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Characters association and path of action in linseed as influenced by soil salinity

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ABSTRACT

Twenty two, promising linseed varieties/cultures were grown in saline plots in randomised block design with 3 replications. The observations were recorded on days to flowering, plant height, number of tillers per plant, dry matter yield, average number of seeds per capsule, 100 grain weight and grain yield per plant. Among these traits, unlike normal growing conditions, grain yield per plant, average number of seeds per capsule and 100 grain weight showed high negative correlation with days to flowering. The direct effect of these traits on days to flowering were substantial and they also operated mainly through each other in desired direction. In grain yield, highest positive effect of average number of seeds per capsule was noted. Days to flowering showed negative direct effect. However, its indirect effect through average number of seeds per capsule was highest and negative. The pertinent data clearly revealed that selections based on days to flowering, average number of seeds per capsule, seed index and grain yield per plant will be very much effective in improving the grain yield per unit area and time, simultaneously.

Key words : Linseed ; character association ; soil salinity

INTRODUCTION

In normal soil conditions, association of characters and path of action of different component characters on grain yield are well documented and discussed (Badwal, *et al.* 1970; Patil *et al.* 1980; Rai, 1981). However, under adverse saline growth conditions where action, interaction and final contribution of various component characters to the desired end product are subjected to substantial change, no study seems to be on record. It was, therefore, of interest to estimate direct and indirect effects of various causal factors on grain yield and days to flowering and also to study their implication in improving grain yield per unit area and time.

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MATERIALS AND METHODS

Twenty two promising salt tolerant cultures/varieties were selected from an initial evaluation trial conducted during 1975-76 with 735 entries under saline soil conditions at CSSRI, Research Station, Canning Town, W. Bengal. During 1976-77, these selected entries were grown in a randomised block design with 3 replications. Seeds of each entry were sown in 3 rows of 3 m length spaced 20 cm apart. Fertilizers were applied @ 60N, $30P_2O_5$ and 30 K_2O, kg/ha.

Salinity status of 10-15 cm. soil as measured in ECe varied from 5.71 to 11.30 mmhos/cm at the time of sowing. At harvest, ECe ranged from 7.37 to 13.23 mmhos/cm. The pH of the soil was 7.2 in 1:2 soil water suspension. The soil at the experimental site was rated as silty clay loam.

Observations were recorded on 10 randomly selected plants from each entry in each replication. For recording the average number of seeds per capsule, two capsules were selected randomly from each of the 10 plants selected, originally. After usual analysis of variance and covariance, based on phenotypic correlations, direct and indirect effects of different traits on grain yield per plant and days to flowering which is considered as an index of the crop period were estimated as suggested by Dewey and Lu(1959).

RESULTS

Analysis of variance revealed significant differences for all the traits studied except the number of primary branches per plant. Data on association of different traits with days to flowering, presented in Table 1 showed that at phenotypic level, grain yield per plant, average number of seeds per capsule and 100 grain weight were negatively but highly correlated with days to flowering. Also, their major contribution to flowering duration was noted through their direct negative effects. Interestingly, average number of seeds per capsule and 100 grain weight were substantially operative through grain yield per plant while grain yield per plant itself showed high indirect effect through average number of seeds per capsule and 100 grain weight. As negative effects on days to flowering and thereby in reducing the crop period is desired, selections based on higher grain yield per plant, more seed set per capsule and better seed index will bring about a substantial improvement in crop period.

Pertinent data on grain yield per plant (table 2) showed a very high positive phenotypic association with average number of seeds per capsule and a similar negative association with days to flowering. The highest, positive direct effect of average number of seeds per capsule on grain yield per plant was

Table 1 : Direct (diagonal) and indirect effects of different traits on days to flowering in linseed grown in saline soils

Traits	Plant height	No. of tillers per plant	Dry matter yield	Av. No. of seeds per capsule	100 grain weight	Grain yield per plant	Phenotypic correlation with days to flowering
Plant height	—0.15855	0.00659	0.16784	0.20303	0.02413	0.12002	0.3630
No. of tillers per plant	0.04758	—0.02195	0.01832	—0.11215	0.10967	—0.07923	—0.0377
Dry matter yield per plant	—0.12535	—0.00189	0.21229	0.13768	—0.11799	0.06920	0.4099
Av. No. of seeds per capsule	0.08083	—0.00618	—0.7339	—0.39825	—0.07889	—0.28015	—0.7560
100 grain weight	0.01053	0.00662	—0.06893	—0.08646	—0.36339	—0.11610	—0.6178
Grain yield per plant	0.06163	—0.00563	—0.04757	—0.36133	—0.13663	—0.30877	—0.7983

Residual effect=0.44456

Table 2 : Direct (diagonal) and indirect effects of different traits on grain yield/plant in linseed grown in saline soil

Traits	Days to flowering	Plant height	No. of tillers per plant	Dry matter yield per plant	Av. No. of seeds per capsule	100 grain weight	Phenotypic correlations with grain yield per plant
Days to flowering	—0.16806	—0.05176	—0.00121	0.11460	—0.56833	—0.12349	—0.7983
Plant height	—0.06101	—0.14260	—0.00960	0.22104	—0.38325	—0.01327	—0.3887
No. of tillers per plant	0.00634	0.04279	0.03199	0.02413	0.21170	—0.06033	0.2566
Dry matter yield per plant	—0.06889	—0.11274	0 00276	0.27959	—0.25988	—0.06490	—0.2241
Av. No. seeds per capsule	0.12705	0.07270	0.00901	—0.09665	0.75176	0.04340	0.9073
100 grain weight	0.10383	0 00947	—0.00965	—0.09078	0.16321	0.19989	0.3760

Residual effect = 0.32806

noted. Days to flowering showed a negative direct effect and also very high negative indirect effect through average number of seeds per capsule on grain yield per plant. Interestingly, indirect effect of average number of seeds per capsule on grain yield per plant was also mainly through days to flowering. Direct as well as indirect positive effects of 100 grain weight through average number of seeds per capsule and days to flowering on grain yield per plant showed its merit in selection in conjunction with these traits. Pertinent data persented in table 1 and 2 showed that in improving the grain yield per unit area and time, simultaneously, selections based on average number of seeds per capsule, seed index, days to flowering and grain yield/plant will be the most effective.

