, first flowering was noticed between 26 and 30th day. It is in confirmity with the results of Edwards and Hartwig (1971) in soybean in which they found no association of seed size with early flowering. The inter-relationship between seed size and both the total number of flowers and their rate of production studied had revealed the existence of very high positive correlation in both the cultivars. The plants from the largest seeds produced 68.57 and 22.36 per cent more flowers, over those from the smallest seeds, respectively in POL 1 and TMV 2. Peak flowering had occured in all the treatments of both the varieties between 31st and 50th day and during these periods the number of flowers produced was comparetively more in size grades of 21, 22 and 18 retained than in others.

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TABLE 1. Effect of seed size on pattern of flowering and total flower production *in* POL. 1 and TMV. 2 groundnut (Mean values)

Seed sizes	Number of flowers produced/plant at *different intervals*						Total flowers produced/ plant	Percentage on 16/64″ to total flowers
	F_1	F_2	F_3	F_4	F_5	Mean		
POL. 1								
21/64″	0.07	18.00	16.13	2.60	0.47	7.45	37.27	168.57
20/64″	—	16.07	18.40	5.27	1.06	8.16	40.80	184.53
18/64″	0.40	14.20	13.47	2.27	0.10	6.09	30.44	137.68
16/64″	0.07	7.00	11.27	3.10	0.67	4.42	22.11	100.00
ungraded	0.20	7.87	14.80	3.60	0.40	5.37	26.87	121.53
Mean :	—	—	—	—	—	6.30	31.50	
TMV. 2								
21/64″	0.33	21.93	16.67	3.20	0.53	8.53	42.66	122.36
20/64″	0.26	16.67	19.53	3.00	0.80	8.05	40.26	115.46
18/64″	0.07	16.07	15.40	3.40	1.27	7.24	36.21	103.84
16/64″	0.67	14.93	14.80	3.27	1.20	6.97	34.87	100.00
ungraded	—	9.93	14.00	2.70	0.20	5.37	26.83	76.94
Mean :		—	—	—	—	7.23	36.17	

	Variety (V)	Size (S)	Flowering (F)	F X V	F X S
CD (P = 0.05)	0.619	0.980	0.980	1.385	2.163

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EFFECT OF TIME OF APPLICATION OF NITROGEN, PHOSPHORUS AND GYPSUM ON GROUNDNUT

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Time of nutrient supply considerably influences the productivity of groundnut especially on light soils where there is loss of nutrients by leaching. Hence, greater pod yield of groundnut was increased when 20 N, 70 P and 25 K kg/ha was applied as basal and the remairing 10 kg N at 30 days after sowing (Narasimhulu *et al.* 1982). Application of P at sowing and preflowering stage increased the pod yield of groundnut on sandy loam soils (Virmani and Dhaliwal, 1970). Application of 720 kg gypsum/ha at early flowering in the fruiting zone together with 24 kg N/ha at early growth and 38 P_2O_5 and 58 K_2O kg/ha in the rooting zone before sowing increased the pod yield (Omar *et al.* 1970). Keeping this in view, experiments were conducted to investigate the effect of time of application of N, P and gypsum on groundnut.

Field experiments were conducted for two years (*rabi* 1984 and 1985) on sandy loam soils of Agricultural College Farm, Bapatla. The soil was neutral in reaction (pH 7.1), low in available nitrogen (118 kg/ha), medium in available P_2O_5 (22 kg/ha) and low in exchangeable calcium (0.224 %). Nine treatments consisted of control (no fertilizer), basal application of N (80 kg/ha), P (35 kg/ha) and gypsum (˚00 kg/ha) and split application of these three nutrients at sowing and 30 days after sowing were tested in RBD with four replications. Nitrogen and phosphorus were applied through urea and single superphosphate. Groundnut was sown with a spacing of 30 × 8 cm.

Number of filled pods per plant, volume weight of pods, shelling percentage and 100-kernel weight varied significantly due to treatments in both the years (Table 1).

Split application of N, P and gypsum significantly enhanced the number of filled pods per plant (18.4 and 20.1) over the rest of the treatments in both the years. Significantly higher volume weight of pods was recorded with split application of N, P and gypsum in both the years. Which was on par with split application of gypsum with or without split application of N and P except with split application of gypsum with entire N and P as basal in second year. In both the years, split application of gypsum with or without split application of N and P resulted in significantly higher shelling percentage than the entire gypsum as basal with or without split application of N and P except application of entire gypsum as basal with split application of N and P in first year. Maximum 100 kernel weight was recorded with split application of N, P and gypsum as compared to applicatiodn of entire gypsum as basal with or without split application of N and P in both the years. Lower number of pods per plant, volume weight of pods, shelling percentage and 100 kernel weight was observed with control in both the years. Increased-

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TABLE 1. Effect of time of application of N, P and gypsum on yield attributes of groundnut

Treatments	1983				1984			
	No.of filled pods per plant	Volume weight (g/l)	Shelling percentage	100 kernel weight (g)	No. of filled pods per plant	Volume weight (g/l)	Shelling percentage	100 kernel weight (g)
Control	9.5	259.0	69.50	29.03	10.9	273.0	70.25	31.35
80 N + 35 P + 500 kg gypsum basal	14.6	263.0	72.63	30.63	16.6	278.8	73.25	32.63
80 N + 17.5 P + 500 kg gypsum basal + 17.5 P at 30 DAS	15.5	266.3	73.95	31.65	17.7	282.5	75.13	33.42
40 N + 35 P + 500 kg gypsum basal + 40 N at 30 DAS	14.8	264.7	73.28	31.25	15.2	281.0	74.13	33.20
40 N + 17.5 P + 500 kg gypsum basal + 40 N + 17.5 P at 30 DAS	15.3	267.3	74.03	31.88	16.9	283.7	75.25	33.90
80 N + 35 P + 250 kg gypsum basal + 250 kg gypsum at 30 DAS	16.6	270.5	74.53	32.13	18.4	286.0	76.13	34.15
80 N + 17.5 P + 250 kg gypsum basal + 17.5 P + 250 kg gypsum at 30 DAS	16.9	272.5	74.65	32.38	18.3	287.8	76.75	34.35
40 N + 35 P + 250 kg gypsum basal + 40 N + 250 kg gypsum at 30 DAS	16.7	271.5	74.55	32.15	18.2	289.8	76.25	34.15
40 N + 17.5 P + 250 kg gypsum basal + 40 N + 17.5 P + 250 kg gypsum at 30 DAS	18.4	273.8	75.23	32.50	20.1	291.0	77.25	34.50
C D (P=0.05)	0.7	4.9	0.87	0.84	0.6	4.0	1.33	0.94

D A S — Days after sowing.

