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SHORT COMMUNCIATIONS

Genetic divergence its relationship with heterosis and character association among seed yield and its components traits in Indian mustard

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ABSTRACT

Seven parents alongwith their 21 F_1 hybrids were assessed for genetic divergence, association and heterosis with respect to seed yield and other quantitative characters. The progenies were grouped into five clusters, clusters 1, possessed 2 parents and 8 hybrids followed by Cluster II which exhibited 2 parents and 7 hybrids. The Cluster III, IV and V included 1 parent each and 3, 2 and 1 hybrids respectively. The association analysis indicated that characters like primary branches, seeds per siliqua, plant height, 1000 seed weight and days to maturity be given due importance for making worthwhile improvement in Indian mustard. There was no correspondence between the divergence of parents in crosses and the heterosis exhibited by hybrid combinations.

Key words : Heterosis; Genetic divergence; Character association; Indian mustard; *Brassica juncea*

INTRODUCTION

Indian mustard (*Brassica juncea* L. Czern and Coss), an important oil yielding crop constitute approximately 80 per cent of the total production of rapeseed and mustard in India. But, very limited success has been attained by breeders to break the yield plateau. It may be attributed due to the narrow genciic base in the material available with the breeder. Therefore, the selection of parents on the basis of genetic divergence is important because more diverse the parents, the greater are the chance of obtaining larger amount of heterosis in F_r's and broad spectrum of variability in segregating generations. Several workers (Moll

et al., 1962; Miller and Masani 1963; Peter and Rai, 1976; Narsinghani *et al.*, 1978) have successfully made use of genetic divergence for the selection of parents in different crop species. In this manuscript, attempts have been made to discuss the genetic divergence, its relationship with heterosis and asssociation among 7 parents and its 21 hybrids for yield and its contributing attributes in Indian mustard.

MATERIALS AND METHODS

Seven parents namely Prakash, RL 18, RH 30, T 59, Laha 101, D.M. and Rai B/85 alongwith their 21 F_1 hybrid combination obtained by crossing them in all possible combinations (excluding reciprocals) were grown at the oilseed research farm of Haryana Agricultural University, Hisar. The progenies which included the parents and F_1's were grown in a randomized block design represented by a single row plot of 4·5 meter length with a spacing of 30 x 15cm. The crop was rasied with full package of practices like application of 80 kg N/ha at the time of sowing, two irrigations (i.e., one at the time of flowering and the other at pod formation stage) and control measures to protect the crop from insect pests and diseases. Five random competitive plants were tagged in each progeny to record observations on the following quantitative traits namely seed yield (g), days to maturity, days to first flowering. days to 50 per cent flowering, plant height, primary branches, secondary branches, siliqua length, seeds per siliqua, 1000-seed weight and total siliquae. Further the data recorded for all the above traits were subjected to biometerical analysis (Rao, 1952) to study the diveasity in characters using D^2 technique. The correlation and path coefficient analysis were done as per Aljibouri *et al.*, (1958) and Dewey and Lu (1959) respectively. Heterosis measured as the increased or decreased seed yield of F_1 over better parent was also computed to see its relationship with genetic divergence.

RESULTS AND DISCUSSION

The analysis of variance on the basis of plant average revealed significant differences among the progenies including parents and F_1's for all the traits indicating thereby the presence of considerable amount of variability. Wilk's crieterion test revealed highly significant differences among the progenies for the aggregate of all the characters. The 7 parents and its 21 hybrids were grouped into five clusters (Table 1). Clustes I possessed 2 parents and 8 hybrids followed by cluster II which exhibited 2 parents and 7 hybrids. The clusters III, IV and V included 1 parent each and 3, 2 and 1 hyhrids respectively. Usually, the hybrids and parents should have been grouped in the same cluster or in cluster having minimum distance between them because of close affinity between parents and their hybrids. But this does not holds true in the present results because a

Table 1 :   Grouping pattern of parents and their F_1's in five clusters

Cluster	Number of progenies	Progenies
I	10	Prakash, Prakash × RL-18, Prakash × Laha 101, RL-18 × Laha 101, RH-30, RH-30 × T-59', RH-30 × Laha 101, RH-30 × D. M., RH-30 × Rai B/85 and D. M. × Rai B/85.
II	9	Prakash × RH-30, Prakash × T-59. Prakash × D.M., RL-18, RL-18 × D. M., T-59, T-59 × D. M., T-59 × Rai B/85 and Laha 101, × D. M.
III	4	Rai B-85, RL-18 × RH-30, RL-18 × T-59 and T-59 × Laha 101.
IV	3	RL-18 × Rai B 85, Laha 101 × Rai B/85 and D. M.
V	2	Prakash × Rai B/85 and Laha 101.

particular parent and its hybrids failed to appear in   the same cluster but   were contrarily scattered among different clusters.   The present results were in confirmation to the findings of Chaudhary and Singh (1975) and Singh *et al.* (1981), who also observed that parents and their hybrids were distributed in   different clusters.   The intra-and intercluster D^2 and D values indicated maximum divergence between cluster I and V followed by that between cluster III and V (Table 2).   On the cotrary, least divergence appeared between cluster I and III. Further, the lowest (58.59) intracluster divergence was recorded for cluster IV possessing only 3 genotypes where as the highest (228.04) intracluster divergence was exhibited by cluster III comprising of only 4 genotypes. The high intercluster values and low intracluster values indicated that the genotypes grouped were heterogenous between and homogeneous within clusters.

The characterwise mean performance of progenies in 5 clusters indicated that cluster III had highest values for seed yield   (Table 3).   Besides seed yield, this cluster also exhibited appreciably high values for other yield contributing characters like primary branches, secondary branches, siliqua length, seeds per siliqua, total siliquae and 1000 seed weight.   Further, in order to confirm the results obtained on the basis of mean values, an attempt was made to correlate the seed yield with yield attributing traits using method proposed by Aljibouri *et al.* (1958) and further partitioning of genotypic correlation into direct and indirect effects using Dewey and Lu (1959).

Table 2 :   Average intra (diagonal) and inter cluster D values (above diagonal)

Cluster	I	II	III	IV	V
1	70.13	298.68	107.75	378 24	520.04
II		104.31	201.32	111.35	221.68
III			228.05	225.42	508.42
IV				58.59	167.53
V					0.0

The estimation of correlation coefficients both at genotypic and pheno-
typic level have been presented in Table 4.   The persual of data indicated the
higher magnitude of genotypic correlations. This suggested the presence of strong
inherent association among the various characters, the phenotypic expression of
a character in lessened under the influence of enviroment. Seed yield exhibited
significant positive association with days to maturity, primary branches, secon-
dary branches and 1000 seed weight. The results with regard to the association
of seed yield with days to maturity were in confirmation to the findings of Singh
et al. (1969), Yadava (1973) and Asthana and Pandey (1977). Few workers
like Singh et al. (1969) and Gupta (1972) confirmed the association of seed yield
with primary branches. The significant association of seed yield with 1000-seed
weight was in accordance to the results of Chaudhary (1967) and Singh et al.
(1969). Further, days to maturity possessed significant positive association wite
days to first flowering, days to 50 per cent flowering and plant height confirming
thereby the results of Singh et al. (1969), Gupta (1972) and Yadava et al. (1978).
Contrary to the findings of above workers days to maturity exhibited significant
negative association with seeds per siliqua. Days to first flowering and days to
50 per cent flowering were also correlated among themselves. The primary
branches exhibited significant positive association with secondary branches and
1000 seed weight. Siliqua length attained significant positive association with
total siliquae.

The genotypic correlations of seed yield with other attributes under study
were partitioned into direct and indirect effects, through other characters and
the results obtained, thereby, have been presented in Table 5. The trait siliquae
possessed maximum direct value (0.741) followed by primary branches (0.528),
seeds per siliqua (0 415), plant height (0.414) 1000 seed weight (0.320) days to

Table 3 : Characterwise mean performance of progenies in five clusters

Character	Seed yield	Days to maturity	Days to first flowering	Daps to 50 per cent flowering	Plant height	Primary branches	Secondary branches	Siliqua length	Seeds per siliqua	Total siliqua	1000 seed weight
I	26.32	154.95	49.33	56.82	224.63	6.10	15.09	3.78	13.48	544.97	3.83
II	21.41	144.33	44.89	51.70	201.49	5.28	13.27	4.01	13.93	470.68	4.37
III	36.31	151.11	45.44	52.66	213.85	6.22	15.50	4.10	14.55	669.94	4.33
IV	22.43	140.00	44.67	53.16	234.56	6.20	16.23	3.87	14.43	660.67	3.40
V	8.86	141.33	35.33	42.00	156.33	5.20	11.70	3.93	15.76	283.16	3.23

Table 4 : Phenotopic (above diagonal) and genotypic (below diagonal) correlation in Indian mustard

Character	Seed yield	Days to maturity	Days to first flowering	Days to 50 per-cent flowering	Plant height	Primary branches	Secondary branches	Siliqua length	Seeds per siliqua	1000-seed weight	Total siliquae
Seed yield	—	0.321*	0.088	0.055	0.260	0.422*	0.552*	0.127	0.076	0.640*	0.019
Days to maturity	0.390	—	0.465*	0.423*	0.515*	0.130	0.285	—0.180	—0.394*	0.182	0.026
Days to first flowering	0.116	0.554	—	0.657	0.575*	0.205	0.017	—0.069	—0.274	—0.121	—0.063
Days to 50 percent flowering	0.118	0.556	1.000	—	0.646*	0.088	0.049	—0.179	—0.300	—0.086	—0.080
Plant height	0.407	0.667	0.913	0.822	—	0.177	0.233	—0.159	—0.421*	0.087	—0.005
Primary branches	0.531	0.160	0.285	0.263	0.354	—	0.404	—0.068	0.200	0.397*	—0.373
Secondary branches	0.629	0.322	—0.003	0.115	0.331	0.473	—	—0.070	0.076	0.660*	—0.278
Siliqua length	—0.307	0.344	—0.390	—0.291	—0.315	—0.094	0.414	—	0.119	—0.084	0.334*
Seeds per siliqua	0.020	—0.530	—0.498	—0.472	—0.584	0.208	0.053	0.124	—	0.058	—0.270
1000 seed weight	0.728	0.202	—0.109	—0.118	0.176	0.423	0.713	0.788	0.096	—	—0.185
Total siliquae	0.014	0.022	—0.080	—0.102	0.006	—0.489	0.296	0.574	—0.344	—0.185	—

* significant at P = 0.05

Table 5 : Direct (diagonal) and indirect effects (off diagonal) on ssed yield

Character	Days to maturity	Days to first flowering	Days to 50 percent flowering	Plant height	Primary branches	Secondary branches	Siliqua length	Seeds per siliqua	1000-seed weight	Total siliquae	Correlation with seed yield
Days to maturity	0.284	0.433	—0.065	0.276	0.084	—0.024	—0.244	—0.471	0.064	0.046	0.390
Days to first flowering	0.067	0.281	—0.013	0.170	0.050	0.016	0.076	—0.436	—0.035	—0.060	0.116
Days to 50 percent flowering	0.161	0.139	—0.018	0.140	0.039	0.118	0.049	—0.413	—0.038	—0.060	0.118
Plant height	0.190	0.713	—0.875	0.414	0.187	0.004	0.223	—0.511	0.055	0.005	0.407
Primary branches	0.045	0.223	—0.303	0.126	0.528	0.005	0.067	0.131	0.085	—0.372	0.531
Secondary branches	0.092	—0.017	—0.136	0.137	0.249	0.011	0.294	0.046	0.228	—0.225	0.629
Siliqua length	—0.098	—0.304	0.051	—0.130	—0.193	—0.005	—0.109	0.108	—0.060	0.437	—0.307
Seeds per siliqua	0·153	—0.389	0.555	—0.242	0.109	0.043	—0.088	0.415	0.031	—0.261	0.020
1000 seed weight	0.058	—0.085	0.139	0.072	0.143	0.008	0.133	0.084	0.320	—0.143	0.728
Total siliquae	0.006	—0.062	0.119	0.003	0.058	0.023	—0.407	—0.290	—0.060	0.741	0.014

Table 6 : Heterosis (over better parent and mid parent) and genetic distance with respect to hybrids for seed yield

| Crosses | Heterosis over | | Genetic* distance. |
	Better parent %	Mid parent %	
RH-30 × Laha 101	98.98	109.98	375.15
RL 18 × D.M-	81.89	98.72	311.94
RH-30 × Rai B/85	80.37	140.20	275.66
T-59 × D.M.	76.00	90.88	154.56
Prakash × D.M.	63.19	80.00	342.83
Laha 101 × D.M.	57.66	71.06	393.04
Prakash × T-59	57.36	91.06	228.24
Laha 101 × Rai B/85	47.97	104.19	779.32
T-59 × Laha 101	42.56	66.46	251.02
RL 18 × Laha 101	41.52	42.71	57.66
RL 18 × T-59	35.54	59.37	286.26
Prakash × Laha 101	35.27	41.80	29.23
T-59 × Rai B/85	30.33	59.88	388.12
RL 18 × Rai B/85	27.90	77.41	77.41
Prakash × Rai B/85	22.08	73.42	653.10
RH-30 × D.M.	16.22	19.61	144.57
Prakash × D.M.	15.95	31.25	287,29
D.M. × Rai B/85	14.40	49.34	134.50
Laha 101 × D.M.	11.34	15.78	24.11
RL 18 × RH-30	3.65	10.24	351.70
RH-30 × T-59	3.01	14.70	102.70

* Distance among the varieties included in a particular cross

maturity (0.284) and days to first flowering (0.281). Remaining traits like days to 50 per cent flowering (—0.018). secondary branches (0.011) and siliqua length (—0.088) had either low or negative direct effects towards seed yield. The maximum direct effect of total siliquae was counter balanced mainly through the negative indirect effect of siliqua length and seeds per siliqua. Therefore; the highest positive direct contribution of this character was converted in low order negative correlation with seed yield. Days to maturity affected positively towards seed yield mainly via days to first flowering and plant height. Likewise plant height also had appreciably high indirect effect towards seed yield through days to first flowering   Secondary branches exhibited significant positive correlation with seed yield but on the contrary its direct effect was very low.

Few workers like Joshi and Dhawan (1966) and Anand and Murthy (1968) have laid out the importance of genetic diversity among the parents to be involved in crossing programme for better production. Keeping this in view, an attempt was made to work out the relationship between D^2 of the parents and the heterosis (over better parent) of hybrids for seed yield   The crosses have been arranged in descending order of heterosis. A cross RH-30 x Laha-101 exhibiting highest heterosis faild to show maximum genetic distance which indicated the absence of relationship between genetic distance and heterosis. In general, it was observed that crosses ataining high heterosis value do not necessarily possessed more genetic distance between varieties. The results with respect to the lack of association between genetic divergence and heterosis were in confirmation to the findings of Anand and Murty (1968), Chrudhary and Singh (1975) and Singh and Ramanujam (1961). Lack of association between the divergence of parents and vigour exhibited by hybrids may be attributed because of lack of optimal environment for the expression of heterosis, internal cancellation of the components of heterosis, cancellation due to varied response of the components of multiple character. Some times even more genetic divergence might itself result in non-realization of expected performance of the hybrids such as in case of Laha-101 x Rai B 85 where the genetic distance was maximum (779.32) but did not show much vigour (47.97 per cent).

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Association of some physiological determinants with seed yield in toria

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ABSTRACT

The study was conducted on 20 genotypes of toria and observations were recorded on different physiological traits like leaf area ratio (IAR), leaf area duration (LAD), crop growth rate (CGR), relative growth rate (RGR), at three phases (i.e. vegetative phase, pre-flowering phase, post bloom phase). The data with respect to harvest index (HI) was also recorded. The attribute like LAR (2nd phase), CGR (2nd phase) and harvest index (HI) showed positive significant correlation with seed yield. The negative significant correlation of seed yield were also observed with LAR (3rd phase) and CGR (1st phase). Path co-efficient analysis indicated that LAR (2nd phase), LAD (2nd phase),CGR (2nd phase) and harvest index besides affecting directly also affected seed yield indirectly through other component characters.

Key words : Correlation pathanalysis; toria; *Brassica campestris*; physiological determinants

INTRODUCTION

Yield is a quantitative character and the nature of its inheritance is complex. As Grafius (1952) pointed that there can be no gene for yield which can bypass the components. Koller (1971) has rightly pointed out that for the better understanding of the physiological basis of crop yield differances, it is essential that the components of growth in the plant community be quantified. There is an agreement among researchers that knowldege of physiological basis of yield will not substitute for an replace standard plant breeding procedure but would be an complementary effort. The green leaf suface is one of the important physiological atttributes considered for higher yield in crop plants because it represents a measure of photosynsthesis and also effects the net CO_2 exchange. The present study has been initiated to study the associations of seed yield with some physiological attributes.

MATERIALS AND METHODS

The present investigation was conducted on 20 genotypes of toria (*Brassica campestris* L. var. *toria*)   from different maturity groups, were grown in randomized block design consisting of three replications. Each genotype had 5 rows plots of 6m length with a spacing of 30 cm × 10 cm between and within respectively. Normal agronomic practices and plant protection measures were adopted.

For recording the data of physiological parameters 5 competitive plants were uprooted at each of the four stages viz. vegetative, pre-flowering, full bloom and post bloom stages i e. 20 days, 40 days, 60 days and 80 days after sowing respectively.   Leaf area was measured with the help of leaf area meter in cm^2. Harvested material was kept in a hot air oven at $80° ± 2°C$ for 48h and the total day matter was weighed.   In the present experiment, data were utilized to have three phases i.e. 1st phase obtained by substracting vegetative stage from preflowering stage, 2nd phase obtained by substracting pre-flowering stage from full bloom stage and 3rd phase was obtained by substracting full bloom stage from post bloom stage.

The physiological determinants namely LAR, LAD, CCR, RCR and HI were calculated (Radford, 1967).   Genotypic and phenotypic correlation co-efficients were calculated as per Aljibouri *et al.* (1958). The path coefficient analysis was done using the procedure of Dewey and Lu (1959).

RESULTS AND DISCUSSION

Correlation coefficient :

Results on correlation coefficients to genotypic (G) and phenotypic (P) leveles are presented in Table 1. The magnitude of correlation coefficient at genotypic level was higher than the corresponding phenotypic level for all the traits indicating a good extent of inherent association between various characters. Invariably the phenotypic expression was found to be reduced due to the environmental effect.   Kaw and Menon (1972) also reported similar results in soybean.

LAR (2nd phase) exhibited a positive significant correlation with seed yield. Wallace and Munger (1965) reported that the high leaf area and leaf area ratio go together and leads to the higher yield.   In kale and sugarbeet, Watson (1958) also demonstrated that LAR to be chief determinant of seed yield in contrast to the present findings. On the contrary Yadav *et al.* (1979) reported the lack of positive correlation of LAR (post flowering) with seed yield in green gram. LAD (2nd phase) possessed significant positive correlation with seed yield. Welabnk *et al.* (1966) found that LAD representing integrated leaf area over plant growth

Table 1 : Genotypic (G), phenotypic (P) correlations between seed yield and different physiological characters in toria

			LAR			LAD		
			1st phase	2nd phase	3rd phase	1st phase	2nd phase	3rd phase
	Seed yield	G	—0.316	0.560	—0.468	—0.347	0.628	—0.181
		p	—0.286	0.543*	—0.459*	—0.289*	0.572*	—0.170
LAR	1st phase	G		0.658	0.164	0.653	0.255	—0.048
		p		0.596*	0.134	0.609*	0 220	—0.039
	2nd phase	G			0.745	0.486	0.689	0.491
		p			0.727*	0.468*	0.582*	0.468*
	3rd phase	G				0.212	0.808	0.800
		p				0.188	0.800	0.694*
LAD	1st phase	G					0.462	0.088
		p					0.432	0.077
	2nd phase	G						0.786
		p						0.744*
	3rd phase	G						
		p						
CGR	1st phase	G						
		p						
	2nd phase	G						
		p						
	3rd phase	G						
		p						
RGR	1st phase	G						
		p						
	2nd phase	G						
		p						
	3rd phase	G						
		p						

* Significant at P = 0.05

Table 1 .   (Contd.)

CGR			RGR			HI
1st phase	2nd phase	3rd phase	1st phase	2nd phase	3rd phase	
—0.496	0.931	0.075	0.113	—0.038	0.193	0.636
—0.453*	0.885*	0.062	0.085	—0.028	0.190	0.528*
0.206	—0.460	0.245	0.226	—0.374	0.326	—0435
0.204	—0.397	0.160	0.224	—0.369	0.251	—0336
0.206	—0.468	0.219	—0.067	—0.278	0.349	—0.208
0.173	—0.444*	0.177	—0.041	—0.164	0.248	—0.201
—0.188	—0 365	0.175	—0.132	—0.265	0.290	0.009
—0.164	—0.307	0.166	—0.057	—0.250	0.171	0.008
—0.148	—0.458	0.236	0.250	—0 674	0.279	—0.397
—0.132	—0.431	0.095	0.193	—0.534*	0.269	—0.333
0.536	—0.111	0.120	—0.033	—0.173	0.071	—0.277
0.491*	—0.082	0.074	—0.029	—0.132	0.053	—0.231
0.084	0.166	0.255	—0.134	0.154	0.129	—0.093
0.084	0.168	0.202	—0.085	0.128	0.099	—0.046
	—0.172	0.211	0.719	—0.492	0.153	0.217
	—0.166	0.173	0.598*	—0.421	0.146	0.195
		—0.341	—0.196	0.885	—0.662	—0.088
		—0.228	—0.162	0.656*	—0.533*	—0.062
			0.261	—0.315	0.912	—0.216
			0.193	—0.239	0.900	—0.173
				—0.330	0.245	—0.201
				—0.227	0.217	—0.169
					—0.560	0.044
					—0.483*	0.028
						—0.047
						—0.042

Table 2 :   Direct (diagonal) and indirect (off diagonal) effects of different physiological
characters at genotypic level on seed yield in toria

		LAR			LAD		
		1st phase	2nd phase	3rd phase	1st phase	2nd phase	3rd phase
LAR	1st phase	—0.129	0.657	—0.290	—0.749	0.078	—0 041
	2nd phase	—0.085	0.999	—1.020	—0.556	0 671	0.423
	3rd phase	—0.021	0.744	—1.771	—0.243	0.247	0.680
LAD	1st phase	—0.084	0.485	—0.375	—1.145	0.141	0.075
	2nd phase	—0.033	0.689	—1.431	—0.029	0.706	0.677
	3rd phase	—0.006	0.490	—1.418	—0.100	0.240	0.862
CGR	1st phase	—0.026	—0.287	0.262	—0.613	0.026	—0.085
	2nd phase	0.059	—0·467	0.646	0.612	—0.034	0.143
	3rd phase	—0.032	0.219	—0.309	—0.270	0.037	0.220
RGR	1st phase	—0.029	—0.067	0.234	—0.286	—0.010	—0.115
	2nd phase	0.048	—0.277	0.470	0.572	—0.053	0.133
	3rd phase	—0.042	0.349	—0.513	—0.320	0.022	0.111
HI		—0.056	—0.208	—0.015	—0.455	—0.085	—0.080

Residual effect = 0.08

Table 2 :   (Contd.)

CGR			RGR			HI	Genotypic correlation with seed yield
1st phase	2nd phase	3rd phase	1st phase	2nd phase	3rd phase		
0.027	—0.218	—0.190	0.015	0.456	0.297	—0.229	—0.316
—0.025	—0.221	—0.170	—0.004	0.339	0.318	—0.109	0.560
—0.019	—0.372	—0.236	—0.069	0.324	0.264	0.004	—0.468
0.070	—0.218	—0.183	0.017	0.823	0.255	—0.208	—0.347
0.067	—0.052	—0.093	—0.002	0.211	—0.146	0.064	0.628
—0.012	—0.078	—0.198	—0.009	—0.189	0.1.8	—0.049	— 0.181
0.131	—0.081	—0.463	0.048	0.568	0.138	—0.114	—0.496
—0.023	0.473	0.264	—0.013	—0.080	—0.603	—0.046	0.931
0.028	—0.161	—0.775	0.017	0.384	0.831	—0.114	0.075
0.094	—0.093	—0.202	0.067	0.402	0.224	—0.106	0.113
—0.065	0.419	0.244	—0.022	—1.020	—0.510	0.023	—0.038
0.720	—0.313	—0.707	0.016	0.683	0.212	—0.025	0.193
—0.028	—0.041	—0.278	—0.013	—0.054	—0.043	0.526	0.636

cycle, was closely related to biological yield and was a particularly efficient attribute by virtue of its ability to integrate differences due to early vs late maturity of a genotype. Further Thurling (1974) also reported the importance of LAD after anthesis as a determinant of seed yield.

CGR was positively associated with seed yield at 2nd phase but attained negative significant correlation at 1st phase. Prasad *et al.* (1978) obtained reduced CGR during flowering and siliquae development.

In the present investigation, there was no significant correlation between RGR and seed yield but there was significant correlation of RGR and CGR. According to Wallace and Munger (1965) genetic differences for RGR occur due to genetic differences for LAR and / or NAR and when both contribute simultaneously to RGR.

Harvest index (HI) showed positive significant correlation with seed yield. Similar results were reported by Thurling (1974) in *Brassica campestris* and Mehrotra *et al* (1976) in Indian mustard.

Path coefficient analysis :

Path coefficient at genotypic levels indicating the extent of direct and indirect effects of yield components upon seed yield have been presented in Table 2. It was found out that correlation of LAD, LAR and CGR was positive at post anthesis period with seed yield. Harvest index also showed positive correlation with seed yield. These characters also showed high direct effect on seed yield. Besides these, positive direct effect of LAD (3rd phase) and CGR (1st & 3rd phase) were accompanied with negative correlation value.

Regarding indirect effects, LAR (2nd phase) contributed towards seed yield through LAD (2nd&3rd phase) and RGR (2nd & 3rd phase), LAD (2nd phase) had indirectly contributed towards seed yield via LAR (2nd phase), LAD (3rd phase), and RGR (2nd phase). CGR (2nd phase) was found to be contributing indirectly towards seed yield through LAR (3rd phase), LAD (1st phase) and CGR (3rd phase). HI was also observed to be contributing towards seed yield through CGR (3rd phase). The residual effect factor (0.08) indicated that the growth parameters under study constitutes 92 per cent of variability in seed yield.

In conclusion, it may be mentioned that the traits like LAR, LAD and CGR at post anthesis phase and harvest index are expected to be more significant for

higher yield in toria But, it is very difficult to measure these traits (LAR, LAD, CGR) in large breeding populations and, therefore, does not appear to be of much significance. However, HI could be used as a selection criterion in the future breeding programme aiming at the improvement of yield in toria.

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Leaf number and pod yield of groundnut

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ABSTRACT

The number of compound leaves (tetrafoliate leaves) produced upto different stages of post podding phase were positively related with pod numbers in groundnut (*Arachis hypogaea* L.) JL 24. At harvest the number of compound leaves present and nodes that held leaves and filled pod numbers were also positively related. The above were found during a season conducive for excessive vegetative growth (*Kharif* 1983) that had above optimal rainfall and was generally cloudy. The highly significant relationship between leaf numbers and pods is interpreted to be due to the integrated effect of the leaf area index (LAI) and its duration (LAD). This physiologically significant relationship was observed to have greater association with pod production than some of the known pod yield regulating characteristics.

Key words : *Arachis hypogaea* L.; Leaf and pod numbers

INTRODUCTION

The source sink dynamics regulate crop yields. These dynamics are influenced by the genetic make up and the crop environment (Apel 1984). Inspite of the general belief that the source in the groundnut is well developed and non-limiting, significant environmentally induced differences exist (Kanwar, *et al.* 1983).

The photosynthetic source is represented by the leaves that is the physiological basis for yield production measured as leaf area index (LAI) (Watson, 1947) and leaf area duration (LAD) (Woolhouse, 1981). This paper reports the integrating nature of leaf number and its relationship pod numbers during podding and their filling upto harvest just as the presently used yield regulating characters, and as observed by Prevot and Bilaz (1962) under drought conditions where a proportion between leaf number produced upto 65 days after sowing and yield was shown.

MATERIALS AND METHODS

Groundnut cultivars JL 24 (Valencia bunch) and Kadiri 2 (Virginia bunch) (were grown in a factorial randomised block design with the following treatment (T_1) plants were raised from kernels retained over a 9mm (9 mm diameter holed) sieve. Treatment 2 (T_2) Plants were raised from kernels retained over an 8 mm sieve but passing through a 9 mm sieve. Treatment 3 (T_3) plants were raised from kernels retained over a 7 mm sieve but passing through an 8 mm sieve Treatment 4 (T_4) plants were raised from kernels retained over 9, 8 and 7 mm, sieves mixed proportionately as they occurred in the original population of kernels of each cultivar.

In each treatment the seed rate by weight was maintained constant as a consequence, the spacing between plants plant population density varied. In T_1 the plants were spaced at 30×20 cm; in T_2 30×15 cm and in T_3 and T_4 30×10 cm in the case of JL 24. In Kadiri 2 spacing was maintained as in JL 24 in treatments 1, 2 and 3. The spacing in treatment 4 was at 30×15 cm. The gross plot size was 3.3×3.6 m with a net plot area of 2 1 x 3.0 m for JL 24 The gross plot size for Kadiri 2 was the same as for JL 24. The net plot size for Kadiri 2 was 2.6 x 2.5m All plots received 30:10:25 kg/ha N:P:K and each treatment was replicated into 4 randomised plots. Both the cultivars were sown on 14th July 1983 and JL 24 was harvested on 26th October 1983 while Kadiri 2 was harvested on 26th November 1983. At harvest data on all plants in the net plot area were recorded on leaf numbers and filled pods per plant in JL 24 and 160 plants per treatment drawn equally from the four replications were sampled in Kadiri 2.

Ten plant samples from the net plot area of each replication were collected at harvest and were pooled for observations on forty individual plants on numbers of leaves (pinnately compound tetrafoliate leaves present at harvest and leafless nodes), number of filled pods, number of primary and secondary branches and pod bearing nodes of JL 24.

During the post podding phenophase (40 days after sowing (DAS) plant samples were collected at 45 DAS, 60 DAS and 75 DAS. The leaf numbers including leafless nodes if any and the number of pods set upto that sampling occasion were recorded. Similar data were collected on four other cultivars and as similar trends were noted the same are not included.

RESULTS AND DISCUSSION

In the groundnut excessive vegetative growth during pod filling phase in either *kharif* or *rabi* is believed to cause loss on pod yield. Excessive vegetative

growth causing pod loss is believed to result from excessive rainfall/irrigation and cloudy weather.   However, the precise causes for excessive vegetative growth or the critical level of vegetative growth beyond which pod loss may result are not established.   The macroclimatic data presented in Table 1 show conditions con-ducive for excessive vegetative growth in terms of the total rainfall, its ·distribu-tion, the mean monthly sunshine hours and other parameters.   The vegetative growth was more than that observed during the previous two years of different macroclimatic conditions.

Table 1 :   Crop macroclimatic environment during the *kharif* 1983

Year and month	Mean temperature		Mean humidity		Total rainfall (mm)	No. of rainy days	Mean monthly hours	Evapora-tion (mm)
	Maximum	Manimum	F. N	A. N				
1933								
June	37.6	25,2	61	40	121.0	5	6.5	12.2
July	34.8	23.3	71	47	233.8	10	4.4	7.1
August	33.2	22.4	76	53	191.7	14	4.2	6.5
September	31.9	21.2	81	58	311.4	16	6.0	4.5
October	31.6	20.7	80	57	194.7	9	6.1	5.4

F.N :   Forenoon   A.N :   Afternoon

Data on leaf numbers including leafless nodes if any presented in Table 4 at 45, 60 and 75 days after sowing in JL 24 show a highly significant relation-ship with pods present at the above periods. This is indicative sink establishment on the vegetative photosynthetic source even at a relatively early phenophase.

At harvest the plants raised from bold kernels with wider spacing in T_1 exhibit maximum vegetative development compared with the other treatments in both JL 24 and Kadiri 2.   From the data presented in Table 2 and 3 showing plant and yield characteristics were the leaf number at harvest is regressed over filled pod numbers the vegetative growth did not exceed the cut off levels from which point vegetative growth may have caused pod yield loss. It was also obser-ved that filled pod numbers increased with leaf numbers upto about 230 per plant in JL 24 and the pod numbers increased upto about 430 compound leaves produ-ced in Kadiri 2 as *evident from the data of standard deviations   presented in*

Table 3 and as observed from the unprocessed data. Thus vegetative growth as represented by the numbers of compound leaves produced promotes greater pod load establishment and production of filled pods.

Table 2 : Leaf area at emergence (6 DAS) and at complete depletion of cotyledonary reserves (15 DAS) biomass and harvest parameters of groundnut grown from four different kernel grades at three spacing levels.

	Leaf area per plant at		Biomass g/plant at				100-Pod weight (g)	100-kernel (g)	Shelling (%)	Yield per (kg)
	6 DAS	15 DAS	20 DAS	40 DAS	60 DAS	80 DAS				
JL 24										
T_1	33.02	181.24	1.84	11.50	28.24	45.18	136.72	52.52	77.57	2515.9
T_2	28.87	149.95	1.66	9.75	25.62	32.92	127.91	52.80	78.82	2765.9
T_3	28.48	125.26	1.42	8.33	15.24	23.83	130.12	50.80	76.67	2511.9
T_4	32.25	141.82	1.57	12.88	17.38	24.05	133.35	54.00	77.67	2535.7
KADIRI 2										
T_1	25.01	130.73	1.64	13.48	23.11	43.53	117.82	37.37	74.45	2569.2
T_2	25.32	109.89	1.47	8.60	20.73	30.64	119.00	44.82	74.27	2288.5
T_3	20.36	83.66	1.13	8.23	14.75	20.07	125.20	47.97	74.20	2596.2
T_4	20.10	106.88	1.31	9.63	21.03	27.53	115.82	40.12	73.05	2146.2

DAS = Days after sowing.