DISCUSSION

Due to osmotic and specific ion effects, plant growth on saline soils is adversely affected. In different crop plants, differential varietal and trait responses to salinity are on record (Bernstein, 1975; Rai, 1977a, 1977b, 1977c; Rai and Sinha, 1980; Epstein, 1980). Based on these observations and also on the thesis that parameters to be selected in guiding the breeding programmes should invariably be estimated under the environmental condition for which a varietal improvement programme is proposed, present study undertaken in saline growth conditions, merit consideration.

The pertinent data showed that under salinity conditions early flowering habit and high ovule fertility (as assessed in terms of average number of seeds per capsule) are very much desired. Role of earliness and high spikelet fertility are also highly regarded in improving grain yield in rice under salt affected soils (Rai and Sinha, 1978). Here, it is worth pointing out that under salinity conditions, delay in flowering and increase in pollen and ovule sterility are the two well established phenomena. The observations recorded in the present study under salinity conditions are in contrast to one recorded by Rai (1981) under normal soils where no such association between grain yield and days to flowering and seed set per capsule was noted. However, the role of seed index recorded in the present study is in agreement to normal soil observations (Badwal *et al.* 1970; Rai, 1981).

Phenotypic correlation coefficients in conjunction with direct and indirect effects of different traits on grain yield/plant and days to flowering clearly revealed that selection practiced with early flowering, high seed set/capsule, high seed index and high grain yield/plant will be very much effective in improving the grain yield per unit area and time, simultaneously. The efficiency of selection through these traits may also be rated high due to available reports of their high heritability values with high genetic gain attainable (Rai and Sinha, 1980).

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Varietal response to plant densities and nitrogen application in castor

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ABSTRACT

This experiment was conducted in *kharif* seasons of 1977, 1978 and 1979 under rainfed conditions to study the varietal response to the levels of plant densities and nitrogen in castor *(Ricinus communis L.)*. Irrespective of seasonal effects, the variety VI-9 amongst varieties, 24,691 (90 x 45 cm) out of three plant densities and 60 kg nitrogen per hectare amongst nitrogen levels tested gave significantly higher yields. All interactions viz., variety x spacing, variety x nitrogen and spacing x nitrogen were significant.

Key words : Castor; plant densities; nitrogen application.

INTRODUCTION

Castor *(Ricinus communis L.)* has a considerable export value because its oil is used as lubricant for high quality engines. India accounts for 25 per cent of the castor production in the world and is next to Brazil (George *et al., 1978*). Castor is however, generally grown either as pure crop with wider spacing or as a border crop around irrigated crops like chillies, sugarcane, banana etc. and even on bunds in the scarcity zone of Maharashtra. Hence, the development of agrotechnique for castor crop was considered essential. The present study was, therefore, undertaken to know effects of various plant densities and nitrogen levels of three promising varieties of castor.

MATERIALS AND METHODS

The present investigation was carried out in *Kharif* seasons, 1977-1979. All seasons were normal. The treatments consisted of 3 varieties, Girija, SA-1 and VI-9 with 3 plant densities, 74,074/ha(45×30 cm), 55,555/ha (60×30 cm) and 24,691/ha (90×45 cm) and 3 levels of nitrogen, 0, 30 and 60 kg/ha. The combinations were laid out in 3^3 confounded design with two replications. The higher order interaction was confounded. Phosphatic fertilizers at the rate

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of 40 kg P_2O_5 per ha was applied as a basal dose at the time of sowing. Semi-looper was controlled by applying the proper schedule of plant protection i. e the spraying of endrin 20 EC and parathion (0.025%). The bean yield per plot and ancillary data for yield components were recorded.

RESULTS AND DISCUSSION

The data obtained on yield and its attributes due to varieties, plant densities and nitrogen levels are presented in Table 1 and 2. Data revealed that differences in yield due to varieties, plant densities and nitrogen levels were significant in all the years as well as in pooled results.

Varietal effects : The variety VI-9 gave the highest yield and was significantly superior over Girija and SA-1 in all seasons as well as in pooled resulis (Table 1). It showed 24 per cent increase in yield over both the varieties, Girija and SA-1. The varieties differed significantly for bean yield components except for length of spike. The high yield of VI-9 might be due to more number of primary branches, number of effective spikes per plant and number of fruits per spike (Table 3).

Effect of plant densities : Significant differences in the bean yield of castor were observed due to various plant densities in all seasons except between two plant densities, 74,074 (45 × 30 cm) and 55,555/ha (60 × 30 cm) in 1978 and pooled analysis. On pooling the data over seasons, it was found that the plant density 24,691/ha (90 × 45 cm) gave significantly higher yield (1067 kg/ha) over rest of the plant densities (Table 1). It gave 29 per cent and 25 per cent higher yield compared to 74,074 (45 × 30 cm) and 55,555/ha (60 × 30 cm) respectively. Similar findings were reported by Mishra and Jain (1968). The bean yield attributes were significantly affected due to various plant densities per hectare (Table 3). Ancillary data revealed that there was a consistant increase in the yield components with decrease in plant density and was in conformity with a report of Sundersan *et al.* (1977).