TABLE 2. Effect of split application of N, P and gypsum on pod and haulm yield of groundnut

Treatments	1983		1983		Pooled Pod yield
	Pod yield (kg/ha)	Haulm yield (kg/ha)	Pod yield (kg/ha)	Haulm yield (kg/ha)	(kg/ha)
Control	1386	2079	1751	2850	1568
80 N + 35 P + 500 kg gypsum basal	**1710**	2592	2205	3241	**1958**
80 N + 17.5 P + 500 kg gypsum basal + 17.5 P at 30 DAS	**1806**	2709	2284	3331	**2045**
40 N + 35 P + 500 kg gypsum basal + 40 N at 30 DAS	**1791**	**2651**	2281	3328	**2036**
40 N + 17.5. P + 500 kg gypsum basal + 40 N + 17.5 P at 30 DAS	**1822**	2696	2300	3339	**2061**
80 N + 35 P + 250 kg gypsum basal + 250 kg gypsum at 30 DAS	**2031**	**2904**	2541	3633	2286
80 N + 17.5 P + 250 kg gypsum basal + 17.5 P 250 kg gypsum at 30 DAS	2102	**3006**	2573	3680	**2338**
40 N + 35 P + 250 kg gypsum basal + 40 N + 250 kg gypsum at 30 DAS	**2078**	**2951**	2559	3659	**2318**
40 N + 17.5 P + 250 kg gypsum basal + 40 N + 17.5 P + 250 kg gypsum at 30 DAS	2122	**3011**	2590	3687	**2356**
C D (P =0.05)	195	136	230	285	144

D A S — Days after sowing

yield attributes might be due to availability of calcium in the fruiting zone with the application of gypsum as top dressing leading to better filling of the pods thereby improving *the volume weight of pods shelling percentage and 100 kernel weight* (Walker and Csinos, 1980).

Pod yield was significantly higher with split application of gypsum irrespective of time of application of N and P when compared to application of gypsum as basal irrespective of time of application of N and P in both the years. Lower pod yield was recorded with no fertilizer treatment. Similar trend was observed in pooled analysis in respect of pod yield. Increase in pod yield was due to increase in number of filled pods per plant, volume weight of pods, shelling percentage and 100 kernel weight (Table 1). These findings are in agreement with the results of Raddar and Biradar (1973) and Chandrasekhar Reddy and Patil (1980). Haulm yield followed similar trend as that of pod yield in both the years. The increase in haulm yield with top dressing of gypsum is due to increased dry matter accumulation and better root and shoot growth through the sulphur content of fertilizer (Nijhawan and Maini, 1966). This may be quite evident as soil of the experimental site was light textured sandy loam which may be deficit in available sulphur. Increase in phytomass yield due to addition of sulphur on such soils was also reported by Chalal and Virmani (1973).

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STUDIES ON YIELD AND QUALITY OF SUNFLOWER VARIETIES IN RELATION TO NITROGEN FERTILIZATION

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Sunflower (*Helianthus annuus* L.) is a newly introduced oil seed crop to Indian agriculture which is a good source of high quality edible oil. Present availability of oil is 14 g/capita/day as against recommended 18 g/capita/day. The gap between demand and supply is expected to be widen because of increased population growth rate (Swaminathan, 1979). To get potential oil production from this crop, it is essential to work out its nutritional requirement particularly nitrogen because it is one of the most important plant growth element. The present investigation was conducted to study the yield and quality of sunflower varieties in relation to nitrogen application.

A field study was under taken during *rabi* seasons of 1974-75 and 1975-76 at the Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Nainital.). The soil was silty loam with pH values of 7.0 and 7.5 and had 0.52 and 0.42 per cent organic carbon; 100 and 160 kg available P_2O_5/ha and available potash 228.5 and 315.8 kg K_2O/ha, respectively during 1974-75 and 1975-76. Rainfall in 1974-75 was lower (28.73 mm) than that of 1975-76 (40.00 mm).

The experiment was laid out in a RBD with 25 treatments consisting of combination of five varieties (UPS 2, UPS 5, UPS 6, UPS 8 and EC 68414) and five levels of nitrogen (0, 40, 80, 120 and 160 kg N/ha) with four replication. Seeding was done on December 3 in first year and November 5 in the second year. Seed were sown in line at 60 cm apart maintaining 20 cm space within row. Recommended package of practices were followed while raising the crop, till it was harvested on April 30 in first year and April 8, in second year.

Oil, protein, saponification and iodine values of seed were determined. Oil per cent was determined by Soxhlet extraction method using petroleum eather as solvent (Anon. 1974). Total N content in seed was determined by Semi microkjeldahl method, which was converted into protein by multipling it with 6.25. The oil was used to determine iodine and saponification values. Iodine and saponification values were determined by the method described by Denial and Neal (1967).

Varieties did not differ significantly among themselves in respect to either seed or oil or protein yield (Table 1). Nitrogen rates differed significantly among themselves for the yields of seed and protein during both the years. Seed yield increased significantly upto 80 kg N/ha and thereafter the rate of increase was not statistically significant. A similar trend for oil and protein yield was recorded under various levels of

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TABLE 2. Oil, Protein (%), Saponification and Iodine values influenced by sunflower varieties and nitrogen rates

Treatment	Oil (%)		Protein (%)		Saponification No.		Iodine value	
	1974–75	1975–76	1974–75	1975–76	1974–75	1975–76	1974–75	1975–76
Varieties								
UPS 2	40.77	41.60	21.84	22.13	185.7	189.3	114.8	113.3
UPS 3	40.76	41.28	21.70	22.11	184.2	187.7	115.4	112.8
UPS 6	41.34	41.83	21.43	21.70	186.1	190.1	116.4	113.0
UPS 8	40.19	41.88	21.35	21.64	185.1	190.2	115.6	113.5
EC 68414	41.40	42.03	22.01	22.60	186.3	190.2	116.0	113.6
SEm ±	0.06	0.08	0.08	0.08	0.50	0.60	0.70	0.70
CD (P=0.05)	0.19	0.25	0.24	0.25	1.50	1.50	NS	NS
N rates (kg N/ha)								
0	42.16	42.59	19.42	19.86	185.4	189.7	115.3	113.7
40	41.75	42.10	20.26	20.81	184.8	188.4	116.1	113.4
80	40.85	41.85	22.05	22.42	186.4	189.3	114.8	113.4
120	40.27	41.42	22.99	23.34	185.9	190.3	115.8	113.4
160	39.98	40.59	23.60	23.84	185.0	189.9	116.2	112.3
SEm ±	0.06	0.08	0.08	0.08	0.50	0.60	0.70	0.70
CD (P=0.05)	0.19	0.25	0.24	0.25	NS	NS	NS	NS

nitrogen. N rates affected oil content of seed. Variety EC 68414 had significantly higher oil content over all other varieties, followed by UPS 2. Oil percent decreased with increasing N rates. Highest and lowest oil content was recorded under no N treatment and 160 kg N, respectively.

Likewise variety EC 68414 had the highest protein content followed by UPS 2. Protein content increased with each increment of N rates, indicating a negative relation ship between oil and protein content. Similar relationship was also observed by Loaf (1960). Variety EC 68414 also had the highest saponification value. Nitrogen rates did not show any effect on saponification value. Iodin values remained unaltered due to varieties and N rates. Sharif (1973) reported no significant difference in saponification and iodine values in sunflower under different N rates. Krishnakumari and Narasimham (1975) found the same iodine values for EC 68414 selection sunrise.