The data of filled pods per plant, their leaf numbers of all treatmental populations presented in Table 3 show a strong positive interlocking relationship between leaf numbers at harvest and pod yields. However from the data of intercept as leaf numbers were regressed over filled pods per plant presented in the same table the minimal number of leaves required for the plants metabolic maintenance and for vegetative growth at which no pod production can occur shows an increasing trend from T_3 and T_4 to T_2 and T_1. Thus the large plants with larger leaf number snot only produced larger filled pod numbers but also have a greater demand for maintenance and growth. Similar relationship between leaf

Table 3 : Fil'ed pods per plant of total treatments in four replications

	Net plot population	Mean filled pods per plant	Mean leaf number per plant	Crrelation coefficient (r)	Slope	Intercept on pods (leaf number required for '0' pod production)
JL 24						
T_1	313	16.8 ± 4.2	139.4 ± 28.6	0.597*	4.09	70.50
T_2	468	12.6 ± 3.8	104.7 ± 25.0	0.636*	4.21	51.71
T_3	647	8.2 ± 3.1	75.1 ± 18.9	0.728*	4.43	38.76
T_4	650	8.1 ± 2.9	80.4 ± 20.6	0.603*	4.23	45.94
KADIRI-2						
T_1	160	15.1 ± 6.3	260.9 ± 82.5	0.556*	7.74	143.83
T_2	160	9.9 ± 5.0	193.3 ± 78.4	0.737*	11.54	78.54
T_3	160	8.9 ± 3.7	170.9 ± 56.5	0.829*	12.66	58.00
T_4	160	10.4 ± 5.2	260.0 ± 84.2	0.731*	11.89	82.16

* Significant at 93.9%

Table 4 : The relationship between leaf numbers and podding (numbers of developing pods) at different stages of pod gro*w*th in groundnut (*Arachis hypogaea* L.) JL 24

	Population examined	Mean pod numbers per plant	Mean leaf number per plant	Correlation coefficient r	Slope	Intercept
45 DAS	60	4.05 ± 2.3	41.6 ± 14.1	0.503*	0.155	-0.234
60 DAS	90	9.27 ± 2.8	56.58 ± 18.5	0.882*	4.492	14.949
75 DAS	120	10.46 ± 4.1	55.25 ± 18.2	0.817*	3.454	19.113

* Significant at 99.9%

Table 5　The relative significance of pod yield regulating characteristics in groundnut
(*Arachis hypogaea L.*) JL 24

		T_1	T_2	T_3	T_4
Mean leaf number/plant		151.6 ± 28.2	113.3 ± 21.3	86.8 ± 18.8	80.7 ± 18.1
Mean filled pod numbers/plant		16.7 ± 3.9	12.4 ± 2.9	9.6 ± 2.9	9.3 ± 2.2
Leaves at harvest and filled	r	0.657	0.687	0.815	0.654
pods per plant	Slope	4.554	4.754	5.345	5.486
	Intercept	76.148	51.424	35.239	29.514
Leaves at harvest and peimary	r	0.513	0.341	0.202	0.197
branches per plant	Slope	13.356	10.501	7.274	6.789
	Intercept	77.103	71.508	59.529	52.033
Leaves at harvest and	r	0.449	0.450	0.569	0.415
secondary branches per plant	Slope	0.681	8.121	6.498	4.842
	Intercept	122.087	95.175	76.491	72.416
Primary branches and filled	r	0.320	0.344	0.178	-0.041
pods per plant	Slope	0.079	0.087	0.033	-0.009
	Intercept	3.880	2.871	3.371	4.312
Secondary branches and	r	0.328	0.338	0.488	0.244
filled pods per plant	Slope	0.147	0.168	3.281	0.176
	Intercept	1.923	0.250	-1.185	0.072
Pod bearing nodes and	r	0.818	0.739	0.666	0.755
filled pods per plant	Slope	1.021	0.919	0.945	1.038
	Intercept	2.668	3.195	2.253	2.029
Leaves at harvest and pod	r	0.591	0.705	0.558	0.511
bearing nodes	Slope	5.284	6.074	5.247	5.883
	Intercept	79.248	49.523	45.623	39.355

numbers and filled pod numbers was noted by us in different cultivars and under a range of experimental and farmers field conditions. During the *Kharif* based on the performance of individuals, comprising a population, a strong relationship

with large plants and larger per plant yield production was observed. The same was noted with reference to the plants drought tolerance/avoidance where large individuals in a population remains normal while the smaller succumb (Ramesh Babu and Rao, 1983).

The ratio or proportion between the number of leaves at harvest and the filled pods number along with the intercept of the regression line indicate the minimal leaves required for production of photosynthates for metabolic maintenance and growth. This ratio was noted to be an elastic character that varies with cultivar and crop environment. Yet, these attributes may be gainfully employed for 1. selection for greater photosynthetic partitioning to pods, when the material for selection were subjected to uniform growth environment and 2. for agronomic manipulations to increase pod yield.

The relative significance of this relationship (between leaf numbers and filled pod yield) and the other yield regulation attributes like the number of primary and secondary branches per plant and pod bearing nodes data on 40 samples of each treatment were present in Table 5. Amongst these characters leaf number at harvest has the strongest relative significance other than pod bearing nodes and pod numbers. Therefore, the source and sink relationships in the groundnuts and possibly in other legumes may be represented by an easy to measure leaf numbers and pod production compared with the existing techniques. This relationship also takes merit from the complex physiological regulation that exists with reference to the leaf initiation, appearance and expansion, that add to the leaf area at different stages and leaf senescence and death that substract from the area and as the factors responsible for development and death of leaves known to be of greater significance in determining crop yields (Monteith and Elston, 1983).

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Identification of parents for hybridization through combining ability analysis in Indian mustard

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ABSTRACT

Fortytwo hybrids, obtained by crossing 14 female lines with 3 male testers, alongwith parents were evaluated in randomized block design with 3 replications. Mean data on 12 quantitative traits were analysed using line × tester analysis. Mean squares due to genotypes, parents, crosses, lines, testers and line × testers were significant for most of the characters except days to flowering and maturity. The general combining ability effects indicated that parent P11/7-1 was best among testers exhibiting high gca values for seed yield, number of secondary branches, plant high and 1000 seed weight. Among lines, RC 1263 was characterized best exhibiting high gca values for seed yield and its component traits like primary branches, secondary branches, plant height, siliqua on main raceme and oil content. Similarly RC 1258 also attained appreciably high gca effects for seed yield and other yield contributing characters. The use of genetically promising lines for their use in hybridization programme is advocated. A cross combination RC 48 × P11/7-1 was found best specific combiner for seed yield, number of secondary branches and number of siliqua on main raceme. The use of such crosses in multiple crossing programme followed by intermating is also advocated.

Key words : Hybridization; Combining ability; Indian mustard; *Brassica juncea* L.

INTRODUCTION

Among the various oil yielding crops grown in India, the Indian mustard, is next to groundnut in area and production due to built in capacity for high yield potential. Therefore, the genetic information with respect to seed yield and its component traits would be of immense help in devising an effective breeding programme for this crop. Line x tester appeared to be most appropriate mating design as it assessed the breeding potential of larger number of parents than diallel etc. Keeping this in view, the line x tester analysis comprising of 14 lines and 3 testers was undertaken to identify parents on the basis of combining abilities for hybridization in Indian mustard.

Table 1 : Analysis of variance and combining abilities in Indian mustard

Source	d. f.	Seed yield	Days to flowering (first)	Days to flowering (50%)	Days to maturity	No. of primary branches
Replications	2	0.14	5.84	0.18	2.50	8.27
Treaments	58	83.29*	4.81*	4.13*	4.23*	4.29*
Parents	16	45.47*	11.69*	9.99*	9.82*	3.37*
Parents vs crosses	1	973.06*	0.50	3.45	1.40	20.48*
Crosses	41	76.35*	2.23	1.86	2.12	4.25*
Females	13	134.44*	2.88	2.38	4.65	1.58*
Males	2	42.98*	3.39	2.64	3.04	9.45*
Females x Males	26	88.57*	1.60	1.42	1.47	1.86*
Error	116	0.22	2.12	1.98	1.85	0.45

* Significant at 5%

Table 1 :   (Contd.)

No. of secondary branches	Plant height	No. of siliqua on main raceme	Siliqua length	Seeds per siliqua	1000 seed weight	Oil content
1.15	35.30	1.45	0.20	0.93	0.05	3.73
48.05*	790.21*	74.48*	0.12*	7.67*	0.37*	8.34*
46.86*	971.11*	67.70*	0.10*	4.81*	0.29*	4.16*
355.86*	8897.80*	1050.98*	0.18	3.08*	2.65*	135.43*
41.01*	521.87*	53.31*	0.13*	8.89*	0.34*	6.87*
45.05*	1631.65*	41.75*	0.22*	14.73*	2.08*	18.90*
56.07*	974.10*	72.58*	0.25*	14.69*	0.32*	8.55*
33.18*	210.38*	44.56*	0.07	5.55*	0.22*	5.10*
1.05	10.56	1.60	0.05	0.50	0.03*	0.36

MATERIALS AND METHODS

Fourteen promising lines of Indian mustard (*Brassica juncea* (L.) Czern and Coss) viz., RC48, RC55, RC 105, RC 116, RC 212, RC 213, RC 279, RC 365, RC 440, RC 1203, RC 1220, RC1221, RC 1258 and RC1268 and 3 testers, Prakash, RLM198 and P11/7-1, selected from the germplasm lines and advanced breeding material of oilseed section, H.A.U., Hisar, were crossed to produce 42 F_1 hybrids. The lines and testers were selected on the basis of genotypic variability. Tester Prakash was stable and RLM 198 was resistant to aphid. P11/7-1 was most stable for yield and yield components. Hybrids alongwith their parents were sown in a randomized block design with 3 replications during 1980-81. Each genotype was accommodated in a single row of 3 meters spaced 45 cm between rows and 15 cm within rows. All the normal and recommended cultural practices were followed to raise a good crop. Data on 5 randomly selected competitive plants were recorded on 12 characters. Oil content was determined by N. M R. Combining abilities were estimated following Kempthorne (1957).

RESULTS AND DISCUSSION

Mean squares due to treatments including parents and F_1's were significant for all the characters (Table 1) indicating the presence of sufficient genotypic variability in the present material. Similarly, mean squares due to parents, crosses and parent vs crosses were significant indicating that variable parents have created enough variability in the hybrids for most of the characters, except days to flowering and maturity. It was further, confirmed by the range of variation for mean values. The range was high among the hybrids as compared to the parental means indicating that much variability has been generated through hybridization, which can, further, be exploited by selecting better promising genotypes.

The variance (mean squares) due to lines, testers and line x tester were significant for all the characters, except days to flowering and maturity. However, line x tester mean squares were non-significant for siliqua length. The magnitude of variance for lines and testers, in general, were higher than variance due to lines x testers for most of the characters (Table 1) indicating prepondrance of additive variance.

An examination of combining ability effects (general) showed that the parent RC 48 exhibited highest general combining ability effects for seed yield followed by RC1268, RC105, RC 213 and RC1258 (Table 2). A parent RC 116 was earliest to flower as it possessed highest significant negative gca effects for days to flowering. This parent also recorded highest significant positive gca effects for 1000 seed weight. Further, RC1268 was identified a good general

combiner for primary branches, secondary branches, plant height and siliqua on main raceme as it possessed highest significant positive gca effects for these traits. The other general combiners like RC 213 for siliqua length and RC 55 , and RC 213 for seeds per siliqua were categorized as best. However, for oil content, RC 1203 attained maximum gca effect closely followed by RC1268 and RC1258. Finally, an attempt was also made to spot out a parent possessing desirable gca effects for most of the traits. The results revealed that RC 1268 was the good general combiner for most of the characters. Further, RC1258 was second best parent showing high gca effects for seed yield and other important attributes. Among testers, P11/7-1 was characterized best due to desirable gca effects for seed yield, secondary branches, plant height and seed size. The use of above genetically promising lines for their appropriate use in hybridization programmes for the improvement of seed yield is advocated. An attempt was also made to see the correlation of gca effects and *per se* performance. The results indicated the absence of such correlations in the material at hand. The *per se* performance as such, therefore, does not quantify for effective use in judging the combining ability of parents (Yadava *et al.*, 1981).

The results of specific combining affects (sca) of hybrids indicated that the crosses having significant high sca effects, involved good, average and poor general combining parents (Table 3). It was observed that a cross combination RC 48 $\times$ P11/7—1 was best having highest *per se* performance and significant positive sca effects for seed yield. Interestingly, it involved good general combiners as parents. This cross is expected to yield transgressive segregants which can further be identified and isolated by following conventional breeding programmes. In addition to seed yield, this cross was best for number of secondary branches and siliqua on main receme. For number of primary branches, RC55 $\times$ P11/7-1 was best specific combiner involving high and poor combiners. Further, RC1203 x RLM 198 was best specific combiner for increased plant height (high x high), RC55 x P11/7-1 for seeds per siliqua (high x poor), RC213 x P11/7-1 for 1000 seed weight (poor x high) and RC440 x Prakash for oil content (medium x poor). It was really interesting to note that all these crosses exhibiting high sca effects had appreciably high *per se* performance for their respective traits. This situation is very important from breeding point of view because only high sca effects of any cross will not lead to much improvment unless it is associated with high *per se* performance.

The above results have clearly indicated that none of the cross combinations in the present material was good for all the yield attributes simultaneously. Therefore, it would be worthwhile to attempt multiple crosses using F_1's exhibiting high *per se* performance and sca effects. Further, at least one, preferably both parents of these hybrids should be good general combiners. Such a programme is likely to be effective in bringing the additive genes together and thus,

Table 2 :   Estimates of general combinig ability effects of parents in Indian mustard for different characters

Parents	Seed yield	Days to first flowering	Days to 50% flowering	Days to maturity	Number of primary branches	Number of secondary branches
Testers (**Males**)						
Prakash	—1.36*	—0.27	—0.24	—0.33	0.22	—1.14*
RLM198	—0.67*	0.60	0.00	0.00	—0.14	0.25
P-11/7—1	2.03*	0.26	0.24	0.33	—0.08	0.88*
S. E.	0.14	0.30	0.32	0.31	0.14	0.21
Lines (**Females**)						
RC 48	4.10	—0.08	—0.52	—1.10	—1.35*	—1.35*
RC 55	0.07	0.48	0.48	0.57	1.16*	1.20*
RC 105	1.56*	0.03	0.03	0.13	0.16	—0.44
RC 116	0.19	—1.30*	—1.30	—1.21	—1.35*	1.78
RC 212	—0.98*	—0.08	0.03	0.02	—0.67*	0.33
RC 213	1.36*	—0.19	—0.19	—0.10	0.30	—3.74*
RC 279	—1.48*	—0.19	0.03	0·13	—1.18*	—2.91*
RC 365	—1.78*	0.52	—0.52	—0.43	—0.38	2.15*
RC 440	—2.16*	0.37	0.37	0.46	—0.23	1.75*
RC 1203	0.01	0.14	0.14	0.13	0.72*	—3.09*
RC 1220	—3.10*	0.03	0.03	0.02	1.08*	—0.91
RC 1221	—2.48*	0.03	—0.08	0.02	—0.54	—1.82*
RC 1258	1.07*	0.92	0.70	0.57	0.17	1.86*
RC 1268	3.61*	1.03	0.81	0.79	2.12*	5.19*
S. E.	0.23	0.65	0.69	0.66	0.31	0.51
r	—0.13	—0.01	0.03	0.03	0.47	—0.09

Table 2 :   (Contd.)

Plant height (cm)	Number of siliqua on main raceme	Siliqua length (cm)	Seeds per siliqua	1000-seed weight (g)	Oil content (%)
—4.68*	—1.08*	0.06	0.54*	—0.17*	—0.50°
7.08*	0.89*	0.02	0.09	—0.08	0.76*
—2.40*	0.19	—0.08	—0.63*	0.25*	—0.26*
0.55	0.25	0.06	0.15	0.04	0.11
—12.86*	—0.22	0.11	0.89*	—0.15	—0.93*
4.50*	—0.52	0.03	1.80*	0.13	0.10
—4.65*	3.63*	0.09	0.01	—0.18*	—0.22
—10.26*	—0.79	—0.08	—1.12*	0.38*	0.73*
3.47*	—2.32*	—0.10	—0.52	0.03	—0.13
2.84*	—2.52*	0.24*	1.74*	0.06	—0.85*
—12.05*	1.90*	0.19	0.93	—0.12	—0.22
—5.91*	—2.54*	0.12	0.43	—0.12	—0.06
—4.88*	—2.18*	—0.16	—2.15*	0.28*	0.68*
13.75	3.04*	0.11	0.77	—0.11	1.38*
—2.20	—1.87*	—0.48*	—0.48	—0.13	—1.19*
—1.31	—2.14*	—0.38*	—2.45*	—0.11	—0.68*
3.87*	—1.67*	0.16	0.33	0.08	0.17*
—25.69*	6.64	—0.08	—0.19	—0.30	1.32
1.17	0.52	0.11	0.32	0.08	0.25
0.48	0.16	0.46	0.27	0.27	—0.11

Table 3 : Specific combining ability effects in Indian mustard

Crosses	Seed yield	Days to first flowering	Days to 50% flowering	Days to maturity	No. of primary branches	No. of secondary branches
1	2	3	4	5	6	7
RC-48 × Prakash	—6.60	—0.18	—0.10	—0.33	—0.20	—0.83
RC-55 × ,,	2.01	0.26	0.24	0.33	—0.08	2.54
RC-105 × ,,	6.54	0.04	0.02	0.11	0.42	0.67
RC-116 × ,,	—0.17	—1.29	—1.32	—1.22	—0.43	—1.18
RC-212 × ,,	—1.13	—1.18	0.02	—0.11	0.16	3.34
RC-213 × ,,	2.31	0.60	0.57	0.87	0.18	—1.66
RC-279 × ,,	—3.69	—0.40	—0.65	—0.56	—1.20	—0.68
RC-365 × ,,	—0.92	0.26	0.24	0.33	0.13	—3.21
RC-440 × ,,	2.26	0.04	0.02	0.11	0.71	—1.78
RC-1203 × ,,	—1.40	0.26	0.24	0.11	0.57	1.89
RC-1220 × ,,	—2.76	0.37	0.35	0.22	—0.13	—2.88
RC-1221 × ,,	1.60	0.71	0.46	0.56	—0.98	0.89
RC-1258 × ,,	—2.65	0.15	0.35	0.00	0.38	0.27
RC-1268 × ,,	4.61	—0.63	—0.43	—0.22	0.49	1.58*
RC-48 × RLM-198	—8.24	—0.11	0.00	—0.33	—0.13	—4.77
RC-55 × ,,	—4.87	—1.00	—1.00	—1.00	—1.38	—3.12
RC-105 × ,,	—0.87	0.44	0.44	0.44	0.22	1.85
RC-116 × ,,	3.87	0.78	0.78	0.78	—0.01	4.43
RC-212 × ,,	2.40	0.56	0.44	—0.56	—0.68	—1.52*
RC-213 × ,,	2.02	—1.00	—1.00	—1.00	0.81*	0.28
RC-279 × ,,	0.97	0.00	—0.22	—0.22	0.36	—4.08
RC-365 × ,,	5.51	0.67	0.67	0.67	—0.37	—0.28
RC-440 × ,,	0.36	0.78	0.78	0.78	0.01	1.79
RC-1203 × ,,	5.83	0.33	0.33	—0.44	—0.64	2.37
RC-1220 × ,,	—2.23	—0.56	—0.56	—0.44	—0.24	—0.01
RC-1221 × ,,	1.27	—0.56	—0.44	—0.44	—0.92*	3.23
RC-1258 × ,,	—1.21	0.22	—0.22	0.00	0.28	1.95
RC-1268 × ,,	—4.80	—0.56	0.00	—0.22	0.60	—2.11

Significant at P = 0.05

Table 3 : (Contd.)

Plant height	No. of siliqua on the main raceme	Siliqua length	Seeds per siliqua	1000-seed weight	Oil content
8	9	10	11	12	13
—9.82	—0.47	0.06	—0.61	—0.16	—0.10
0.73	—3.12	0.17	—1.76	0.21*	—1.25
4.21	—2.97	0.03	0.16	0.39	—0.45
5.43	5.63	0.06	—0.12	—0.10	—0.97
—0.17	1.61*	0.04	1.58	—0.25*	0.89
6.19	—1.19	—0.09	1.23	—0.04	1.01
1.86	—2.01	0.03	0.41	0.14	—0.26
4.74	—2.37	—0.09	—0.34	—0.33	—0.63
1.24	4.21	—0.20	—0.10	0.07	2.01
—12.46	—0.95	0.04	0.50	0.02	1.60
5.10	—3.97	0.12	0.61	—0.19	—0.63
—2.59	—3.70	—0.08	—1.39	0.32	0.72
7.83	—0.03	—0.06	—0.34	—0.03	—0.95
—8.59	—1.35*	—0.03	0.16	—0.05	—1.00
2.01	—5.65	—0.15	0.38	0.25*	—0.15
—3.02*	—1.02	0.18	—1.44	—0.31	1.77
5.32	—4.50	—0.07	—0.82	—0.06	0.66
—12.06	—6.47	—0.01	—1.76	—0.18	1.44
—3.59*	—2.49	—0.12	—0.85*	—0.01	—1.61
—0.83	2.41	0.07	0.89*	—0.36	0.34
—0.52	2.62	0.11	0.64	0.08	1.45
—4.28	—1.34*	0.14	0.57	0.32	1.19
—12.94	—0.36	—0.06	0.20	—0.02	—2.02
13.66	1.55*	—0.04	—0.09	0.34	—0.93
—1.25	2.86	—0.26	—1.52	0.19	—0.45
6.06	3.13	—0.10	—0.73	—0.16*	—1.83
—1.85	1.13	0.05	0.30	0.05	0.30
2.26	—0.58	0.15	0.68	—0.07	—0.18

Table 3 :   (Contd.)

1	2	3	4	5	6	7
RC-48 × P11/7-1	14.83	0.29	0.10	0.67	0.07	5.60
RC-55 × ,,	2.86	0.34	0.76	0.67	1.46	1.58
RC-105 × ,,	—5.66	—0.47	—0.46	—0.56	—0.64	—2.51
RC-116 × ,,	—3.70	0.52	0.94	0.44	0.44	—3.25
RC-212 × ,,	—1.27	—0.37	—0.46	—0.44	0.53	—1.82
RC-213 × ,,	—4 33	1.40	0.43	0.33	—0.99	0.38
RC-279 × ,,	2.72	0 4 1	—0.87	0.78	0.84*	4.76
RC-365 × ,,	-4.58	—0.93	-0.91	0.00	0.24	3.49
RC-440 × ,,	-2.72	-0.82	—0.80	—0.89	—0.82*	—0.04
RC-1203 × ,,	—4.43	-0.60	-0.57	—0.56	0.07	-4.20
RC-1220 × ,,	5.00	0.18	0.21	0.22	0.37	2.89
RC-1258 × ,,	3.86	-0.37	-0.13	0.00	—0.65	—2.22
RC-1221 × ,,	—2.87	—0.15	—0.12	—0.11	0.06	—4.13
RC-1268 × ,,	0.19	1.18	0.43	0.44	—1.06	0.53
S. E. (D)	0.40	1.12	1.19	1.16	0.52	0.52

* Significant at $P = 0.05$

fixable through selection. Multiple crossing programme initiated between RC48 x P11/7-1, RC55 x P11/7-1, RC116 x RLM198, RC 1203 x RLM 198 and RC213 x P11/7-1 followed by relative intermating seems to be most appropriate for best utilization of the present material aimed at further improvement as pointed out by Jensen (1970).

Table 3 : (Contd.)

8	9	10	11	12	13
7.82	6.12	0.10	0.22	—0.09	0.24
2.89*	4.14	—0.35	3.20	—0.09	—0.53
—9.53	—7.46	0.03	0.67	—0.33	—0.21
6.63	0.84	—0.06	—1.64	0.28	—0.47
3.75	0.88	0.08	—0.73	0.26*	0.72*
—5.36*	0.92	0.01	—2.12	0.40	—1.37
—8.67	—0.61	—0.13	—1.05	—0.22	—1.19
—0.47	—1.03	—0.04	—0.24	0.01	—1.56
11.70	—3.85	0.14	—0.10	—0.05	0.02
—1.20	—0.61	—0.01	—0.41	—0.36	—0.68*
—3.85	1.10	0.14	0.91*	—0.10	1.11
5.98	—1.10	0.01	0.03	—0.02	0.63
—3.47*	0.57	0.18	2.12	—0·10	1.11
6.33	1.93	—0.10	—0.84*	0.13	1.16
2.05	0.90	0.20	0.57	0.14	0.45

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Root cation exchange capacity of mustard varieties in relation to age and fertility levels in growth medium

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ABSTRACT

Root C. E. C. of different varieties of mustard, an important oilseed crop, grown in quartz sand and soil with varying levels of nitrogen and phosphorus showed the significant influence of both nitrogen and phosphorus in increasing the C.E.C. value. Significant varietal differences were observed. Change in root C.E.C. was also observed due to physico-chemical properties including fertility levels of different soils. There was no variation between root C.E.C. of fresh roots. The highest C.E.C. value was observed for the variety, Varuna.

INTRODUCTION

The concept of exchange adsorption as the first step in the nutrient uptake by the roots of higher plants has gained ground in recent years. The determination of C.E.C. of the roots and the above concept are linked together. Smith and Wallace (1956) obtained increased C.E.C. values for the roots of a few crops with the increase in nitrogen levels. Huffaker and Wallace (1959) reported the influence of phosphorus level on root C.E.C. of soybean. The C.E.C. of plant roots is highly affected by varieties and age of the crop which has been reported by some workers (Ram, 1980; Sarkar, 1969; Singh and Ram, 1973). The purpose of the present study was to determine whether there was any difference of root C.E.C. among newly introduced varieties of mustard, an important oilseed crop at different stages of growth and how these root C.E.C. values differed when grown in soil or quartz sand under different nutritional levels of nitrogen and phosphorus. The determination of root C.E.C. of the

newly introduced varieties of mustard grown in a number of other soils belonging to different agro-climatic zones of West Bengal with diverse physico-chemical properties was also made with a view to find out any possible variation of the root C.E.C. with the type of soil.

MATERIALS AND METHODS

The experiments were carried out in pots at the net house. Four varieties of mustard, (*Brassica juncea*) namely B-85 (V_1), RW-351 (V_2), Varuna (V_3) and RW-85/59 (V_4) were sown in quartz sand for one month with Hewitt's nutrient solution (control-N_0P_0) and giving three different treatments (60 kg. nitrogen/hectare-N_1P_0, 30 kg phosphorus/hectare-N_0P_1 and 60 kg nitrogen/hectare + 30 kg phosphorus/hectare-N_1P_1) in addition to the nutrient solution to determine the effect of nitrogen and phosphorus on root C.E.C.

In another set of experiment, all the above four varieties were grown in Kalyani soil (alluvial sandy loam, pH 6.7), taken in a pot with different nutrient treatment combinations (control-N_0P_0, 60 kg N/ha. -N_1P_0, 30 kg P/ha- N_0P_1 and 60 kg N/ha + 30 kg P/ha-N_1P_1) like before to determine their root C.E.C. at three stages of growth, *viz.* 30 days after sowing (D.A.S) (Stage-I), 60 D.A.S. (Stage-II) and at maturity (Stage-III).

The varieties of mustard were also grown for one month in seven different soils of Nadia (Kalyani) Burdwan, Midnapur (Garbeta) Murshdabad, (Kandi) 24-Parganas (Basirhat), Bankura and Jalpaiguri to see the influence of soil type on root C.E.C.

The important properties of all the soils were determined by the methods given by Jackson (1967) and Piper (1942) in their respective treatises. The soils had pH values varied from 5.1 to 7.6, C.E.C. values in meq./100g. varied from 6.30 to 17.73, O.C, (%) varied from 0.41 to 1.72, total N(%) varied from 0.060 to 0.210, available P (%) varied from 0.004 to 0.009, available K (%) varied from 0.010 to 0 019, exch. Ca (meq/100 g) varied from 2 to 8.10, exch. Mg (meq/ 100 g) varied from 1.10 to 8.45, sand (%) varied from 51.50 to 65.50, silt (%) varied from 21.80 to 32. 45 and clay (%) varied from 10.50 to 14.68. Three replications for each variety with all treatments at each stage were made and 20 plants were retained in each pot. The root samples ware collected at correct time for the different experiments and their C.E.C. values were determined by acid washing methods proposed by Crooke (1964). Three replications of each sample were taken for each determination. In all the cases root C.E.C. was determined taking dry roots, but at the second stage of growth C.E.C. of fresh roots was also determined for comparing with root C.E.C. of dry roots.

RESULTS AND DISCUSSION

The root C.E.C. of different varieties of mustard, an important oilseed crop grown in sand medium with nitrogen and phosphorus treatments are presented in Table 1. Perusal of Table 1 reveals that increasing level of nitrogen and phosphorus influence the root C.E.C. significantly. There was also

Table 1 : Root C. E. C. of different varieties of mustard, grown in sand medium in relation to nitrogen and phosphorus fertility

Treatment	C. E. C. of roots (me q./100 g)			
	Variety			
	V_1	V_2	V_3	V_4
N_0P_0	21.93	23.03	24.73	20.40
N_0P_1	23.30	25.23	26.03	21.73
N_1P_0	23.47	26.80	28.10	22.60

Mean effects	C. E. C. of roots (me q./100 g.)	Mean effects	C.E.C. of roots (me q./100 g.)
Variety		Nitrogen	
V_1	23.33	N_0	23.29
V_2	25.97	N_1	25.92
V_3	26.98	C. D. (P = 0.05) 0.27	
V_4	22.15	Phosphorus	
C. D. at (P = 0.05) 0.38		P_0	23.92
		P_1	25.30
		C. D. (P = 0.05) —0.27	

significant effect of variety x nitrogen interaction. Smith and Wallace (1956) obtained increased root C.E.C. value with the increase in nitrogen level. Influence of phosphorus level on root C.E.C. of soybean was reported by Huffaker and Wallace (1959) but it was reported by Sarkar (1969) on maize and wheat that there was no significant difference of root C.E.C. due to various phosphorus

levels ; it was due to lower concentration of phosphorus treatment. Effect of nitrogen on root C.E.C. was more than that of phosphorus. There was also significant difference in root C.E.C. among varieties. Significant varietal effects were also reported by Ram (1980) and Sarkar (1969). The root C.E.C. of V_3 was highest among the varieties studied.

Table 2 : Root C.E.C. of different varieties of mustard in relation to nitrogen and phosphorus fertility at different stages of growth

| Treatment | C.E.C. of roots (meq./100 g.) | | | | | | | | | | | |
| | Stage-I | | | | Stage-II | | | | Stage-III | | | |
	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4	V_1	V_2	V_3	V_4
N_0P_0	22.40	24.20	25.50	20.40	21.60	22.80	23.60	20.20	20.50	20.60	20.60	20.00
N_0P_1	24.00	26.60	27.80	22.00	22.50	24.50	26.00	21.40	20.40	20.20	20.73	20.40
N_1P_0	23.90	27.60	29.00	22.60	23.20	25.40	26.10	22.00	20.20	20.20	20.80	20.60

| Mean effects | C.E.C. of roots (meq. / 100 g.) | | |
Variety	Stage-I	Stage-II	Stage-III
V_1	23.83	22.95	20.38
V_2	26.63	24.88	20.40
V_3	28.18	25.88	20.78
V_4	22.20	21.70	20.42
C. D. (P = 0.05)	0.326	0.264	0.246
Nitrogen			
N_0	24.06	22.83	20.44
N_1	26.35	24.88	20.55
C.D. (P = 0.05)	0.231	0.186	N.S.*
Phosphorus			
P_0	24.45	23.11	20.44
P_1	25.96	24.59	20.55
C.D. (P = 0.05)	0.231	0.186	N.S.*

N.S. = Not significant.

The C.E.C. of different varieties of mustard roots with nitrogen and phosphorus treatments at different stages of growth are presented in Table 2.

Table 3 : Comparison of C.E.C. of fresh-roots and dry roots of mustard varieties at Stage-II growth

| Treatment | C. E. C. of roots (meq./100 g.) | | | | | | | |
| | V_1 | | V_2 | | V_3 | | V_4 | |
	Fresh roots	Dry roots	Fresh roots	Dry roots	Fresh roots	Dry roots	Fresh roots	Dry roots
N_0P_0	21.60	21.60	22.83	22.80	23.67	23.60	20.27	20.20
N_0P_1	22.27	22.50	24.28	24.50	26.20	26.00	21.27	21.40
N_1P_0	23.30	23.2)	25.43	25.40	26.20	26.10	22.13	22.0)
N_1P_1	24.38	24.50	26.90	26.80	27.80	27.80	23.30	23.20

| Mean effects | C.E.C. of roots (meq/ 100 g) | |
Variety	Fresh roots	Dry roots
V_1	22.88	22.95
V_2	24.86	24.88
V_3	2g.97	25.88
V_4	21.74	21.70
C. D. (P = 0.05)	0.279	0.264
Nitrogen		
N_0	22.80	22.83
N_1	24.90	24.88
C. D. (P = 0.05)	0.197	0.186
Phosphorus		
P_0	23.18	29.11
P_1	24.54	24.59
C. D. (P = 0.05)	0.197	0.166

reveals that varieties were significantly different from each other in relation to C.E.C. of roots at first two stages of growth which supports the results of first experiment. At the third stage there was no significant difference of root C.E.C. among V_1, V_2 and V_4. The trend of root C.E.C. of different varieties is changed after 60 days age. The C.E.C. of roots was highest at Stage-I growth and continued to reduce as crops reached to maturity which supports the work of Ram (1980) and Singh and Ram (1973) on paddy and wheat crops. Root C.E.C.