Effect of Nitrogen Levels : The increase in the dose of nitrogen from 0 to 60 kg/ha except that of 30 kg/ha over 60 kg N/ha in 1977 had given a proportionate significant increase in the bean yield of all the varieties during all the seasons (Table 1). Pooled analysis revealed that application of 60 kg N per hectare gave the highest yield (1126 kg/ha) which was significantly superior over both the levels, 0 and 30 kg N/ha. The different doses of nitrogen had significantly affected the components of bean yield, viz., plant height, length of spike and test weight. The increase in yield due to 60 kg N/ha was found to the extent of 37 per cent and 23 per cent more than the yields of 0 and 60 kg N/ha respectively. This increase might be due to more length of

Table 1 : Bean yield of castor as affected by varieties, plant densities and nitrogen levels

Treatments	Bean yield (kg/ha)			
	1977	1978	1979	Pooled mean
I. Varieties				
i) Girija	934	540	910	795
ii) SA-1	947	392	1049	796
iii) VI-9	1191	755	1208	1051
S. E. (±)	12	27	36	42
C. D. (5%)	35	70	105	167
II. Plant densities/ha				
i) 74,074 (45 × 30 cm)	873	493	843	737
ii) 55,555 (60 × 30 cm)	946	548	1017	837
iii) 24,691 (90 × 45 cm)	1252	644	1307	1037
S. E. (±)	12	27	36	50
C. D. (5%)	35	79	105	197
III. Nitrogen levels/ha				
i) 0 kg	954	329	728	670
ii) 30 kg	924	573	1027	844
iii) 60 kg	1194	784	1402	1127
S. E. (±)	12	27	36	69
C. D. (5%)	35	79	105	271

Table 2 : **Bean yield components as influenced by varieties, plant densities and nitrogen levels over seasons**

Treatments	Plant height (cm)	No. of Primary branches/ plant	Length of spike (cm)	No. of effective spikes/ plant	No of fruits on main spike	Test weight (100 seeds) (g)	Days to maturity
I. Varieties							
i) Girija	181.3	2.3	21.5	1.6	28.0	218	120
ii) SA-1	173.4	2.4	19.6	2.3	19.0	250	125
iii) VI-9	142.2	3.3	19.8	2.4	25.0	216	113
S. E. ±	4.1	0.1	0.6	0.3	2.6	0.7	0.1
C.D. (5%)	11.8	0.4	N.S.	0.9	7.6	2.2	0.4
II. Plant densities/ha							
i) 74,074 (45×30 cm)	153.3	1.3	16.3	1.6	18	228	122
ii) 55,555 (60×30 cm)	162.2	1.4	18.2	2.2	20	229	121
iii) 24,691 (90×45 cm)	187.6	2.4	25.0	3.0	35	232	118
S. E. ±	4.1	0.1	0.6	0.3	2.6	0.7	0.1
C.D. (5%)	11.0	0.4	1.7	0.9	7.6	2.1	0.4
III. Nitrogen levels/ha							
i) 0 kg	125.7	2.3	17.3	1.8	20	224	124
ii) 30 kg	150.6	2.3	19.8	2.5	23	226	123
iii) 60 kg	208.0	2.5	22.7	2.8	26	231	116
S. E. ±	4.1	0.1	0.6	0.3	2.6	0.7	0.1
C.D. (5%)	11.8	N.S.	1.7	N.S.	N.S.	2.1	0.4

Table 3: Bean yield of castor as affected by interaction of factors

Variety	1977–78 Plant population/ha 74074	55555	24691	1978–79 Plant Population/ha 74074	55555	24691	1979–80 Plant population/ha 74074	55555	24691
1. Girija	765	821	1215	455	519	645	644	902	1186
2. SA-1	842	828	1173	321	345	503	713	1022	1412
3. VI-9	1013	1191	1370	698	782	785	828	1188	1609
S. E. ±	**21**			47			63		
C. D. (5%)	61			N. S.			N. S.		
Variety	**Nitrogen level (kg/ha) 0**	**30**	**60**	**Nitrogen level (kg/ha 0**	**30**	**60**	**Nitrogen level (kg/ha) 0**	**30**	**60**
1. Girija	1027	862	1041	369	576	615	722	904	1105
2. SA—1	954	951	937	174	327	676	864	1033	1249
3. VI—9	1010	959	1606	445	818	1002	942	1115	0569
S. E. ±	21			47			63		
C. D. (5%)	**61**			137			N.S.		
Plant population/ha	**Nitrogen level (kg/ha) 0**	**30**	**60**	**Nitrogen level (kg/ha) 0**	**30**	**60**	**Nitrogen level (kg/ha) 0**	**30**	**60**
1. 74074	843	786	992	273	490	718	542	873	1113
2. 55555	913	895	1032	304	568	774	767	997	1288
3. 24691	1107	1000	1561	409	662	861	873	1243	1807
S. E. ±	**21**			47			**63**		
C. D.	61			N. S.			**181**		

N. S. = Non significant

spike (22.7 cm), number of effective spikes per plant (2-8), number of fruits per main spike (26) and test weight(231 g) (Table 3).

It was found that all interactions namely variety x nitrogen and spacing x nitrogen were significant during 1977 whereas only variety x nitrogen and spacing x nitrogen were observed to be significant in 1978 and 1979 respectively (Table 3). Further all first order interactions were studied over three seasons and the same were found to be significant.

The variety, VI-9 yielded the maximum with a plant density of 24,691 kg/ha (90X45 cm) and a dose of 60 kg N/ha.