TABLE 1. Seed, oil and protein yield (q/ha) as influenced by sunflower varieties and rates

Treatment	Yield (q/ha)					
	Seed		Oil		Protein	
	1974–75	1975–76	1974–75	1975–76	1974–75	1975–76
Varieties						
UPS 2	17.86	18.47	7.26	7.50	3.94	3.97
UPS 5	17.29	17.29	7.02	4.47	3.78	4.01
UPS 6	15.97	15.94	6.81	7.12	3.58	3.75
UPS 8	16.91	17.25	6.94	7.25	3.64	3.74
EC 68414	17.26	18.03	6.97	7.68	3.74	4.11
CD (P=0.05)	NS	NS	NS	NS	NS	NS
N rates **(Kg N/ha)**						
0	13.56	14.19	5.77	6.15	2.64	2.83
40	15.66	16.11	6.42	6.57	3.12	3.21
80	18.67	18.93	7.62	7.94	4.12	4.24
120	18.90	19.50	7.61	8.57	4.34	4.45
160	19.05	19.80	7.59	7.76	4.48	4.56
SEm ±	0.55	0.48	0.22	0.28	0.13	0.14
CD (P=0.05)	1.45	1.35	0.67	0.83	0.39	0.40

NS - Not significant

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OBSERVATIONS ON REACTION OF MUSTARD APHID TO WHITE PETAL AND GLOSSY PLANTS OF INDIAN MUSTARD

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The mustard aphid, *Lipaphis erysimi* (Kalt), is considered as the most damaging pest for Brassica crops. There seems to be no record of any other aphid causing such alarming damage to the field crops. The average loss in yield of Indian mustard by the aphid is about 62% (Bakhetia, 1983). Success in transfer of resistance gene(s) to the adapted high yielding varieties is difficult in absence of any marker character for such gene(s) since large scale screening of plants in segregating generation has to be undertaken under natural epiphytotic condition and the process of selection is severely affected by chance of escapes. The present investigation reports the response of two morphological traits on aphid and suggests that these traits can be exploited in breeding aphid resistant varieties.

Two lines from Indian mustard variety B-85, one with white petals and the other with glossy (bloomless) stem, were derived at Pulses and Oilseeds Research Station, Berhampore, West Bnegal. White petal was observed to be governed by a single recessive gene and the bloomless stem by a single dominat gene. In the present study the normal B-85 with yellow flower and waxy stem along with the two lines - one breeding true for white petal and the other for bloomless (glossy) stem were grown in non-replicated plot (100 m $\times$ 10 m) for three consecutive years (1980-81 to 1982-83) without any insecticidal sprays for aphid control. The experiments were sown late in end of November to ensure higher aphid incidence. In each plot 100 plants were labelled at random and aphid density was recorded at 10 days interval from the first appearance of aphids until the crop matured (Table 1).

Aphid density was very high during 1982-83, moderate during 1981-82 and very low during 1980-81. During each year, however, percentage of plants with colonies of more than 5 cm in length was observed to be negligible (0-3%) in glossy stemed plants. The value in this regard varied from 0-48% in respect of plants with white flower and 6-58% in respect of plants with yellow petalic normal stem in different experimental years. Colony size increased to a maximum length of 8 cm on glossy plants but 70-80 cm in waxy plants. A majority of glossy plants had colony length below 2 cm and were discrete in distribution and confined to the areas of anchorage on plants. Since colony length exceeding 5 cm is considered to have an adverse effect on crop performance and the frequency of plants with such colony determines the damage intensity, glossy plants could be considered as the most non-preferred ones for aphids. The glossy B-85 being otherwise similar to normal B-85, it may be reasonably assumed that either the glossy surface acts as a barrier for colonization of aphid or the alatae are deterred from such plants after alighting or pherhaps the apterous progeny develop less well on glossy plants. Resistant behaviour of waxless type has also been reported by Srinivaschar and Malik

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TABLE 1. Records of aphid infestation on mustard variety B 85 and its two derivatives namely white petal and glossy stem at Berhampore (India)

Treatment	Year	% plant infested (Initial count)	% plant infested (Final count)	%plant showing aphid without forming any colony		% plant showing aphid with colony length			Maximum length of colony	Nature of distribution of the colony
				Aphid population ranging 1-100	Aphid population above 100	below 2 cm	from 2-5 cm	above 5 cm	observed (cm)	
1. B-85 with glossy stem/ yellow flower	1980-81	—	74.0	53.0	0	21.0	0	0	—	Confined to the areas
	1981-82	30.0	71.0	27.0	0	33.0	8.0	3.0	8.0	
	1982-83	23.0	74.0	10.0	4.0	54.0	4.0	2.0	6.0	of anchorage
	Mean	26.5	73.0	30.0	1.30	36.0	3.6	1.6	7.0	
2. B—85 with waxy stem/ white flower	1980-81	—	61.0	30.0	1.0	30.0	0			
	1981-82	18.0	64.0	25.0	0.0	29.0	4.0	8.0	32.0	to any
	1982-83	12.0	90.0	2	10.0	20.0	10.0	48.0	70.0	specific area
	Mean	15.0	71.6	19.0	3.60	26.3	4.6	18.6	51.0	
3. B—85 with waxy/ stem/ yellow flower (Normal)	1980-81	—	75.0	43.0	3.0	14.0	9.0	6.0	—	Not confined
	1981-82	36.0	90.0	30.0	0.0	6.0	27.0	27.0	40.0	to any
	1982-83	27.0	96.0	2.0	14.0	10.0	12.0	58.0	80.9	specific area
	Mean	31.5	87.0	25.0	5.60	10.0	16.0	30.3	60.0	

(1972) in *B. rapa* and by Thompson (1963) in *B. oleracea* var *acephala*. But such reports in *B. juncea* are very scanty.

Plants with white petal were considerably less infested by aphid at the initial count. Subsequently, however, data on percentage of plants infested was as high as the normal yellow petalic plants. It may be stated in this connection that plants with white petal had waxy stem and the aphids after their initial settlement found no difficulty in reproduction and colonization. As a matter of fact the subsequent infestation resulted from the trivial dispersing behaviour of adults. Under this situation it is thus concluded that white colour of the petal does not attract the alate, while these have a preference to alight on yellow colour.

The results thus revealed that in future breeding programme white petal may be exploited as a tool for curtailing the settlement of the immigrating alatae and glossy surface for erecting mechanical barrier for colonization.

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CORRELATION STUDIES IN SUNFLOWER

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The cross pollinated nature of sunflower crop (*Helianthus annuus* L.) makes the seed production an important step in the development of its cultivation. Sunflower seed production involves the technique of varietal renovation formulated by Russian academician, V.S. Pustovoit. This method aims not only at maintenance of original varietal characters but also improves the variety for seed yield and oil content. Information on association between economic traits would help the breeder in isolating desired genotype.

With these objectives in view, the present investigation was taken up in 'Modern' sunflower variety raised during *Kharif* season of 1984 under rainfed conditions. Observations on 50 random plants in respect of various parameters *viz.* plant height, stem girth, head diamter, 1000-seed weight, sesd yield/plant and oil content were recorded and means arrived at. Correlation coefficients based on the means were worked out between seed yield and other yield attributes as per procedure outlined by Al Jibouri *et al.* (1958) and the data are furnished in Table. 1.

TABLE 1. Correlation coefficients between different characters

Character	Plant height (cm)	Head Diameter(cm)	Stem girth (cm)	1000-seed wt.(g)	oil content
Yield/Plant(g)	0.227	0.004	0.460*	0.500*	0.419*
Plant height (cm)		0.056	0.380*	0.174	0.004
Head diameter (cm)			0.767*	0.282	0.210
Stem girth (cm)				0.070	0.240
1000 seed wt.(g)					0.191

* Significant at P=0.05

The seed yield was positively and significantly related with 1000-seed weight and oil content (Table 1). Strong and positive correlation between seed yield and 1000-seed weight was also noticed by Burns (1970), Sidhu and Bains (1980) and Varshney and Busudeo Singh (1977). A significant positive correlation between seed yield/Plant and oil content was also observed by Ross (1939), Giriraj *et al.* (1979), Sidhu and Bains (1980) and Shrinivasa (1980).