Table 4 : Root C.E.C. of different varieties mustard grown in different soils of West Bengal

Soil	Root C.E.C. (meq/100 g)			
	V_1	V_2	V_3	V_4
Nadia	22.40	24.20	25.50	20.40
Burdwan	22.70	24.33	25.50	21.53
Midnapur	21.92	23.57	23.80	20.10
Murshidabad	22.83	24.50	25.67	21.40
24-Parganas	22.27	24.00	24.23	20.23
Bankura	22.17	23.70	24.08	20.00
Jalpaiguri	22.47	24.17	25.17	20.33
Mean effects	*C.E.C. of roots (meq/100 g)*			
Variety				
V_1	22.39			
V_2	24.07			
V_3	24.84			
V_4	20.57			
C. D. (P = 0.05)	0.189			

was also significantly different due to nitrogen and phosphorus addition in soil at Stage-III growth due to unavailability of added nitrogen and phosphorus to plants after 60 days age. Interaction effect of variety x nitrogen on root C.E.C.

was also singificant at first two stages of growth, but interaction effect of nitrogen x phosphorus and variety x nitrogen x phosphorus was significant only in Stage-1 and interaction effect of variety x phosphorus was significant only in Stage-II.

It can be observed from comparing the root C.E.C. of different varieties of mustard grown in sand medium and soil medium that root C.E.C. was less in most of the cases when the varieties of mustard were sown in sand medium. This was probably due to extra nutrients in soil medium.

From the data presented in Table 3, it is indicated that the C.E.C. of fresh roots was more or less equal with C.E.C. of dry roots. Helmy and Elgabaly (1958) also reported that there was no variation between C.E.C. of fresh roots and dry roots. The effects of N and P on root C.E.C. were same in case of fresh root.

The data presented in Table 4 reveal that there was difference in root C.E.C. due to diverse physico-chemical properties of different soils of West Bengal. Root C.E.C. was highest in Murshidabad soil and lowest in Midnapur soil. It can be reported that among soil separates, effect of clay particles on root C.E.C. was more pronounced. Root C.E.C. was increased due to increase in clay percentage, but the root C.E.C. was decreased in acidic soil. It was also observed that there was direct relation of nitrogen, phosphorus, calcium and magnesium with root C.E.C., but that relation was affected in strongly acidic soil. No such direct relations of other nutrients such as organic carbon and potassium with root C.E.C. was observed. Varietal effects on root C.E.C. was observed in each soil.

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Effect of different irrigation schedules and fertility levels on yield and yield attributes of linseed

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ABSTRACT

Results revealed that the crop irrigated at branching stage alone or in combination with flowering or capsule formation stage produced significantly superior yield attributes such as plant height, number of branches/plant, number of capsules/plant, number of grains/capsule and number of grains/plant which ultimately produced highest grain yield per plant and per unit area. Increasing levels of fertilizer application from 0:0.0 to 60.40 20 kg N:P:K/ha showed spectacular increase in higher grain and straw yield. Irrigation at branching + flowering stages (I_4) with 60:40:20 kg N:P:K/ha (F_2) gave the highest net return.

Key words : *Linum usitatissimum* L.; Irrigation schedules; Fertility levels

INTRODUCTION

Linseed is an important oilseed crop for its industrial value. India, with over two million hectares under linseed cultivation, accounts for about 25 per cent of the total world area, ranking first in area, fourth in production and eighth in productivity. Madhya pradesh ranks first in both area and production among the linseed growing states of India. However, the productivity (209 kg/ha) in this state is low as compared to the national average (266 kg/ha). The low productivity warrants the attention of research workers to find out the causes of low productivity and ways to improve it. Growing of linseed in unirrigated areas with rare or unbalanced use of fertilizer appear to be major causes of its low productivity. Linseed is extensively grown in rice growing tracts of central India after the harvest of rice which normally delays the sowing of linseed. The crop faces increasing moisture stress and high temperature during capsule formation

and grain filling stages causing severe setback to the yield. Thus an investigation was undertaken to ascertain the suitable irrigation schedule and fertilizer dose for linseed grown after the harvest of paddy.

MATERIALS AND METHODS

The experiment was carried out at the research farm of J.N. Krishi Vishwa Vidyalaya, Jabalpur, during the *rabi* season of 1983-84. The soil of the experimental plot was sandy clay in texture with 7.8 pH, low in available N (265 kg/ha), medium in available P_2O_5 (19 kg/ha) and K_2O (186 kg/ha) contents. The experiment was laid out in split plot design keeping irrigation schedules in main plot and fertility levels in sub-plots with three replications. The treatment details are given in Table 1.

Table 1 : Details of irrigation schedules and fertility levels

Treatment	Notation
Main plot treatments - Irrigation schedules	
1. No irrigation	I_0
2. One irrigation at branching stage (B)	I_1
3. One irrigation at flowering stage (F)	I_2
4. One irrigation at capsule formation stage (C)	I_3
5. Two irrigations at B + F stages	I_4
6. Two irrigations at B + C stages	I_5
7. Two irrigations at F + C stages	I_6
8. Three irrigations at B + F + C stages	I_7
Sub-plot treatments - Fertility levels	
1. 0:0:0 kg N:P.K/ha	F_0
2. 30:20:10 kg N:P.K/ha	F_1
3. 60:40:20 kg N:P:K/ha	F_2

Newly evolved variety Pratibha (SPS 23-10) was sown on November 11, 1983 using 30 kg seed/ha. The gross plot size was $4 \times 3 \, m^2$ accommodating 15

rows spaced 20 cm apart. The crop was irrigated by flooding method of irriga-
tion as per schedule of irrigation. The required quantities of fertilizer as per
treatments were applied as basal dose by drilling before sowing. The irrigation
scheduled at branching, flowering and capusle formation stages were at 35, 55
and 75 days after sowing respectively. Two hand weedings were done at 25 and
50 days after sowing.

Observations were recorded for plant population/m row length, plant height,
number of branches/plant, number of capsules/plant, number of grains/capsule,
number of grains/plant, test weight, grain weight/plant, grain and straw yield/ha.
Results were statistically analysed as per the procedure suggested by Pance and
Sukhatme (1967).

RESULTS AND DISCUSSION

The uniform germination and crop stand under all the treatments at
15 days after sowing (Tabla 2) reveal that the field retined suifficient residual
moisture after the harvest of irrigated rice during the preceding season.

Effect of irrigation schedule:

It is evident from the data (Thable 2) that irrigation scheduled at branching
alone (I_1) or in combination with flowering or capsule formation stages (I_4, I_5 and
I_7) were significantly superior to the rest of the irrigation schedules with respect
to growth characters like plant height and primary branches/plant. Similarly,
yield attributing characters *viz.*, capsules/plant, grains/capsule, grains/plant and
grain weight/plant were also found to be superior in the crop irrigated at branch-
ing stage alone (I_1) or supplemented with irrigation at other stages *viz.*, flowering
or capsule formation stages (I_4, I_5 and I_7). Consequently, grain and straw produc-
tion per hectare were also high with these schedules of irrigation (Table 2).
The above mentioned yield attributing characters have positive association with
the grain yield of linseed as similar results were also reported by Gupta and
Godawat (1981). Branching stage has been found to be the most critical one for
irrigation as when the irrigation was missed at this stage could not been compen-
sated for by provision of irrigation at flowering and capsule formation stages (I_2, I_3
and I_6). Similar findings were also reported by Drewit (1980) and Koshta and
Battawar (1981).

Effect of fartility levels :

Increasing levels of fertility from control (F_0) to 60:40:20 kg N:P: K/ha
(F_2) showed tremendous increase in the height of plant and number of branches/
plant. Similarly, fertilizer application with increased rate resulted in the

production of superior yield attributes *viz.*, number of capsules and grains/plant, grains/capsule, test weight and grain weight/plant which ultimately enhanced the grain production significantly. The beneficial effects of fertilizer application have been reported by several workers (Singh *et. al.*, 1982). Similarly, increasing levels of fertility from 0:0:0 to 60:40:20 showed apprarent increase in the straw yield per hectare.

Effect of irrigation schedule x fertility levels :

Though both the grain and straw yields increased with the combination of higher fertility levels (F_2) and irrigation scheduled at branching stage alone (I_1) or in combination with other stages (I_7, I_5 and I_4), but the rate of increase was high in first increment of fertilizer dose from control (F_0) to 30:20:10 kg N:P: K/ha (F_1) but the rate of increase declined with further addition of fertilizer dose. Similar results were also reported by Pande *et al.* (1970).

Economics of the treatments :

The economics and net return per hectare showed spectacular variations due to different irrigation schedules and fertility levels. Maximum net return per hectare (Rs. 2881.23) was under the treatment when single irrigation was given at branching stage (I_1). Other treatments which received irrigation in addition to branching stage fetched considerably good net return ranging from Rs. 2200 to Rs. 2600/ha. The treatment with no irrigation at branching stage gave the profit of less than Rs. 2303/ha (Table 2).

Fertilizer application was quite remunerative in linseed crop. The unfertilized linseed crop resulted in the lowest income of Rs. 1619.20/ha (Table 2). But addition of Rs. 315 and Rs. 630/ha as a cost of fertilizer under F_1 and F_2 fertility levels gave the addtional profit of Rs. 920.60/ha and Rs. 1669.40/ha respectively.

Among the different treatment combinations (Table 3), irrigation at branching + flowering stages with 60:40:20 kg N:P: K/ha (I_4F_2) gave the highest net return of Rs. 3737.15/ha followed by Rs. 3546.85 under irrigation at branching stage with 60:40:20 kg N:P: K/ha (I_1 F_2) and Rs. 3500.20/ha with irrigation at branching + flowering + capsule formation stages with 60:40:20 kg N:P: K/ha (I_7F_2).

Table 2 : Mean plant population, growth characters and yield attributes as influenced by different irrigation schedules and fertility levels

Treatment	Plant population/ m row	Plant height (cm)	No. of branches/ plant	No. of capsules/ plant	No. of grains/ capsule
Irrigation Schedules :					
I_0	44.15	56.86	5.13	21.6	5.72
I_1	43.15	64.50	5.34	29.2	7.13
I_2	43.48	58.80	5.12	21.6	5.90
I_3	43.68	60.08	5.32	21.6	6.00
I_4	39.20	63.86	6.35	28.10	6.81
I_5	45.13	65.32	6.10	28.0	6.69
I_6	46.95	59.27	5.30	22.5	6.18
I_7	44.18	64.67	6.32	28.8	6.98
SE ±	1.19	1.44	0.18	0.67	0.11
CD (P = 0.05)	NS	4.37	0.55	2.04	0.34
Fertility levels :					
F_0	45.26	55.15	4.43	16.60	5.78
F_1	43.97	63.05	5.59	24.60	6.50
F_2	42.00	67.56	6.82	34.30	7.00
SE ±	0.01	0.62	0.06	0.88	0.05
CD (P = 0.05)	NS	1.77	0.17	2.54	0.15

NS = Non significant

Table 2.   (Contd.)

No. of grains/ plant	Grain weight/ plant (g)	Test weight (g/1000 seed)	Grain yield (kg/ha)	Straw yield (kg/ha)	Net return (Rs.)
127	0.97	7.58	967	2562	2356.56
217	1.34	7.84	1133	2827	2881.23
130	1.07	7.53	980	2532	2397.51
135	0.98	7.46	950	2678	2257.48
196	1.11	7.86	1065	2832	2607.81
191	1.13	7.92	1050	2889	2504.70
141	1.01	7.63	969	2385	2277.75
207	1.32	7.73	1066	3000	2577.30
5.3	0.06	1.30	29.73	67.93	—
16.1	0.18	NS	90.17	205.24	—
96	0.86	7.30	705	1810	1619.20
163	1.11	7.60	1048	2758	2539.81
244	1.32	6.10	1317	3571	3288.61
2.7	0.02	0.05	9.47	35.07	—
7.9	0.05	0.15	27.21	100.02	—

Table 3 : Economics of treatment combinations (per hectare)

Treat-ments	Yield (kg/ha)		Return (Rs./ha)		Gross Income (Rs/ha)	Total cost of cultiva-tion (Rs./ha)	Net Income (Rs./ha)
	Grain	Straw	Grain	Straw			
I_0F_0	599	1779	2096.50	266.85	2363.35	1026.50	1336.85
I_0F_1	1024	2688	3584.00	403.20	3987.20	1449.50	2537.70
I_0F_2	1279	3221	4476.50	483.15	4959.65	1764.50	3195.15
I_1F_0	847	2130	2964.50	319.50	3284.00	1158.65	2125.35
I_1F_1	1174	2961	4109.00	444.15	4553.15	1581.65	2971.50
I_1F_2	1410	3390	4935.00	508.50	5443.50	1896.65	3546.85
I_2F_0	569	1896	1991.50	284.40	2275.90	1026.50	1249.40
I_2F_1	1082	2675	3787.00	401.25	4188.25	1449.50	2738.75
I_2F_2	1290	3026	4515.00	453.90	4968.90	1764.50	3204.48
I_3F_0	725	1571	2537.50	235.65	2773.15	1084.55	1688.60
I_3F_1	930	2682	3255.00	402.45	3657.45	1507.55	2149.90
I_3F_2	1197	3780	4189.50	567.00	4756.50	1822.55	2933.95
$I4F_0$	727	1835	2544.50	275.25	2819.75	1158.55	1661.10
I_4F_1	1030	2679	3605.00	401.85	4006.85	1581.65	2425.22
I_4F_2	1439	3982	5036.50	597.30	5633.80	1896.65	3737.15
I_5F_0	788	1831	2758.00	174.65	3032.65	1216.70	1815.95
I_5F_1	1034	2798	3619.00	419.70	4038.70	1639.70	2399.00
I_5F_2	1328	4039	4648.00	605.85	5253.85	1954.70	3299.00
I_6F_0	621	1532	2173.50	229.80	2403.30	1084.55	1318.75
I_6F_1	1072	2520	3752.00	378.00	4130.00	1507.55	2622.45
I_6F_2	1214	3104	4249.00	465.60	4714.60	1822.55	2892.05
I_6F_0	768	1909	2688.00	286.35	2974.35	1216.70	1757.65
I_7F_1	1044	3065	3654.00	459.75	4113.75	1639.70	2474.05
I_7F_2	1386	4026	4851.00	603.90	5454.90	1954.70	3500.20

Note : Price of N, P&K Rs. 5.90, Rs. 6.10 and Rs. 1.60 per kg respectively. Price of linseed grain
and straw @ Rs. 3.50 and Rs. 0.15 per kg respectively.

Cost of irrigation @ Rs. 111.15 and Rs. 37.05/ha for the first and subsequent irrigation,
respectively.

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Physiological aspects of yield improvement in Brassica species with reference to plant density II yield and yield components

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ABSTRACT

The seed yield of mustard cv Pusa Bold (*Brassica juncea*) and rapeseed cv Pusa Kalyani (*B. campestris*). and its components in relation to plant density and irrigation was analysed under field conditions during the *rabi* (winter) seasons of 1980 and 1981. The total number of branches per m^2, pod number per m^2, 1000-seed weight and the number of seeds per pod were altered by population density. Seed yield of both cultivars increased with increasing plant density per unit area. Pusa Bold out yielded Pusa Kalyani with increase in plant density from 15 to 22 plants per m^2. Correlation studies revealed that total pod number, pod number on secondary branches and total dry matter were positively correlated with yield, but the proportions remained unaltered at different levels of plant density. Combination of irrigation with higher plant density gave maximum seed yield of 478 to 497 g/m2 in the two clutivars. The study suggests that plant density can be increased beyond 44 plants per m^2 with beneficial effects on yield.

Key words : Rapeseed-mustard physiology; plant population; yield and yield components

INTRODUCTION

In India, by traditon the two rapeseeed-mustard species, *Brassica campestris* and *B. juncea* are grown in mixed cropping systems (e.g. with wheat, barley and chickpea) or as a secondary rainfed crop during *rabi* (winter) season. More recently the trend has been towards monoculture of these species which has raised the question of planting them at much higher densities. Kondra (1975) and Clark and Simpson (1978) reported increased yields with increased seeding rates for *B. napus* while Degenhardt and Kondra (1981), Borthakur and Borthakur (1981) and Scarisbrick *et al.* (1982) found no increase in yield with increased

population density with the same species. There is clearly a pressing need to resolve this matter for *Brassica* species grown under Indian conditions (Patel *et al.* 1980 ; Bhan *et al.* 1980). In our earlier paper (Khader and Bhargava, 1984) it was concluded that total dry matter production increased significantly with increasing plant density and irrigation, and approximately 85 to 90% of the total dry matter accumulated after flowering. In the present paper we measure the yield and yield components of *Brassica* species grown at various plant densities, the greatest of which was three time greater than traditional practice.

MATERIALS AND METHODS

Experiments were carried out during the *rabi* winter seasons of 1980-81 and 1981-82 at Indian Agricultural Research Institute, New Delhi with *Brassica campestris* cv. Pusa Kalyani commonly known as Brown Sarson and *Brassica juncea* cv. Pusa Bold also known as rai, raya and mustard. The dates of sowing were 16th and 22nd October in 1980 and 1981 cropping seasons respectively. The experiment was based on a split plot design with three replications with irrigation as main plot and variety and spacings as sub-plot treatments. Two irrigations were given - one at flowering and other at pod filling stage. The plot size was 5×5 m with three levels of spacing. Plant to plant distance was kept constant at 15 cm while row spacings were 15, 30 or 45 cm; giving plant populations of 44, 22 or 15 plants per m^2 respectively. The desired population was maintained by thinning 15 days after sowing. All the plots received basal fertilizer of 40 kg N, 40 kg P_2O_5 and 40 kg K_2O per hectare prior to sowing. During the crop growth, 105 and 188 mm of rainfall were experienced by the plants in 1980-81 and 1981-82 seasons respectively. At maturity, the plants in one square metre area were cut at ground level and yield and yield components determined. Seed number per pod was counted in each of 10 pods from each replicate and 1000 seed weight was determined on hand counted seeds taken from yield samples. Statistical analysis was carried out by the analysis of variance technique (Cochran and Cox, 1967) for split plot design.

RESULTS

The growth of the crop in two seasons showed similar trends and hence only the results of the first season are described in detail. Total branch number per m^2 increased considerably with irrigation and increasing plant population .Pusa Bold exhibited superior branching vigour than Pusa Kalyani. Closer spacing increased branch number to 692, 500 and 468 under 44, 22 and 15 plants per m^2 spacing respectively (Table 1). Pod number increased with irrigation and spacing. There was significant difference between cultivars with Pusa Bold having the greater number of pods. With increase in plant population the pod

number increased with respective mean values of 3621, 4862 and 7679 for 15, 22 and 44 plants per m². Seed number per pod was not affected by irrigation, The cultivar Pusa Kalyani had more seeds per pod (15.1) than Pusa Bold (13.2).

Table 1 : Yield and yield components in relation to plant density and irrigation

Treatments	Total branch No/m²	Total pod	Seed No./pod	1000 seed weight(g)	Yield (g/m²)	Biological yield (g/m²)	Harvest index
Irrigation							
Unirrigated	485.5	4821.6	13.9	4.31	352.0	1118.9	31.8
Irrigated	621.1	5953.8	14.3	4.60	424.9	1430.7	30.0
C.D. (P = 0.05)	87.1	630.9	NS	0.20	52.2	109.9	1.6
Cultivar							
Pusa Bold	650.2	6056.9	13.2	4.90	410.0	1489.5	27.6
Pusa Kalyani	456.7	5717.8	15.1	3.98	368.6	1059.5	34.2
CD (P = 0.05)	11.6	104.1	0.2	0.03	5.7	29.8	0.4
Plant density (cm)							
15 × 15	692.2	7679.0	13.2	3.91	487.9	1502.5	33.0
30 × 15	500.6	4861.9	13.9	4.20	365.2	1257.6	30.0
45 × 15	467.7	3621.1	15.3	5.24	314.0	1063.3	20.6
CD (P = 0.05)	14.1	126.7	0.14	0.03	4.7	36.2	0.5

N. S. = Non Significant

However, increase in population singnificantly decreased the seed number. Irrespective of treatments the mean seed number per pod was 13.2, 13.9 and 15.3 under 44, 22 and 15 plants per m² respectively. Thousand seed weight significantly increased with irrigation. Pusa Bold had significantly higher seed weight than Pusa Kalyani.

Seed yield of both cultivars increased by 21% due to irrigation. Highly significant differences in seed yield between species was noticed with Pusa Bold

Table 2 :   Average effects of irrigation and plant density on yield components and yield of   ' Pusa Bold and Pusa Kalyani

Treatment	Pusa Bold	Pusa Kalyani	Plant density/m²			Cultivar	Plant density/m²		
			44	22	15		44	22	15
			Branch number/m²				*Branch number/m²*		
Unirrigated	615.3	355.4	634.2	426.0	326.2	Pusa Bold	790.4	592.9	567.7
Irrigated	685.3	567.96	750.2	575.2	554.5	Pusa Kalyani	594.1	408.3	383.0
LSD (P = 0.05)	26.7			32.5				19.8	
			Pod number/m²				*Pod number/m²*		
Unirrigated	5469.0	4174.0	6591.0	4490.5	3382.5	Pusa Bold	7900.5	4886.5	4353.5
Irrigated	6645.0	5261.0	8767.5	5232.5	3859.0	Pusa Kalyani	7428.0	3836.5	2888.0
LSD (P = 0.05)		239		290			177		
			1000 seed wt (g)				*1000 seed wt (g)*		
Unirrigated	4.91	3.82	3.79	4.23	5.07	Pusa Bold	4.38	4.71	5.86
Irrigated	5.07	4.13	4.15	4.30	5.36	Pusa Kalyani	3.55	3.81	4.57
LSD (P = 0.05)		0.07		0.07				0.05	
			Seed yield g/m²				*Seed yield g/m²*		
Unirrigated	374.3	329.3	422.2	339.7	293.5	Pusa Bold	478.2	398.7	353.8
Irrigated	446.1	408.0	553.3	393.2	334.6	Pusa Kalyani	497.4	334.3	274.4
LSD (P = 0.05)	13.2			16.0				9.8	

outyielding Pusa Kalyani by 11%. Response to   variation in spacing was particu-larly marked.   In general exceptionally higher yield was obtained under   narrow

spacing than wider spacing. The extent of the increase was over 56% (Table 1). Thus it is obvious that higher plant populations resulted in substantially increased seed yield per unit ground area but not when computed on per plant basis.

Table 1 further indicates that the biological yield or the biomass accumulation was significantly higher under irrigated than unirrigated condition, and with increased population density Pusa Bold accumulated more dry matter than Kalyani. Harvest Index (HI) not only varied due to inherent genetic differences between the varieties but was influenced considerably by spacing and irrigation. In unirrigated condition HI was significantly higher than under irrigation. Pusa Kalyani had significantly higher HI than Pusa Bold. Spacing affected HI considerably, values being relatively higher under high population density.

The interactions among treatments were significant in all the components studied except seed number per pod (Table 2). Seed yield of both varieties increased with irrigation at all three spacings. Variety x spacing interaction was significant with Pusa Bold having higher yield than Pusa Kalyani except at narrow spacing. Three way interaction showed that irrigation x Pusa Bold x 44 plants per m^2 outyielded all other combinations significantly.

The simple correlation coefficients between various character pairs (Table 3) revealed that characters such as total pod number, pod number on secondary branches and biological yield were positively and strongly correlated with yield at all levels of spacing. The number of secondary branches and the 1000-seed weight were positively associated with yield only at a population density of 22 plants per m^2. When the population density was decreased to 15 plants per m^2, seed yield of secondary branches and the number of pods on main branches also showed positive correlation with yield.

DISCUSSION

In *Brassica* species, seed yield is a function of branches and pod number per m^2, 1000 seed weight and seed number per pod. Earlier Ohlsson (1972), Clarke (1977) and Clarke and Simpson (1978) reported that a substantial increase in these components in *B. napus* were associated with increasing densities and with irrigation. In the present study, the number of branches and pods per m^2 and 1000 seed weight was influenced by irrigation and plant density treatment. However, the seed number per pod remained unaffected by irrigation. Branch and pod number increased with increasing plant density although they declined on per plant basis; this decline was probably related to the plant competition for nutrients, space and light. Nevertheless, the greater number of plants per unit area more than compensated for the decline. It was noted in an earlier experi-

ment that leaf area index and crop growth rate were significantly higher under high population density leading to more dry matter production (Khader and Bhargava, 1984). Allen and Morgan (1972) suggested that the ability of the rape plant to supply assimilates during flowering is important in determining the pod number. Therefore, in the present work it is quite possible that the mineral nutrient coupled with greater exploitation of light would have been better under high population density leading to production of more branches and pods per m^2.

Table 3 : Positive correlation of various characters with seed yield under different levels of spacings

Characters	Plant density (cm)		
	15 × 15	30 × 15	45 × 15
Pod number on secondary branch/m2	0·74*	0.90**	0.96**
Total pod number/m2	0.85**	0.91**	0.83**
Seed yield on primary branch/m2	0.80*	—	—
Biological yield g/m2	0.86**	0.95**	0.85**
Leaf area index	—	0.76*	0.86**
Secondary branch number/m2	—	0.80*	0.72*
Total branch number/m2	—	0.88*	0.84**
1000 seed weight	—	0.15**	0.71**
Pods on main steam	—	—	0.726
Seed yield on secondary branch/m2	—	—	0.89**

The varieties responded to increased plant population. By increasing the plant population three times (15 to 44 plants per m^2) the yield increase was 1.5 times. Thus competitive effects become operative which countered density effects. Of the two varieties, Pusa Bold produced more dry matter and branches per m^2 than Pusa Kalyani but had only 13.2 seeds per pod compared to Pusa Kalyani with 15.1 seeds per pod. However, the seeds of Pusa Bold were

heavier than Pusa Kalyani 4.90 compared to 3.98g per 1000 seeds. Thus a difference of approximately 6% in the seeds number was outweighed by 20% increase in seed weight. Adams (1967) postulated similar compensation in field beans. As the pod number per m² was greater in Pusa Bold it gave a better yield than Pusa Kalyani.

The nature and relative strength of relationship of yield with various components have been extensively studied by various workers (Singh et al. 1969; Thurling 1974; Krogman and Hobbs 1975; Chauhan1980; Bhargava, and Tomar 1982). Most characters are positively correlated with yield. Studies by Hunn and Schuster (1975), Thurling (1974), Rawat and Anand (1978) showed that pod number was most reliable index for selection in yield improvement in mustard. In the present investigation, the total number of pods was, as expected, strongly correlated with seed yield. Interestingly, it was the number of pods on secondary branches which gave a strong correlation with yield at all the three levels of spacing. However, pod numbers on main branch were significantly correlated with yield at wider spacing. There was a positive but not significant relationship between the pods on primary branches and seed yield at all plant densities. This study shows that the secondary branches are the most important in contributing to seed yield. Further interaction between treatments suggested that irrigation × Pusa Bold × spacing, 15 × 15 cm was the combination which gave the highest yield. The study indicates that plant density can be further increased beyond 44 plants per m² to attain higher yield.

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Resistance of some *Brassica napus* and *B. campestris* strains to the mustard aphid

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ABSTRACT

Relative resistance of six strains of *Brassica napus* (Gulliver, Regent, GSD, GSA, GSV2 and GSV3) and four strains of *B. campestris* (Tora, Trope, Span and BSH 1) against the mustard aphid, *Lipphis erysimi* (Kaltenbach) was studied in the field at Ludhiana during 1982-83. In the three sowing dates, all *B. napus* strains except GSV3 harboured significantly lower aphid population and thus proved more resistant, whereas *B. campestris* strains supported very high population and were considered highly susceptible to the aphid.

There was a positive correlation between the aphid population and total ash, nitrogen and phosphorus whereas total sugars, flavcuoids and glucosinolates had inverse relationship with the aphid population. The higher resistance in *B. napus* strains may be attributed to higher concentration of glucosinolates, flavonoids, total sugars and reducing sugars and the lower amount of total ash, nitrogen and phosphorus. A reverse trend was discrenible in the susceptible group of *B. campestris* strains.

Key words : Insect-pest; aphid resistance; pest management; *Brassica napus*, *B. campestris*; *Lipphis erysimi*

INTRODUCTION

Some strains of *Brassica napus* and *B. campestris* have been introduced from other countries to India to test their performance for yield and other traits. No work has been done on their differential response to the mustard aphid, *Lipaphis erysimi* (Kaltenbach), a very serious pest of rapeseed-mustard in India. It is known to cause heavy yield losses in *Brassica* crops (Bakhetia, 1983). The present communication combines the results of the investigations on the resistance response of some new introductions of *B. napus* and *B. campestris* to the mustard aphid.

MATERIALS AND METHODS

Five strains of *Brassica napus* (Gulliver, Regent, GSA, CSD, GSV2 and GSV 3) and four of *B. campestries* (Tora, Torpe, Span and BSH 1) were sown in a randomized block design with three replications. Each strain was sown in 30 cm row-to-row and 15 cm plant-to-plant distance in a 15 m x 5 m plot. Sowing was done on three different dates i.e. early, mid and late (12 and 26 October and 10 November, 1982 respectively), with a view to get the crop in different growth stages in the season.

Aphid population counts were made on the basis of whole plant at seedling stage, six leaves (2 leaves each from top, middle and bottom portion of a plant) at vegetative stage and 10 cm shoot per plant at the flowering and podding stages. Five plants per plot were observed and a plant observed once was not taken for subsequent observations. The observations were recorded at 10-days interval starting from first week of December to end of Feruary.

The leaf samples for biochemical analysis were collected from the mid-sown crop during second fortnight of January which coincided with the peak period of aphid incidence in the fields. Two leavas from each of the lower, middle and top protion of a plant were plucked, dried in oven at 50°C, ground and stored in sampling bottles for analysis. The glucosinolate contents were, however, estimated in the defatted seeds of each strain. Different biochemical constituents were determined using known standard methods i.e. total sugars by Yemm and Willis (1954); reducing sugars by Bernfeld (1955); nitrogen by Mckenzie and Wallace (1954); phosphorus and potassium by Jackson (1967); glucosinolates by Mcghee *et al.* (1965); oil content by Tiwari *et al* (1974); total ash by Piper (1966); total phenols by Swain and Hillis (1959); Orthodihydroxy phenols by Nair and Vaidyanathan (1964) and flavonols by Balbaa *et al.* (1974).

The data derived from different exparimants were subjected to analysis ot variance by the method of Steel and Torrie (1981). Correlation coefficients were worked out between different biochemical constituents and the mean aphid population recorded from 2nd January to 12th February.

RESULTS AND DISCUSSION

The data regarding the field population of the mustard aphid on early, mid and late sown crops of different strains, *B. napus* and *B campestris* are given in Tables 1, 2 and 3 respectively.

The aphid population on early sown crop of different strains did not show any significant differences upto December 13 (Table 1). On December 23, all

the *B. napus* strains harboured significanly lower aphid population (10.69 to 26.62 aphids per plant) than the *B. campestris* strains (33.75 to 104.85 aphids per plant). However, the aphid population on Span was on per with that on Gulliver, GSD, Regent and GSV3.

Among *B. napus* cultivars, lowest aphid population on January 2 was observed on GSV2 which differed significantly from that on Regent only. On January 12, all the *B. napus* strains were similar to each other and better than *B. campestris* strains. A similar trend was noticed on January 22 except that GSV3 was on par with Tora and BSH 1. On February 2, the aphid population on GSV2 and GSV3 was non-significant and the later being on par with all the *B. campestris* strains. In general, *B. napus* strains supported significantly lower aphid population than *B. campestris* strains upto mid-February. The trend was, however, reversed on February 22, when the pest population (27.24 aphids) was lowest on Tora and it differed significantly from that on all other strains except BSH 1.

The data in respect of the field population of the aphid on mid and late sown crops (Tables 2 and 3) showed the same pattern as exhibited by the early sown crop of different test strains (Table 1).

It was observed that *B. campestris* strians namely BSH 1, Span, Tora and Torpe supported comparatively higher aphid population and thus were considered more susceptible. On the other hand, aphid population remained very low on *B. napus* strains namely Gulliver, GSD, GSA, GSV2 and Regent. Hence these were grouped as highly resistant. Another *B. napus* strain GSV3, showing the intermediate reaction, was considered as less susceptible. The trend was more or less the same in the three sowing dates.

In general, the aphid population on all the cultivars under three sowing dates was very low and more or less non-significant during first two weeks of December. It showed that the number of early settlers was similar on all the cultivars, which suggested their equal preference by the alate aphids. However, the subsequent build-up of the aphid population varied significantly on different strains indicating thereby the presence of some resistance factors in the less infested strains.

The different strains of *B. napus* and *B. campestris* differed in their maturity (Table 4). In general, it was observed that all the *B. campestris* strains matured

Table: 1 Field population of *L. erysimi* on different strains of *Brassica napus* and *B campestris* at Ludhiana.