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A new approach for assessing the zone-wise performance of the groundnut cultures tested under the coordinated research project

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ABSTRACT

The practice of promoting the entries to the next higher stage of varietal testing based on general mean yields in the case of non-orthogonal data leads to erroneous conclusions. In the Coordinated trials complete sets of varieties are seldom tested uniformly due to various reasons. To process such non-orthogonal data, a new approach has been suggested in this paper. In this procedure the performance of the entries is judged based on four statistical parameters viz., pooled general mean, mean percentage over the checks, performance score and stability based on regression coefficient and Deviation Mean Sum of Squares (DMSS). The entries are evaluated from the sum-total effect of the above listed statistical parameters in the new method but not on the general mean yield alone as in the old method. The superiority of the new method over the old one has been explained with the help of yield data of the groundnut varietal trials conducted under the All India Coordinated Research Project on Oilseeds (AICORPO) Rabi/Summer programme for three years from 1980—81 to 1981—83.

Key words: Varietal trials; non-orthogonality; AICORPO; general mean; performance score; stability

INTRODUCTION

The purpose of conducting varietal trials with new materials generated in the Coordinated Project is to test a uniform set of entries/cultures and to promote or discard or retain some of them based on their performance. An entry has to undergo the following 4 stages of testing before it is recommended for release :

(1) Initial Evaluation Trial, (2) Coordinated Varietal Trial,

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(3) National Elite Trial and (4) Minikit Trial.

The procedure generally adopted by the Coordinated Projects for promotion of cultures to the next stage of varietal testing is on the basis of the general mean of yields pooled over the locations for the year under consideration.

In the case of groundnut, complete sets are seldom tested uniformly at all the locations for the following reasons :

1. The high seed rate in groundnut makes it practically impossible to pool the entries from all the sources and re-distribute the same to the testing centres in the form of full sets because of the huge quantity of the seed involved.
2. The time gap between the workshop and the sowing period is too less to undertake such an exercise.
3. Sometimes the entries are supplied to only a few selected centres due to inadequate quantities of seed available with the sources.

Data obtained thus resulted to non-orthogonality. Drawing conclusions from the general means of the non-orthogonal data will be erroneous. The testing environments will not be the same for all the entries. The numbers of favourable and unfavourable environments differs from entry to entry which ultimately lead to unreliable and misleading general means of yield. For processing such non-orthogonal data a new method is necessary. The objective of this paper is to suggest a new method to evaluate the entries from the non-orthogonal data by considering all the possible parameters in totality.

MATERIALS AND METHODS

The yield data pertaining to the following 12 entries which were tested in the Rabi/Summer groundnut varietal trials under the AICORPO for 3 years (1980—81 to 1982—83) were used in this paper.

Entries : The performance of the entries viz., Co-1, Dh. 3-30, TG-3, TG-17, Robout 33-1, ICGS-11, ICGS-12, ICGS-15, J-1, J-2, RSHY-1 and ICGS-6 was compared with two checks viz., J-11 (National Check) and Local Checks (differed from centre to centre). During the first two years the entries were in different categories whereas all of them were pooled together and tested under the Final Evaluation Trial during the year 1982-83. In 1980-81, Co-1, Dh. 3-30, TG-3 and TG-17 were in CVT-I; Robout 33-1 was in CVT-II and ICGS-11, ICGS-12 and ICGS-15 were in AICORPO/ICRISAT (International Crop Research Institute for Semi Arid Tropics) Cooperative Trial. In 1981-82, J-1, J-2 and RSHY-1 were promoted to CVT-II and ICGS-6 to AICORPO/ICRISAT Cooperative Trial.

Testing and evaluation of the above listed entries were done on zonal basis. The groundnut growing area has been divided under the following zones (Pandey and Murthy, 1982).

1. *Zone-I (Northern Zone)* : Uttar Pradesh, Punjab, Haryana, Bihar and Northern Rajasthan (Jaipur, Ajmer, Bharatpur, Sawai, Madhopur and Tonk districts).

2. *Zone-II (Central Zone)* : Gujarat, Southern Rajasthan (Chittorgarh, Udaipur and Jhalawar districts) and Western Madhya Pradesh (Mandsour and Ratlam districts).

3. *Zone-III (Central Zone)* : Madhya Pradesh (excluding Mandsour and Ratlam districts) and Maharashtra (excluding Satara, Sanghi, Solapur, Kolhapur, Osmanabad, Latur and Nanded districts).

4. *Zone-IV (Southeastern Zone)* : Orissa and North coastal Andhra Pradesh (Srikakulam, Visakhapatnam and Vijayanagaram districts).

5. *Zone-V (Peninsular Zone)* : Karnataka, Andhra Pradesh (excluding Srikakulam, Visakhapatnam and Vijayanagaram districts) and Southern Maharashtra (Satara, Sangli, Solapur, Kolhapur, Osmanabad, Latur and Nanded districts).

6. *Zone-VI (Southern Zone)* : Tamil Nadu and Kerala.

The yield data have been analysed for the following parameters zone-wise:

1. *Pooled general mean* : A simple arithmetic mean based on number of observations.

2. *Mean percentage over the checks* : Percentage over the National Check and the Local Check for each environment was independently worked out and the simple arithmetic mean obtained zone-wise. This parameter indicated the performance of the entry in relation to the checks.

3. *Performance score* : The varietal trials are generally laid out in the Randomised Block Design. When the pod yield data are subjected to statistical analysis, the significance of the test cultures over the checks will be known. The factor for knowing the superiority or inferiority of the test culture is the critical difference of the pod yield data.