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Significant and positive relationship has been found between plant height and stem girth (0.38)*, head diameter and stem girth (0.76)* and stem girth and seed yield/ plant (0.46)*, showing a direct bearing on the ultimate seed yield. The study revealed that emphasis should be given on stem girth and seed weight while selecting individual plants in the varietal renovation programme of sunflower populations.

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INHERITANCE OF SEED COAT COLOUR IN YELLOW SEED TURNIP RAPES

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While breeding for zero erucic fatty acid ($C_{22:1}$) in the oil of the Indian domesticated yellow sarson (*Brassica campestris* ssp. *oleifera* var. yellow *sarson*), a cross was made between high erucic yellow sarson strain DYS-1 of Indian origin with the zero erucic cultivar 'Candle' of Canada. The strain DYS-1 was characterised by medium to bold seeds with light creamish yellow colour, while seeds of the variety, Candle were small, pale yellow in colour with brownish tinge at the chalazal end. As the F_2 seeds from the F_1 plants of the cross turned up to be brownish black in colour, study was undertaken to determine the pattern of inheritance of the seed coat colour of the two yellow seeded cultivars.

Reciprocal crosses were made between the two yellow seeded cultivars Candle and DYS-1 in the green house of the Institute of Agronomy and Plant Breeding, University of Goettingen, Goettingen, Germany. When yellow sarson DYS-1 was used as female, the seed setting was much lower and the Crossed seed had higher shrivelling.

The F_1 plants were grown in pots in the green house and selfed to advance to F_2 generation and also backcrossed with both the parents to raise BC^1 and BC_2 generations. The F_2, BC_1 and BC_2 generations were planted in the fileds of IARI farm during the crop season of 1981-82. All the plants of various generations were observed for seed coat colour and X^2 test was applied to determine the goodness of fit to the observed ratio.

The F_0 crossed of DYS-1 X Candle was light creamish yellow while the reciprocal cross Candle X DYS-1 had pale yellow seed colour with brownish tinge like their respective mother parents. This suggested that the seed coat colour was determined by the genetic constitution of female parent on which it is borne. This finding is in accordance with the previous reports of Vaughan (1956), Vaughan *et al.* (1963), Stringam *et al.* (1974) and Anand *et al.* (1985) who also reported the material control of seed coat colour in various *Brassicae*.

The seed coat colour of the F_1 and reciprocal F_1 plants was brownish black in colour which was contrary to the expectation of yellow seeded parents. The data from F_2 distribution (Table 1) showed a digenic mode of inheritance with plant population segregating into 98 light creamish yellow, 70 pale yellow and 212 brownish black seed colour. The observed F_2 ratio of 4:3:9 indicated a digenic epistatic interaction due to recessive allele. This was further supported by the backcross data where in BC_1 plants segregated into 76 light creamish yellow and 71 brownish black seeds, and in BC_2, 48 pale yellow and 53 brownish black seeds giving a good fit of 1:1 ratio. The genotypic

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TABLE 1. Mode of inheritance of seed colour in yellow seeded turnip rapes

Generation	Number of plants with seed colour			Ratio	X^2 value
	Light yellow	Pale yellow	Brownishblack		
Candle (P_1)	—	All	—		
DYS—1 (P_2)	All	—	—		
P_1 X P_2 (F_0)	—	All	—		
P_2 X P_1 (Reci F_0)	All	—	—		
F_1	—	—	44		
Reci F_1	—	—	12		
F_2	98	70	212	4:3:9	.0467
BC_1	76	—	71	1:1	.170
BC_2	—	48	53	1:1	.2474

symbols assigned to the factors are *YYbrbr* (light creamish yellow) and yy*BrBr* (pale yellow colour with brcwnish tinge), where *yy* hides the effect of *BrBr* and is therefore epistatic. Consequently, *yyBrBr* is pale yellow and represents the genotype of cv. Candle and *Yybrbr* is light creamish yellow of the yelow sarson variety DYS-1. The double recessive *yybrbr* is also light creamish yellow due to the absence of either of the dominant alleles.

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CORRELATION AND REGRESSION STUDIES BETWEEN DIFFERENT PHYSIOLOGICAL ATTRIBUTES AND POD YIELD IN GROUNDNUT

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Variation in dry matter accumulation by different varieties may be related to the factors such as leaf area, net assimilation rate, leaf area ratio and relative growth rate (Wallace and Munger, 1965). Koller (1971) pointed out that for the better understanding of the physiological basis of crop yield differences, it is essential that the components of growth in plant community be quantified. Understanding of physiological determinants that influence the final yield of the crop, assumes greater importance in groundnut due to the fact that pods are formed beneath the ground, and unless correlation between the external physiological characters and the yield are established, it may not be possible to establish proper cause of yield variation. However, knowledge of physiological basis would only be a complementary effort. Keeping this in view the present investigation was carried out.

The field experiment was laid out at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar during *Kharif* season of 1983-84 in a split-plot design with three replications, taking four planting dates (June 10, June 25. July 10 and July 25) as main-plot treatment and five varieties (T 28, Robout 33-1, M 13, GAUG 10 and J 11) as sub-plot treatments. The dry matter was recorded at 30, 60, 90 and 120 days after sowing and was reported as the average of five plants. The pod yield (q/ha) reported was the converted pod yield of per plot. The various physiological determinants were calculated as per procedure described by Radford (1967). Correlation coefficients between various characters were worked out as per procedure of Panse and Sukhatme (1967).

The study showed that there was a positive and significant correlation between dry matter per plant and pod yield ($r = 80^{**}$) (Fig. 1 a). LA was found to have a positive and significant correlation with dry matter per plant and pod yield at all the four growth stages (Fig. 1 b) except at 60 DAS with pod yield ($r = 0.35$). Shilke and Khuspe (1982) have also reported similar findings where dry matter and LA had a positive and significant correlation with pod yield.

LAR at 30-60 DAS had a positive and significant relationship with pod yield ($r = 0.45^{*}$) (Fig. 1 c) and at later stage (90-120 DAS) with dry matter ($r = 0.54^{*}$). Yadav *et al.* (1979) reported that seed yield was associated with LAR positively at pre-flowering stage and negatively at the post flowering stage in green gram.