(Early sown crop: 12 October)

Cultivar	Mean aphid population per plant								
	3.12.82	13.12.82	23.12.82	2.1.83	12.1.83	22.1.83	2.2.83	12.2.83	22.2.83
Brassica napus									
Gullivar	9.98	14.44	18.98 (4.35)abc	39.56 (6.29)ab	26.62 (5.16)a	19.62 (4.43)a	20.16 (4.49)a	31.69 (5.63)a	156.50 (12.51)bc
GSD	3.68	9.42	16.89 (4.11)abc	28.19 (5.31)a	20.70 (4.55)a	21.80 (4.67)a	33.40 (5.78)ab	37.21 (6.10)a	184.68 (13.59)bc
Regent	10.24	13.32	21.25 (4.61)abc	66.91 (8.18)bc	33.98 (5.83)a	24.80 (4.98)a	25.80 (5.08)a	40.44 (6.36)a	239.63 (15.48)c
GS A	5.80	10.82	13.83 (3.72)ab	34.57 (5.88)ab	22.84 (4.78)a	24.70 (4.97)a	33.17 (5.76)ab	49.42 (7.03)ab	122.54 (11.07)b
GSV2	6.15	9.24	10.69 (3.27)a	23.13 (4.81)a	15.13 (3.89)a	22.75 (4.77)a	59.13 (7.69)bc	49.14 (7.01)ab	179.02 (13.38)bc
GSV3	6.20	14.13	26.62 (5.16)bc	38.06 (6.17)ab	25.80 (5.08)a	49.56 (7.04)ab	95.06 (9.75)cd	127.23 (11.28)e	184.41 (13.58)bc
Brassica campestris									
Tora	11.08	19.80	104.85 (10.24)e	122.32 (11.06)d	185.23 (13.61)b	112.78 (10.62)bc	95.25 (9.76)cd	95.45 (9.77)bc	27.24 (5.22)a
Trope	6.05	6.96	52.70 (7.26)d	70.39 (8.39)bcd	2 4.49 (14.30)b	172.65 (13.14)e	143.52 (11.98)d	148.35 (12.18)c	126.33 (11.24)b
Span	8.46	9.61	33.75 (5.81)cd	109.83 (10.48)cd	190.71 (13.81)b	147.37 (.2.14)c	146.65 (12.11)d	165.12 (12.85)c	125.44 (11.20)b
BSH 1	5.19	9.67	85.19 (9.23)e	83.17 (9.12)cd	163.58 (12.79)ᵇ	106.70 (10.33)bc	126.78 (11.26)d	118.37 (10 88)c	38.31 (6.19)a

Note: (i) Figures in parentheses are $\sqrt{\dfrac{}{n}}$ transformations.

(ii) Figures followed by the same letter(s) in a given column do not differ significantly as per Duncan's mutiple-range test

Table 2 Field population of *L. erysimi* on different cultivars of *Brassica napus* and *B. campestris* at Ludhiana

(Mid – sown crop : 26 October)

	3.12.82	13.12.82	23.12.82	2.1.83	12.1.83	22.1.83	2.2.83	12.2.83	22.2.83
				Mean aphid population per plant					
Brassica napus									
Gulliver	3.28	5.85 (2.42)abc	19.36 (4.40)ab	38.06 (6.17)a	21.80 (4.67)a	22.27 (4.72)ab	16.24 (4.03)a	32.26 (5.68)a	174.50 (13.21)
GSD	4.04	4.41 (2.10)ab	18.14 (4.26)a	28.19 (5.31)a	21.06 (4.59)a	17.22 (4.15)ab	18.49 (4.30)a	49.28 (7.02)ab	220.22 (14.84)bc
Regent	3.61	4.12 (2.03)ab	26.41 (5.14)ab	33.75 (5.81)a	19.71 (4.44)ab	19.80 (4.45)ab	28.62 (5.35)ab	24.80 (4.98)a	145.44 (12.06)b
GSA	2.59	6.30 (2.51)abc	14.54 (3.81)a	26.21 (5.12)a	28.09 (5.30)a	20.43 (4.52)ab	36.96 (6.08)ab	55.35 (7.44)abc	234.70 (15.32)c
GSV2	2.72	3.68 (1.92)a	14.74 (3.84)a	19.80 (5.45)a	20.25 (4.50)a	15.13 (3.89)a	16.56 (4.07)a	59.90 (7.74)abc	205.53 (14.34)bc
GSV3	3.09	8.88 (2.98)c	22.27 (4.72)ab	42.38 (6.51)ab	39.43 (6.28)a	63.04 (7.94)bc	51.84 (7.20)bc	126.56 (11.25)cd	183.52 (13.51)bc
Brassica campestris									
Tora	5.38	6.65 (2.58)bc	45.15 (6.72)bc	72.08 (9.49)bc	205.34 (14.33)b	141.13 (11.88)cd	108.36 (10.41)d	105.88 (10.29)bcd	64.16 (8.01)a
Torpe	2.19	54.62 (2.15)ab	59.98 (7.68)cd	91.20 (9.56)c	128.36 (11.33)b	155.25 (12.46)d	127.91 (11.31)d	191.54 (13.84)d	150.06 (12.25)bc
Span	3.92	4.62 (2.15)ab	58.13 (7.69)cd	71.06 (8.43)bc	161.29 (12.70)d	184.96 (13.60)d	137.12 (11.71)d	171.34 (13.09)d	205.34 (14.33)bc
BSH 1	2.07	5.29 (2.30)ab	84.45 (9.19)d	73.10 (8.55)bc	139.47 (11.81)b	137.59 (11.73)cd	97.61 (9.88)cd	105.88 (10.29)bcd	55.20 (7.43)a

Note : i) Figures in parentheses are $\sqrt{n}$ transformation

ii) Figures followed by the same letter(s) in a given column do not differ significantly as per Duncan's multiple-range test

Table 3 :   Field population of *L. erysimi* on different cultivars of *Brassica napus* and *B. campestris*

(Late sown crop : 10 November)

Cultivar	Mean aphid population per plant								
	3.12.82	13.12.82	23.12.82	2.1.83	12.1.83	22.1.83	2.2.83	12.2.83	22.2.83
Brassica napus									
Gullivar	3.53	5.95 (2.44)b	4.65 (2.73)bc	14.76 (3.97)bc	12.39 (3.52)a	18.06 (4.25)a	19.98 (4.47)a	32.32 (4.83)a	131.10 (11.45)ab
GSD	2.34	3.53 (2.13)b	6.61 (2.67)bc	10.22 (3.35)ab	12.04 (3.47)a	20.25 (4.50)a	16.81 (4.11)ab	31.58 (5.62)a	101.80 (10.09)a
Regent	2.13	4.10 (2.26)b	6.56 (2.75)bc	13.82 (3.85)bc	13.75 (3.71)a	15.52 (3.94)a	16.24 (4.03)a	17.89 (4.23)a	163.07 (12.77)b
GS A	0.00	0.53 (1.24)a	0.00 (1.00)a	4.33 (2.31)a	7.67 (2.77)a	13.76 (3.71)a	10.89 (3.30)a	15.36 (3.92)a	132.52 (11.50)ab
GSV2	1.52	2.61 (1.90)b	3.70 (2.17)b	10.9 (3.45)abc	13.32 (3.65)a	19.27 (4.39)a	17.47 (4.18)a	27.35 (5.23)ab	139.00 (11.79)ab
GSV3	2.49	2.31 (1.82)ab	7.64 (2.94)bc	13.51 (3.81)bc	12.74 (3.57)a	26.52 (5.15)a	35.04 (5.92)ab	50.52 (7.78)abc	205.63 (14.34)b
Brassica campestris									
Tora	1.68	3.53 (2.13)b	22.42 (4.84)d	34.16 (5.93)d	52.99 (7.28)b	132.02 (11.49)b	92.16 (9.60)c	100.40 (10.02)c	65.61 (8.10)a
Trope	1.92	2.09 (1.76)ab	4.80 (2.41)bc	11.67 (3.56)abc	56.25 (7.50)b	145.20 (12.05)b	94.28 (9.71)c	141.27 (10.69)c	188.23 (13.72)b
Span	1.62	2.24 (1.80)ab	4.19 (2.28)bc	20.06 (4.59)bcd	48.44 (6.961)b	112.36 (0.60)b	80.10 (8.95)bc	123.43 (11.11)c	218.44 (14.78)b
BSH 1	1.52	2.49 (1.87)ab	8.73 (3.12)c	22.23 (4.82)cd	62.41 (7.90)b	135.95 (11.66)b	100.20 (10.01)c	88.90 (9.16)bc	57.30 (7.57)a

Note :   (i) Figures in parentheses are $\sqrt{\dfrac{}{n}}$ transformations

(ii) Figures followed by the same letter(s) in a given column do not differ significantly as per Duncan's mutiple-range test

earlier than the *B. napus* strains. Among the *B. campestris* strains Tora and BSH 1 matured earliest. Among the *B. napus* strains, GSV3 was earlier in maturity than all others.

Table 4 : Growth stages of different cultivars of *B. napus* and *B. campestris* grown under different sowing dates

(Date of observation : 21 Feb. 1983)

Cultivar	SD$_1$: 12 Oct.	SD$_2$: 26 Oct.	SD$_3$: 10 Nov
Brassica napus			
Gulliver	Flower-buds appeared	Flower-buds appeared	Early-bud stage
GSD	Flower-buds appeared and initiation of flowering	-do-	-do-
Regent	Flower-buds appeared	-do-	Vegetative and early bud formation
GSA	Flower-buds appeared and initiation of flowers	-do-	Early-bud stage
GSV2	-do-	-do-	-do-
GSV3	flowering stage	-do-	-do-
Brassica campestris			
Tora	Pod formation complete	pod formation complete	flowering and pod formation
Torpe	-do-	flowering and pod stage	flowing stage
Span	-do-	-do-	-do-
BSH-1	-do-	Pod formation complete	Pod formation more or less complete

SD = Sowing date

It was because of early maturity, that irrespective of sowing time, BSH 1 and Tora harboured lower populations during last week of February. However, it cannot be considered a trait for resistance, because the aphid populations on these strains declined due to hardiness of the host tissue at maturity.

Some strains of *B. napus* have been reported as resistant to the mustard aphid (Singh *et al.*, 1965; Bakhetia and Sandhu, 1973). However, Jarvis (1970) found that except Pl 171538, all other strains of *B. napus* and *B. campestris* were equally susceptible. The strains tested in present investigations were new introductions and showed resistance against the mustard aphid.

B. campestris strains exhibited a highly susceptible reaction to mustard aphid. Out of these, only BSH 1 has been tested earlier and was reported as susceptible to the aphid (Bakhetia and Bindra, 1977).

Biochemical constituents of the strains in relation to aphid population

The data in Table 5 show that the strains of *B. napus* possessed lower amounts to ash, nitrogen and phosphorus and higher amount of potassium, glucosinolate and oil content as compared to the strains of *B. campestris*.

Ash, nitrogen and phosphorus contents of different test strains had a positive correlation with the aphid population, which showed that with an increase in the concentration of these constituents, aphid population also increased. However, there was a negative correlation of aphid population with potassium and oil content.

Narang (1982) reported higher potassium content in the resistant than the susceptible strains. Further contrary to present findings, no correlation of nitrogen with aphid population was found by Kundu and Pant (1982). However, none of the hosts tested were common.

Glucosinolates were higher in *B. napus* strains as compared to the *B. campestris* strains. These compounds had a significantly negative correlation (-0.63*) with the aphid population indicating that the higher amount of gluco-sinolates in the seed was responsible for low population of the aphid on a cultivar. Based on their studies on some other cruciferous plants. Josefsson (1967) and Malik (1981) reported that glucosinolates in the seeds were high in resistant and low in susceptible plants.

All the *B. napus* strains, except GSV contained much higher total sugars than the *B. campestris* strains (Table 6). Similar trend was observed in case of reducing sugars. These two constituents were found to be negatively associated

with aphid population. However, the non-reducing sugars did not show any association with aphid population. Relatively high dietary levels of sugars are known to inhibit the growth and development of many insects (Chapman, 1974).

Table 5 :   Correlation of some biochemical traits of the leaf and seed of *Brassica napus* and
           B. campestris strains with mean aphid population per plant

Cultivar	Aphid population per plant	Total ash (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Glucosi- nolate	Oils content (%)
Brassica napus							
Gulliver	25.50	10.4	3.80	0.665	2.50	4.48	44.70
G.S.D.	25.70	11.5	4.54	0.600	2.60	4.72	46.40
Regent	25.00	13.4	4.20	0.600	2.55	3.92	44.10
C.S.A.	32.37	12.2	4.76	0.595	2.60	5.84	40.40
G.S.V2	24.30	12.0	4.48	0.590	2.70	4.00	45.80
G.S.V3	61.30	15.5	4.48	0.580	2.50	4.88	43.70
Mean		12.5 ± 1.6	4.37 ± 0.30	0.605 ± 0.027	2.57 ± 0.07	4.64 ± 0.64	44.18 ± 1.93
Brassica campestris							
Tora	122.76	19.5	5.09	0.610	2.20	3.12	42.20
Torpe	136.89	18.8	6.55	0.790	2.80	3.36	42.30
Span	141.84	15.7	4.93	0.690	2.40	3.68	41.20
BSH 1	109.20	18.8	5.30	0.670	2.40	1.60	41.70
Mean		18.2 ± 1.5	5.46 ± 0.64	0.690 ± 0.064	2.45 ± 0.21	2.94 + 0.80	41.85 ± 0.44
'r' (*Aphid* population)		0.90**	0.76**	0.63**	— 0.36	—0.63*	—0.57

Mean of observation taken from 2 January to 12 February, * and ** denote significance at 5 and 1 per cent level respectively

'r' = Correlation coefficient

Table 6 : Correlation of some biochemical traits of of the leaf of *Brassica napus* and *B. campestris* strains with mean aphid population per plant

Cultivar	Aphid population per plant	Total sugars (%)	Reducing sugarss (%)	Non-reducing sugar (%)	Total phenols (%)	Orthodi-hydroxy phenols(%)	Flavo-noids (%)
Brassica napus							
Gulliver	25.50	5.25	3.15	2.10	1.49	0.132	1.049
G. S. D.	25.70	7.44	3.65	3.79	1.58	0.112	1.332
Regent	25.00	5.63	2.52	3.11	1.19	0.102	0.944
G.S.A.	32.37	4.10	3.50	0.60	1.40	0.072	1.159
G.S.V2	24.30	2.73	2.25	0.48	1.43	0.112	1.332
G.S.V3	61.30	4.46	2.56	1.91	1.20	0.032	1.030
Mean		4.93 ± 1.45	2.93 ± 0.52	1.99 ± 1.20	1.38 ± 0.14	0.102 ± 0.2	1.141 ± 0.148
Brassica campestris							
Tora	122.76	2.23	1.05	1.18	1 36	0 067	0.604
Torpe	136.89	2.36	1.50	0.86	1.23	0.082	0.840
Span	14 .84	2.62	1.55	1.07	1.22	0.102	0.712
BSH 1	109.20	2.23	1.40	0.83	1.00	0.062	0.632
Mean		2.36 ± 0.16	1.37 ± 0.19	0.98 ± 0.14	1.20 ± 0.13	0.078 ± 0.016	0.697 ± 0.091
'r' (Aphid population)		−0.74**	−0.85**	−0.47	−0.58	−0.57	−0.84**

Mean of 5 observations taken from 2 January to 12 February; * and ** denote significance at 5 and 1 per cent level respectively

'r' = Correlation Coefficient

Malik (1981) reported that total sugars and reducing sugars were higher in the susceptible than that in resistant varieties, whereas *Kundu and Pant (1967)*

did not observe any correlation between the aphid population and total sugars.

Total phenols, orthodihydroxy phenols and flavonols, in general, were higher in *B. napus* group than that in *B. campestris* group (Table 6). However, a highly significant and negative correlation was observed between the flavonols and the field population of the aphid. Thus, the high content of total flavonol imparted resistance in *B. napus*. According to Todd *et al.* (1971), higher amount of phenolic acids in barley leaves were responsible for the reduced survival of green bug. *Schizaphis graminum* (Rondani).

It is thus, inferred that the higher resistance in *B. napus* strains may be due mainly to the higher concentration of glucosinolates, flavonols, total sugar and reducing sugars and the lower amounts of total ash, nitrogen and phosphorus. A reverse trend was discernible in the susceptible group of *B. campestris* strains.

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Estimates of variability, heritability and genetic advances in seed and oil components of linseed

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ABSTRACT

A replicated trial with 10 varieties of linseed (*Linum usitatissimum* L.) was conducted and chemical analysis of seed and oil was performed. Significant varietal difference with regard to oil, protein, fibre and moisture contents of seed and iodine value, saponification value, palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid contents of oil were observed.

The genotypic as well as phenotypic coefficients of variability was higher in moisture, fibre and protein contents of the seed. Among the quality, components of the oil, maximum variability was recorded in stearic and palmitic acids. The heritability of all the traits was quite high. The genetic advance as per cent of mean at 5 per cent selection intensity varied between 0.07 per cent in saponification value to 36.23 per cent in stearic acid. The data clearly revealed that over 25 per cent improvement in moisture, protein and fibre contents of seed and palmitic acid and stearic acid components of oil can be brought about by utilizing effective breeding methodologies. The possibility of genetic gain in linolenic acid content was only 6.6 per cent where as for oil content it was about 15 per cent.

Key words : Linseed; components of seed and soil; variability; heritability; genetic advance

INTRODUCTION

During the last 3 decades, yield and yield components of linseed have been studied extensively and various genetic parameters for the improvement of these traits have been well documented and discussed. Also, these basic informations are well utilized and a number of varieties superior in yield and yield attributes

are evolved.   However, the oil and protein contents of the seed which are the actual end products are either not studied or the efforts are too meagre to make much dent.   Similarly, the iodine value of the oil which is so essential for paint and varnish industries could receive attention only in seventies (Das and Rai, 1973), and since then no systematic study seems to be on record.   As a knowledge of the fatty acid composition of the oil is essential to bring about an improvement in the iodine value of the oil, it was thought appropriate to study the entire fatty acid profile.

MATERIALS AND METHODS

Ten different varieties of linseed *(Linum usitatissimum* L.) were grown at Subour under rainfed condition in the field in a RBD with 3 replications during 1981-82. Seeds were analysed for oil protein moisture and fibre content by ACAC procedure.   The same procedure was also adopted for estimating the iodine and saponification values of the oil.   Different fatty acids, *viz.* palmitic, stearic, oleic, linoleic and linolenic were analysed as per the trans-estrification and gas-liquid chromatographic procedures. After usual analysis of variance, genotyyic and phenotypic coefficient of variability, broad sense heritability and genetic advance were estimated by partitioning the phenotypic variance (6^2ph) genotypic $(6g^2)$ and environmental (6^2e) variances assuming no genotypic $\times$ environmental interaction.

RESULTS AND DISCUSSION

Varietal differences with regard to all the components of seed and oil studied were significant (Table 1).

Among the varieties, oil percentage of seed ranged between 37.3 to 46.2 while protein percentage varied between 11.5 to 18.4 (Table 2). The fibre content was in between 5.6 to 9.5 percent. Differences in saponification value were meagre.   However, considerable variability among varieties with regard to palmitic, stearic, oleic, linoleic and linolenic acids was observed.   On an average, linolenic acid which is so important for paint and varnish industries was observed to be 50.5 per cent.   The oleic acid was 22.1 while linoleic acid was observed to be 15.1 per cent.

The highest oil percentage was recorded in variety T 397 (46.2)   while it was the lowest in LMH 438 (37.3). Interestingly, protein content was the highest (18.4%) in LMH 438. The fibre content was maximum in LMH 328 (9.5%) while oil and protein contents were moderate in this variety. This variety also axhibited maximum percentage of linolenic acid (53.7) with a minimum amount of linoleic acid.

Table 1 :   Analysis of variance for different characters in linseed

Source of variation	D. F.	Oil content	Protein content	Fibre content	Moisture content	Iodine value
Block	2	0.2129	0.0254	0.1013	0.1110	0.056
Varieties	9	26.5004**	10.5171**	4.1265**	2.4040**	32.0876**
Error	18	0.1270	0.2779	0.0398	0.0525	0.1458

**Significant at P = 0.01

Table 1 : (Contd.)

Saponification value	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid
0.0391	0.0303	0.0063	0.0492	0.0042	0.0298
1.5070**	2.2741**	3.4037**	4.3998**	4.5817**	8.2407**
0.0338	0.0414	0.0226	0.0445	0.0525	0.0581

The genotypic and phenotypic coefficients of variability was maximum in stearic acid, which was closely followed by fibre palmitic acid and protein contents (Table 3). Minimum variability was observed in iodine value and linolenic acid contents. The broad sense heritability was high in all the traits studied.

The genetic advance at 5 per cent selection intensity was highest in iodine value followed by oil content. However, the genetic advance as per cent of

mean attainable at 5 per cent selection intensity was observed to be maximum in stearic acid (36.2%). The genetic gain as per cent of mean attainable was minimum in saponification value and iodine value. However, it was also low with

Table 2 : Comparative performance of different linseed varieties with regard to various components of seed and oil in linseed.

Variety	Oil content (%)	Protein content	Fibre content	Moisture content	Iodine value	Saponification value	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid	Linolenic acid
T 397	46.23	14.70	6.37	4.23	182.87	196.50	6.23	5.60	21.23	14.43	52.50
Jawahar-23	43.83	13.07	7.17	6.13	176.73	196.23	7.87	6.03	22.57	12.90	50.63
LMH-328	39.97	16.03	9.53	4.30	184.70	196.13	6.60	5.63	19.70	14.40	53.67
SPS 77/43-2	39.37	13.10	7.67	4.93	181.73	196.57	7.63	4.40	20.50	15.53	51.93
SPS 77/30-3	38.17	15.00	8.67	4.27	181.07	194.17	5.53	5.90	22.63	16.07	49.87
LMH 408	39.63	14.03	8.77	4.53	181.90	195.73	6.30	4.43	22.33	16.67	50 27
LMH 360	39.13	14.47	8.00	4.43	178.70	195.60	5.40	6.20	22.73	16.67	49 00
LMH 438	37.33	18.43	8.83	5.80	175.73	195.23	6.03	7.63	23.00	13.73	49.60
LMH 350	43.40	11.50	7.97	4 40	175.10	195.47	5.53	7.37	23.50	15.23	48.37
CS-9	43.80	14.00	5.71	6.67	177.71	195.90	5.63	6.57	22.73	15.33	49.73
G. M.	41.09	14.43	7.87	4.97	179.03	195.75	6.28	5.98	22.09	15.10	50.56
S. E. ±	0.21	0.30	0.12	0.13	0.22	0.11	0.12	0.09	0.12	0.13	0.14
C.D. (P = 0.05)	0.61	0.90	0.34	0.39	0.66	0.32	0.35	0.23	0.36	0.39	0 41
CV %	0.87	3.65	2.54	4.61	2.21	0.09	3.24	5.52	0.96	1.52	0.48

regard to linolenic acid content(6.6%). The pertinent data of broad sense heritability estimates in conjunction with genetic advance attainable at 5 per cent selection intensity appeared to be promising with regard to stearic acid palmitic acid

moisture content, fibre content and protein content. Such informations in linseed are well documented and discussed with regard to yield and yield components (Rai and Das, 1976;   Rai and Sinha, 1980).   However, such basic informations in different components of seed and oil have by far been lacking and it is felt that these initial informations will provide a base for future in-depth studies before contemplating final breeding strategies for the improvement of

Table 3 : Estimate of genetic parameters for different components of seed and oil in lineeed

Character	G. C. V. (%)	P. C. V, (%)	Heritability (%)	Genetic Advance	Genetic advance as percent of mean
Oil content	7.22	7.27	98.58	6.06	14.76
Protein content	12.80	13.31	92.47	3.65	25.36
Fibre content	14·82	15.04	97.16	2.37	30.10
Moisture content	17.81	18.40	93.73	2.77	36.53
Iodine value	1.82	1.83	98.65	6.68	3.72
Saponification value	0.36	0.37	93.53	1.39	0.71
palmitic acid	13.74	14.12	94.73	1.73	27.56
Stearic acid	17.76	17.94	98.03	2.17	36.23
Oleic acid	5.45	5.54	97.03	2.45	11.07
Linoleic acid	8.14	8.28	96.64	2.48	16.48
Linolenic acid	3.27	3.30	97.71	3.37	6.66

seed and oil qualities in linseed.   It is hoped that the spectrum of variability might be quite broad with regard to different components of seed and oil in the genus *Linum* which needs to be adequately sampled and properly utilized. Such investigations merit consideration as tremendous variability in quality components is recorded by Yermanos and Hemstreet (1965) and possibility of having linseed varieties of different types of oil has been advocated.

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Effect of pre-sowing seed treatment and spraying of
Rhizobium culture on the productivity of groundnut

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ABSTRACT

Field experiments carried out in two seasons revealed that yields of groundnut pods can appreciably be increased (30-50 %) through pre-sowing seed treatments with water or with $Na_2 HPO_4$ solutions (5×10^{-4} M) or moncozeb slurry (2 g/250 ml of water). AK 12-24 with foliaceous semi-erect plant types yielded 10-20 % more than MH-2 having dwarf compact plant type. The former variety also responded significantly (34 % increase) to the spraying of a non-specific *Rhizobium* culture. The increases in yield were mainly due to increases in number of pods/plant and the test weight of kernels.

Key words : Groundnut; *Arachis hypogea*; seed treatment; culture spraying

INTRODUCTION

Pre- sowing seed treatments have been reported to increase vigour of plants (Basu *et al.*, 1974). This increase in vigour has been reported to also improve the drought tolerance of direct seeded upland rice (Singh and Chatterjee, 1981), barley (Chatterjee and Singh, 1983) and blackgram (Sengupta *et al.*, 1983) when grown under rainfed condition with limited moisture supply. Nandi *et al.* (1982) reported that when legumes (soybean, Bengal gram and lentil) were sprayed with suspensions of different strains of *Rhizobium*, irrespective of cross incoulation groups, beneficial effects were similar to those obtained with seed treatment by appropriate *Rhizobium* strains. The results of an experiment, where groundnut was grown with pre-treated seeds both under rainfed condition in pre *kharif* season and with limited number of irrigations (only 3 as against 6 to 8 irrigations), along with a treatment where *Rhizobium* culture was sprayed, have been presented in this paper.

MATERIALS AND METHODS

Field experiments were carried out in *kharif* (mid-July to mid-November) and pre-*kharif*, 1982 (February to early June) in sandy loam neutral soil having 0.06% N, 13 and 80 kg available P and K/ha. The experiment was conducted with two varieties, MH-2 and AK 12-24, five seed treatments *viz.* (1) control (sowing with untreated kernels), (2) water soaked (kernels soaked in water for 4 hr and then dried in shade for 1h), (3) seed kernels soaked in solutions of Na_2HPO_4, 12 H_2O (5×10^{-4} M) for 4 h and then dried in shade for 1 h, (5) kernels treated with a mancozeb slurry (2 g in 250 ml of water) for 4 h and (6) sowing of untreated kernels as in control treatment but later on, the crop was sprayed with *Rhizobium* culture solution at 30, 45 and 60 days after sowing. All the seeds were sown uninoculated. The field had groundnut crop in previous two years. Therefore, no seed treatment with *Rhizobium* culture was done. Treatment 5, was included to test the efficacy of foliar spraying of non-specific *Rhizobium* culture, isolated from groundnut nodule. The strain *Rhizobium* Arachis-1 was maintained in Ashby's yeast extract agar slants in the laboratory of Professor Sen, Department of Botany, Kalyani University. For the production of bulk culture for field experiments the *Rhizobium* was multiplied in Burk's medium. The OD at 540 nm of the culture was 0.4. One litre of culture solution was sprayed in 10 m^2 of crop.

The crop was fertilized (basal) with 20 : 17 : 32 kg NPK/ha in the form of urea, single super phosphate and muriate of potash, respectively. The experiment was conducted in split plot design with 4 replicates in 12.6 m^2 plots, accomdating seven 6 m long rows, 30 cm apart, with varieties as main plot and treatments as sub-plots. The crop was adequately protected against insects by using monocrotophos.

Two plants per plot were dug out (in blocks of 15 cm x 15 cm x 15 cm soil with the groundnut plant at the centre, at 90 days after sowing) to find out the treatment differences with regard to the number of nodules and their weights per plant. All the data were subjected to statistical analysis.

RESULTS AND DISCUSSION

The crop stand was uniform but in both the years about 5-8% of the plants died due to wilt disease. Statistical analysis of the treament variations of disease incidence did not reveal any significant difference.

Grain yield :

In both the years crops raised from seed kernels treated with water or Na_2HPO_4 solution or mancozeb slurry significantly increased yields (30-50%)

over the crop raised from untreated seed kernels. In absence of dry fungici-
dal seed treatment it is difficult to say as to whether the effect of mancozeb slurry
was due to water soaking or fungicidal action. The crop raised from PEG treated
seed and the crop receiving spraying of *Rihzobium* bacteria also yielded signifi-
cantly more than the control treatment in 1982, however in 1983, PEG treatment
was dropped. The variety AK 12-24 yielded significantly more than MH-2 in
both the years. Spraying of *Rhizobium* culture increased seed production more
in AK 12-24 having better foliage, than MH-2 having dwarf plant type with
compact leaf arrangements; the interaction between variety and treatment was
significant. Increase in the yield of grain legumes with spraying of non-specific
Rhizobial cultures have also been reported by Nandi *et al*. (1982) in soybean,
Bengal gram and lentil.

Table 1 : Effect of pre-sowing seed treatment and spraying of *Rhizobium* on the pod yield
of groundnut in kg/ha

| Treatments | Varieties | | | | | |
| | 1982 | | | 1983 | | |
	MH 2	AK 12-24	Mean	MH 2	AK 12-24	Mean
Control	899	1057	978	830	982	906
Water	1476	1660	1568	1487	1564	1526
$Na_2 HPO_4$	1506	1631	1569	1211	1623	1417
PEG	1202	1382	1292	—	—	—
Mancozeb	1454	1585	1520	1373	1788	1581
Rb spray	1188	1419	1304	932	1514	1223
Mean	1288	1456	1372	1167	1494	1331
	V	T	VXT	V	T	VXT
S. Em (±)	57.8	136.0	141·5	117.5	167.6	250.2
C. D. (P = 0.05)	126.0	293.5	308.5	250.3	365.0	537.9

Yield components :

The increases in yields were mainly due to the increase in the number of
pods/plant (Table 2) and test weight of the kernels (Table 3).

Nodulation :

The treatment differences in nodulation were significant but not due to varieties (Table 4). Although the treated plots showed greater number as well as incresed nodule weights per plant over the control yet the differences from the control treatment only due to seed treatment with Na_2HPO_4 (in case of number of nodules) and with mancozeb (in case of nodule weight) were significant.

Table 2 : Effect of pre-sowing seed treatment and spraying of *Rhizobium* on the number of groundnut pods/plant

| Treatments | Varieties | | | | | |
| | 1982 | | | 1983 | | |
	MH2	AK 12-24	Mean	MH 2	AK12-24	Mean
Control	8.8	10.2	9.5	7.9	12.4	10.2
Water	9.8	11.3	10.6	18.3	20.3	19.4
$Na_2 HPO_4$	10.5	14.4	12.5	14.6	18.1	16.4
PEG	13.3	15.8	14.6	—	—	—
Mancozeb	11.5	12.3	11.9	13.9	17.7	15.8
Rb spray	11.9	13.2	12.6	13.8	18.7	16.3
Mean	11.0	13.9	12.0	13.7	17.5	15.6
	V	T	V × T	V	T	V × T
S.Em (±)	0.90	0.66	2.26	15.3	2.16	3.25
C. D. (P = 0.05)		3.69	4.99		4.72	7.00

The seeds had good germination percentage and were from the previous crop. It may be quite possible that due to the seed soaking the inhibiting factors present in the seed coat got diluted and caused vigorous growth right from the beginning. The enhanced vigour of the crop due to seed treatment has been reported to increase production in other crops as well (Singh and Chatterjee, 1981; Chatterjee and Singh, 1983; Dasgupta *et al.*, 1984). Root growth studies further revealed that plants raised from treated seeds had increased root growth and so helped plants to utilize soil moisture in a better way. In groundnut crop raised from

Table 3 : Effect of pre-sowing seed treatments and spraying of *Rhizobium* on the test weight of 1000 kernels in groundnut

| Treatments | Varieties | | | | | |
| | 1982 | | | 1983 | | |
	MH 2	AK 12-24	Mean	MH 2	AK 12-24	Mean
Control	172.8	224.3	198.9	197.2	379.4	288.3
Water	192.3	315.2	253.8	227.0	370.4	298.7
Na$_2$ HPO$_4$	208.5	335.0	271.8	210.3	397.1	303.7
PEG	188.4	262.0	225.2	—	—	—
Mancozeb	197.1	290.8	244.0	224.7	430.0	327.4
Rb spray	192.1	249.2	220.7	205.2	392.1	298.7
Mean	191.9	279.5	235.7	212.9	393.8	303.5
	V	T	V × T	V	T	V × T
S Em (±)	7.3	10.9	16.7	14.7	17.4	29.0
C. D. (P = 0.05)	15.9	24.4	36.8	31.2	38.1	62.4

Table 4 : Effect of pre-sowing seed treatments and spraying of *Rhizobium* bacteria on the nodule number and their weight/plant of groundnut at 60 days after sowing

| Treatments | Varieties | | | | | |
| | No. of nodules/plant | | | Wt. of nodules (g)/plant | | |
	MH2	AK 12-24	Mean	MH 2	AK 12-24	Mean
Control	140	138	139	0.062	0.156	0.109
Water	180	190	185	0.117	0.227	0.172
Na$_2$ HPO$_4$	172	261	217	0.121	0.416	0.269
Mancozeb	167	210	189	0.418	0.522	0.470
Rb spray	185	232	209	0.080	0.202	0.141
Mean	169	206	188	0.160	0.305	0.233
	V	T	V × T	V	T	V × T
S Em (±)	33.5	34.2	63.1	0.091	0.099	0.174
C. D. (P = 0.05)		74.6			0.216	

treated seeds, the growth of nodules improved and this might have helped in increasing the productivity of grains. Sengupta *et al* (1983) further observed that pre-sowing seed treatments with water or Na_2HPO_4 increased the nitrogenase activity in the blackgram nodules.   ,

Groundnut is an important oilseed crop and can be extensively grown in well drained light soils of West Bengal. The experimental results projected in this paper confirmed that AK 12-24 variety yields better than the dwarf MH 2 variety and their yields can appreciably be increased (20-50%) by pre-sowing seed treatments either in water or in Na_2HPO_4 solutions or in mancozeb. This experiment further revealed that spraying of non-specific *Rhizobium* strains of bacteria on the foliageous AK 12-24 variety can bring about 30-50 % increase in yield of groundnut.