The significantly superior performance of the entry over the National and the Local Checks is indicated by alphabets 'a' and 'b' respectively. Similarly significantly inferior performace is indicated by 'x' and 'y'. For each superior performance a weightage of '+1' and for the inferior performance a weightage of '—1' were given and the performance worked out as follows :

$$\text{Performance score} = \frac{P1 - P2}{\text{Maximum possible score}}$$

where, P1 = Total number of positive weightages

P2 = Total number of negative weightages

4. *Stability parameters :* Two stability parameters viz., Regression Coefficient and Deviation Mean Sum of Squares were worked out as follows.

a) *Regression Coefficient (RC) :* The regression coefficient is worked out by regressing the mean yield of each genotype upon the environmental index (general mean yield of the trial at the given centre). For working out RC in each zone the minimum number of environments considered was five. Value closer to unity (1) ranks the highest.

b) *Deviation Mean Sum of Squares (DMSS) :* This value was obtained from the regression analysis. The DMSS were considered based on the degrees of freedom (d. f.) which were different for different cultures due to non-orthogonality of the data. The least value ranks the highest.

The stability parameters were worked out as per the procedure suggested by Narasimhayya (1979).

The above statistical parameters were worked out from the pooled data of different yield trials. The entries tested in the Coordinated Varietal Trials during the years 1980-81 and 1981-82 and in the Final Evaluation Trial in the year 1982-83 were used for comparison, although these trials were labelled differently. The plot size was the same for all the trials in all the years. Hence, the data were pooled centre-wise for assessing the performance of entries by applying the above listed parameters.

RESULTS AND DISCUSSION

The statistical parameters viz., General Mean, Mean Percentage Over Checks, Performance Score, Regression Coefficient and Deviation Mean Sum of Squares are given zone-wise in Table 1. In Table 2 the zonal means pertaining to the Final Evaluation Trial conducted during 1982-83 are given. The data presented in these tables pertain to Zones II to VI. In the absence of Rabi/Summer groundnut no trials were conducted in Zone I.

For judging the performance of any culture the following four points were considered.

a. Mean yield of the variety indicated the average performance over locations and seasons.

b. Mean percentage of the varietal yields over the checks indicates the comparative performance of the entry in relation to the checks.

c. Significantly superior performance as judged from the C D value.

d. Stability of the entry over the environments as seen from the regression coefficient and D M S S.

The present method assumes that all the above listed parameters have equal importance. Before promoting an entry, in addition to the above parameters, the number of environments in which it was tested should also be considered. The culture tested in greater number of environments will have preference over the culture tested in only a few environments.

A critical comparision of the data presented in Table 1 (statistical parameters as per the new method) and Table 2 (zone-wise general means as per the old method) clearly indicates the superiority of the new method in judging the performance of the entries. The zone-wise performance of the entries based on both the methods is discussed below.

It can be seen that in Zone-II ICGS-12 and Robout 33-1 have ranked 1st and 2nd in the general mean yield by recording 3277 kg and 2889 kg respectively (Table 2) whereas, as per the data in Table 1 (new method) the entries J-1 and Robout 33-1 ranked 1st and 2nd for the pooled general mean. For the other parameters viz., mean percentage over checks and performance score, Robout 33-1 ranked 1st whereas J-1 ranked 4th and 2nd, ICGS-12 ranked 3rd for mean percentage over the checks and 8th for performance score. Moreover, the number of environments in which Robout 33-1 was tested, was 7 whereas for J-1 and ICGS-12 the environments were only 4. Because of this assessment, the entries Robout 33-1 and J-1 were promoted to the minikit trials but not ICGS-12.

Table : 1 Final Evaluation Trial (FET) statistical parameters for the yield data (1980-81, 1981-82 and 1982-83)

Sl. No.	Genotypes	ZONE II					
		No. of tests	General mean	Mean percentage over		Perfor-mance score	Regression coefficient
				N. C.	L. C.		
1.	Co-1	7(3)	2211(9)	2.61(9)	10.8(7)	0.0(8)	0.086(3) (0.25)
2.	Dh 3-30	7(3)	1859(12)	-14.93(12)	-18.8(12)	-0 286(11)	0.71(6) (0.33)
3.	TG-3	7(3)	2268(7)	2.37(10)	23.3(5)	0.0 8)	0.69(7) (0.18)
4.	TG-17	7(3)	2438(5)	12.48(5)	28.9(4)	0.071(6)	0.87(2) (0.20)
5.	R 33-1	7(3)	2749(2)	35.37(1)	44.39	(1)0.429(1)	0.72(5) (0.17)
6.	ICGS-11	4(10)	2321(6)	6.41(7)	2.77(8)	0.125(4.5)	—
7.	ICGS-12	4(10)	2740(3)	17.71(3)	32.43(3)	0.0(8)	—
8.	ICGS-15	4(10)	2078(11)	-2.45(11)	-0.84(9)	-0.125(10)	—
9.	J—1	4(10)	3211(1)	16.53(4)	33.4(2)	0.25(2)	—
10.	J—2	5(6.5)	2589(4)	21.66(2)	12.8(6)	0.20(3)	0 88(1) (0.21)
11.	RSHY-1	5(6.5)	2249(8)	3.76(8)	-8.5(11)	-0.30(12)	0.85(4) (0.28)
12.	ICGS-6	4(10)	210(10)	11.22(6)	-7.68(10)	0.125(4.5)	—

Figures in parenthesis indicate the ranks

Table 1 : (Contd.)