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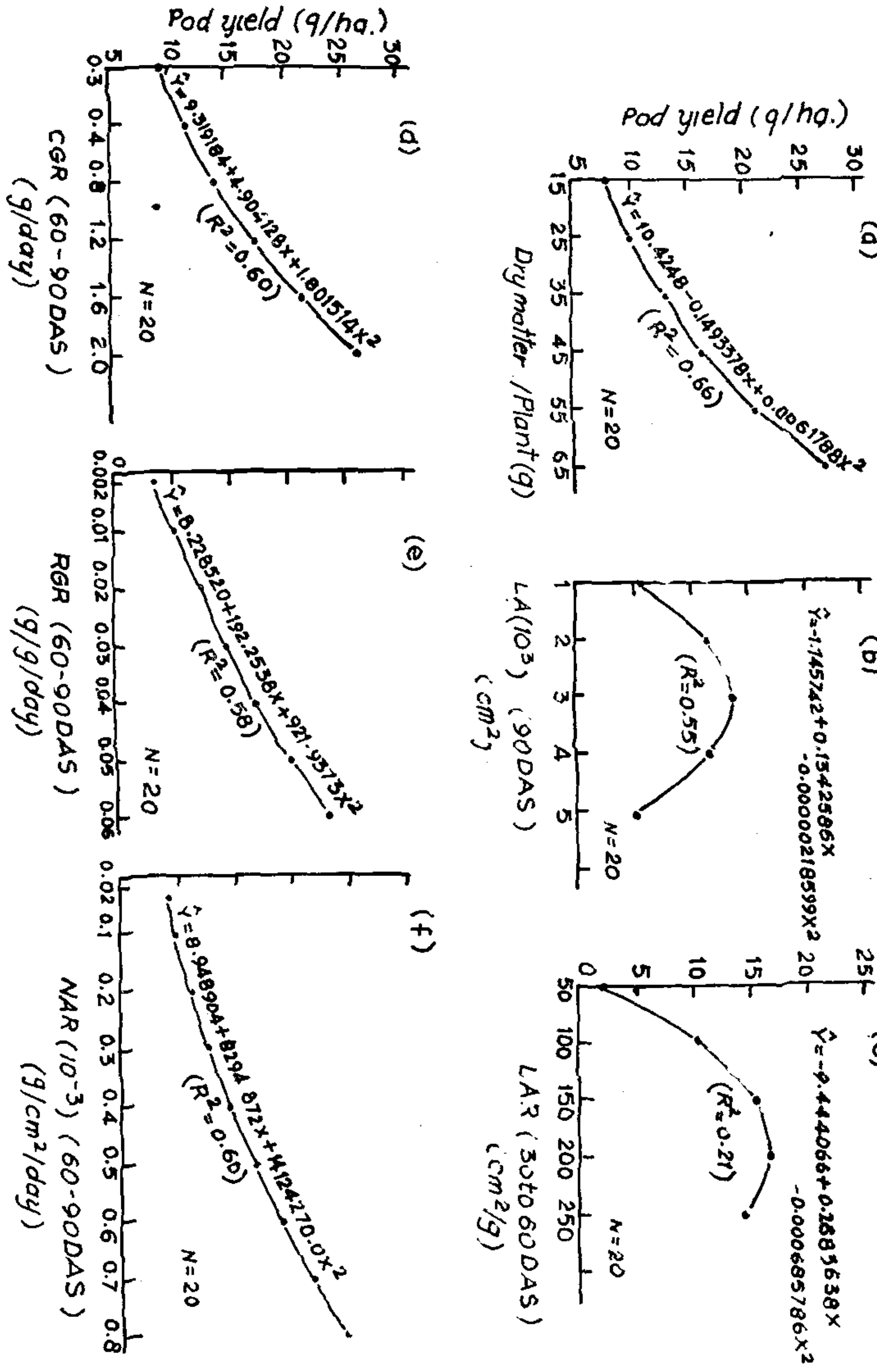

Fig. 1. Correlation coefficient and regression relation between pod yield and different physiological attributes.

TABLE 1. Correlation coefficeint (r) and multiple coefficent of determination (R^2) between different physiological attributes and pod yield

Character	Dry matter per plant r	Pod yield r	Pod yield R^2	Character	Dry matter per plant r	Pod yield r	Pod yield R^2
Dry matter per plant	—	0.80**	0.66	Crop growth rate(CGR)			
Leaf area (LA)				30–60 DAS	–0.44*	–0.50*	0.25
30 DAS	0.65**	0.56**	0.32	60–90 ,,	0.91**	0.77**	0.60
60 ,,	0.46*	0.35	0.19	90–120 ,,	–0.27	–0.27	0.95
90 ,,	0.75**	0.57**	0.55	Relative growth rate (RGR)			
120 ,,	0.90**	0.62**	0.43	30–60 DAS	–0.73**	–0.64**	0.48
Leaf area ratio (LAR)				60–90 ,,	0.85**	0.76**	0.58
				90–120 ,,	–0.29	–0.34	0.12
				Net assimilation rate (NAR)			
30–60 DAS	0.41	0.45*	0.21	30–60 DAS	–0.58**	–0.59**	0.45
60–90 ,,	0.16	0.17	0.05	600–90 ,,	0.83**	0.77**	0.60 0.15
90–120 ,,	0.54*	0.36	0.11	90–120 ,,	–0.29	–0.34	

* Significant at P = 0.05

** Significant at P = 0.05

DAS — Days after sowing

CGR, RGR and NAR Had highly significant and positive correlationwith dry matter ($r = 0.91^{**}$, $r = 0.85^{**}$ and $r = 0.83^{**}$, *respectively) and pod yield* ($r = 0.77^{**}$, $r = 0.76^{**}$ and $r = 0.77^{**}$, respectively) at 60-90 DAS. However, at other stages these parameters had negative relationship. Further, it was observed that CGR had positive and significant correlation with RGR ($r = 0.98^{**}$) and NAR ($r = 0.93^{**}$) at 60-90 DAS but at other stages the relationship was negative. Yadav *et al.* (1979) indicated that seed yield in green gram was associated with NAR negatively at pre-flowering stage and positively at post-flowering stage.

Regression studies revealed that there was significant and positive regression of pod yield with CGR (Fig. 1 d), RGR (Fig. 1 e) and NAR (Fig. 1 f) at 60-90 DAS.

It may, therefore, be concluded that LA had positive significant correlation with pod yield upto 120 DAS except at 60 DAS. While LAR was only significant at 30-60 DAS with pod yield. CGR, RGR and NAR were highly significant and positively correlated with dry matter and pod yield only between 60-90 DAS. The study, thus, provides an understanding of the association of pod yield with some physiological attributes.

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EFFECT OF SALINITY ON GERMINATION AND SEEDLING GROWTH OF SUNFLOWER GENOTYPES

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Studies on the salt tolerance of oilseed crops like safflower (Francois and Bernestein, 1964; Yermonos *et al.*, 1964), and sunflower (Sulthana *et al.*, 1985) have been reported earlier. Extensive work has been done on salt tolerance of rice, wheat, barley, cotton, etc. to isolate salt-tolerant genotypes. Such studies help in understanding the response of genotypes to stress caused by salinity during germination and seedling growth and its effect on yield and other parameters. Sunflower (*Helianthus annuus* L.) has established as a potential oilseed crop of dryland agriculture next only to groundnut in Karnataka state. It is classified under medium salt tolerant crops (Richards, 1954). There is, therefore, scope for extending its cultivation to adverse soil conditions. In the present study, four sunflower populations and three hybrids have been evaluated for tolerance to salinity during germination and seedling growth.

Sunflower seeds were surface sterilized with 0.1% mercuric chloride for 2 to 3 minutes and the dried seeds were used for germination. For each salt (NaCl) concentration there were three replications and in each replication 10 seeds were used per plastic bowl containing soil and farm yard manure in almost equal proportion. Five levels of salinity ranging from 0 to 7.5 m.mhos/cm were used in the study and the seeds were allowed for germination for 10 days. Germination count was taken every day and at termination of the experiment shoot and root length of the seedlings were recorded. Vigour index was calculated as per the formula given by Abdul Baki and Anderson (1973). Four populations viz., Ec. 68414, EC. 68415, CGP-1, Morden and three hybrids: BSH-1, KBSH-4, SEH-4 were evaluated in the present study.