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Effect of different levels of nitrogen and phosphorus on yield and yield attributes of sesame

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ABSTRACT

The effect of different levels of nitrogen and phosphorus on sesame c. v. B-67 was studied during 1976-1979 on sandy clay loam soil at Kalyani West Bengal. Application of nitrogen and phosphorus significantly increased the seed yield, number of branches per plant, number of capsules per plant, number of seeds per capsules and 1000-seed weight. The seed yield was significantly and positively correlated with number of capsules per plant, number of seeds per capsule and 1000- seed weight. The optimum dose of nitrogen was 48 kg/ha. Benefit cost ratio indicates that 20 kg N application gave maximum benefit of Rs. 8.30 per rupee invested on N-fertilizer. Highest benefit due to the application of P_2O_5 was obtained from 15 kg $P_2O_5/$ ha (Rs. 9.50).

Key words : *Sesamum indicum*; sesame; fertilization; yield attributes

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important oil seed crop. Average yield of this crop in India is low (180 kg/ha) as compared to the very high yield level obtained in Venuzuela (1960 kg/ha). The low yield of sesame may be attributed to a wide variety of factors. Important among them are inadequate application of fertilizer and imporper water management. The response of this crop to nitrogen and phosphorus application in West Bengal is not well worked out. An experiment was, therefore, conducted to study the effect of nitrogen and phosphorus on the yield and yield attributes and to determine the optimum fertilizer schedule to sesame.

MATERIALS AND METHODS

The experiment was laid out at Kalyani Campus of Bidhan Chandra

Krishi Viswavidyalaya, West Bengal. The soil was sandy clay loam (sand 20.2%, Silt 32.1%, Clay 21.5%), low in total nitrogen (0.054%), high in available phosphorus (35.7 kg/ha) and medium in available potassium (175.2 kg/ha)'with npH 6.7.

The study was conducted in a split plot design with five levels of nitrogen (0, 20, 40, 60 and 80 kg/ha) and three levels of phosphorus (0, 15 and 30 kg P_2O_5/ha) replicated three times. Seeds were sown during first to second week February at a distance of 30 cm between rows. To study the input-output relationship between levels of nitrogen and seed yield, response function were fitted to yield data and economic analysis of fertilization was also done.

RESULTS AND DISCUSSION

Influence of nitrogen on yield and yield components ;

Nitrogen significantly increased the seed yield upto 60 kg N/ha in all the years as well as in pooled data (Table 1). This dose produced 4.3, 3.3, 7.7, 3.4 and 5.0 q/ha more seed yield during 1976, 1977, 1978, 1979 and in pooled data respectively. The increase in seed yield due to applied nitrogen could be assigned to improvement in yield components viz., capsules per plant, seeds per capsules and test weight. The seed yield of Sesame was significantly and positively correlated with number of capsules per plant number of seeds per capsule and 1000 seed weight (Table 3).

Significant positive correlations between seed yield and capsule number, seed number and test weight were also reported earlier by Khidir and Osman (1970) in sesame. Nitrogen application significantly increased the capsules per plant and seeds per capsule upto 60 kg N/ha (Table 1). This is in conformity with the earlier findings of Singh *et al.* (1960) and Subramanian *et al.* (1979) who also reported that nitrogen application to sesamum increased the capsules per plant and seeds per capsule. Application of 60 and 80 kg N/ha produced significantly heavier seeds as compared to other levels of nitrogen (Table 1), but these doses were at par in all years except 1976.

Influence of phosphorus on yield and yield component ;

Phosphorus in all the years as well as on pooled basis significantly influenced seed yield of sesame (Table-1). Addition of 15 kg P_2O_5/ha enhanced seed yield by 1.6 q/ha over no phosphorus and it amounted to 2.9 q/ha due to 30 kg P_2O_5/ha. Seed yields at 15 and 30 kg P_2O_5 were at par. Application of 30 kg P_2O_5 produced significantly more capsules as compared to other doses of phosphorus (Table-1). Seeds per capsule and 1000 seed

weight were increased steadily with every increase in **the dose of phosphorus**
in 1977, 1978 and 1979.

Nitrogen and phosphorus interaction on seed yield :

Nitrogen and phosphorus inter act significantly in respect of seed yield
during 1977 (Table 2). The influence of application of phosphorus was marked
only at 60 and 80 kg/ha N. The increase in seed production at 15 kg/ha P_2O_5

Table 1 : Yield and yield components of sesame as affected by varying levels of nitrogen and
phosphorus

Treatment	Seed yield (q/ha)					No. of capsules/plant			
	1976	1977	1978	1979	Pooled	1976	1977	1978	1979
Levels of nitrogen (kg/ha)									
0	7.8	7.5	6.5	7.0	7.9	33.5	43.5	21.9	60.2
20	10.9	9.7	11.9	8.2	11.1	51.5	48.8	61.7	70.1
40	11.1	9.4	13.8	8.6	11.7	56.8	52.6	80.1	13.7
60	12.1	10.8	14.2	10.4	12.9	68.2	56.7	113.8	87.5
80	10.4	9.2	11.9	8.7	10.9	55.6	53.9	101.3	83.7
S Em ±	0.5	0.6	0.7	0.3	0.3	0.5	1.6	1.2	6.8
C. D. (P = 0.0)	1.6	1.9	2.0	0.8	1.1	1.6	5.2	3.7	21.5
Levels of Phosphorus (kg/ha)									
0	9.6	8.8	8.6	7.5	9.4	50.4	44.8	51.0	63.4
15	10.3	9.1	12.6	8.5	11.0	52.3	51.7	82.6	79.3
30	11.4	10.2	13.8	9.7	12.3	56.1	56.8	93.7	88.2
S.Em ±	0.6	0.4	0.4	0.4	0.5	0.7	1.0	7.6	2.3
C. D. (P = 0.05)	1.8	1.2	1.3	1.3	1.5	2.1	2.9	22.4	6.8

Table 1 :   (Contd.)

Treatment	No. of seed/capsule				1000 seed weight (g)			
	1976	1977	1978	1979	1976	1977	1978	1979
Levels of nitrogen (kg/ha)								
0	38.8	56.3	40.6	55.8	2.50	2.48	2.54	2.59
20	47.9	57.8	55.6	58.8	2.52	2.55	2.56	2.63
40	49.4	62.3	60.4	59.9	2.53	2.56	2.57	2.65
60	55.0	57.9	71.7	62.5	2.75	2.73	2.73	2.74
80	46.9	58.6	61.4	60.8	2.81	2.75	2.75	2.74
S.Em ±	2.0	2.3	0.5	3.9	0.01	0.01	0.02	0.01
C. D. (P = 0.05)	6.3	N.S.	1.6	N.S.	0.04	0.03	0.07	0.05

Table 1 :   (Contd.)

Treatment	No. of seeds/capsule				1000 seed weight (g)			
	1975	1977	1978	1979	1976	1977	1978	1979
Levels of Phosphorus (kg/ha)								
0	46.4	51.4	51.3	48.8	2.55	2.54	2.57	2.62
15	48.4	57.1	59.1	61.1	2.65	2.62	2.63	2.68
30	48.1	67.2	62.7	68.8	2.68	2.66	2.69	2.73
S.EM ±	0.8	1.2	1.1	1.2	0.14	0.003	0.007	0.007
C.D. (P = 0.05)	N. S.	3.7	3.2	3.7	N. S.	0.01	0.02	0.02

was perceptible only at 60 and 80 kg/ha N application but that at 30 kg/ha P_2O_5 was significant at 20 kg/ha N and above.   The enhancement upto 80 kg/ha N

was not significant at zero level of phosphorus. A combination of 60 kg N with 30 kg P_2O_5 recorded maximum seed yield. Singh and Kanshal (1975) also obtained higher seed yield of 617 kg/ha with application of 50 kg N and 50 kg P_2O_5/ha as compared to only 431 kg/ha in control.

Table 2: Effect of interaction of levels of nitrogen and phosphorus on seed yield during 1977

Levels of phosphorus (kg/ha)	Levels of nitrogen (kg/ha)				
	0	20	40	60	80
0	8.5	9.8	9.7	8.4	7.3
15	7.4	8.4	7.5	11.7	10.2
30	6.7	11.0	11.1	12.5	10.0
S. Em ± 0.9	C. D. (P = 0.5)		2.7		

Table 3: Simple correlation between seed yield and yield components

Characters	Correlation coefficient (r)			
	1976	1977	1978	1979
Seed yield and number of capsules/plant	0.82**	0.60**	0.83**	0.82**
Seed yield and number of seeds/capsule	0.85**	0 25 (N.S.)	0.90**	0.75**
Seed yield and 1000 seed weight	0.49*	0.41 (N.S.)	0.63*	0.65**

** Significant at P = 0.05   * Significant at P = 0.01   NS = Nonsignificant

Response function :

Response functions to nitrogen fertilization were averaged over phosphorus levels and studied for all the years of experimentation as well as for pooled average of four years. The response functions to phosphorus application were averaged over nitrogen levels. The nature of response was first studied by

Table 4 :   Functional relationship between levels of nitrogen and seed yield of sesame under different years

Year	Progression equation	Optimum doses kg/ha N
1976	$Y = 7.92 + 3.16X - 0.63X^2$	47
1677	$Y = 7.58 + 2.17X - 0.43X^2$	45
1978	$Y = 6.59 + 6.24X - 1.23X^2$	49
1979	$Y = 6.83 + 1.80X - 0.31X^2$	51
Pooled	$Y = 7.98 + 3.59X - 0.70X^2$	48

where

Y is the expected yield of grain in quintal per hectare due to an application of 'X' unit of nitrogen per hectare, where one unit is 20 kg N per hectare.

Price of sesame = Rs. 300/q

Price of urea = Rs. 150/q

Table 5 :   Response of sesame to fertilizer in kg per kg of applied nutrient (based on pooled 1976-1979 data)

Doses of fertilizers (kg/ha)	Kg seed/kg N or P_2O_5 1976-1979
Doses of nitrogen	
20 (First dose over control)	16.3
40 (Second dose over control)	9.5
60 (Third dose over control)	8.5
80 (Fourth dose over control)	3.8
Doses of phosphorus	
15 (First dose over control)	10.3
30 (Second dose over control)	9.5

testing the linear and quadratic components of the fertilizer effects.   Response functions between levels of nitrogen and seed yield was characterised by the

quadratic relationship.   Production function between levels of phosphorus and
seed yield was found to be linear.   The relationship between nitrogen and seed
yield is described by the equation given in Table -4.   The data indicate that
the optimum rate of nitrogen was 47 kg/ha for 1976, 45 kg/ha for 1977, 49
kg/ha for 1978, 51 kg/ha for 1979 and 48 kg/ha for the pooled average of four
years.

Table 6 :   Economics of fertilizer application

Fertilizer kg/ha	Yield (q/ha)	Return from fertilizers (Rs.)	Cost of fertilizer (Rs.)	Net return from fertilizer (Rs.)	Marginal benefit cost ratio Rs/Re invested on fertilizer
Nitrogen :					
0	7.8	—	—	—	—
20	11.1	565.6	66.6	498.8	8.3
40	11.6	583.0	133.0	450.0	4.4
60	12.9	647.5	200.0	447.0	3.2
80	10.9	547.0	266.6	280.3	2.1
Phosphorus :					
0	9.4	—	—	—	—
15	11.0	454.4	47.7	406.6	9.5
30	12.3	374.7	91.5	283.2	4.1

Price of sesame Rs. 3.00/kg; Price of urea Rs. 1.50/kg and Price of single super phosphate
Rs. 0.61/kg.

Maximum response of 16.3 kg seed kg N application over control was
observed at 20 kg N/ha and the response was decreased with each increase in the
levels of N (Table 5). The application of 15 kg/ha P_2O_5 gave maximum response
of 10.3 kg seed/kg P_2O_5 application over control (Table-5). The benefit cost
ratio indicates that the application of 20 kg/ha N gave maximum benefit of Rs. 8.30.

per rupee invested on nitrogen fertilizer (Table 6). The ratio fell below Rs. 4.00 above 60 kg/ha N level. Highest benefit (Rs. 9.50) due to application of P_2O_5 was obtained from 15 kg/ha P_2O_5 and it was decreased to Rs. 4.10 when the fertilizer dose was increased to 30 kg/ha P_2O_5 (Table 6).

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Inheritance of grain yield and its components in sesame

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ABSTRACT

Gene effects, heterosis and inbreeding depression of four characters *viz.*, days to flowerin plant height, number of capsules per plant and grain yield per plant were studied in a six genera-tion set $(P_1, P_2, F_1, F_2, B_1$ and $B_2)$ of five crosses at four locations in sesame (*Sesamum indicum* L.) Gene effects were worked out. Pre-ponderance of dominance was observed in all the characters under study. Among epistasis dominance × dominance was of higher magnitude than others. Duplicate epistasis generally occurred in the traits studied over the locations. The heterosis in grain yield was due to simultaneous heterosis for plant height and number of capsules per plant. Significant positve heterosis for the characters under study revealed signifi-cant inbreeding depression which indicated involement of non-addtive gene action in the inheritance of these traits.

Key words : *Sesame indicum* L.; sesame; yield components; inheritance; grain yield

INTRODUCTION

An understanding of the mode of inheritance of complex quantitative traits have a direct bearing on the method of hybridization and selection, which should be adopted in a specific breeding programme. The expression of heterosis and gene effects vary widely among the environments (Chaudhary and Paroda, 1978; Rehman, 1978; Singh *et. al.*, 1981) The present study was designed to investigate the genetic system controlling the complex traits in five crosses of (*Sesamum indicum* L.) under varying environmental conditions.

MATERIALS AND METHODS

The experimental materials consisting of six parents (SI 1776, ES 188, MT 67-52, JT 7, RSE 1 and Hawari), their five F_1s (SI 1776 x ES 188, MT 67-52 x JT 7, RSE 1 x Hawari, RSE 1 x ES 188 and JT 7 x ES 188), five F_2s, five B_1s and five B_2s were grown in a randomised block design with three replications. Plant to plant distance of 20 cm was maintained in 4 m row spaced 60 cm apart. Two rows each of the parents and F_1s, 3 rows each of the B_1s and B_2s and 4 rows in each of the F_2s were planted in each replication. The experiment was conducted at 4 locations viz, Udaipur (L_1), Sumerpur (L_2) and Banswara (L_3) during kharif, 1981 and Udaipur (L_4) during kharif 1982. Ten plants from each parent and F_1 and 20 plants from each B_1, B_2 and F_2 in each replication were randomly selected for recording data on days to flowering, plant height (cm) number of capsules per plant and grain yield per plant (g). The adequacy of additive-dominance model was tested by joint scaling test proposed by Cavalli (1952) Gene effects were estimated as per method evolved by Hayman (1958). Heterosis over mid parent and inbreeding depression were also estimated.

RESULTS AND DISCUSSION

Significant differences were observed among generation means of each cross for all the traits under study. Joint scaling test revealed that additive-dominance model was inadequate in the crosses for the characters studied except in the cross SI 1776 x ES 188 for plant height (L_4), number of capsules per plant at all locations and grain yield per plant (L_2). The cross RSE 1 x Hawari indicated lack of epistasis for plant height (L_3), number of capsules per plant (L_2) and grain yield per plant (L_4). Non-interacting trend was also observed in JT 7 x ES188 and MT 57-52 x JT 7 for plant height (L_2) and days to flowering (L_4) respectively.

In the cross RSE 1 x Hawari, additive component was positive and significant at all the four locations, whereas dominance component was significant over the locations in cross JT 7 x ES 188 for days to flowering (Table 1). Besides, the non-allelic interactions were also significant in the cross JT 7 x ES 188. In other crosses for this trait, the non-allelic interactions were usually non-significant. Opposite signs of dominance (h) and dominance x dominance (1) indicated presence of duplicate epistasis in most of the crosses. Heterosis and inbreeding depression did not reveal any significance for days to floowering in all the crosses. Negative inbreeding depression could be explained on the preponderance of dominance deviations. Present findings are similar to the observations made by Dixit (1976) and Chaudhary et. al. (1977).

Table 1: Estimates of gene effect, heterosis and inbreeding depression for different traits in sesame

	Location	m	d	h	i	j	l	Epistasis	Heterosis (%)	I.D.
1	2	3	4	5	6	7	8	9	10	11

Days to flowering

	Location	m	d	h	i	j	l	Epistasis	Heterosis (%)	I.D.
SI 1776 ×	L_1	47.76**	−3.16**	−3.25**	−3.80	−1.28	1.16	D	1.20	−2.86
ES 188	L_2	40.76**	0.40	−6.63**	−5.13**	0.83	2.59	D	−1.29	−7.00
	L_3	47.56**	0.56	−3.48	−3.93	0.91**	2.43	D	0.09	−2.43
	L_4	40.92**	−0.60	−4.26	−2.67	0.87	0.39	D	−3.96	−5.24
MT 67-52 ×	L_1	48.53**	−3.53**	−7.33**	−6.53**	−1.43	1.60	D	−1.73	−7.22
JT 7	L_2	37.66**	−2.70**	2.08	2.60	−1.31**	−3.63	D	−1.35	0.03
	L_3	43.36**	−3.76**	2.26	1.93	−2.23*	−2.80	D	0.08	0.09
	L_4	39.42**	−1.58**	−3.88	—	—	—	—	−3.15	−1.60
RSE 1 ×	L_1	46.60**	2.33**	−1.21	−0.53	−1.25*	−6.76	C	−1.51	−5.19
Hawari	L_2	37.06**	2.26**	−6.54**	−4.93**	−0.31	8.83**	D	−4.30	−2.97
	L_3	45.73**	3.13**	−6.38**	−6.13*	0.08	4.10	D	−0.05	−4.98
	L_4	37.20**	2.13**	−2.82	−2.42	−1.07	4.25	D	−1.08	−0.92
RSE 1 ×	L_1	48.53**	1.86**	5.64**	−5.06**	1.35*	5.69*	C	−1.21	−2.97
ES 188	L_2	41.03**	1.53	−5.73**	−4.13*	0.86	−0.26	C	−4.03	−7.69
	L_3	47.16**	0.76*	−1.48	−1.40	1.05**	3.63	D	−0.01	0.03
	L_4	42.33**	−0.78**	−3.40	—	—	—		−1.75	−2.25
JT 7 ×	L_1	48.43**	1.30**	−3.68**	−2.88**	−2.80**	2.84	D	−1.66	−2.38
ES 188	L_2	40.83**	−4.03*	−9.35**	−7.66**	−1.91**	11.76**	D	−4.11	−4.42
	L_3	47.73**	−1.26	−5.11**	−5.06**	−0.11	6.63	D	−0.01	−1.92
	L_4	42.00**	−2.24**	3.73**	−4.08**	−3.11**	4.11*	D	0.84	−2.04

Table 1 :   (Contd.)

1	2	3	4	5	6	7	8	9	10	11
Plant height										
SI 1776 ×	L$_1$ 146.80**	6.76**	—3.40	—17.40*	10.63**	59.60**	D	9.58**	8.25**
ES 188	L$_2$ 101.53**	1.90	29.66*	21.53	7.86	—2.13	D	7.54*	12.34**
	L$_3$ 100.76**	—14.20**	65.00**	49.86	—15.43**	—47.73	D	6.26*	16.95**
	L$_4$ 110.15**	—2.28	20.84	—	—	—	—	—1.30	1.64
MT 67-52 ×	L$_1$ 135.26**	—3.90	42.30**	29.28	—2.16	30.71*	C	9.60**	9.05**
JT 7	L$_2$ 94.23**	4.56	41.31**	37.26*	—0.94	—47.29	D	4.09	8.56*
	L$_3$ 100.30**	3.40	91.23**	71.20**	9.30	—65.66**	D	18.29**	22.54**
	L$_4$ 111.86**	—13.23**	27.57	18.82	—17.76**	502.58**	D	'7.88	6.55
RSE 1 ×	L$_1$ 145.46**	21.23**	—0.73	—22.46**	7.73	50.26**	D	15.98**	7.73**
Hawari	L$_2$ 101.43**	5.73	12.46	—8.00	5.40	22.26	C	10.15**	10.42**
	L$_3$ 98.64**	11.14**	7.13**	—	—	—	—	8.07**	6.70**
	L$_4$ 100.90**	8.26**	42.72**	34.12**	—3.41	—27.05	D	8.86	12.64
RSE 1 ×	L$_1$ 144.53**	6.73**	11.56	—8.53	9.14	48.23*	D	—1.98	4.15
ES 188	L$_2$ 94 40**	5.43**	21.93**	16.33**	9.21**	0.90	C	5.62**	10.60**
	L$_3$ 111.36**	3.80	—18.44	—19.06	4.88	46.89	D	0.05	2.19
	L$_4$ 112.00**	—0.67	26.78**	26.78**	6.20	—22.24	D	0.00	6.53
JT 7 ×	L$_1$ 149.53**	—12.73**	49.91**	37.33	—4.48	—56.23**	D	8.58*	6.79*
ES 188 ×	L$_2$ 103.42**	—4.11**	17.24**	—	—	—	—	15.66**	4.49*
	L$_3$ 110.40**	0.58	29.59**	20.39**	2.43	—20.13	D	8.29**	8.13**
	L$_4$ 104.43**	—2.50	77.68**	79.28**	3.40	—101.88**	D	—1.34	11.35

Table 1 : (Contd.)

1	2	3	4	5	6	7	8	9	10	11

Number of capsules per plant

1	2	3	4	5	6	7	8	9	10	11
SI 1776 ×	L_1 72.85**	18.34**	41.99**	—	—	—	—	—	—52.79**	18.08**
ES 188	L_2 38.79**	4.53**	21.63**	—	—	—	—	—	—59.11**	21.66**
	L_3 42.81**	5.25*	18.79**	—	—	—	—	—	—38.12**	19.65**
	L_4 54.27**	2.31	5.68	—	—	—	—	—	—36.75**	12.18**
MT 67-52 ×	L_1 62.26**	15.76**	3.56	—14.20	10.56	51.53**	C	30.03**	19.06**
JT 7	L_2 26.40**	0.70	10.55	10.20	—3.61	1.69	C	1.05	17.75*
	L_3 36.23**	—7.23**	13.45	2.60	—11.08**	31.49*	C	27.13**	28.72**
	L_4 41.96**	—5.57**	—18.15*	—18.06**	—9.24*	20.70*	C	0.23	—10.24
RSE 1 ×	L_1 54.56**	2.03	37.83**	30.86	1.00	—28.73*	D	11.74*	17.69**
Hawari	L_2 32.92**	2.63	22.71**	—	—	—	—	—62.56**	25.34**
	L_3 40.96**	14.33**	54.35**	37.86**	4.78	—55.10**	D	43.50**	24.64**
	L_4 43.36**	8.50**	2.11	—14.32**	9.94**	22.86*	C	48.71**	13.55
RSE 1 ×	L_1 56.10**	—3.00	2.95	—0.40	—8.41**	11.43	C	3.79	7.16
ES 188	L_2 27.30**	—2.03	15.69	7.79	—5.03	20.20	C	24.45	32.08
	L_3 44.33**	9.16**	—10.31*	—14.46**	3.15	33.56**	D	8.72	6.78
	L_4 41.83**	—12.54**	5.46	—0.80	—20.61**	4.79	C	15.86	8.58
JT 7 ×	L_1 53.73**	—6.16	52.69**	32.46**	—2.86	—22.86**	D	37.37**	26.73**
ES 188	L_2 32.26	—3.76	32.40**	21.80**	—1.90	—26.40*	D	33.90**	22.92**
	L_3 37.30**	—8.06**	22.50	7.99	—3.93	5.66	C	40.88**	25.35**
	L_4 40.86**	—11.73**	1.10	—3.58	—20.83	14.75	C	12.00	9.40

Table 1 : (Centd.)

1	2	3	4	5	6	7	8	9	10	11
Grain yield per plant										
SI 1776 ×	L₁	15.65**	3.19**	8.74**	1.23	—0.49	2.76	C	56.82**	24.45**
ES 188	L₂	6.37**	1.07**	5.13**	—	—	—	—	78.54**	25 84**
	L₃	10.24**	0.36	6.95**	2.80**	1.40	—3.19	D	47.46**	20.74**
	L₄	12.20**	1.95**	—4.00**	—9.50**	39.99**	15.29**	D	59.56**	12.36
MT 67-52 ×	L₁	13.64**	2.94**	1.94	—2.76	2.06**	7.95**	C	38.49**	17.83**
JT 7	L₂	5.00··	0.91··	4.95··	4.71··	0.63·	—2.44	D	3.61	27.07··
	L₃	7.94··	0.59··	3.89··	0.93	0.38··	7.86··	C	33.14··	32.96··
	L₄	16.07··	—0.05··	—2.05	1.42	—1.38	0.66	C	58.96··	15.53
RSE 1 ×	L₁	12.45··	3.90··	11.98··	7.50	1.75··	—13.02··	D	41.50··	17.93··
Hawari	L₂	6.81··	1.96··	7.37··	5.17··	0.67	—10.54··	D	25.38··	17.37··
	L₃	9.29··	4.26··	10.58··	5.48··	1.50··	—5.69··	D	63.43··	29.40··
	L₄	11.05··	1.45··	—6.38	—	—	—	—	51.49··	8 97
RSE 1 ×	L₁	9.58··	0.96··	—3.91··	—4.57··	—0.81·	16.23··	D	5.93·	17.82··
ES 188	L₂	5.36··	0.24	0.50	—1.19·	—0.50·	8.23··	C	28.45··	30.11··
	L₃	8.79··	1.76	—3.65··	—4.29··	—0.03	10.45··	D	7.04··	8.14··
	L₄	8.04··	—0.65	—0.40	—0.30	—0.09··	6.09··	D	—1.27	0.00
JT 7 ×	L₁	9.68··	0.56··	17.86··	13.80··	0.84··	—17 07··	D	39.45··	32.49··
ES 188	L₂	5.41··	0.50··	6.91··	4.11··	0.58··	—1.39	D	49.16··	46.50··
	L₃	7.38··	1.12··	0.69	4.88··	0.71	—4.80··	D	26.54··	23.36··
	L₄	7.58··	—0.83··	—0.52	—2.22	0.12	6.64··	D	23.35	15.59

* Significant at $P = 0.05$ ·· Significant at $P = 0.01$

I. D. = Inbreeding depression   C = Complementary type of epistasis

C = Duplicate type of epistasis

Preponderance of dominance effects was observed for all the traits under study. However, additive effects though were also significant in the crosses over the locations for these characters. Table 1 indicated that contribution of dominance x dominance (1) was greater than additive x additive (i) and additive x dominance (j) components for grain yield per plant, plant height and number of capsules per plant. Duplicate type of epistasis was usually present in most of the crosses for these traits.

Manifestation of heterosis for grain yield was mainly through plant height and number of capsules per plant. This finding is further substantiated by similar results reported by Gupta (1980). Significant positive heterosis followed by significant inbreeding depression in all the crosses indicated that non-additive gene actions played a major role in the inheritance of grain yield per plant, number of capsules per plant and plant height.

The present study revealed that the estimates of gene effects, heterosis and inbreeding depression differed from environment to environment suggesting considerable amount of genotype x environment interactions in the expression of various traits studied. Hence before deciding any breeding methodology, gene effects should be studied in a wide range of environments. Grain yield per plant and its attributes under study revealed that both additive and non-additive gene effects are operative, therefore, reciprocal recurrent selection (Comstock *et. al.*, 1949) procedure may be used to improve such traits as it will concentrate additive effects. Early generation selects may be intermated in biparental fashion to accumulate favourable genes to breakup undesirable linkages.

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Short Communications

Combining ability for seed yield and its components in yellow sarson

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Yellow sarson (*Brassica campestris* L. var. *yellow sarson*) is an important oilseeds crop of *Brassica* group. Genetical amelioration has been very limited in this crop because of narrow genetic base used by the breeders and lack of availability of information on the nature of genetic control of yield and its components. The present study was, therefore, undertaken to determine the nature of gene action, combining ability for seed yield and its components in yellow sarson.

The five genotypes, viz. YSC-70, YSC-98, YSB-9, DYS-5 and YSIK-741 of yellow sarson were crossed in all possible combinations (excluding reciprocals). Ten F_1's and their parents were grown at Haryana Agricultural University, Regional Research Station, Bawal during winter 1982-83, in a randomized block design with three replications. Each entry was represented by 5 m long single row spaced 30 cm apart. The distance between plants was maintained at 15 cm within the row. Five plants per row in each of the three replications were selected at random for recording data on days to flowering, plant height (cm), number of primary and secondary branches/plant, number of seeds/siliqua, number of siliquae/plant, 1000-seed weight (g) and seed yield/plant (g). Statistical analysis for combining ability was done following method -2, Model-1 of Griffing (1956).

Analysis of combining ability (Table 1) showed that both genetic (gca) and specific combining ability (sca) squares were significant for all the traits except

number of seeds/siliqua, indicating the importance of both additive and non-additive gene effects.   However, the gca/sca ratio indicated a preponderance of additive gene effect in controlling all the traits.   The highest ratio was observed for seed weight followed by plant height.

Table 1 :   Analysis of variance for combining ability in yellow sarson

Source of variation	d. f.	Days to flowering	Plant height	Number of primary branches per plant	Number of secondary branches per plant	Number of seeds per siliqua	Number of siliquae per plant	1000-seed weight(g)	Seed yield/ plant (g)
gca	4	26.163**	19.652**	45.393**	20.872**	0.0013	1225.503**	55.554**	74.912**
sca	10	10.137**	11.604**	3.753	3.992	0.0010	282.747**	4 402**	9.154**
Error	28	1.363	2.564	6.034	2.744	0.0013	46.901	0.318	1.422
gca/sca		2.6:1	1.6:1	12.9:1	5.3:1	1.4:1	4.4.1	12.9:1	8.2:1

* * Significant at P = 0.01

YSC-98 showed positive and significant gca for days to flowering, secondary branches/plant and seed yield/plant. YSC-70 showed positive and significant gca only for primary branches/plant (Table 2).   DYS-5 exhibited significant positive gca for days to flowering, plant height and seed weight.   YSB-9 had positive and significant gca for secondary branches/plant and seed yield/plant while YSIK-741 showed significant positive gca for siliquae/plant and seed yield/plant.

Specific combining ability effect (Table 3) for three characters, *viz.*, primary branches/plant, secondary branches/plant and seeds/siliqua were not significant.   For days to flowering, two crosses, *viz.*, YSC-98 × YSB-9 and YSB-9 x YSIK-741 showed positive significant sca effect while four crosses showed highly significant negative sca effect. For plant height, YSC-70 x YSIK-741 and YSC-98 x DYS-5 had positive significant sca effect. Two crosses, YSC-70 x YSIK-741 and YSC-98 x YSIK-741 for siliquae/plant, three crosses, *viz.*, YSC-98 x DYS-5, YSC-70 x DYS-5 and YSB-9 x DYS-5 for seed weight; and three crosses, *viz.*, YSC-98 x YSIK-741, YSB-9 x YSIK-741 and YSC-98 x YSB-9 for seed yield showed positive significant sca effect.