ZONE II	ZONE III						
Dev. MSS	No. of tests	General Mean	Mean percentage over N. C.	Mean percentage over L. C.	Performance score	Regression coefficient	Dev. MSS
355514(5)	5(2)	2350(6)	-9.66(10)	-6.8(10)	0.0(6.5)	0.89(1) (0.33)	92581(1)
593695(7)	4(6)	2272(9)	-5.6(8)	4.5(5)	0.0(6.5)	—	—
180035(1)	4(6)	2151(11)	-18.9(12)	-0.8(7)	-0.125(10)	—	—
210700(3)	5(2)	2120(12)	3.70(5)	-6.0(9)	-0.10(9)	0.21(3) (0.56)	260993(2)
202302(2)	5(2)	2290(7)	-6.92(9)	8.65(4)	-0.20(11)	1.32(2) (0.61)	392839(3)
—	3(10)	2968(1)	26.43(1)	18.95(1)	0.50(1)	—	—
—	3(10)	2592(4)	13.26(2)	17.95(2)	0.33(2.5)	—	—
—	3(10)	2279(8)	1.63(6)	12.95(3)	0.33(2.5)	—	—
—	4(6)	2759(3)	10.99(3)	-7.45(11)	0.25(4)	—	—
331758(4)	4(6)	2454(10)	-12.63(11)	-31.55(12)	-0.50(12)	—	—
570050(6)	4(6)	2433(5)	-3.31(7)	-1.25(8)	0.0(6.5)	—	—
—	2(12)	2921(2)	7.9(4)	1.98(6)	0.0(6.5)	—	—

Table 1 (Contd.)

Sl. No.	Genotypes	ZONE IV: No of test	General mean	Mean percentage over: N. C.	L. C.	Performance score	ZONE V: No of test
1.	Co-1	3(3)	2993.3(5)	7.38(4)	9 32(2)	0.0(4)	18(3.5)
2.	Dh 3-30	3(3)	2622.3(7)	6.22(6)	-2.24(7.5)	-0.17(8.5)	18(3.5)
3.	TG-3	3(3)	2635.0(6)	1.66(7)	-1.0(4)	-0.17(8 5)	19(1.5)
4.	TG-17	3(3)	2293.0(9)	-11.12(10)	-21.7(10)	-0.17(8.5)	19(1.5)
5.	R-33-1	3(3)	1943.3(10)	13.13(2)	-1.65(6)	-0.17(8.5)	15(5)
6.	ICGS-11	1(10)	3252.0(2)	7.00(5)	-1.21(3)	0.0(4)	8(10)
7.	ICGS-12	1(10)	3365.0(1)	10.8(3)	2.21(3)	0.0(4)	8(10)
8.	ICGS-15	1(10)	3085.0(4)	1.54(8)	-6.3(9)	0.0(4)	8(10)
9.	J—1	3(7)	2393.5(8)	-6.25(9)	-2.24(7.5)	0.0(4)	11(7)
10.	J—2	2(7)	1483.0(11)	-34.1(11)	-64.0(11)	-0.50(11)	11(7)
11.	RSHY-1	2(7)	3094.5(3)	25.7(1)	12.4(1)	0.25(1)	11(7)
12.	ICGS-6	—	—	—	—	—	6(12)

Figures in parenthesis indicate the ranks

Table 1 (Contd.)

ZONE V					
General mean	Mean percentage over N. C.	Mean percentage over L. C.	Performance score	Regression coefficient	Dev. M S S
2499(9)	13.71(5)	11.9(5)	0.0(8)	0.86(8) (0.12)	362582(6)
2500(8)	10.12(8)	2.1(9)	-0.227(9)	1.07(3) (0.08)	162895(3)
2619(5)	12.50(6)	3.6(8)	0.078(5.5)	0.87(7) (0.40)	1536893(12)
2503(7)	-1.28(11)	-6.4(12)	0.078(5.5)	1.10(4.5) (0.09)	202806(4)
2617(6)	25.64(3)	29.53(2)	0.233(2)	1.04(2) (0.14)	147772(2)
3532(2)	31.76(1)	25.75(3)	0.25(1)	1.12(6) (0.18)	521750(8)
3045(4)	10.57(7)	11.28(7)	-0.063(11)	1.39(12) (0.26)	1115447(11)
3243(3)	18.84(4)	29.63(1)	0.125(4)	0.72(11) (0.14)	320302(5)
2276(11)	0.30(10)	0.40(10)	0.136(12)	1.19(9) (0.12)	90839(1)
2165(12)	5.73(9)	-2.5(11)	-0.045(10)	0.74(10) (0.28)	461525(7)
2321(10)	-6.32(12)	12.3(5)	0.0445(7)	1.10(4.5) (0.30)	534269(9)
3646(1)	26.944(4)	29.39(4)	0.167(3)	1.02(1) (0.19)	559141(10)

Table 1 : (Contd.)

Sl. No.	Genotypes	ZONE–VI						
		No. of tests	General Mean	Mean percentage over		Performance score	Regression coefficient	Deviation M.S.S.
				N. C.	L. C.			
1.	**Co-1**	5(5)	1934(1)	21.81(1)	13.2(1)	0.30(1)	1.25(4) (0.04)	1206(1)
2.	Dh-3-30	5(5)	1135(11)	–15.28(12)	–11.35(12)	–0.1(7.5)	0.52(8) (0.14)	16361(2)
3.	TG-3	5(5)	1138(0)	2.65(10)	–10.55(11)	0.0(3 5)	0.78(3) (0.15)	17536 (3)
4.	TG-17	5(5)	1098(12)	–2.27(11)	–8.6(10)	–0.1(7.5)	0.74(5.5) (0.16)	21055(4)
5.	R-33-1	5(5)	1401(6)	15.02(4)	–2.2(5)	0.1(2)	0.86(2) (0.41)	85137(7)
6.	ICGS-11	6(2)	1226(9)	8.37(8)	–4.40(8)	–0.25(12)	1.26(5.5) (0.24)	43433(6)
7.	ICGS-12	6(2)	1273(7)	17.96(2)	1.885(4)	–0.08(5.5)	0.95(1) (0.22)	35306(5)
8.	ICGS-15	6(2)	1245(8)	17.10(3)	8.08(2)	–0.08(5.5)	1.44(7) (0.40)	119883(8)
9.	J–1	3(11)	1455(4)	5.73(9)	–3.8(7)	–0.17(10.5)	—	—
10.	J–2	3(11)	1503(2)	9.83(7)	–3.3(6)	–0.17(10.5)	—	—
11.	RSHY-1	3(11)	1473(3)	10.5(6)	–4.9(9)	0.0(3.5)	—	—
12.	ICGS-6	4(9)	1447(5)	12.85(5)	8.01(3)	–0.125(9)	—	—