Sunflower genotypes can tolerate salinity upto 4.5 m.mhos/cm during germination beyond which both germination per cent and seedling vigour decreased (Table 1). It is also evident that the salinity at which there was 50% reduction in germination per cent lies between 6 to 7.5 m.mhos/cm for all the genotypes studied.

Similarly, seedling length also decreased with increase in salinity indicating the adverse effect of salinity on the growth of seedling (Table 2). Shoot to root ratio of seedlings also decreased with increase in salinity indicating more pronounced effect on shoot growth than that of root.

The effect of salt concentration on the germination of both hybrids and varieties were highly significant. Genotypic effect on germination per cent was not significant and so also the interaction between genotypes and salt concentration on germination.

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TABLE 1. Per cent germination and vigour index as affected by salinity.

Sunflower genotypes	Per cent germination						
	Salt concentration in m.mhos/cm						
		1.5	3.0	4.5	6.0	7.5	Mean
BSHM—1	60.0	43.3	36.7	30.0	23.3	6.7	33.3
KBSH—4	80.0	73.3	76.7	56.7	43.3	33.3	60.6
SEH—4	100.0	100.0	93.3	90.0	90.0	50.0	87.2
	C.D. salinity at P=0.01,			12.79			
	C.D. Hybrids at P=0.01,			9.05			
	C.D. Interaction			N.S.			
CGP—1	90.0	96.7	80.0	63.3	50.0	33.3	68.9
EC. 68414	73.3	90.0	83.3	66.6	63.3	26.7	67.2
EC. 68415	73.3	90.0	83.3	93.3	80.0	46.7	77.8
Morden	93.3	93.3	90.0	70.0	46.7	46.7	73.3
	C.D. Salinity at P=0.01,			13.66			
	C.D. Varieties at P=0.01,			N.S.			
	C.D. Interaction			N.S.			
				Vigour index			
BSH—1	1730	805	505	517	245	66	
KBSH—4	1674	1520	1396	867	515	434	
SEH—4	2436	2296	1766	1322	911	415	
CGP—1	1739	1602	1046	525	446	221	
EC. 68414	1792	2200	1186	1155	734	253	
EC. 68415	1880	2273	1946	1868	1352	602	
Morden	1886	1800	1281	800	423	439	

The hybrids differed in their response to germination at different levels of salinity. It was also established that salinity delayed the onset of germination of sunflower genotypes. Amongst hybrids SEH-4 and amongst populations EC. 68415 appeared to be comparatively more tolerant to salinity over other genotypes.

TABLE 2. Effect of salinity on seedling length and shoot to root ratio

Sunflower genotypes	Seedling length in cm Salt concentrations in m.m hos/cm						Mean over Salinity levels
	0	1.5	3.0	4.5	6.0	7.5	
BSH—1	28.0 (1.48)	18.6 (1.30)	13.8 (1.13)	17.2 (0.74)	10.5 (0.97)	10.0 (0.53)	14.02 (0.93)
KBSH—4	20.9 (0.92)	20.7 (0.97)	18.2 (0.95)	15.3 (0.63)	11.9 (0.55)	13.0 (0.62)	15.82 (0.74)
SEH—4	24.4 (2.59)	23.0 (1.84)	18.9 (1.52)	14.7 (1.10)	10.1 (0.95)	8.3 (0.81)	15.00 (1.24)
CGP—1	19.3 (1.03)	16.6 (1.05)	13.1 (0.75)	8.3 (0.63)	8.9 (0.49)	6.6 (0.59)	10.70 (0.70)
EC. 68414	24.4 (1.45)	22.1 (1.41)	17.8 (1.21)	17.3 (1.05)	11.6 (0.81)	9.5 (0.53)	15.67 (1.00)
EC. 68415	25.7 (1.63)	25.3 (1.00)	23.4 (0.84)	20.0 (0.63)	16.9 (0.51)	12.9 (0.61)	19.70 (0.72)
Morden	20.2 (1.02)	19.3 (1.09)	14.2 (0.99)	11.4 (0.66)	9.1 (0.73)	9.4 (0.56)	12.68 (0.82)

Figures in the parenthesis are shoot and root ratio.

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J. Oilseeds Res. 4(1987) : 139 - 140

A NOTE ON THE PERFORMANCE OF HAND OPERATCD U.L.V. SPRAYER EOR THE CONTROL OF THE GROUNDNUT LEAFMINER

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Groundnut is extensively cultivated during the *Kharif* season under rainfed conditions. Insect pests accounts for substantial loss in groundnut in India (Amin, 1983). The need for developing appliances that minimise or avoid water in spraying and so help dryland cultivators in their effort of chemical control of insect pests is considerable.

The Aspee C.D.A. (Controlled Droplet Applicator) is an indegenous U.L.V. (Ultra-Low Volume) hand operated sprayer. This was compared with an Aspee power sprayer for its efficiency in controlling groundnut leafminer. An area of one hectare of groundnut (JL. 24) crop was chosen at Mudanai village in South Arcot District of Tamil Nadu. This field was heavily infested with groundnut leafminer, *Aproaerema modicella* (Deventer). Monocrotophos 36 E.C. at 750 ml/ha was used in both the sprayers. In the power sprayer 200 litres spray fluid/ha was used while in the ULV it was 2.5 lit/ha. An area of 0.4 ha was sprayed with the power sprayer. In the U.L.V. water or 10% sugar solution or 10% glycerine solution were compared as carriers for making the spray solution. A quantity of 100 ml of monocrotophos 36 E.C. plus 250 ml of any one of the carrier solutions was used for spraying 0.13 ha through the U.L.V. A portion of the area (0.13) was left unsprayed for comparison. One spraying was done in August 1985. The live larval density was estimated in five locations each of 1 m (plough row) in each of the plots before and after (10 days) spraying operation. Based on the data the per cent control of the pest was worked out and the data were processed statistically. The results are presented in the Table 1.

TABLE 1. Efficacy of ULV sprayer in the Control of *A. modicella*

Treatments	Mean larval density		Leafminer control (% reduction)
	Before Spraying	After Spraying	
Power sprayer	52.0	14.8	71.7 (58.43)*
U.L.V.			
i) Insecticide + Water	51.8	23.0	57.9 (49.63)
ii) Insecticide + 10% glycerine in water	51.0	12.0	76.7 (62.41)
iii) Insecticide + 10% sugar in water	45.2	14.0	68.6 (56.09)
Control	44.0	43.4	— —
CD at (P=0.05)			(6.52)
CV %			(15.7)

* Figures in parenthesis are arcsin transformed values

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The U.L.V. hand operated sprayer was equal in efficacy to the power sprayer, when the insecticide was applied after mixing in either 10% glycerine or 10% sugar solution. The insecticide made into water solution and used as U.L.V. gave significantly lower percentage kill of the pest than the other treatments.

The efficacy of U.L.V. hand operated C.D.A. sprayer for the control of rvd hairy caterplillar in groundnut was reported by Venkataraman *et al.* (1970) and Paramasivam *et al.* (1973). The present study indicates the usefulness of this sprayer for controlling groundnut leafminer pest.