Table 2 :   Estimate of general combining ability effect

Parents	Days to flower-ing	Plant height	Number of primary branches per plant	Number of secondary branches per plant	Number of seeds per siliqua	Number of siliquae per plant	1000-seed weight(g)	Seed yield plant (g)
YSC-70	0.592	0.307	3.104**	—0.47	0.004	3.66	—1.110**	—1.77**
YSC-98	9.124**	—1.790**	—3.241**	2.39**	—0.024	—6.69	—0.964**	0.97**
YSB-9	—0.220	0.200	0.451	0.96**	0.021	—0.26	—0.925**	1.34**
DYS-5	0.878	2.520**	1.511	—1.99**	0.021	—16.19**	4.980**	—4.76**
YSIK-741	—3.174**	—1.824*	—1.627*	—0.87	0.020	19.48**	—1.981**	4.22**
S. E.	0.39	0.54	0.83	0.56	0.112	2.32	0.19	0.41

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

Table 3 :   Estimate of specific combining ability effect

Crosses	Days to flower-ing	Plant height (cm)	Number of pri-mary branches per plant	Number of secon-dary branches per plant	Number of seeds per siliqua	Number of siliq-uae per plant	1000-seed weight(g)	Seed yield/ plant (g)
YSC-70 x YSC-98	1.95	0.839	—0.961	2.58	0.024	11.004	—0.02	—0.66
YSC-70 x YSB-9	—3.57**	—2.321	1.405	—0.69	—0.003	7.310	—1.317*	1.00
YSC-70 x DYS-5	1.94	—1.667	—1.894	2.00	—0.004	—5.260	—3.268**	—1.06
YSC-70 v YSIK-741	4.29	3.268*	—3.277	1.80	—0.045	24.420**	—3.143**	1.13*
YSC-98 x YSB-9	4.41	0.570	4.093	1.54	—0.004	—17.150**	—1.062*	2.13*
YSC-98 x DYS-5	2.08	4.425**	1.033	—0.27	—0.045	—13.000*	3.362**	—1.92
YSC-98 x YSIK-741	—4.26**	2.435	3.229	—2.22	—0.003	19.708**	—0.473	4.32**
YSB-9 x DYS-5	—2.86**	—3.695**	—1.004	2.89	—0.048	6.870	3.173*	—1.62
YSB-9 x YSIK-741	5.51**	—0·605	—4.494	—0.88	0.002	—10.660	—2.891**	2.23*
DAS-5 x YSIK-741	—3.91**	—1.226	—1.100	—2.25	0.032	—23.730**	—2.983**	—3.23*

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

In autogamous species, breeders are interested in identifying parental com-
binations that are likely to produce superior homozygous segregates. The utility
of attempts to isolate such prodigious pure lines is supported by the pre domina-
nce of additive genetic variance in self fertilizing crops (Joshi and Dhawan, 1966).
Matzinger (1963) stated that large amounts of dominance may be due to inher-
ant bias in the estimates. Athwal and Borlaug (1967) have also suggested that
the non-additive portion of the genotypic variance in autogamous crops can on
evolutionary ground, be expected to be relatively small. The present study reve-
aled that both general and specific combining ability variances were important
but the magnitude of former was greater than the latter for all the characters
studied. It indicated a greater role of additive gene action in the control of quan-
titative characters studied. These findings are in agreement with the observations
made by Duhoon *et al.* (1979). However, Labana *et al.* (1978) reported greater
role of non-additive gene action for seed yield and pods/plant.

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Inheritance of seed weight in brown sarson

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Brown sarson *(Brassica campestris* L. var. *brown sarson)* is the most important member of *Brassica* oilseed. Understanding the genetic architecture of important yield components like seed weight is obviously a pre-requisite for any crop improvement effort. In this paper, the results of different genetical studies on seed weight in brown sarson using various breeding approaches have been reported.

Eight brown sarson varieties of different height, maturity group and seed size, were crossed in all possible ways, excluding reciprocals. The 8 x 8 diallel set, thus prepared, was grown under two environments (normal and sodic soils). Sowings were done in 5 m rows spaced 30 cm apart with a plant to plant distance of 15 cm. Data were recorded on five randomly selected plants on 1000-seed weight. Diallel analysis was done according to the method proposed by Hayman (1954). Narrow sense hertitability was calculated as $\frac{1}{4} D/(\frac{1}{4} D \times \frac{1}{4} H_1$ F$+$E) following Crumpacker and Allard (1962). Combining ability analysis was carried out following Griffing (1956) method 2 model 1.

The mean squares due to gca and sca for seed weight were highly signifi-cant under normal as well as sodic conditions revealing thereby that both additive and non-additive types of gene actions were involved in the inheritance of this trait (Table 1). Swami Rao (1971) also reported the importance of both additive and non-additive types of gene action in brown sarson. The gca : sca ratio was more than one, suggesting pre-dominance of additive genetic variance. The esti-mates of gca effects are given in Table 2. BSH-1 had maximum gca effects under both the environmental conditions. BSH-1, Assam selection and BSH-40 under normal condition and BSH-1, BSH-40 and BC-2 under sodic condition

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Table 1 : Mean squares for general combining ability and specific combining ability for seed weight in brown sarson

Source	d. f.	Mean squares	
		Normal condition	Sodic condition
General combining ability (gca)	7	0.762**	0.124**
Specific combining ability (gca)	28	0.098**	0.092**
Error	70	0.029	0.025
gca : sca ratio		10.510	1.990

** Significant at P = 0.01

Table 2 : Estimate of gca effects for seed weight

Genotype	Normal condition	Sodic condition
BC-2	—0.09	—0.02
BSH-40	0.08	0.01
BSH-1	0.72	0.08
Pusa Kalyani	0.14	—0.04
BSC-72	0.09	—0.02
BSC-124	—0.07	—0.09
BSH-42	0.16	0.06
Assam selection	0.21	—0.05
C. D. (P = 0.05)	0.090	0.043

were found to be good general combiners for higher seed weight. The BSH-1 x Assam selection under normal condition and BSH-1 x BSH-42 under sodic con-

ditions were identified to be the best crosses for this attribute. Interestingly, parents of these crosses were also good general combiners. Hence, these hybrids could be exploited more profitably in the varietal breeding programme. The three best crosses selected on the basis of sca effect calculated from F_1 generation were not similar.

Table 3 : Three best parents and cross combinations for seed weight selected on the basis of different criteria

Criterion	Normal condition			Sodic condition		
	First	Second	Third	First	Second	Third
Parents						
per se performance	BSH-1	Assam-selection	BC-2	BSH-1	BSH-42	Pusa Kalyani
Array mean	BSH-1	Assam-selection	BSH-40	BSH-1	BSH-40	BC-2
gca	BSH-1	Assam-selection	BSH-40	BSH-1	BSH-40	BC-2
Cross Combinations						
per se performance	BSH-1 × Assam-selection	BSH-40 × BSH-1	BSH-1 × BSC-72	BSH-1 × BSH-42	BSH-1 × BSC-124	BSH-40 × BSH-1
Heterosis over better parent	BC-2 × Assam-selection	BSH-40 × BSC-124	Pusa Kalyani × BSH-42	Pusa Kalyani × Assam selection	BSH-40 × Assam-selection	BC-2 × Assam-selection
sca	BC-2 × Assam selection	BSH-1 × BSC-72	BSH-40 × BSC-124	BSH-1 × Assam selection	BSC-72 × BSC-124	BSH-1 BSH-42

The estimate of the components of genetic variation (D, H_1, H_2, F) along with their ratios are presented in Table 4. The estimates of t^2, b and $H_2/4H_2$ fulfilled the assumptions of the diallel. The D and H_1 components were found

to be statistically significant in both the environments.   Both additive and non-additive types of gene action were involved in the inheritance of seed weight in brown sarson.

Table 4 : Estimates of the genetic components of variation for seed weight in brown sarson

Genetic components of variation	Normal condition	Sodic condition
D	$0.217^* \pm 0.009$	$0.119^* \pm 0.011$
H_1	$0.244^* \pm 0.021$	$0.210^* \pm 0.026$
H_2	0.221 ± 0.017	0.118 ± 0.023
F	-0.130 ± 0.021	0.011 ± 0.026
E	0.023 ± 0.003	0.015 ± 0.004
Heritability % (Narrow sense)	20.15	31.42
$(H_2/D)^{\frac{1}{2}}$	1.06	1.33
$H_2/4H_1$	0.22	0.22
$(4DH_2)^{\frac{1}{2}} + F/(4 DH_1)^{\frac{1}{2}} - F$	0.56	1.07
h^2/H_2	2.02	1.07
r	-0.95^*	0.91^*
$b \pm Sb$	1.02 ± 0.173	0.17
t^2	1.23	0.77

* Significant at $P = 0.05$

The estimated degree of dominance was more than one, suggesting over dominance and thus, preponderance of non-additive gene action. Symmetry in the proportion of the positive and negative genes was indicated by the ratio $H_2/4H_1$. The estimates of the ratio $(4DH_1)^{\frac{1}{2}} + F/(4 DH_1)^{\frac{1}{2}} - F$ which gives the relative estimate of dominant and recessive alleles, did not give consistant results in the two environments. The negative correlation between parental order of dominance and the parental measurements indicated that the positive genes i. e. those for heavier seed weight were mostly dominant. The ratio h^2/H_2 indicated

that two genes or gene groups exhibited dominance out of all the genes controlling seed weight. However, the ratio appeared to have been under estimated under sodic condition. Narrow sense heritability was moderate under normal as well as sodic conditions.

From the foregoing discussion it is not clear that both additive and non-additive types of gene effects were responsible for the inheritance of 1000-seed weight in brown sarson. The breeding plan such as recurrent selection which can exploit both the fixable and non-fixable components of gene action is suggested. Further, the handling of this trait for genetic manipulations appeared to be easier since it was governed by a few genes and heavier seeds were dominant over lighter ones. Moreover, environmental influence was relatively low.

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Effect of sulphur and molybdenum application on uptake of N, S and Mo by groundnut

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Groundnut needs adequate supply of sulphur for optimum yield. In the recent years, responses of groundnut to molybdenum application have been reported (Shukla and Pathak, 1973). Application of sulphur and molybdenum effect the nutrition of crops with respect to not only these nutrients but also other nutrients. Molybdenum shows interaction with sulphur and its antagonistic effects on sulpuhur nutrition of crops like, peas (Reisenauer, 1965), raya (Pasricha and Randhawa, 1972) and berseem (Shukla and Pathak, 1973) have been reported. However, such information is lacking in groundnut.

A greenhouse experiment was conducted in pots with 4 kg of red sandy loam soil (pH, 6.18; EC, 0.152 m mhos/cm; CEC, 14.47 me/100 g soil; O. C, 0.32%; available SO_4-S, 8.12 ppm; available molybdenum 0.030 ppm) during *kharif*, 1982 using J-11 groundnut. The experiment was laid out in a factorial CRD with 9 treatments, each replicated thrice. The treatments consisted of 3 levels each of sulphur and molybdenum i.e, 0 (S_0), 30 (S_{30}) and 60 (S_{60}) ppm of sulphur and 0 (M_0), 1 (M_1) and 2(M_2) ppm of molybdenum applied basally through elemental sulphur and ammonium molybdate respectively. Nitrogen, phosphorus and potassium were applied basally to the soil through DAP and KCl to supply 20, 40 and 20 kg/ha respectively. The nitrogen supplied through ammonium molybdate was also taken into account while calculating the nitrogen dose and the rest was made up through urea The crop was harvested at maturity and yields of pods and haulms were recorded. Plant samples collected at this stage were analysed for N (Jackson, 1967), S (Chesnin and Yein, 1951) and Mo (Black *et al.*, 1967). The uptake of N, S and Mo by groundnut were seperately computed for seed and haulms.

Nitrogen uptake : Maximum nitrogen uptake of 415 mg/pot by haulms and 1,156 mg/pot by seed were observed with 60 ppm sulphur application. Yadav and Singh (1960) and Chesney ('1975) also reported similar results.

Application of molybdenum through ammonium molybdate at both levels had significantly increased the nitrogen uptake by haulms and seed. This is expected since one of the function of molybdenum is to effect a greater supply of nitrogen to the plant through nitrogen fixation process (Haque and Amara, 1978). The highest N uptake of 438 mg/pot by haulms and 1267 mg/pot by seed were recorded with S_{60} M_2 treatment (Table 1).

Table 1 :   Effect of different treatments on nitrogen uptake (mg/pot) by groundnut

S- levels	Mean (mg/pot)							
	Seed				Haulms			
	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean
S_0	429	741	870	680	261	341	385	329
S_{30}	691	94)	1008	880	336	394	411	380
S_{60}	954	1248	1267	1156	385	424	438	415
Mean	691	976	1048		327	386	411	
	S.Em(±)		C.D. (P = 0.05)		S.Em (±)		C.D. (P = 0.5)	
Sulphur levele (S)	16.9		50.3		7.1		21.0	
Molybdenum level (M)	16.9		50.3		7.1		21.0	
S × M	29.3		N.S.		12.3		N.S.	

Sulphur uptake : The uptake of sulphur by haulms and seed increased with increase in levels of sulphur application (Table 2). These results are in agreement to those reported by Dungarwal *et al* , (1974). The maximum values of sulphur uptake were 42.87 and 77.11 mg/pot as observed in haulms and seed respectively when sulphur was applied at 60 ppm (S_{60}) level. The average values of sulphur uptake were 33.72, 35.31, and 33.97 mg/pot by haulms and 45.08, 57.39 and 56.88 mg/pot by seed with 0, 1 and 2 ppm molybdenum application respectively (Table 2). This indicates that the effect of molybdenum application on sulphur content was more at no sulphur (S_0) followed by S_{30} and S_{60} treatments. This might be due to antagonism between M_0O_4 and SO_4 ions during absorption (Stout *et al.*, 1951) probably competing for the same absorption site. The decrease in sulphur content with molybdenum application was also

Table 2 :   Effect of different treatments on sulphur uptake (mg/pot) by groundnut

S-levels	S-Uptake (mg/pot)							
	Seed				Haulms			
	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean
S_0	24.19	35.37	37.36	32.30	23.07	25.65	24.48	24.40
S_{30}	43.82	52.97	53.03	49.94	35.04	36.72	35.46	35.74
S_{60}	67.24	83.84	80.27	77.11	43.06	43.57	41.99	42.87
Mean	45.08	57.39	56.88		33.72	35.31	33.97	
	S.Em ($+$)	C.D. (P = 0.05)			S.Em($\pm$)		C. D. (P = 0.05)	
Sulphur levels (S)	1.06	3.17			0.23		0.68	
Molybdenum levels (M)	1.06	3.17			0.23		0.68	
S × M	1.85	N.S.			0.89		N.S.	

N. S. = Nonsignificant

Table 3 :   Effect of different treatments on molybdenum uptake (μ g/pot) by groundnut

S-levels	Mo-Uptake (μ g/pot							
	Seed				Haulms			
	M_0	M_1	M_2	Mean	M_0	M_1	M_2	Mean
S_0	2.09	12.18	19.58	11.28	7.49	32.05	47.18	28.90
S_{30}	2.61	14.29	21.94	12.95	7.37	34.29	48.90	30.18
S_{60}	2.42	17.37	26.24	15.34	6.18	32.16	47.15	28.61
Mean	2.37	14.61	22.58		7.01	32.83	47.86	
	S.Em ($\pm$)	C.D. (P = 0.05)			S.Em ($\pm$)		C.D. (P = 0.05)	
Sulphur levels (S)	0.28	0.84			0.22		0.66	
Molybdenum levels (M)	0.28	0.84			0.22		0.66	
S × M	0.49	1.47			0.38		N.S.	

N. S. = Nonsignificant

reported by Pasricha and Randhawa (1972). The highest sulphur uptake of 43.57 mg/pot by haulms and 83.84 mg/pot by seed were observed with S_{60} M_1 treatment.

Molybdenum uptake : The data presented in Table 3 show that application of sulphur at 30 ppm level could increase the molybdenum uptake (30.18 μ g/pot) by haulms while 60 ppm level decreased drastically (28.61 μ g/pot) and this was on par with control (28.90 μ g/pot). This is due to more increase in dry matter because of sulphur application than decrease in molybdenum content caused by sulphur application. However, in seed, application of sulphur continuously increased the molybdenum uptake. Similar observations were also made by Shukla and Pathak (1973) in berseem crop. Highest molybdenum uptake of 47 86 μ g/pot (haulms) and 22.58 μ g/pot (seed) were recorded under M_2 treatment. Interaction effects of sulphur and molybdenum applications on molybdenum uptake were significant on seed but not on haulms,

Thus, the results of this investigation revealed that there is antagonism between sulphur and molybdenum at higher levels. Hence it can be concluded that whenever excess molybdenum are noticed, it can be effectively reduced by the application of sulphur. However, one should be careful in application of sulphur as its application in molybdenum deficient soil makes the groundnut crop suffer more due to molybdenum deficiency. It is also necessary to carry out further researches on other crops to confirm these findings under field conditions.

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Efficacy of different fungicides and number of sprays in controlling Alternaria leaf spot of safflower

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Alternaria leaf spot of safflower (*Carthamus tinctorius L*), caused by *Alternaria carthami* Chowdhury is a major and destructive disease of safflower in India. Thomas (1950) has reported the better control of *Alternaria* leaf spot of safflower by use of parzate (Zinc ethylene bis dithiocarbamate) than Copper oxychloride. Besides this, no information on fungicidal control of this disease is available. In order to find out the effective and economical control measure for the leaf spot, the present study was undertaken.

The field experiment was conducted with variety Bhima (S-4) during the *Rabi*, 1982-83 at Agril. School Farm, Solapur. The experiment was laid out in a randomised block design with plot size, 5.0 x 4.5 m and spacings, 45 x 20 cm with three replications. Sowing by dibbling method was done on September 13,1982. Four fungicides *viz.*, Dithane M-45 0.25% (Zinc ion + Manganese ethylene bis dithiocarbamate), Copper oxychloride 0.3%, Bavistin 0.1% (Methyl 2 - benzimidazole carbamate) and Bayleton 0 1% (1-(chorophenoxy)-3, 3 dimethyl-1(H-1,2,4-Triazol-1-yl)-2-butonan) were evaluated. The fungicides were sprayed with knapsack sprayer using one or two applications as per the treatments at an interval of 15 days. First spraying was done on November 18,1982 immediately after appearance of the disease. For disease assessment, 10 randomly selected plants from each plot were observed by using 1-9 point scale, and the percent disease intensity was converted into transformed values. The data on disease intensity and seed yield are presented in table 1. The efficacy of each fungicides was judged by the following criteria a) Disease intensity percentage b) increase in seed yield over control and c) spray frequency.

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Table 1 : Screening of fungicides in controlling Alternaria leaf spot of safflower

Fungicides	Seed yield (kg/ha)		Disease Index		%Increase in yield over control		Benefit cost ratio*	
	One spray	Two sprays	One spray	Two sprays	One spray	Two sprays	One spray	Two sprays
Dithane M-45 (0.25 %)	1450	1527	61.35 (51.55)	52.35 (46.34)	15 90	21.98	5 94	4.10
Copper oxychloride (0.3 %)	1340	1389	70.00 (56.79)	66.65 (54.74)	7 03	11.03	3.20	2.51
Bavistin (0.1 %)	1445	1501	57.85 (49.52)	57.65 (49.41)	15.50	19.98	2.58	1 66
Bayleton (0.1 %)	1480	1556	58 75 (50.05)	58.65 (49.99)	18.30	22.78	3.05	1.90
Unprotected control	1251	1251	79.66 (62.99)	79.66 (62.99)	—	—	—	—
Mean	1393.2	1444.8	54.18	52.69	14.18	18.94	3.69	2.54

Figures in parenthesis are transformed values

	S. E. m ±	C. D. (P = 0.05)	S. E. m ±	C. D. (P = 0.05)
Fungicides (A)	31.9	95.4	0.30	0.89
Frequencies (B)	22.6	N. S.	0.21	0.63
A × B	45.1	N. S.	0.42	1.26
Fungicides vs Control	45.1	135.3	0.42	1.26

'Market rates : 1. Safflower Rs. 325/q, 2. Dithane M-45 Rs. 60/kg. 3. Copper oxychloriae Rs. 37/kg, 4. Bavistin Rs. 420/kg, 5. Bayleton-Not marketed, but price pressumed Rs. 420/kg.

The differences in disease intensity percentage due to spraying of different fungicides were significant. All the fungicides, irrespective of one spary or two sryas have significantly reduced the disease intensity as compared to control.

The treatments with Dithane M-45, Bavistin and Bayleton with two sprays have resulted in low disease intensity percentage of 46.34, 49.41 and 49.99 respectively as against 62.99 per cent in control. In merit, next were the same fungicides with one spray followed by copper oxychloride with two sprays and one spray.

Application of fungicides viz. Bayleton, Dithane M-45 and Bavistin with two sprays and one spray have increased the seed yield significantly over copper oxychloride and control. Application of Bayleton with two sprays has resulted in the highest seed yield of 1556 kg/ha, producing 22.78 per cent higher seed yield over the control. The Dithane M-45 with two sprays has recorded the seed yield of 1527 kg/ha producing 21.98 per cent increase in seed yield over the control. The treatment with Bayleton, Dithane M-45 and Bavistin with one spray have produced 18.30, 15.90 and 15.50 percent increase yield over control. However, there is no significant yield differences between one and two applications.

The highest benefit cost ratio of 5.02 has realised with one spray followed by 4.10 with two sprays of Dithane M-45. Inspite of low yield advantages, the copper oxychloride has given higher benefit cost ratio of 3.20 than Bayleton (3.05) and Bavistin (2.58) with one spray because of low cost of the former and exorbitant cost of latter.

Thus the present study indicated that leaf spot disease of safflower can be effectively managed by one spray of 0.1 percent of either Bayleton or 0.25 percent of Dithane M-45 followed by 0.1 per cent Bavistin applied soon after the appearance of disease. This findings which shows the effective control of the disease with one spray of either of Bayleton, Dithane M-45 and Bavistin is of great sinificance since the need of minimising the amount of fungicides in rainfed crops for effective and economic control of disease has been stressed from time to time.

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Heritability of oil content in five safflower crosses

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Safflower (*Carthamus tinctorius* Linn.) grouped under minor oilseeds, is low in oil content. Hence, breeding for high oil content assumes importance particularly in view of the competition from other oilseed crops (Weiss, 1971). This communication reports the estimates of heritability and number of genes controlling oil content in five crosses of safflower.

A study was made in five crosses *viz.*, G1311 $\times$ 168, G1311 $\times$ S-144, G1311 x G992A, G1157 x 168 and G1157 x G1311, involving 5 parents. G1311, an introduction from USA is a high oil parent. S-144, G992A and G1157 are medium in oil content while 168 is a low oil parent. Parents, F_1 and F_2 populations of each of the 5 crosses were grown in compact family block layout with 3 replications at Agricultural Research Station, Annigeri, during October, 1978. In each replication a single row accommodating 15 plants was allotted to parents and F_1 and 15 rows were allotted to F_2 population. A spacing of 45 x 20 cm was adopted. The seeds of main capitula of 5 random plants in parents and F_1's and 140 to 160 plants in F_2 population in each replication were used for estimation of oil content through Bruker Minispec 20 pi NMR-Spectrometer. Replicationwise data were pooled for the genetic analysis. Heritability in broad sense and minimum number of genes were computed according to the formulae given by Burton (1951).

The oil content in parents ranged from 29.03% (168) to 44.70% (G1311). S-144, G992A and G1157 had 35.23, 36.34 and 33.73 per cent oil content, respectively. The mean values of the F_1's for oil content ranged from 31.15 to 39.81% and 28.44 to 38.00% in F_2 generation (Table 1). In each cross except G1157 x 168, F_1 mean values were lower than the mid-parent values

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as well as F_2 mean values except for G1157 x G1311, of the five segregating populations studied. Positive transgressive segregation was observed only in G1311 x G992A.

Table 1 : Mean performance of F_1's and their F_2's, estimates of heritability and gene number for oil content in five crosses of safflower

Generation	Oil content (%)	Variance	Minimum gene number	Heritability
Crosses				
G 1311 x 168	34.11 (33 34)	3.54 (17.79)	2.24	0.92
G 1311 x S-144	39.81 (35.97)	1.92 (5.29)	3.87	0.77
G 1311 x G 992 A	39.41 (38.00)	3.20 (8.51)	1.94	0.86
G 1157 x 168	31.15 (28.44)	1.04 (6.90)	0.33	0.67
G 1157 x G 1311	36.78 (27.86)	1.47 (8.75)	2.15	0.72

Figures in parenthesis pertain to values of F_2 generation

The results showed that F_2 variances were 2 to 6 times higher than corresponding F_1 variances in different crosses. The F_1 variances ranged from 1.04 to 3.54 indicating differences in oil content among the F_1's of various crosses. There was wide range of differences in the F_2 variances and it ranged from 5.29 to 17.79. In general, the magnitude of F_2 variance was proportional to the degree of diversity of parents in a cross combination for oil content.

The minimum number of genes controlling oil content ranged from 0.33 to 3.87 in various crosses. It may be said that at least one to four groups of dominant genes control the inheritance of oil content. The calculated gene number is an unbiased estimate if it confirms to the assumptions given by Sewell Wright as cited by Burton (1951). Heritability estimates in broad sense were high and

ranged from 0.67 to 0.92. In the studies of Ramachandram and Goud (1981), the narrow sense heritability was also as high as 92%. Besides, Vijayakumar and Giriraj (1980) opined that improvement in oil content could be brought about as oil content was mainly governed by additive gene action.   The present study has further substantiated that high heritability estimates coupled with fewer number of genes controlling oil content, it is possible to isolate high oil lines in the segregating populations of safflower.

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Studies on the relative efficacy of some insecticides against groundnut leafminer

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Groundnut (*Arachis hypogea* L.) is an important oilseed crop of Maharashtra. The yields in rainy season are generally low due to erratic rainfall, diseases and pests. In the recent years leafminer *Aproaerema modicella* Dev. = *Stcmopteryx subscivelea* Z.) became a serious pest in Maharashtra (Khan and Raodeo, 1979). Atwal (1976) reported yield loss as high as 70% by this pest. Considering the severity of the pest and its devastating damage, studies were conducted to find out effective insecticides in controlling leafminer.

Field trials were conducted at the research farm, Pulse and Oilseed Crops Research & Training Centre, Pandharpur, Solapur (Maharashtra) during *Kharif* 1982 and 1983 with insecticides. Trials were arranged in RBD with 14 treatments replicated thrice. Insecticides were applied at concentrations mentioned in Table 1 and were compared with water spray. Other details of experiments were as; sowing dates : 3-7-82 and 16-7-83 ; plot size : Gross 3.0 x 2.4 m; net 2.6 x 1.8m with two gaurd rows; variety : SB XI; spacing : 30 x 10 cm and fertilizers : 20 N : 40 P kg/ha.

Two insecticidal applications with Knapsack sprayer were given at 40 days after sowing and 20 days thereafter first spraying up to the runoff. Gunny bag screen was used between two plots to avoid drift. Number of dead and live larvae on randomly selected 10 plants from each treatment were recorded prior to and 72 hours after application. Method as suggested by Krishnananda and Kaiwar (1965) was followed with modification for computing the larval mortality. Only post treatment observations were taken into consideration. Pod yield after drying for a week was also recorded. Data regarding larval mortality and yield were statistically analysed.

Table 1: Larval mortality 72 hours after application of insecticides and corresponding dry pod yield

Treatments	Mortality per cent			Yield /ha		
	1982	1983	Pooled average	1982	1983	Pooled average
Monocrotophos 0.05% (Nuvacron)	99.15 (86.53)	92.29 (79.71)	95.72 (83.12)	13.57	12.07	12.82
Malathion 0.05% (Cythion)	60.04 (50.81)	78.89 (67.18)	69.47 (59.00)	12.19	11.14	11.67
Phosphamidion 0.025% (Dimecron)	99.29 (86.84)	90.00 (76.56)	94.65 (81.70)	13.61	11.42	12.52
Quinalphos 0.05% (Ekalux)	95.50 (77.88)	93.33 (81.15)	94.42 (79.52)	13.28	10.73	12.02
Fenitrothion 0.05% (Folithion)	100.00 (90.00)	83.33 (70.08)	91.67 (80.04)	13.81	10.66	12.11
Acephate 0.05% (Orthane)	96.97 (83.77)	86.67 (72.17)	91.82 (77.97)	13.53	10.66	12.10
M Parathion 0.05% (Metacid)	99.28 (86.78)	87.09 (72.73)	93.19 (79.76)	13.65	10.62	12.14
Endosulfan 0.05% (Endocel)	98.53 (84.14)	83.33 (70.78)	90.93 (77.46)	13.54	10.58	12.06
BHC 50% WP + Carbaryl 50% WP (1 : 1) 0.2%	88.49 (70.42)	76.97 (62.81)	82.73 (66.22)	12.78	10.02	11.40
Carbaryl 0.2%	65.89 (78.32)	85.24 (71.63)	90.57 (74.94)	13.33	10.31	11.82
Permethrin 0.016% (Permasect)	99.38 (87.02)	92.96 (80.22)	96.17 (83.62)	13.68	11.68	12.68
Oncol 0.2% (Carbamate, BPM)	100.0 (90.00)	83.62 (69.85)	91.81 (79.93)	13.71	9.79	11.75
Chlorfenvinphos 0.05% (Fenocil)	100.00 (90.00)	91.85 (79.23)	95.93 (84.62)	13.76	10.19	11.98
Water spray (Control)	29.94 (33.18)	25.00 (29.92)	27.47 (31.55)	11.71	9.29	10.50
S E. ±	2.48	7.72	4.38	0.39	0.51	0.33
C. D. (P = 0.05)	7.16	22.38	13.19	1.12	1.49	0.99
C. V. (%)	19.20	17.34	17.20	4.28	6.78	4.53

Data in parenthesis are the angular traniformed values.

Effect on larval mortality:

Results of pooled analysis revealed that all the insecticides recorded significantly more larval mortality than water spray. Average larval mortality at 72 hours after application ranged between 69.47 and 96.17 per cent amongst the insecticidal treatments as compared to 27.47 per cent in water spray. Permethrin, chlorfenvinphos, monocrotophos, phospoamidon quinalphos and methyl parathion recorded more than 93% larval mortality and had statistiscal significance over mixture of BHC and carbaryl at 0.2% and malathion 0.05%. Rest of the chemicals were equally effective in checking the attack of pest to that of earlier group of insecticides. In general, synthetic pyrethroid and systemic organo-phosphorus insecticides were more effective.

Khan and Raodeo (1979) also reported the effectiveness of quinalphos 0.05%, monocrotophos 0.06%, chlorfenvinphos 0.04% and phosphamidon 0.02% against the groundnut leafminer.

Effect on dry pod yield :

Owing to application of insecticides incidence of pest was found minimized and thereby resulted into increase in dry pod yield. All the insecticidal treatments except BHC 50% WP+ carbaryl 50% WP at 0.2% registered significantly higher dry yield than water spray. Highest yield of 12.82 q/ha was recorded in monocrotophos treated plots followeed by permethrin, phosphamidon parathion, fenitrothion, acephate, endosulfan, quinalphos, chlorfenvinphos and carbaryl.

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Response of groundnut variety Robot 33-1 to phosphorus application under varying plant population levels

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The reasons for low yields of groundnut (*Arachis hypogea* L.) are non usage of improved varieties, inadequate fertilization, low plant population and lack of proper plant protection measures. Robot 33-1 belong to Virginia group with smei-spreading habit, is a short duration variety (110-115 days). The agronomic requirements of this variety were not worked out. Hence, a study was conducted at College of Agricultue farm, Rajendranagar, Hyderabad, in 1983 to find out the optimum plant population in relation to phosphate fertilization under rainfed condition in sandy loam soil.

The soil of the experimental field was with pH 7.6, medium in available N (287.7 kg/ha), P (19.5 kg/ha) and K (172.9 kg/ha). The treatments comprised of four plant population levels (2.0, 2.66, 3.33 and 4.0 lakhs/ha) and four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 /ha). The experiment was laid out in a split plot design by allocating population levels to main plots and phosphorus levels to sub-plots. The treatments were replicated thrice. Requisite amount of phosphorus in the form of single super phosphate was applied to the respective treatmental plots. A uniform does of 30 kg N and 40 kg K_2O/ha reepectively was aplied. Robot 33-1 was sown on June 28, 1983.

Results (Table 1) revealed that growth in terms of plant height and LAI increased with an increase in plant population from 2.0 to 4.0 lakhs/ha. Whereas, number of branches per plant decreased with increase in population level (Envey, 1977). Yield attributes like number of matured pods/plant significantly reduced due to corresponding increase in population level. While 100-kernel weight and shelling per cent increased significantly with increase in population upto 3.33 lakhs/ha. Higher population of 4.0 lakhs/ha recorded the highest

Table 1 :   Effect of plant population and phosphorus levels on growth and yield of groundnut

Treatment	Plant height (cm)	Branches LAI per plant	LAI	Matured pods per plant	100-kernel weight (g)	Shelling per cent	Pod yield (q/ha)	Haulm yield (q/ha)
Population levels								
2.00 lakh/ha	31.1	6.81	2.96	12.3	37.0	63.1	18.99	34.55
2.66 ''	32.7	6.47	3.00	11.9	37.7	65.7	20.50	38.44
3.33 ''	33.1	6.07	3.13	10.4	39.6	68.6	22.25	44.72
4.00 ''	33.4	5.73	3.15	9.3	39.7	68.4	22.47	46.11
C. D. (P = 0.05)	0.73	0.35	0.124	0.44	0.54	2.56	0.61	3.71
Phosphorus levels								
0 kg P_2O_5/ha	32.3	5.93	2.95	9.7	36.9	64.9	19.22	37.40
20 kg ''	32.5	6.39	3.09	11.1	39.0	66.4	21.27	41.55
40 kg ''	32.8	6.41	3.12	11.5	39.1	67.2	21.78	42.29
60 kg ''	32.1	6.36	3.10	11.6	39.1	67.3	21.94	42.58
C. D. (P = 0.05)	NS	0.24	0 122	0.31	0.41	1.30	1.01	1.55

NS = Nonsignificant

pod and haulm yields of 22.47 and 46.11 q/ha respectively.   The differences
between 4.0 and 3.33 lakhs/ha were not significant.   These results are in con-
firmity with the findings of Kushwaha and Misra (1978).