Figures in parenthesis indicate the ranks

Table 2 : Zone-wise mean yields of Final Evaluation Trial for the year 1982-83

Sl No.	Name of cultures	ZONE—II	ZONE—III	ZONE—IV	ZONE—V	ZONE—VI
1.	Co—1	2242.7 (8)	2097.7 (9)	3599.0 (3)	2247.0 (9)	1858.5 (1)
2.	Dh 3—30	1670.0 (12)	1969.5 (11)	3218.0 (7.5)	2207.5 (10)	1405.5 (10)
3.	TG—3	2431.0 (4)	2098.5 (8)	3259.0 (5)	2467.4 (5)	1444.5 (9)
4.	TG—17	2428.0 (5)	1845.0 (12)	2577.0 (10)	2087.9 (12)	1460.0 (8)
5.	R-33—1	2889.0 (2)	2522.0 (5)	3612.0 (2)	2967.3 (4)	1354.5 (11)
6.	J—1	2639.7 (3)	2563.0 (4)	3218.0 (7 5)	2348.9 (6)	1575.5 (5)
7.	J—2	2291.3 (6)	2074.3 (10)	1182.0 (11)	2140.1 (11)	1587.5 (4)
8.	RSHY—1	1875.3 (11)	2419.3 (6)	3699.0 (1)	2343.9 (7)	1526.5 (6)
9.	ICGS—6	2169.3 (9)	2921.0 (2)	—	3028.8 (3)	1599.0 (3)
10.	ICGS—11	2285.0 (7)	2968.0 (1)	3252.0 (6)	3079.2 (2)	1600.5 (2)
11.	ICGS—12	3277.0 (1)	2591.7 (3)	3365.0 (4)	2331.7 (8)	1523.0 (7)
12.	ICGS—15	2077.5 (10)	2279.0 (7)	3085.0 (9)	3242.8 (1)	1245.0 (12)
13.	J—11 (N.C.)	2279.0	2279.0	3085.0	2666.0	1696.5
14.	Local check	2138.0	2340.7	3038.0	2043.2	1583.5

Figures in parenthesis indicate the ranks

For Zone-III as per the old method ICGS-11 ranked 1st when the mean yield (2968 kg) was considered over the environments. Similarly, in the new method also ICGS-11 occupied the 1st place for all the 4 statistical parameters. In this case assessment based on both the methods has tallied because the testing environments in both the methods were the same.

For Zone-IV, RSHY-1 ranked 1st in old method although it ranked 3rd in new method. Since this entry ranked 1st for all the other statistical parameters and also tested over a relatively large number of environments it was promoted to the minikit trials.

For Zone-V the entries ICGS-6, ICGS-11 and Robout 33-1 occupied 1st, 2nd and 3rd rankes respectively for the general mean yield (old method). As per the new method Robout 33-1 ranked 2nd uniformly for percentage over the local check, performance score, RC and DMSS although it ranked 3rd for percentage over national check and 6th for the pooled general mean. ICGS-11 ranked 1st for percentage over the national check and performance score, 2nd for the pooled general mean, 3rd for the percentage over the local check, 6th for the RC and 8th for the DMSS. ICGS-6 ranked 1st for the general mean yield and RC, 2nd for percentage over the national check, 3rd for the performance score, 4th for percentage over the local check and 10th for DMSS. The total number of environments in which these three entries were tested showed a wide range of variation. Robout 33-1 was tested in 15 environments whereas ICGS-11 and ICGS-6 were tested in 8 and 6 environments respectively. Since the number of environments in which ICGS-6 was tested, were few, this culture was retained in the trial for one more season for final assessment whereas Robout 33-1 and ICGS-11 were promoted to the minikit trials.

For Zone-VI Co-1 ranked 1st for the general mean yield (old method). As per the new method also it occupied the 1st place for all the statistical parameters except RC for which it occupied the 4th place. Since this variety has already been released for Kharif season in Zone-VI, the test has confirmed its suitability for Rabi/Summer cultivation also in this zone.

Conclusion based on general mean yield alone will be erroneous. The general mean yield for the top ranking entries in the old and the new method are compared (Table 3).

Table 3 : Comparison of old and new method

Zone	Old method			New method		
	Recommended cultures	No. of tests	General mean	Recommended culture	No. of tests	General mean
II	ICGS-12	2	3277	Robout 33-1	7	2749
	Robout 33-1	3	2889	J—1	4	3211
III	ICGS-11	3	2968	ICGS-11	3	2968
IV	RSHY-1	1	3699	RSHY-1	2	3095
V	ICGS-11	6	3079	Robout 33-1	15	2617
	ICGS-6	5	3029	ICGS-11	8	3532
	Robout 33-1	7	2967	ICGS-6	6	3646
IV	Co-1	2	1859	Co-1	5	1934

It can be observed that the results are tallying in the case of zones II, IV and VI in both the methods. But for Zones II and V the results are varying in the case of Robout 33-1. Other point to be noted here is that the general mean values show considerable variation between the two methods due to variation in the number of tests. Hence, the conclusion based on general mean alone will be misleading. If the number of environments are the same, the results may tally in both the methods. For drawing valid conclusions the number of testing environments should be adequate.