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SEED—BORNE MICROFLORA OF SESAMUM AND THEIR SIGNIFICANCE

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Sesamum (*Sesamum indicum* L.) is one of the most important oilseed crops that suffers due to a number of diseases, many of which are incited by seed-borne pathogens (Noble and Richardson, 1968; Kushi, 1977). The most important among these seed-borne pathogens are *Alternaria sesami* causal organism of leaf spot (Leppik and Sowell, 1964), *Fusarium oxysporum* f.sp. *sesami* responsible for wilt (Buldeo and Rana, 1978), *Helminthospoium sesami* causing leaf blight (Poole, 1956) and *Myrothecium roridum* incitant of foliar blight (Singh and Shrivastava, 1967). Studies were conducted to know the range of microflora associated with sesamum seeds and their significance.

The seeds of 12 varieties of sesamum were stored at 4°C. Two lots of two hundred seeds of each variety were tested by Standard Blotter Method (ISTA, 1976) without any pre treatment and pre treatment with 0.1 per cent mercuric chloride for two minutes followed by three washings in sterile distilled water. Twenty five seeds were kept in each petriplate containing three moist blotters. The plates were incubated in a growth chamber at 28°C under alternate cycle of 12 hours light and 12 hours darkness. The seeds were examined on the eighth day under stereoscopic binocular microscope. Pathogenicity of the associated fungi was tested following usual procedures by seed and soil infestation and percentage seed germination and seedling mortality were recorded.

The microflora found associated with seeds of 12 varieties of sesamum are presented in Table 1. In all, eight fungi and two bacteria were found associated. The per cent association of microflora was less in pre-treated seeds as compared to untreated seeds in all the varieties. *A. sesami* was found associated with 11 varieties and ranged from 12 per cent (pre-treated seeds of Kanke) to 47 per cent (untreated seeds of Purva-1). *F. oxysporum* f. sq. *sesami* was associated with 10 varieties and the range of association was 7 to 51 per cent (pre-treated and untreated seeds of Kanke). *H. sesami* was detected with seven varieties (all untreated seeds) whereas *M. roridum* with six varieties and the range of association was 2 to 18 and 6 to 24 per cent respectively. The range of other important microflora found associated with sesamum seeds were : *Pseudomonas sesami*. (4 to 43 per cent with 10 varieties), *Xanthomonas sesami* (2 to 6 per cent with 5 varieties) *Penicillium* sp. (8 to 28 per cent with 10 varieties); *Curvularia lunata* (6 to 31 per cent with 10 varieties); *Botrytis cinerea* (4 to 28 per cent with 8 varieties) and *Aspergillus* sp. (2 to 20 per cent with 6 varieties).

The higher percentage association of *Pseudomonas sesami* in pre-treated seeds may be due to the lesser incidence of saprophytic fungi, due to pre treatment in these varieties.

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TABLE 1. Microflora associated with seeds of different varieties of sesamum as detected by standard Blotter Method (figure in per cent)

Variety	Treat-ment	Germi-nation (%)	A.S.	H.S.	F.O.S.	M.R.	P.S.	X.S.	P.	C.L.	B.C.	A.
CO—1	P	92.00	—	—	—	—	5.00	2.00	—	—	—	—
	U	77.00	21.00	—	25.00	10.00	—	—	11.00	8.00	28.00	—
Gujrat—1	P	83.00	—	—	—		24.00	—	—	—	—	—
	U	84.00	32.00	—	16.00	—	2.00	—	—	—	—	—
Kanke	P	64.00	12.00	—	7.00	—	43.00	—	—	—	8.00	—
	U	30.00	40.00	—	51.00	—	38.00	—	28.00	31.00	—	20.00
Kanke white	P	48.00	30.00	—	20.00	—	12.00	—	8.00	2.00	—	—
	U	40.00	13.00	18.00	25.00	—	25.00	—	—	—	9.33	—
Kayamkulum-1	P	90.00	25.00	—	—	—	16.00	3.00	—	—	—	—
	U	82.00	—	7.00	23.00	6.00	4.00	—	24.00	6.00	7.00	—
Madhavi	P	42.00	18.00	—	12.00	—	24.00	—	—	—	—	—
	U	38.00	44.00	—	33.00	—	43.00	—	14.00	20.00	—	4.00
Murg—1	P	76.00	—	—	22.00	—	16.00	3.00	—	—	4.00	—
	U	67.00	12.00	6.00	—	6.00	4.00	—	24.00	6.00	—	3.00
Pp—T—1	P	76.00	13.00	—	25.00	—	26.00	3.00	15.00	27.00	8.00	—
	U	56.00	—	2.60	32.00	—	—	16.00	—	—	10.00	6.00
Pratap	P	48.00	—	—	—	20.00	—	—	—	24.00	—	—
	U	18.00	15.00	16.00	—	24.00	—	16.00	—	18.00	—	—
Purva—1	P	88.00	—	—	—	—	—	—	—	—	—	—
	U	76.00	47.00	17.00	12.00	7.00	24.00	—	18.00	7.00	6.00	2.00
TC—25	P	73.00	6.00	—	6.00	—	22.00	—	—	—	16.00	—
	U	44.00	46.00	—	48.00	—	42.00	—	10.00	22.00	—	—
Vinayak	P	92.00	—	—	—	—	—	—	—	—	—	—
	U	80.00	—	17.00	—	6.00	—	—	20.00	—	—	6.00

A.S. = *Alternaria sesami*
H.S. = *Helminthosporium sesame*
F.O.S. = *Fusarium oxysporum* f.sp. *sesami*
M.R. = *Myrothecium roridum*
P.S. = *Pseudomonas syringae* pv. *sesami*
X.S. = *Xanthomonas campestris* pv. *sesami*

P. = *Penicillium* sp.
CL. = *Curvularia lunatai*
B.C. = *Botrytis cinerea*
A. = *Aspergillus* sp.

P = Pretreated seeds
U = U ntreated seeds

The germination percentage of seeds ranged from 18 (untreated seeds of Pratap) to 92 (pertreated seeds of Vinayak and Co-1). Further, it was observed that pre-treatment of seeds enhanced germination percentage and resulted in lesser number of microflora in all the varieties.

The data on the influence of four fungi in causing mortality of sesamum are furnished in Table 2. The data reveal that influence varied in both seed as well as soil infestation. Among four fungi, *F. oxysporum* f.sp. *sesami* caused maximum total mortality (72 and 64 per cent respectively), whereas *M. roridum* caused minimum (32 and 16 per cent respectively) by seed and soil infestation. *A. sesami* caused total mortality of 58 and 60 per cent respectively due to seed and soil infestation. Similarly the mortality due to *H. sesami* was 35 and 38 per cent respectively by seed and soil infestation.

TABLE 2. Pre and post emergence mortality of sesamum under seed and soil infestation of four fungi

Treatments	Germination (%)		Pre-emergence (%)		Post-emergence (%)		Totalmortality (%)	
	Seed	Soil	Seed	Soil	Seed	Soil	Seed	Soil
Alternaria sesami	60	55	40	45	18	15	58	60
Fusarium oxysporum f.sp. *sesami*	65	70	35	34	37	30	72	64
Helminthosporium sesami	75	82	25	18	10	20	35	38
Myrothecium roridum	80	94	20	6	12	10	32	16
Control	95	85	5	15	3	10	8	25

The data further indicate an indirect relationship between germination percentage and mortality. The germination per cent was maximum in seed as well as soil infestation (80 and 94 per cent respectively) be *M. roridum* which caused minimum mortality under both the conditions.

Similar results have been reported by other workers (Vidyasekaran *et al.*, 1972; Mathur and Kabeere, 1975; Kushi and Khare, 1979). They have also reported that seed borne fungi affect the seed germination as well as seedling growth by causing losses at pre and post emergence stages which was confirmed in the present investigation.