There was significant increase in plant height, number of branches/plant
and LAI due to increase in the leveal of phosphorus upto 40 kg P_2O_5/ha. Similarly,
matured pods/plant, 100-kernel weight and shelling per cent also increased
with the increase in phoshporus level.   The highest pod yield of 21.94 q/ha was
obtained with 60 kg P_2O_5/ha.   Significant differences in pod yield were not
observed among 20 and 60 kg P_2O_5/ha.   The out turn of pod yield was

Table 2   Interaction of plant population × phosphorus levels on pod yield (q/ha)

Phosphorus levels (kg $P_2 O_5$/ha)	Population levels (lakhs/ha)				Mean
	2.00	2.66	3.33	4.00	
0	17.51	18.46	20 28	20 63	19.22
20	19.22	20.68	22.75	22.41	21.27
40	19.54	21.33	22.74	22.51	21.78
60	19.67	21.53	23 24	23.33	21.94
Mean	18.99	20.50	22.25	22.47	—

	S. E.	C. D. (P = 0.05)
a) Plant population levels	0.25	0.61
b) Phosphorus levels	0.49	1.01
Interaction a)	0.98	2.02
b)	0.65	1.36

maximum from 0 to 20 kg P_2O_5/ha. Significant response of Robot 33-1 was upto 20 kg P_2O_5/ha which might be due to medium status of available phosporus in the soil.   The optimum level of phosphorus was worked out to be 31.7 kg $P_2 O_5$/ ha.   Similar response to phosphorus was also found in haulms yield.   Such an increase in pod yield with the application of phosphorus was reported by Madhawadia *et al.*   (1981).

The interaction effect of population and phosphorus levels (Table 2) on pod yield indicated significant variation.   Under a given level of phosphorus, population levels of 4.0 and 3.33 lakhs/ha remaining at par gave significantly more pod yield over 2.66 and 2.0 lakhs/ha.   Maximum pod yield of 23.51 q/ha was obtained in 4.0 lakhs/ha population with 40 kg $P_2 O_6$/ha application.

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Response of sunflower variety Morden to nitrogen application in relation to varying plant populations

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Sunflower serves as a good substitute in place of groundnut, whenever there is a considerable delay in the monsoon. Moreover, it is adoptable to a wide range of soils (Singh et al., 1977) Exploitation of the yield potential of the presently available varieties would be possible with the adoption of suitable agro-technology. Plant population and fertilization are known to influence the seed yields of sunflower. Hence, an attempt has been made to find the economic dose of nitrogen and optimum plant population in variety Morden under rainfed condition.

A field experiment was conducted at Agricultural College Farm, Rajendranagar, Hyderabad during *Kharif*, 1981. The soil of the experimental site was sandy clay loam with 7.6 pH and available N, P_2O_5 and K_2O of 328, 34 and 464 kg/ha respectively. The treatments comprised of four levels of nitrogen (0, 40, 80 and 120 kg/ha) and four plant populations (0.55, 0.74, 1.11 and 2.22 lakhs plants/ha). Corresponding spacings of 30 x 60, 30 x 45, 30 x 30 and 30 x 15 cm respectively were laid out in split plot design allocating nitrogen levels to main plots and plant populations to subplots. The treatments were replicated four times. The variety Morden was sown on 29.7.1981 and harvested on 22.10.1981. P and K were applied uniformly at the rate of 60 kg each of P_2O_5 and K_2O. Nitrogen was applied in three splits, half at sowing and the remaining half in two equal splits on 30 and 45 days after sowing.

Application of nitrogen resulted in significant increase in growth characters like plant height, leaf area index, stem girth and dry matter yeild than the control (no nitrogen). The above growth characters were maximum with 120 kg N/ha. Plant height, leaf area index and dry matter yield increased whereas stem girth decreased with increase in plant populations from 0.55 to 2.22 lakhs/ha.

Table 1 : Effect of different levels of nitrogen and plant population on growth characters in sunflower

Treatment	Plant height (cm)	Leaf area index at 45 DAS	Stem girth at 60 DAS (cm)	Dry matter yield (q/ha)		
				30 DAS	60 DAS	Harvest
Nitrogen						
0 kg/ha	97.2	2.36	4 : 2	2.6	11.1	35.9
40 kg/ha	117.7	3.10	6.08	4.3	20.3	44.9
80 kg/ha	124.5	3.55	6.21	4.6	23.3	50.6
120 kg/ha	128.0	3.73	6.42	5.4	25.0	58.7
C. D. (P = 0.05)	13.3	0.28	0.56	0.6	2.9	6.8
Plant Population						
0.55 lakhs/ha	111.9	2.64	6.35	2.4	13.5	35.3
0.74 lakhs/ha	110.3	2.86	6.21	3.4	16.6	40.5
1.11 lakhs/ha	119.8	3.38	5.59	4.5	19.1	51.5
2.22 lakhs/ha	125.3	3.85	5.17	6.5	30.6	62.9
C. D. (P = 0.05)	7.2	0.21	0.61	0.7	1.4	4.3

DAS = Days after sowing.

Yield attributes such as flower head diameter, number of filled seeds per head and test weight (100-seed weight) increased with the corresponding increase in nitrogen level.   Maximum flower head diemeter and number of filled seeds per head were recorded with 120 kg N/ha which was on par with control. Test weight increased significantly upto 80 kg N/ha thereafter showed decreasing trend. Flower head diameter, number of filled seeds per head and test weight significantly increased with a reduction in plant population from 2.22 to 0.55 lakhs/ha whereas number of filled seeds decreased with the corresponding increase in plant population.

Table 2 : Effect of different levels of nitrogen and plant population on yield and yield attributes in sunflower

Treatment	Flower head diameter (cm)	No. of filled seeds per head	No. of unfilled seeds per head	100-seeds weight (g)	Stalk yield (q/ha)	Seed yield (q/ha)
Nitrogen						
0 kg/ha	10.67	285.3	22.4	3.61	10.72	6.35
40 kg/ha	12.18	377.1	21.6	3.86	17.38	7.84
80 kg/ha	12.60	440.7	21.9	4.07	20.38	9.47
120 kg/ha	13.25	443.2	23.3	3.96	23.66	8.68
C. D. (P0.05)	1.02	30.9	0.9	0.21	2.44	0.94
Plant Population						
0.55 lakhs/ha	13.16	469.4	23.8	4.33	9.24	6.82
0.74 lakhs/ha	12.88	411.6	23.0	4.04	13.55	7.23
1.11 lakhs/ha	12.18	361.9	21.6	3.74	20.04	9.04
2.22 lakhs/ha	10.49	303.2	20.8	3.38	29.41	9.25
C. D. (P0.05)	0.75	18.3	1.7	0.23	2.25	0.63

There was significant increase in seed yield upto 80 kg N/ha. However, seed yield decreased to an extent of 0.79 q/ha with 120 kg N/ha over 80 kg N/ha. Contrary, highest stalk yield of 23.66 q/ha was obatained in 120 kg N/ha which was significantly more than the other nitrogen levels. Mohan Babu (1979) reported similar response of sunflower to nitrogen application. Significant increase in seed yield was recorded upto 1.11 lakh plants/ha. Though maximum seed yield (9.25 q/ha) was recorded with 2.22 lakh plants/ha, but found on par with 1.11 lakh plants/ha. The results are in accordance with those reported by Surendrababu

(1975). Stalk yield increased significantly with every increase in the level of population from 0.55 to 2.22 lakhs/ha. The results of the present study suggest that application of 80 kg N/ha with a plant population of 1.11 lakhs/ha spacing 30 x 30 cm is optimum for obtaining maximum seed yield.

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Effect of varying plant densities on yield and yield components in niger

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Niger (*Guizotia abyssinica* (L. F.) Cass.) is an important oilseed crop. In view of the demand for vegetable oil, attempts are being made to popularise the cultivation of niger in India. Unfortunately, inspite of high oil content and a wide range of adaptability, little attention has been paid to increase the yield potential of this oilseed crop. Varietal improvement programme has been limited to selections among the heterogenous populations in this oilseed crop. For obtaining maximum seed yield, the relation between plant population/ha and a suitable plant type is very important. Keeping in view the above mentioned facts, this investigation was planned to study the effect of varying plant densities on yield and yield components in niger.

The experiment was conducted at Jawaharlal Nehru Krishi Vishwa Vidyalaya Research Farm, College of Agiculture, Jabalpur during *kharif*, 1983-84. The experiment was conducted in split plot design replicated four times. The material consisted of four cultivars *viz.* V_1 -Ootacomund, V_2 -N-20, V_3 -I GP-76 and V_4 -N-87 as main plot treatments and four population densities (P_1 -2.0, P_2 -3.0, P_3 -4.0, P_4 -5.0 lakh plants/ha) as sub-plot treatments. The inter row distance was 30 cm. Plot size was 2.7×5 sq.m. Fertilizers N:P:K were given @ 10:20:10 kg/ha as basal dose. Prior to sowing, seeds were treated with Thiram @ 3 g/kg seed. Crop was sown on July 8, 1983. Thinning was done after 15 days of germination to get desired plant densities. Crop was weeded manually twice during crop growth period after 20 and 40 days of germination. Twenty-five plants were sampled at maturity from each plot to record yield and its components.

Significant differences due to varieties existed for plant height, number of nodes/plant, seeds/capitulum and seed index (1000 seed weight). The maximum plant height (170.76 cm), number of nodes per plant (17.78) and seeds/capitulum

(23.42) were exhibited by variety N-20, while, Ootacamund had the highest test weight of 3.91 g/ 1000 seed. However, N-20 gave the maximum seed yield (10.20 q/ha) followed by Ootacamund (10.05 q/ha). Incrersing the plant population from 2.0 lakh to 5.0 lakh plants/ha, there was a significant increase in seed yield in

Table 1 : Yield components and yield of four niger cultivars as influenced by varying plant densities

Treatments	Plant height (cm)	No. of nodes/ plant	No. of primary branches/ plant	No of secondary branches/ plant	Capitula/ plant	Seeds/ capitulum	Yield/ plant (g)	1000-seed weight (g)	Seed-yield (q/ha)
Main treatments (cultivars)									
Ootacamund	156.12	16.28	8.87	19.34	35.79	21.26	3.00	3.91	10.05
N - 20	170.76	17.78	8.93	14.82	34.20	25.42	3.01	3.67	10.24
1 GP - 76	140 85	15.26	9.13	18.22	38.00	19.28	2 80	3.84	9.64
N - 87	140.06	14.17	9.26	17.12	34.61	17.86	2.33	3.72	8.08
S. Em. ±	2.50	0.36	0.26	1.05	2.37	0.59	0.24	0.03	0.78
C. D. (P = 0.05)	8.21	1.17	N5	NS	NS	1.91	NS	0.12	NS
Sub-treatments (Plant densities)									
2.0 lakh/ha	150.01	15.90	9 89	19.85	41.44	20.40	3 25	3.79	6.50
3.0 lakh/ha	153.86	16.15	9.18	18.19	36.02	19.87	2.77	3.87	8.33
4.0 lakh/ha	151.79	15.91	8.25	14.88	29.48	21.00	2.45	3.83	9.79
5.0 lakh/ha	152.14	16.14	8.86	16.57	35.64	20.55	2.67	3.65	13.38
S.Em. ±	2.28	0.24	0.30	1.09	1.71	0.60	0.16	0.04	0.60
C.D. (P = 0.05)	NS	NS	0.87	3.13	4.91	N5	0.46	0.13	8.73

NS = Nonsignificant

all the cultivars (Table 1).   An average increase in seed yield was recorded from 8.05 to 13.38 q/ha with increase in plant density from 2.0 to 5.0 lakh plants/ha.

Singh and Verma (1975), Patil and Joshi (1978), Patil   (1979) and Patil and Patil (1981) also reported that increasing plant density increased seed yield in niger while Rao *et al.* (1976) stated that increased plant density in niger decreased yield which was probably due to very high number of plants per row $(60 \times 5$ cm), with plant population of 3.3 lakh/ha. Optimum spacing of 30 x 15 cm was noted by Singh and Verma (1975).   However, maximum seed yield was noted in IGP-76 with 5.0 lakh plants/ha.

Plant height and number of nodes/plant increased upto P_2 (3 0 lakh/ha), further increase in population density decreased these two characters due to higher competition stress in all cultivars except N-87.   There was a continuous incre- ase in these characters with increased population in N-87 (Table 1). The number of primary branches, secondary branches, capitula per plant and 1000 achines weight decreased with increase in population.   However, IGP-76 and N-87 gave increased number of all these parameters in P_4 population (5.0 lakh/ha) except seed index as compared to P_2 & P_3.   Number of seeds per capitulum was not affected by population stress.   Number cf seeds per capitulum was not influenced by mic- roclimatic changes.   However, the later affected test weight indirectly by redu- cing the seed size.   Primary branches, secondary branches, capitula per plant and yield per plant reduced drastically with increase in population density. Similar findings were reported by Patil (1979).   Interactions of varieties x population *were nonsignificant for yield and the components of yield.*

Thus it could be concluded that increased plant density decreased number of primary branches, secondary branches, capitula per plant, seed index and seed yield/plant but due to greater number of plants per unit area under higher population densities there was increased seed yield/unit area.   Hence, the yield components per unit area are of much interest than the per plant, and varieties having the greater number of yield attributes even in higher population stress are better to get maximum economic yield.

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Effect of varying levels of N, P, K on the performance of cultivars of toria

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Toria, (*Brassica campestris* var. *toria*) because of its short duration and low cost of cultivation has become an important catch crop ideally suited for multiple cropping situations in India. It is also becoming very popular under situations where major *kharif* crops like paddy, maize, cotton etc. fail for one reason or the other due to vagaries of nature. Toria variety ITSA, though a good yielder, is of longer duration and hence does not permit timely sowing of succeeding *rabi* crops. To meet this situation, a short duration variety, TL 15, was released in 1978. Since nutritional requirements of varieties may vary according to the yield potential and their duration, it was considered necessary to study the effect of varying levels of N, P, K on different cultivars of toria.

A field experiment was conducted at the Regional Research Station, Gurdaspur of Punjab Agricultural University, Ludhiana during 1977 and 1981 with soil having pH 8.4 loamy-sand, low in available nitrogen and medium in phosphorus and potassium. The experiment with four replications was laid out in a split plot design keeping three varieties (ITSA, TL 15 and local) in the main plots and nine fertilizer levels (Table 1) in the sub-plots. The crop was sown during first fortnight of September in each year keeping a spacing of 30 x 10 cm. Irrigation was applied as and when required. A net plot size measuring 12.60 m² was harvested to compute the seed yield. Composite seed samples were analysed to determine the oil content.

Varieties : The data (Table 1) indicate that the highest seed yield was produced by ITSA followed by TL 15 and local in all the years of study. ITSA significantly out yielded TL 15 in the first three years while TL 15 recorded significantly more yield than local in all the years except 1979. On the average of five years ITSA produced ʃ 82 kg/ha which was 10.4 and 46.3 per cent higher than

Table 1 : Effect of N, P, K, on the seed yield, oil yield and maturity days of different toria
cultivars

Treatments	Seed yield (kg/ha)					Mean
	1977	1978	1979	1980	1981	
Varieties						
ITSA	594	605	895	1333	984	882
TL 15	463	522	731	1328	949	799
Local	332	373	697	887	724	603
C. D. $(P = 0.05)$	92	82	68	237	32	66
Fertilizer levels (kg/ha)						
N_0	263	298	486	984	539	474
N_{40}	398	470	636	1097	831	656
N_{80}	519	493	691	1053	868	725
$N_{40} : P_{20}$	475	536	765	1243	1014	887
$N_{40} : P_{40}$	473	503	827	1362	999	833
$N_{80} : P_{20}$	536	578	776	1071	958	784
$N_{60} : P_{40}$	577	626	883	1332	1006	885
$N_{40} : P_{20} : K_{25}$	—	—	790	1217	849	—
$N_{80} : P_{40} : K_{25}$	—	—	953	1287	907	—
C. D. $(P = 0.05)$	44	79	71	191	51	46

Table 1: (Contd.)

1977	1978	Maturity days 1979	1981	Mean	Mean oil content (%)	Mean oil yield (kg/ha)
82	84	87	108	90.2	43.28	336
74	80	82	100	84.0	40.83	279
68	72	77	88	76.2	40 90	222
72	75	80	102	82.2	41.99	170
75	78	81	104	84.5	42.07	251
77	79	83	102	85.2	40 47	264
75	78	83	102	84.5	41.85	298
75	78	82	105	85.0	42.38	303
77	80	82	103	85.5	41.83	302
76	81	83	98	84.5	41.96	326
—	—	83	102	—	—	—
—	—	83	101	—	—	—

that of TL 15 and local, respectively. However, ITSA took longer period and on an average, matured in 90.2 days whereas TL 15 and local matured in 84.0 and 76.2 days, respectively. ITSA recorded 2.41 and 2.38 per cent higher oil content in its seeds as compared to TL 15 and local, respectively. Similarly the total oil yield produced by ITSA was the highest (336 kg/ha) followed by TL 15 (279 kg/ha) and local (222 kg/ha).

Fertilizers: Application of 80 kg N produced significantly higher seed yield than that of control except in 1980, wheras the yield differences between 40 kg N and 80 kg N remained non-significant during all the years except in 1977. On an average of five years, N_{80} produced 53.0 and 8.9 per cent higher seed yield than that of control and N_{40}, respectively. Phosphorus application in conjunction with lower dose (N_{40}) significantly affected the seed yield upto 20 kg P_2O_5 /ha dose only, but when it was applied with higher dose of N (80 kg), the respons was upto 40 kg P_2O_5 /ha during 1979 and 1980. The highest average seed yield of 885 kg/ha was recorded under $N_{80}+P_{40}$ which was significantly superior to that of all other treatments and 9.7 per cent and 86.7 per cent higher than that of $N_{80}+P_{20}$ and control respectively. These findings are in agreement with those of Wankhede *et al* (1970), Dhindsa *et al* (1973), Bhan and Singh (1974) and Gupta and Saini (1982).

Potassium application had no effect on the seed yield. Nitrogen application delayed the maturity of the crop. Similar observations were reported in earlier studies by Gupta and Saini (1982). Application of 80 kg N alone reduced the oil content whereas phosphorus application increased it slightly. Similar observations were reported by Wankhede *et al* (1970) and Gupta *et al* (1972).

The interaction effect of varieties and fertilizer treatments on the seed yield was non-significant.

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Die back-a new disease of linseed

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During 1984, severe infection of die back disease of linseed (*Linum usitatissimum* L.) was observed in the breeding trial conducted at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur in last week of August. The disease started from the tip and extended downwards killing the leaves, main stem and side branches of a number of cultures. At the later stage of the disease development, the affected plant parts were completely blighted appearing brown and shriveled. Ultimately, the affected tips dried up and dropped off alongwith the leaves. Numerous, scattered black dot like acervuli were produced on the affected parts.

The fungus was isolated from infected tissues on potato dextrose agar. Typical die back symptoms appeared 10 days after inoculation. On the basis of morphololgical characters, the fungus was identified as *Colletotrichum lini* (Westerdijk) Tochinai. The die back disease of linseed caused by *C. lini* is a new record in the world and the fungus is a new record from India (Bilgrami *et al.*, 1979). However, pathogen *C. lini* (*C. linicola*) has been found to be associated with the linseed to cause the anthracnose and seed rot.

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Sulphur, zinc and boron nutrition of Indian mustard

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As the consumption of high analysis fertilizers has gone up now a days, the deficencies of sulphur and some micronutrients are becoming more evident. The problem is further aggravated when crop like mustard is exacting more in its demand for these nutrients particularly for sulphur and zinc (Virmani and Gulati, 1971; Pathak, 1975; Mehrotra *et al*, 1977). Intensive cultivation and change in fertilizer strategy coupled with impoverishment of soil demands a fresh look at the mineral nutrition of this crop. Hence the present study was undertaken to throw light on the influence of micro-nutrients on yield of Indian mustard.

A field experiment was conducted at the Experimental Research Station, Kalyanpur of C. S. A. University of Agriculture and Technology, Kanpur from *rabi*, 1978-79 to 1980-81 under the AICORPO projects. The soil of the experimental plot was sandy loam with pH 7.0-7.5, E. C. 0.25-0.36, organic carbon 0.30-0.45%, available K_2O 150-200 kg/ha, available P_2O_5 15-20 kg/ha, available sulphur 16-20 ppm, zinc and boron 1.5 and 2.0 ppm respectively.

Uniform doses of N. P. K. @ 80: 40: 40 kg/ha through urea, diammonium phosphate and muriate of potash were applied. Sulphur was applied in the elemental form with varied doses of 10, 20 and 40 kg/ha as basal. Zinc and boron were supplied in single dose before sowing i. e. 10 kg and 1 kg/ha throgh zinc sulphate and broax respectively. The treatments were replicated 4 times in Randomized Block Design. Two irrigations, one at 30-35 days after sowing and other at pod development stage were applied. Plant spacing was kept 20 cm during 1978-79 and 1980-81 and 15 cm during 1979-80 by thinning at 15-20 days after sowing. Whereas row spacing of 45 cm was constant. The oil was estimated by Soxhlet method.

Data (Table 1) showed that height of the plant, primary branches and secondary branches per plant were improved with application of sulphur, zinc and

Table 1 :   Effect of sulphr, zinc and boron on the plant height primary and Secondary branches
of mustard

Treatments	Plant height (cm)			
	1978-79	1979-80	1980-81	Mean
1. Control	185.6	185.30	189.10	186.67
2. 10 kg S/ha	186.5	196 57	191.60	191.56
3. 20 kg S ha	187.0	197.72	194.97	183.03
4. 30 kg S/ha	187.3	197.72	193.80	192.74
5. 40 kg S/ha	187.4	197.65	190.90	192.32
6. 10 kg Zn/ha	186.2	196.72	189.45	190.79
7. 1 kg B/ha	186.4	190.72	193.12	190.08
8. 20 kg S + 10 kg Zn/ha	187.4	197.37	192.55	192.44
9. 10 kg Zn + 1 kg B/ha	187.6	195.12	190.72	191.15
10. 20 kg S + 1 kg B/ha	187.9	192.45	188.80	189.72
11. 20 kg S + 10 kg Zn + 1 kg B/ha	187.8	194.05	194.70	192.18
S. E. ±	7.2	5.12	7.72	
C. D. (P = 0.05)	N.S	N.S	N.S	—

born. But differences in height and primary branches were not significant.
However, application of 20 kg sulphur, 10 kg zinc and one kg boron/ha produced
maximum number of secondary branches per plant which is significantly higher
than control.   Whereas significant differences in the above characters due to app-
lication of these nutrients were not recorded.

Table 1 : (Contd.)

No. of primary branches plant				No. of secondary branches plant			
1978-79	1979-80	1980-81	Mean	1978-79	1979-80	1980-81	Mean
5.50	5.10	5.00	5.20	14.25	13.50	12.25	13.33
6.25	5.75	5.02	5.67	15.25	16.50	12.75	14.83
5.75	6.00	5.00	5.58	15.75	16.75	13.00	15.17
5.75	5.75	5.02	5.51	16.00	16.75	14.75	15.83
6.00	5.75	5.57	5.77	16.00	16.75	15.00	15.92
6.00	5.50	5.02	5.51	17.05	16.00	15.25	16.10
5.75	5.75	5.02	5.51	15.75	16.00	16.75	16.17
6.00	5.50	5.02	5.51	18.25	17.00	15.50	16.92
6.75	5.75	5.50	6.00	17.75	16.25	15.00	16.33
6.00	5.75	5.50	5.75	16.50	16.25	15.25	16.00
6.75	5.75	5.50	6.00	18.25	17.50	15.75	17.17
0.45	0.48	0.43	—	1.29	1.12	1.51	—
N.S.	N.S.	N.S.	—	2.64	2.32	3.53	—

Test weight and seed yield per plant were significantly increased by application of nutrients, either alone or in combination over control (Table 2). Sulphur dressings were significantly better than control with regard to seed yield. However, these were not significant among themselves. Sulphur levels of 30 kg and 40 kg/ha were better than 10 and 20 kg/ha on the basis of pooled analysis. Doses of

Table 2: Effect of sulphur, zinc and boron on seed yield, test weight and oil content in mustard seed

Treatments	Seed yield (q/ha)			Mean
	1978-79	1979-80	1980-81	
1. Control	15-80	20.48	15.74	17.34
2. 10 kg S/ha	19.62	22.06	16.51	19.40
3. 20 kg S/ha	18.89	22.30	17.75	19.65
4. 30 kg S/ha	18.72	22.78	17.98	19.83
5. 40 kg S/ha	18.76	22.86	18.05	19.89
6. 10 kg Zn/ha	16.79	23.01	16.67	18.82
7. 1 kg B/ha	18.47	22.54	18.36	19.79
8. 20 kg S + 10 kg Zn/ha	17.53	22.54	18.05	19.37
9. 10 kg Zn + 1 kg B/ha	17.28	22.38	19.29	19.65
10. 20kg S + 1 kg B/ha	17.63	23.81	20.14	20.53
11. 20 kg S + 1 kg Zn + 1 kg B/ha	17.90	22.94	19.91	20.25
S. E. ±	0.48	0.55	0.56	0.52
C. D. (P = 0.05)	1.40	1.60	1.61	1.09

zinc and boron also gave significantly higher seed yield than control and the trend was the same in case of combined doses of these nutrients. Among the combined doses, 20 kg S and 1 kg B/ha gave highest seed yield closely followed by 20 kg S, 1 kg B and 10 kg Zn/ha. Similar results have been reported by several workers (Singh *et al*, 1970; Pathak, 1975; Mehrotra, 1977; Shukla *et al*, 1982).

Table 2: (Contd.)

Seed yield/plant (g)				Test weight (1000 seeds)				
1978-79	1979-80	1980-81	Mean	1978-79	1979-80	1980-81	Mean	Mean oil content(%)
12.58	15.10	15.73	14.47	4.42	4.86	4.73	4.67	37 5
16.43	16.93	18.81	17.39	4.67	4.93	4.79	4.80	40.0
16.95	17.56	19.63	18.05	4.35	5.05	4.73	4.71	39.5
16.48	17.40	20.30	18.06	4.87	5.03	4.77	4.89	38.6
16.46	18.33	20.16	18.32	4.90	5.03	4.78	4.90	39.6
14.40	19.23	17.83	17. 5	4.66	5.11	4.63	4.80	37.4
16.72	18.30	19.56	18.19	4.65	5.10	4.67	4.81	39.1
16.80	18 26	19.36	18.14	4.30	5.08	4.71	4.70	40.0
15.40	18.90	18.62	17.64	4.83	5.07	4.70	4.87	38.0
17.53	19.26	19.95	18.91	4.70	5.11	4.76	4.86	39.8
18.46	18.55	18.90	18.64	4.89	5.06	4.96	4.97	40.5
0.79	1.03	1.34	—	0.25	0.08	0.11	—	—
1.65	2.15	2.79	—	0.53	0.17	0.20	—	—

All the treatments except 10 kg Zn/ha gave numerically higher mean oil content in seed. However, the highest oil content of 40.5% was recorded in the 20 kg S, 10 kg Zn and 1 kg B/ha treatment. Application of sulphur @ 10 kg/ha increased the oil content considerably. Higher doses of sulphur over 10 kg/ha did not increased the oil content. Boron alone also tending to increase the oil content as compared to the control.

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Effect of different production factors on the performance of cultivars of Indian mustard

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Marked improvememnt in the yield and quality of mustard (*Brassica juncea* Czern & Coss) achieved with the adoption of the available improved production technology developed so far which comprise the use of improved varieties, timely sowing, application of balanced fertilizers, adoption of plant protection measures, timely irrigation etc. It was considered desirable to know the contribution and economics of each factor in the production technology on the performance of different cultivars of mustard.

With this objective, a field experiment was conducted at the Punjab Agricultural University, Ludhiana for two years (1979-80 to 1980-81). The experimental soil was loamy sand with pH 8.5, low in nitrogen, medium in available phosphorus and potassium. Ten treatments as given in Table 1 were tested on three approved varieties (RL 18, RLM 198 and RLM 514) separately, in a randomized block design having four replications. The optimum levels of each treatment as determined earlier through separate experimentation, adopted in the experiment were : i) Irrigation (I) : Two irrigations, first after 3-4 weeks of sowing followed by another irrigation 6-7 weeks thereafter (ii) Fertilizer (F) : 75 kg N/ha (through urea) (iii) Pest Control (PC): Two sprays of Metaxystox with 875 ml and one litre/ha respectively (iv) Disease Control (DC) : Three sprays of copper oxychloride (Blitox) @ 625 g/ ha.

The crop was sown in each year after the presowing irrigation at the second fortnight of October in 30 cm rows. A uniform seed rate of about 5 kg/ha was used. Three weeks after sowing, the plant to plant distance of 10 cm was maintained. The weeds were removed by two hand hoeings. At maturity, the seed yield was recorded separately from each plot and subjected to statistical

Table 1 : Effect of packages of practices on the seed yield of different cultivars of Indian mustard

| Treatments | Seed yield (kg/ha) | | | |
| | RL 18 | | | |
	1979-80	1980-81	Mean	% increase
1. Variety (V)	795	372	584	—
2. V + Irrigation (I)	1038	474	756	29.5
3. V + Fertilizer (F)	1115	513	814	39.4
4. V + I + F	1359	397	878	50.3
5. V + Pest Control (PC)	1038	321	680	16.4
6. V + Disease Control (DC)	910	436	673	15.2
7. V + PC + DC	1077	490	784	34.2
8. V + I + PC + DC	1128	500	814	39.4
9. V + F + PC + DC	1282	644	962	64.7
10. V + I + F + FC + DC (Package of Practices)	1679	777	1228	110.3
C. D. (P = 0 05)	241	185	—	—

analysis. The oil content was determined from the composite sample of each treatment.

        Seed yield of all the varieties differed significantly (Table 1) in both the years except in variety RLM 514 during 1979-80, with the adoption of different production factors.   On the average of two years, the increase with the adoption of package of practices, over variety alone, ranged from 15.2 to 110.3 per cent in RL 18, 12.1 to 100.1 per cent in RLM 198 and 4.4 to 54 4 per cent in RLM 514. The overall response of factors over varieties and years varied from 10.2 to 84.4 per cent. RLM 198 and RLM 514, on an average, gave 18.5. and 49.3 per cent

Table 1 (Contd.)

RLM 198				RLM 514				Overall	Mean
1979-80	1980-81	Mean	% increase	1979-80	1980-81	Mean	% increase	Actual (kg)	% increase
1038	346	(92	—	1308	436	872	—	716	—
1192	474	833	20.4	1513	590	1052	20.6	880	22.9
1308	577	943	36.3	1551	705	1128	29.4	962	34.4
1474	649	1062	53.5	1603	713	1158	32.8	1033	44.2
1103	449	776	12.1	1333	487	910	4.4	789	10.2
1108	462	785	13.5	1397	538	968	11.0	809	13.0
1310	567	939	35.7	1449	656	1053	20.8	925	29.2
1462	603	1033	49.3	1513	667	1090	25.0	979	36.7
1615	756	1186	71.4	1628	769	1199	37.5	1116	55.6
1872	897	1385	100.1	1756	936	1346	54.4	1320	84.4
276	80	—	—	NS	255	—	—	—	—

higher seed yield respectively over RL 18. Considering individual factors, fertilizer application contributed the highest of 39.4 per cent in RL 18, 36.3 per cent in RLM 198 and 29.4 per cent in RLM 514 followed by irrigation which brought a respective increase of 29.5, 20.4 and 20.6 per cent. The yield increase with the adoption of either pest control or disease control was invariably the lowest. The combination of two or more factors enhanced the seed yield in all the cases.

The highest seed yield was achieved by the combined adoption of all the four factors (package technology) which yielded 110.3, 100.1 and 54.4 per cent higher in variety RL 18, RLM 198 and RLM 514 respectively, over variety alone. These

findings are in agreement with those of Baral *et al.* (1985).

The oil content in the seed (Table 2) showed variation with production factors. On the average, irrigation alone showed an increase of 2.11 per cent, over variety alone. The positive increase was also observed when two or more factors were integrated.

Table : 2   Economics of different treatments

Treatment	Mean oil (%)	Mean seed yield (kg/ha)	Gross* income (Rs./ha)	Cost (Rs./ha)	Return over V (seed alone) (Rs.)	Cost : benefit ratio
1. V	41.67	716	3580	—	—	—
2. V + I	43.78	880	4400	100	720	1 : 7.2
3. V + F	41.82	962	4810	450	780	1 : 1.7
4. V + I + F	41.37	1033	5165	550	1035	1 : 1.9
5. V + PC	41.22	789	3245	200	165	1 : 0.8
6. V + DC	40.88	809	4045	100	365	1 : 3.6
7. V + PC + DC	43.35	925	4625	300	745	1 : 2.5
8. V + I + PC + DC	42.33	979	4895	400	915	1 : 2.3
9. V + F + PC + DC	42.33	1116	5580	750	1250	1 : 1.7
10. V + I + F + PC + DC (Package of Practices)	43.37	1320	6600	850	2170	1 : 2.5

*mustard @ Rs. 500/-q

Considering the cost involved in the adoption of each factor (Table 2), the highest return of Rs.2170/ha was obtained from the adoption of combination of all the four factors (package technology) followed by Rs. 1250/- available with the

exclusion of irrigation from these four factors. However, when cost : benefit ratio is taken into consideration irrigation, topped in importance as it resulted in the highest cost : benefit ratio of 7.2 (Table 2) being a cheap, though scarce, input.

These results clearly suggest the importance of adoption of improved tech-nology in package form to achieve the desired objective of higher productivity and increased total production of mustard.

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Effect of salt concentration on germination of sunflower genotypes

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The present work was undertaken to study the salt tolerance in sunflower (*Helianthus annuus* L.) genotypes during germination in the presence of chlorides of calcium and magnesium at different concentration levels.

The laboratory studies for germination was taken up with calcium chloride and magnesium chloide alone and in combination of 1 : 1 ratio at six levels of concentrations *viz*, (i) 2 m.mhos/cm; (ii) 4 m.mhos/cm; (iii) 6 m.mhas/cm; (iv) 8 m.mhos/cm; (v) 10 m.mhos/cm; (vi) 12 m.mhos/cm besides one control (distilled water). The test varieties selected for study were Morden and EC 68414.

The seeds were treated with salt solutions as per the treatments and kept for germination in paper towels at $30^{\circ}C \pm 5^{\circ}$ in four replications for seven days. Germination count was recorded on 5th and 7th day.

From the germination count, it is evident that increasing salinity delayed initial emergence and decreased the subequent rate of emergence and the ultimate germination percentage (Table 1). These findings are in conformity with that of Francois and Bernstein (1964) in case of safflower.

Salinity upto 4 m.mhos/cm with calcium chloride and magnesium chloride alone did not have ill-effects on the germination of Morden, whereas EC 68414 could tolerate a salinity level upto 6 m.mhos cm recoding 91% germination. These results indicate that EC 68414 is more salt tolerant.

When salinity effects are compared, calcium chloride is less injurious than magnesium chloride. Magnesium chloride at higher concentration drastically

Table : 1 Germination count on 5th and 7th day for the varieties Morden and EC 68414

Salt	Day	Variety	Treatments (salinity in m. mhos/cm)						
			Control	2	4	6	8	10	12
Calcium	5th	Morden	45.5	42.50	42.00	30.50	25.03	25.00	0 00
chloride		EC 68414	55.0	45.00	52.00	55.00	25.00	25.00	0.00
	7th	Morden	45.5	40.25	42.00	20.00	2.00	0.00	0.00
		EC 68414	88.2	71.25	80 75	87.75	79.5	80.75	2.75
Magnesium	5th	Morden	45.5	40.25	42.00	20.00	2.00	0.00	0.00
chloride		EC 68414	55.0	55.50	52.50	70.00	2.25	0.00	0.00
	7th	Morden	71.5	62.00	70.25	32.00	5.00	0.25	0.25
		EC 68414	88.2	87.00	82.00	21.00	2.25	0.00	2.25
Calcium chloride + Magnesium chloride (1:1)	5th	Morden	45.5	42.50	45.00	35.00	25.50	0.00	0.00
		EC 68414	55.5	56.00	58.00	54.00	0.00	0.50	0.00
	7th	Morden	71.5	67.50	73.25	69.25	46.50	0.75	0.00
		EC 68414	18.2	76.75	88.00	83.25	0.25	0.00	0.00

affected the germination. At 6 m.mhos/cm magnesium chloride had much deleterious effects comparative to Calcium chloride alone and a combination of calcium chloride and magnesium chloride (1 : 1 ratio) in the case of variety Morden, while such effects were not observed in the case of variety EC 68414 at a salinity level of 6 m.mhos/cm.

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Inheritance of leaf pigments in *BRASSICA CARINATA*

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B. carinata A. Br., popularly known as Ethiopian mustard, is currently been introduced as an oilseed crop for rainfed cultivation. In view of its higher yield potential, immunity to major diseases of domesticated oleiferous *Brassica* and higher tolerance to the aphid pest, a number of new accessions of this species have been introduced recently from various sources. In the course of evaluation of the germplasm, a line characterised by the presence of light purple anthocyanin pigment in its leaves was observed. The plants of this line tended to remain light purple at vegetative phase and slowly turning to normal green after flower initiation. The inflorescence was light purple splashes and petals whitish yellow in colour.

The plants of purple pigmented line (BCR-210) was crossed reciprocally with the normal green (BCR-2607) to study the inheritance of leaf anthocyanin pigments. The F_1, F_2 and back cross generations were planted during the crop seasons from 1981-1984.

All plants of the various generations were observed for their pigment colour and X^2 test was applied to determine the goodness of fit to the observed ratios.

The plants in F_1 and its reciprocal cross showed deep (blackish) purple pigment compared to the light purple parent. The deep purple anthocanin pigment of the F_1 plants persisted throughout the plant cycle, though diluting to light purple with greenish tinso in the late reproductive phase. The inflorescence of F_1 plants was deep purple with flowers bearing purple sepals and whitish yellow petals. The F_2 segregated into three phenotypic classes (Table 1) with a frequency of 678 deep purple : 241 light purple : 314 normal green, thus, revealing digenic mode of inheritance. The F_2 frequency fitted in the ratio of 9:3:4 suggesting

thereby a pair of supplementary factors involved in the inheritance of this trait. The deep purple class originating when two dominants, one having marked purple anthocyanin pigment and the other normal green colour, were present together in the dominat state intensifying the purple anthocyanin pigment.

Table 1 : Mode of inheritance of anthocyanin pigment in *B. carinata*

Cross	Generation	Leaf/plant colour			Ratio	x^2 value	P value	Possible genotypes
		Deep purple	Light purple	Normal green				
Light purple (P_1) x Normal green (P_2)	F_1	34	—	—	—	—	—	*Pl pl l i*
Normal green (P_2) x Light purple (P_1) Reci	F_1	32	—	—	—	—	—	*Pl pl l i*
	F_2	678	241	314	9:3:4	0.85	0.750-0.500	*Pl Pl l l, Pl Pl l i, Pl pl l l, Pl pl l i, Pl pl ii, Pl pl i i, pl pl l l, pl pl li, pl pl i i*
	BC_1	104	98	—	1:1	0.18	0.750-0.500	*Pl Pl l i, Pl pl li, Pl Pl i i, Pl pl i i*
	BC_2	88	—	94	1:1	0.13	0.750-0.500	*Pl pl l l, Pl pl l i, pl pl l l, pl pl l i*

The back cross (BC_2) of the deep purple F_1 with the normal green parent (P_2) segregated in the ratio of 1 purple : 1 normal green, while a ratio of deep purple :light purple was observed in the backcross (BC_1) involving the light purple parent (P_1). Thus the backcross data further confirmed the supplementary factor hypothesis.

The gene symbols assigned to the parents are, light purple (*Pl Pl i i*) and normal green (*pl pl l l*), where *Pl* when present alone in the dominant state marked the purple pigmentation, while the remaining alleles (*pl, l, i*) determining normal green colour of the plant. However, when the two dominants (*Pl* and *l*) were present together, the intensification of anthocyanin pigment to deep purple was observed. Based on the hypothesis, the gene symbols for the various progenies of the cross are given in Table 1.

Control of seed rot and collar rot of groundnut

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Groundnut)*Arachis hypogaea* L.) crop is affected by many fungal diseases but seed rot and collar rot caused by *Aspergillus niger* van Tieghem are of considerable importance in India. These diseases cause upto 50 per cent losses in groundnut yield in some parts of the Punjab (Chahal *et al.*, 1974). Sandy and sandyloam soils are more conducive to these diseases and the heavy soil is the least favourable (Chohan, 1973; Gibson, 1953). Therefore, different fungicides were tested *in vitro* and glass house conditions in sandy soil to find out suitable fungicidal control measure. To study the efficacy of different fungicides *in vitro*, the poisoned food technique was employed (Nene and Thapliyal, 1979). The fungicides tested were: carbendazim (Bavistin 50 WP) (Methyl -2-benzimidazol carbamate), benomyl (Benlate 50 WP) (Methyl-N- (1-butyl-carbamoyl)-2-banzimidazol), mancozeb (Dithane M-45 75 WP) [a coordinated compound of zinc ion (2%) and manganese ethylane bisdithiocarbamate (78%)], PCNB (Brassicol) (Pentachloronitrobenzene), Thiram 75 WP (Tetramethyl thiram disulphide), carboxin (Vitavax 75 WP) (Carboxin (5, 6-dihydro-2-methyl-1, 4-oxathin-3-carboxanilide), ziram (Cuman L 80 WP) (Zinc dimethyldithiocarbamate), inorganic sulphur (Wet sulf 80 WP) (elemental sulphur), Captan 50 WP (N-trichloro-methylthio-4-cyclohexene-1, 2 dicarboximide), and ceresan 50 WP (N-(ethyl-mercury) P-toluenesulphonanilide).

Measured quantity of fungicides was incorporated and mixed thoroughly into sterilized potato dextrose agar (PDA) medium in conical flasks to get 25, 50, 100, 200, 400 and 600 ppm concentration of each fungicides. In each petridish 25 ml medium was poured which was later inoculated with 4mm mycelial disc of *A. niger* isolated from groundnut seedlings. The mycelial discs were taken from Richards's agar medium which had 10^{-2}M ammonium floride to inhibit the sporulation completely. PDA without fungicide served as a control. There were

Table : 1   Per cent inhibition of growth over control of *Aspergillus niger* with different fungicides at different concentrations *in vitro*

Fungicides	Concentration in ppm					
	25	50	100	200	400	600
Carbendazim	100.00	100.00	100.00	100.00	100 00	100 00
	(90.00,	(90.00)	(90.00)	(90.00)	(90 00)	(90.00)
Benomyl	100.00	100.00	100.00	100.00	100.00	100.00
	(90.00	(90.00)	(90.00)	(90.00)	(90.00)	(90.00)
Mancozeb	(45.52	51.07	66.77	100.00	100.00	100 00
	(42.42)	(45.62)	(51.24)	(90.00)	(90.00)	(90.00)
PCNB	31.90	38.57	40.77	51.62	55.52	82.45
	(34.37)	(38.36)	(39 66)	(45.93)	(48.19)	(65.32)
Thiram	21.05	23.85	42.45	56.60	100.00	100.00
	(37.27)	(39.52)	(50.65)	(58.79)	(90.00)	(90.00)
Carboxin	15.22	34.40	53.02	56.05	71.35	83.33
	(22.95)	(35.81)	(46.74)	(48.48)	(57.65)	(65 88)
Ziram	9 40	13.57	17.72	26.05	40.52	73.30
	(17.78)	(21.59)	(24.81)	(30.68)	(39.54)	(58.96)
Sulphur	19.10	21.90	24.12	26.87	27.45	31.07
	(25.88)	(27.88)	(29.39)	(31.22)	(31.58)	(31.86)
Captan	58.00	63.57	69.10	71.12	78.85	84.40
	(49.60)	(52.88)	(56.29)	(59.44)	(62.62)	(66.75)
Ceresan	19.12	23.30	26.05	29.70	48.30	81.07
	(25.83)	(28.86)	(30.68)	(32.95)	(44.03)	(64.25)
Control	0.00	0.00	0.00	0.00	0.00	0.00
(No fungicide)	(0.00)	(0.00)	(0.00)	(0·00)	(0.00)	(0.00)

	S. Em. ±	C. D. (P = 0.05)
Within treatment	0.12	0.95
Between treatment	0.72	2.35

1· Average of 4 replications

2. Figures in parenthesis are angular transformed values of percentage

4 replications for each treatment. Colony diameter was measured after 5 days of incubation at $28 \pm 2^{\circ}C$ when the fungus covered the entire Petridish in the control and the mean percent inhibition of growth in different treatments were calculated over control.

Table 2. Efficacy of different seed dressing fungicides against seed rot and collar rot in cultivar GAUG-1 in glass house

Fungicide	Rate (g/kg seed)	Seed rot (%)	Collar rot (%)
Carbndazim	1	6.25 (13.77)	5.27 (14.02)
Benomyl	1	6.25 (13.77)	7.77 (16.36)
Mancozeb	3	12.50 (20.47)	19.77 (25 25)
Thiram	4	17.50 (22.50)	23.60 (28 67)
Captan	3	20.00 (24.53)	27.42 (31 46)
Carboxine	3	27.08 (31.54)	44.60 (41.89)
Ziram	3	30.00 (33.05)	54.59 (47.65)
PCNB	3	27.08 (31.54)	48.62 (44 19)
Sulphur	3	30 00 (33.21)	57.10 (49.11)
Ceresan	2	27.08 (31.54)	41.47 (40.10)
Control	—	40.00 (32.23)	83.30 (65.88)
S. Em ±		1.98	2.69
C. D. (P = 0.05)		5.70	7.76
C. V. %		17.78	14.63

1. Average of 4 replications
2. Figures in parenthesis are angualar transformed values of percentage

Efficacy of various fungicides against seed rot and collar rot was studied in glass house condition. *A. niger* isolated from diseased groundnut seedlings was multiplied on soil maize medium for 7 days at $28 \pm 2^{\circ}C$, mixed thoroughly with

sterilized sandy soil (1: 6) and about 350 g soil mixed with inoculum was filled in each 10 cm plastic pot. Seeds of susceptible cultivar GAUG-1 were treated with different fungicides at the rates given in Table 2. Ten seeds were sown in each pot and each treatment was replicated four times. Untreated seeds sown in pots served as control. The pots were irrigated as and when required.

Seed rot observations were taken 7 days after sowing. After 10 days of sowing, the seedlings were inoculated at collar region with the inoculum multiplied on PDA for 5 days at $28 \pm 2^{0}C$. Mixture of mycelium and spores was put around the collar region and coverd with wet soil to keep inoculum moist. Collar rot observations were taken periodically upto 14 days after inoculation.

Carbendazim and benomyl completely inhibited the growth even at 25 ppm followed by mancozeb, thirm, and captan. Sulphur was found poorest for inhibition of the growth (Table 1).

Mathur and Sharma (1977) found complete inhibition of *A. niger in vitro* with 10 ppm of carbendazin and benomyl followed by mencozeb. The present observations are confirmative with those of Siddaramaiah *et al.* (1979) who also reported that carbendazim completely inhibited growth of *A. niger* at 10 ppm.

All the fungicidal seed treatments were significantly effective over control in reducing seed rot and collar rot. Seed treatments with carbendazim and benomyl were most effective and significantly superior over other fungicides. There was only 6.25 per cent seed rot in carbendazim and benomyl seed treatments and 5.27 and 7.77 per cent collar rot respectively followed by mancozeb, thiram and captin in reducing the seed rot and collar rot. Sulphur and ziram were poorest for the control of seed and collar rots (Table 2).

Seed treatment with carbendazim has been reported effective for the collar rot of groundnut (Gaur and Ahmed, 1983 ; Siddaramaiah, 1979). Mathur and Sharma (1977) found seed treatment with thiram significantly superior on germination and yield of groundnut followed by mancozeb.

Ceresan, agrosan, captan and thiram have been found promising against *A. niger* (Chohan *et al* , 1966 ; El-Khadem, 1968 ; Sidhu and Chohan, 1971). Our results suggest that carbendazim and benomyl (1 g/kg seed) can effectively control seed rot and collar rot caused by *A. niger* in sandy soils.

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Yield attributes and yield of groundnut varieties as influenced by planting dates in tarai region of Uttar Pradesh

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Groundnut is widely grown in mid-western region of Uttar Pradesh but the average productivity of the state during the last three years has remained at a low level of 6 q/ha. The productivity of groundnut can be improved to a greater extent by adjusting the dates of planting, to avoid adverse effect of heavy rains, disease infestation and by adopting suitable varieties under such conditions (Parushotham *et al.*, 1974). Weather conditions prevailing during the crop growth greatly influence productivity and biosynthesis of oil in groundnut. Therefore, by adjusting only the planting dates, an important non-monetary input, net returns could be enhanced. In *tarai* zone of U.P. no such studies have been carried out and as such an experiment was conducted with an objective to find out the optimum time of planting and suitable variety of groundnut for obtaining higher yield levels.

The field experiment was conducted at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar during *Kharif* season of 1983-84 and was laid out in a split-plot design with three replications, taking four planting dates (June 10, June 25, July 10 and July 25) as main plot treatments and five varieties (T-28, Robout 33-1, M-13, GAUG-10 and J-11) as sub-plot treatments. The plot size was 5m × 4.05m and various observations on number of branches per plant, number of pods per plant, number of kernels per pod, dry pod weight per plant, 100 kernel weight and shelling per cent were recorded on the basis of five randomly selected plants in each plot. Yield of pods per hectare was calculated from the net plot yield. Protein and oil contents in kernels were determined using micro-Kjeldhal method (Jackson, 1967) and Soxhlet extraction method. The data were subjected to statistical analysis.

Table 1 : Yield contributing characters and quality parametres in groundnut as Influenced by planting dates and varieties

Treatments	No. of branches/ plant	Dry matter accumulation/ plant (g)	Dry. wt. of pods/ plart (g)	No. of pods/ plant
Planting dates				
June 10,	15.95	52 21	16 52	10·67
June 25,	12.52	38.86	15.02	10 27
July 10,	11.31	24.49	7.07	8.01
July 25,	9.94	25·66	5·86	6.96
S Em ±	0.26	0.72	0.38	0.39
C.D. (P = **0.05**)	0.89	2 49	1.31	1 37
Varieties				
T-28	13.27	35 49	11.75	8.56
Robout 33-1	12.95	32.89	10.35	8.84
M-18	14.27	42.59	13.72	9.54
GAUG-10	12.02	35.68	11.03	8.87
J-11	9 64	29.94	9.52	9.07
S.Em ±	0.42	0.73	0.29	0.31
C.D. (P = 0.05)	1.18	2.09	0.85	0.87

NS = Nonsignificant

1. Yield contributing characters :

The various yield contributing characters consisting of no. of branches per plant, dry matter accumulation per plant, dry pods weight per plant and shelling per cent had significantly higher values in advanced planting over other dates (Table 1). Similar findings have also been reported by Saha and Gupta (1962) and Yang *et al.* (1982). In earlier plantings done on June, 10 and 25, the no. of pods per plant and 100 kernel weight were significantly higher over other two planting dates, the reason being that in advanced planting there

Table 1 : (Contd)

No. of kernels/ pod	100 kernel weight (g)	Shelling per cent	Protein content (%)	oil content (%)
1.75	35.22	74.82	25.46	49.05
1.68	35.41	72.79	25.62	49.34
1.69	32.62	71.66	24.24	48.19
1.74	29.41	68.14	23.42	48.12
0.05	0.67	0.18	0.21	0.24
NS	2.32	0.64	0.70	0.82
1.93	28.26	69.63	25.03	47.42
1.65	31.95	72.06	24.28	50.62
1.55	46.06	70.87	24.82	47.97
1.74	34.74	73.37	25.05	49.04
1.72	24.81	73.32	24.29	48.35
0.04	0.57	0.67	0.17	0.26
0.13	1.64	1.94	0.49	3.75

were more number of branches and possibly due to better availability of photo-synthates for its development. Number of kernels per pod, however, did not differ significantly with different planting dates. Among varieties, M-13 had significantly higher number of branches per plant over all other varieties except T-28. M-13 also had significantly higher dry matter accumulation per plant, dry pods weight per plant and 100 kernel weight. The number of pods per plant in M-13 did not differ with other varieties, except T-28. Shelling percentage was maximum in GAUG-10, however, remaining at par with Robout 33-1 and J-11. T-28 recorded significantly higher number of kernels per pod over all other varieties.

2. Pod Yield :

The pod yield data (Table 2) revealed that the mean pod yield of groundnut on June 10 planting was significantly higher over other planting dates except June 25 planting with which it remained at per and decreased subsequently with delayed plantings. Similar trends have been reported by Parushotham et al.

Table 2 : Pod yield (q/ha) of groundnut as influenced by planting dates and varieties

| Planting dates (D) | Varieties (V) | | | | | |
	T-28	Robout 33-1	M-13	GAUG-10	J-11	Mean
June 10	20.88	13.74	29.33	15.88	10.84	18.14
June 25	13.66	16.33	22.23	17.87	13.11	16.64
July 10	10.03	11.53	15.59	10.78	9.79	11.55
July 25	9.07	8.77	10.25	9.08	9.04	9.24
Mean	13.41	12.59	19.35	13.41	10.69	

	S.Em ±	C. D. (P = 0.05)
D	0.56	1.94
V	0.36	1.04
Comparison of D at same or different V	0.85	2.68
Comparison of V at same D	0.72	2.08

(1974) and Salma et al. (1977). The reduction of pod yield in July 10 and July 25 plantings over June 25 was estimated to be 30.59 and 44.47 per cent. Interaction effect of varying planting dates and varieties was found to be significant on pod yield. Variety M-13 recorded significantly higher pod yield in comparison with other varieties on all planting dates except on July 25 planting where it remained at par with all other varieties. This higher pod yield of M-13 may be due to higher values of the various yield contributing characters viz. dry matter production per plant, dry pod weight per plant, number of pods per plant and 100 kernel weight. These findings are in agreement with findings of Bhattacharya

and Sarkar (1977), Shinde and Pawar (1982) and Shilke and Khuspe (1982.) Robout 33-1, GAUG-10 and J-11 yielded more in June 25 plantings, whereas T-28 and M-13 yielded more in June 10 planting and then their yield decreased subsequently with delay in planting dates. However, the first two dates did not differ significantly in case of GAUG-10. Different varieties, except M-13, were at par with one another when planted on July 10.

3. Protein and oil content :

Protein content in kernels on the first three planting dates did not differ significantly, however, on July 25 planting it was significantly lower in comparison with other dates. Oil content in kernels decreased in plantings done after June 25. Similarly, reduction in oil content has also been reported by Gupta *et al.* (1983) with the delay in planting. Among varieties, GAUG-10 recorded significantly higher protein content over Robout 33-1 and J-11 but remaining at par with T-28 and M-13. Robout 33-1 recorded the highesr oil content.

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Effect of sowing dates on yield and yield attributing traits in Indian mustard

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Mustard (*Brassica juncea* czern & Coss) being genetically a thermosensitive crop the growth and yield of this crop depend largely on the time of planting. Various workers reported different sowing time for different agroclimatic regions. The optimum sowing time as worked out by the previous workers under the West Bengal situation ranged from October 15 to October 27 (Bhattacharya and Pal, 1973; Pal *et al.*, 1976). An attempt has been made in the present study to determine the optimum time for sowing of mustard in the Gangetic West Bengal as well as to identify variety(s) suitable for late sowing condition to suit farmers' practice of taking up mustard after harvest of high yielding *Kharif* paddy.

Ten varieties of Indian mustard belonging to different maturity groups *viz.* early (B-85, RAURP-4, RAURP-5), Medium (RW-351, RW-85-59, Pusa Bold, Varuna) and late (RLM 514, RH 781, PR-35) were put under seven different sowing dates starting from middle of October at an interval of 10 days. The experiment was laid out in a split plot design with three replications during the *rabi* 1981-82, 1982-83 and 1983-84 at the Pulses and Oilseeds Research Station, Berhampore adjusting different sowing dates in the main plots and the varieties in sub plots. The experimental soil was sandy loam having 7.75 pH, 0.053% available N, 80.3 kg/ha available P and 195.6 kg/ha available K. The crop received a basal fertilizer dose of 40 kg (N) : 40 kg (P) : 40 kg (K) /ha at the time of final land preparation. Another 40 kg (N) /ha was top dressed at the time of first irrigation. The crop was irrigated as and when required during the growth period. The plot size was 5.0m x 1.5 m and spacing 33 cm x 10 cm.

The yield over the years revealed that seed yield was affected significantly by dates of sowing (Table 1). The maximum yield over varieties was recorded at November 5 sowing and sowing beyond November 5 reduced the yield significantly. Difference in yield due to sowing in October 25 and November 5 was,

Table : 1   Seed yield (kg/ha) of mustard varieties as influenced by sowing dates

	Varieties	D_1	D_2	D_3	D_4	D_5	D_6	D_7	Mean
1.	B-85	1490	1470	1400	1170	700	520	330	1011
2.	RW-351	1630	1680	1630	1100	970	560	270	1120
3.	Varuna	1690	1620	1940	1590	1100	760	400	1300
4.	Pusa Bold	1470	1680	2130	1550	1220	720	470	1177
5.	RW-85-59	1460	1750	1590	1310	1050	630	390	1168
6.	RLM-514	1640	1810	1760	1170	980	740	330	1204
7.	RH-781	1950	1890	1870	1360	800	750	370	1284
8.	PR-35	1960	1680	1730	1350	970	750	430	1267
9.	RAURP-4	1420	1560	1290	1160	830	510	390	1023
10.	RAURP-5	1490	1420	1540	1170	750	370	390	1018
	Mean	1621	1656	1690	1293	938	631	377	

Dates of sowing

    S. E. = ± 24. 5 kg/ha   C. D. (P = 0.05) = 51.5 kg/ha

Varieties

    S. E. = ± 29.3 kg/ha   C. D. (P = 0.05) = 87.91 kg/ha

Interactions

    Sowing Dates x Variety = ± 77.6 kg/ha   C. D. (P = 0.05) = 232.8 kg/ha

D_1 = October 15, D_2 = October 25, D_3 = November 5, D_4 = November 15,
D_5 = November 25, D_6 = December 5, D_7 = December 15

Date averaged over three years

however, observed to be insignificant. The period between October 25 to November 5 may thus be considered as optimum for sowing mustard in Gangetic West Bengal.   This is in contrast to the observation of Pal *et al.,* (1976). The reason behind such anomaly may be attributed to the changed weather situation.

Table : 2 Effect of sowing dates on yield and yield attributing characters in Indian mustard

Dates of sowing	Primary branches	Secondary branches	Number of siliquae	1000 seed wt.(g)	Yield (kg ha)
D$_1$	5.40	8.33	231.8	3.52	1621
D$_2$	5.40	8.72	249.8	3.55	1656
D$_3$	5.90	8.80	272.8	3.60	1690
D$_4$	4.92	6.07	164.8	2.92	1293
D$_5$	4.74	4.75	140.0	2.92	938
D$_6$	3.87	4.22	109.0	1.72	631
D$_7$	2.75	3.30	86.0	1.50	377
S. E. (±)	0.35	0.34	5.82	0 073	24.5
C. D. (P = 0.05)	1.08	1.02	18.10	0.221	51.5
C. V. %	7	6	5.6	2.87	3
G. M.	4.71	6 30	1.79		1368

Data averaged over years

Sowing dates, further, indicated profound effect on secondary branches, siliquae number and seed weight. A drastic reduction in seed weight, number of secondary branches and number of siliquae/plant were noticed when sown beyond November 5 (Table-2). The depressing effect of late sowing on yield and its component traits may be attributed to the prevalance of higher atmospheric temperatures during flowering and grainfilling stages. The low temperature has already been reported to favour seed formation in mustard (Bose, 1973)

Varieties responded differently to sowing dates. The early maturing and late maturing strains proved to be uneconomical under late sown condition as compared to medium maturing strains like Pusa Bold, Varuna and RW-85-59 (Table 1). Under the situation it may be further assumed that mustard sowing in West Bengal can be extended upto November 25 with varieties like Varuna, Pusa Bold and RW-85-59.

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Transgression in turnip rape (Brassica campestris L.)

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Appearance, in a segregating generation, of one or more genotypes which fall outside the range of its parents in respect of one or more characters is transgression. Positive transgression is a rare event but its occurrence is of immense value in crop improvement. The present paper concerns an isolation of a transgressive genotype from F_3 generation of an intervarietal cross of oleiferous Brassica (Brassica campestris).

In order to evolve a new plant ideotype, by combining oil content, seed colour and seed number per pod of yellow sarson var. YID-I (self-compatible) and branching capacity and adaptability of self-incompatible brown sarson (var. 71/6809 of Swedish origin), an intervarietal hybrid was made in 1979-80. The parental varieties were semidwarf in stature (90-140 cm) and short duration (100-120 days maturity). F_1 hybrid and F_2 population obtained by selfing F_1 generation were grown in 1980-81 and 1981-82 respectively. Biparental mating among F_2 progenies was done to break undesirable associations and to allow recombinations. The seed-pool of biparental matings was then grown as F_3 population in large size plot in 1982-83.

One plant with high number of semiopen branches, dilocular siliquae, bold yellow round seeds and later maturity was isolated from F_3 generation. Progenies of this plant and its parents were grown in 36 sq.m unreplicated plots in 1983-84 and repeated in 1984-85, to evaluate and confirm respectively the potential of a transgressive recombinant over years. Every year the crop was grown in rows spaced at 60 cm and within rows plants were spaced 10 cm by thinning of seedlings. Recommended agrononomical practices were followed. Observations on 11 characters (Table 1) were recorded for both, 1983-84 and 1984-85. A random sample of 10 plants in 1983-84 and 20 plants in 1984-85 was drawn for observations.

Table : 1   Comparative **mean** performance of transgressive genotype and their parents for
different traits

| Character | YID-I | | | Transgressive genotype | | | 1/6809 | | |
	1983-84	1984-85	**Mean**	1983-84	1984-85	Mean	1983-84	1984-85	**Mean**
Plant height (cm)	140.0	117.7	128.9	137.2	97.6	117.4	130.7	99.6	115.2
No. of primary branches	8.4	8 4	8.4	11.0	10.4	10.7	10.0	7.0	8.5
No. of secondary branches	2.5	0.6	1.6	26.3	26.4	26.3	25.2	13.8	19.5
No. of siliquae on primary branches	25.8	21.2	23.5	54.9	33 9	44.4	41.5	53.1	47.3
No. of siliquae on secondary branches	2.2	5.2	3.7	21.4	16.5	19.0	21.0	32.5	26 8
No. of siliquae per plant*	222.0	179.0	200.5	1167.0	788.0	977.5	1044.0	820.0	932.0
No. of seed per siliqua	33.1	37.0	35.1	11.2	13.7	12.5	16.4	21.2	18.8
Seed yield per plant (g)	45.0	40·0	42.5	44.0	36.0	40.0	42.0	38.0	40.0
1000 seed weight (g)	5.2	5.4	5.3	4.8	4.8	4 8	3.0	3.2	3.1
Percent oil content	45.5	45.7	45.6	47.3	47.5	47.4	42.8	43.0	42.9
Maturity (days)	114.0	106.0	110.0	146.0	140.0	143.0	110.0	104.0	107.0

*   Number estimated by multiplying average siliqua with the respective primary and secondary
branches on the plant

Means of different traits depicted in table 1, indicated the positive trans-
gression of new genotype in respect of production of primary and secondary
branches, siliquae and per cent oil content in the seed. Ruposhev (1974) observed
such a transgression in a cross between two parents, one having high while
other low indices for the character. Voskresenskaja and Spota (1967) also
reported an occurrence of positive transgression for oil content and seed size
in the progenies of inter-varietal crosses of *Brassica.* The new genotype exhi-

bited a negative transgression for seed number per siliqua and maturity In respect of other traits, it occupied an intermediate position. More lateral root spreads, bright green medium size leaves, siliquae at $90°$ angle from the bearing axis, high degree of eelf-compatibility, dilocular siliquae with bold and yellow seeds (4.8 g/1000 seeds) are some other important features of the new genotype.

An ideal plant height (Table 2), good distribution of siliquae on both primary and secondary racemes and better spread of roots make the new genotype coparatively more lodging and breaking resistant. The semispreading tendency of the plant in case of sub-optimal plant population, caused due to soil, seed, or any other factor, compensate the yield. However seed setting (seed number per pod) needs attention. Fortunately, sufficient variation for this character (8-26 seeds per siliqua) offers a good scope for the improvement by selection.

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New Epidemic-Sunflower Downy Mildew

Sunflower downy mildew (*Plasmopara halstedi*) a highly destructive disease has been reported for the first time by Drs. C. D. Mayee and M. A. Patil of M. A. U. Parbhani from Marathwada region of Maharashtra specifically from Latur, Bihr and Osmanabad districts. This was a quarantine disease until it was reported. Pathogen is seed and soil borne. It is difficult at this stage to find out the exact period and the source through which it has been introduced because of unauthorised seed materials import by several agencies. It is suspected that the disease might have already been spreaded all over the country. It is necessary to get the information from different parts of the country regarding its extent of spread for successful controlling this disease. Any information in this regard will be highly appreciated by the author. A brief symptamatology is given here for easy identification.

(1) First symptoms are yellowing of first pair of true leaves. Often at the base or along the midrib chlorotic areas expand. Leaves become chlortic and abnormally thick and stem become brittle. On young seedlings, whitish growth appears on the cotyledon under high humidity. Similar white growth also is seen on the under surface of the affected leaves normally in the morning.

(2) Affected plant becomes abnormally stunted or dwarf.

(3) Errect and usually sterile flower heads are being produced on infected plants.

(4) Basal galls in the affected plant are also very common. Oospores are being formed in the gall.

(5) In severe infection, disease may be confused with virus symotoms producing leaf pucuring, leaf curling etc.

How to confirm the disease

Confused sample may be kept in moist chamber or in moist polythene bag for two days. White growth on undersurface after two days confirms the disease.

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Satyabrata Maiti
Editor

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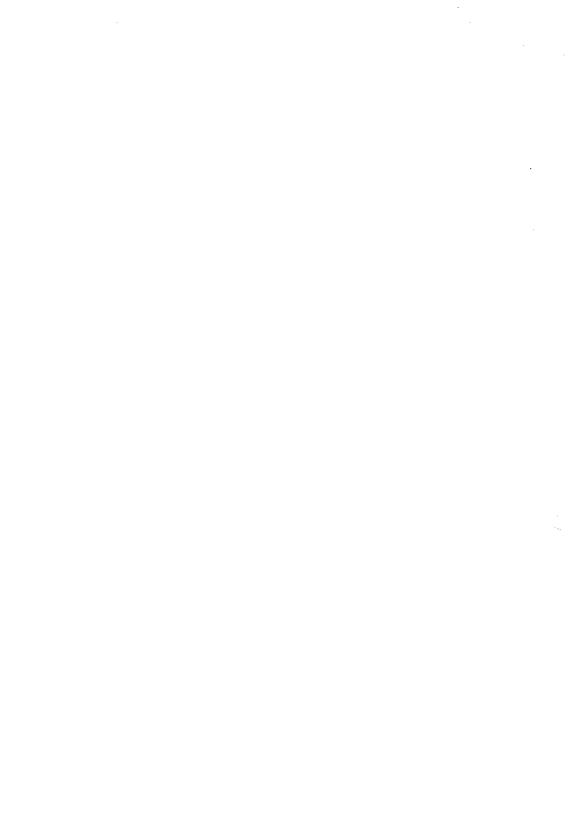
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