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EFFECT OF DIFFERENT FERTILITY LEVELS AND PLANT DENSITIES ON YIELD AND YIELD COMPONENTS OF GROUNDNUT •

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A field experiment was conducted on sandy loam soils in summer season of 1981 at perumala pelli Research Station, near Tirupathi to study the effect of various fertility levels and plant densities on yield and yield components of irrigated Spanish groundnut (TMV-2). The experiment was laid out in factorial RBD with three replications. The treatments consisted of no fertilization and various fertility levels of N at 30 and 45 Kg ha^{-1}, . N:P combination at 30:10 and 45:20 Kg ha^{-1}, NKP combinations at 30:10:25 and 40:20:50 and also addition of gypsum at 500 Kg ha^{-1}, with 30-10:25 and 40:20:50 NPK combinations. Two plant populations of 4.44 lakh (22.5 × 10 cm) and 3.33 lakh (30 × 10 cm) plants ha^{-1} were also included. The field under experimentation was low in available nitrogen, medium in available phosphorus and low in exchangable potassium showing the values of 198, 41.6, 140 Kg ha^{-1} respectively with low exchangable calcium (1.8 me/100 g/soil and pH of 6.6.

The data in Table 1 indicated that application of 500 Kg ha^{-1} gypsum in addition to NPK (F_7 and F_8 treatments) significantly increased number of filled pods per plant, 100 pod weight, 100 kernel weight and shelling percentage by 12.2, 8.0, 7.5 and 5.6 per cent respectively as compared to NPK alone (F_5 and F_6). Application of NPK (F and F^6) on an average increased 100 kernel weight by 7.2 per cent as compared to NP combinations (F_3 and F_4). The characters like days to 50 per cent flowering and oil content in seed were not influenced either by fertility levels of plant densities.

Maximum pod yield of 28.85 q/ha was obtained with 40 N + 20 P + 50 K + 500 gypsum Kg ha^{-1} (F_8) which was on par with 30 N + 10 P + 25 K + 500 gypsum Kg ha^{-1} (F_7) treatment and these were superior to rest of the fertility levels. Supply of calcium and sulphur in the form of gypsum alongwith NPK (F_7 and F_8) on an averag increased pod yield by 10.6 per cent over NPK application (F_5 and F_6), which in turn gave 10.2 and 8.2 per cent more pod yield than NP (F_3 and F_4) and N alone (F_1 and F_2) respectively. Low calcium content of soil might have resulted in better response of the crop by gypsum application. Similar results of favourable influence of gypsum application on yield and yield attributes of groundnut were reported by Radder and Biradar (1973), Loganathan and Krishna Murthy (1977) and Chandrasekhra Reddy and Patil (1980).

Plant population did not influence the pod yield and yield components except volume weight of pods, which was higher at plant density of 3.3 lakh plants ha^{-1} compared

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TABLE 1. Pod yield and yield components of groundnut as influenced by fertility levels and plant densities

Treatmentr		Days to 50% flow-ering	No. of filled pods/ plants	Volume weight (g/l)	Shelling percentage	100 pod weight (g)	100 kernel weight (g)	Pod yield g/ha	Oil content %
F_0 :	No fertilizers	31	11.3	225.8	70.3	79.5	29.8	21.33	48.01
F_1 :	30 N Kg	30	12.2	249.3	69.9	80.2	30.4	19.76	47.98
F_2 :	45 N Kg	31	12.4	245.8	74.4	81.2	31.3	23.17	48.10
F_3 :	30 N + 10 P Kg	32	12.2	238.3	71.0	82.8	32.1	22.06	48.00
F_4 :	45 N + 20 Kg	30	14.6	240.8	73.6	85.5	33.8	24.53	48.14
F_5 :	30 N + 10 P 25 K Kg	32	13.9	241.3	74.2	84.0	35.1	25.62	48.20
F_6 :	40 N + 20 P + 50 K Kg	31	14.8	239.1	73.3	86.6	35.6	25.75	48.10
F_7 :	30 N + 10 P + 25 K Kg + 500 gypsum Kg at 30 DAS	32	16.1	255.8	77.6	89.1	37.3	28.00	48.12
F_8 :	40 N + 20 P + 50 K Kg + 500 gypsum Kg at 30 DAS	33	16.2	265.0	78.1	85.0	38.7	28.85	48.33
	CD at P = 0.05	NS	1.3	0.7	0.42	1.98	1.27	2.10	NS
P_1 :	4.44 lakh plant (22.5 × 10 cm)	30	13.7	241.6	73.1	84.1	33.5	24.08	48.12
P_2 :	3.33 lakh plant (30.0 × 10 cm)	31	13.8	247.6	74.2	85.7	34.0	24.55	48.01
	CD at P=0.05	NS	NS	0.7	NS	NS	NS	NS	NS

NS = Not significant.

to 4.44 lakh plants ha^{-1}. The interaction between fertility levels and plant densities for yield and all yield components were not significant. Pod yield was positively correlated with number of filled pods plants^{-1} (r = 0.9304) 100 pod weight (r = 0.9027), 100 kernel weight (r = 0.9683) and shelling percentage (r = 0.9415). Similar results were reported by Choudhary *et al.* (1977). The results indicated that it is economical to adopt a fertility level of 30 N + 10 P + 25 K + 500 gypsum Kg ha^{-1} and plant density of 3.33 lakh plants ha^{-1} (30 × 10 cm) in sandy loam soils of Rayalaseema region of Andhra Pradesh.

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BOOK REVIEW

Sunflower in Maharashtra by C.D. Mayee and V.B. Shelke, *Technology Transfer Bulletin*—1, M.A.U. Parbhani—431 402.

Sunflower has become an important annual oilseed crop in India and is widely cultivated in Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh. Sunflower cultivation is possible round the year due to its thermo and photo-insensitivity. Short duration, high adaptability, drought and salinity tolerance and good response to limited irrigation make sunflower a most choiced crop both under rainfed and irrigated conditions by the cultivatrs. Sunflower also fits well in multiple and intercropping systems due to several advantages. Location specific informations on the various aspects of sunflower cultivation is not readily available. The authors of Sunflower in Maharashtra-a Technology Transfer Bulletin can justifiably claim to have produced a comprehensive. Objectively analytical and thoroughly informative bulletin, that will be found to be extremely useful to those interested in transfer of technology on Sunflower production. The extension worker will find this an excellant reference book, as information of such wide spectrum as has been provided which is hardly be expected to be available from any other single source. Availability of quality seed is one of the constraints which is coming in the way of large scale cultivation. Therefore, relevant information provided in ths book which include different steps of varietal / hybrrd seed productions for achieving quality seed will help the extension worker as well as farmers in production of quality seed.

Diseases and pests are gradually becoming more serious for continuous and wide scale cultivation in many parts of the country. Recently downy mildew has some how been introduced in our country and become most serious disease in Maharashtra. Authors have elaborately presented the various types of symptoms produced by the disease to educate the extension worker as well as the farmers for identify the disease easily. It will also help to tackle the disease more effectively.

Finally authors have provided a list of practices to be followed step by step for successful cultivation of sunflower which is not only pertinent to Maharashtra but it can be successfully used in other state too by altering it a little.

As a whole, it is an excellent Technology Transfer Bulletin.

Satyabrata Maiti.

INFORMATION FOR CONTRIBUTORS

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