The major drawback in both the methods arises from non-orthogonal data. But the new method has a number of plus points to overcome the difficulty caused by non-orthogonality. However, the new method suffers from the weakness of giving equal weightages to all the satistical parameters. From the data given in this report it is clear that the general mean is highly influnced by the testing environments. On the contrary the mean percentage over the checks and performance score are independent of environments. There is need to develop correct weightages deserved by each of the parameters based on its importance.

The object of varietal trial is to evolve a superior variety over the best existing variety. It is, therefore, necessary to compare the performance of the cultures under test with those recommended for minikit trials since the minikit entries have already been compared with the best released varieties. This aspect has been taken care of in the AICORPO Rabi/Summer 1983—84 programme, by including minikit entries as additional checks.

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Effect of molybdenum, zinc and gypsum with different levels of phosphorus on growth and yield of groundnut

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ABSTRACT

The influence of different levels of phosphorus (0, 40, 80 and 120 kg/ha) and molybdenum (0, 5 and 10 ppm foliar application and 0.8 kg soil application) were studied on growth and yield of groundnut. Application of 0.8 kg molybdenum through soil with 40 kg P_2O_5 /ha significantly increased the pod yield by 4.3, 6.8 and 33.5, 33.9 per cent respectively in both the years. The interaction effect between these treatments was not significant in both the years. Similarly in 40 kg P_2O_5 /ha with gypsum 250 kg/ha and zinc sulphate 25 kg/ha increased the pod yields by 20.2 per cent over control. While individual application of zinc and gypsum contributed 8.0 end 11.2 per cent increase of pod yields respectively.

Key words : Micronutrients; groundnut; molybdenum; zinc ; phosphorus ; gypsum

INTRODUCTION

Groundnut is one of the primary source of vegetable oil in India, contributing nearly 65% of total oil seed production. At present the country is spending about 1000 crores of rupees for importing of groundnut oil alone. The average yields of groundnut in India is not only low (about 8.2 q/ha) as compared to U. S. A. (23.2 q/ha) and Isreal (40.2 q/ha) but also further decreasing trend of per hectare yield of this crop in Andhra Pradesh were observed during last two decades (Reddi and Reddy, 1979). This can be attributed mostly in addition to other factors, to the imbalance in fertilizer use and wide ranging deficiencies of secondary and micronutrients. The problem is further accentuated due to increased production per unit area per unit time, which results in heavy demand for plant nutrients and results in the rapid depletion of nutrient resources of soil, unless regularly replenished. The response of leguminous crops to sulphur containing fertilizers were reported (Aulakh *et al*. 1980).

Recently it was also observed that groundnut based cropping system exhausted much of Ca, S, Fe and Mo. While Basewell and Anderson (1969) were emphasized the importance of molybdenum for improving nodulation and

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N-fixation in legumes. It is needless to emphasis the importance of phosphorus to groundnut. Hence adequate attention particularly regarding Ca, Zn, S and Mo are to be considered to get maximum benefit from applied NPK fertilizers.

Keeping these things in view two field experiments were conducted to study the response of P, Mo, Zn and gypsum on growth and yield of groundnut.

MATERIALS AND METHODS

The first experiment was conducted for two years in the rainy season of 1977 and 1978 and the second experiment was conducted for one season during 1978 *Kharif* at Agricultural College Farm, Rajendranagar, Hyderabad. The soil was sandy loam of 7.7 pH with E. C. 0.03 m mhos/cm and had 0.49% organic carbon, 0.06% total nitrogen, 92 kg/ha of available P_2O_5, 347 kg/ha of exchangeable K_2O and 0.3 ppm of available molybdenum. The physical composition showed coarse sand 54.3%, fine sand 11.4%, silt 22.7% and clay 11.6%. The first trial was laid out in spilt plot design with 4 levels of phosphorus (0, 40, 80 and 120 kg/ha) as main plots and 4 levels of molybdenum as sub plots (foliar application of 0, 5, 10 ppm and soil application of 0.8 kg molybdenum) while the second trial was in RBD with 5 treatment combinations i.e. T_1 = control; T_2 = 40 kg P_2O_5/ha; T_3 = 40 kg P_2O_5/ha + gypsum @ 250 kg/ha applied half at sowing time and the remaing half at pegging stage; T_4 = 40 kg P_2O_5/ha + zinc sulphate @ 20 kg/ha as soil application; T_5 = 40 kg P_2O_5/ha + gypsum @ 250 kg/ha applied half at sowing time and the remaining half at pegging stage+zinc sulphate @ 20 kg/ha as soil application. Both the trials were replicated four times.

An uniform dose of 30 kg nitrogen and 50 kg of potash was applied to all the treatments as basal. Molybdenum and phosphorus were applied in the form of ammonium molybdate and super phosphate respectively. The crop was sown in the month of June and in general the rainfall was quite good for the crop growth in both the years.

RESULTS AND DISCUSSION

The yield data of pods (Table 1) revealed that the mean pod yield of groundnut was significantly influenced due to the application of P fertilization as well as due to Mo levels. In both the years, the mean maximum yield of 26.8 q/ha and 17.9 q/ha were obtained with 40 kg P_2O_5/ha during 1977 and 1978 respectively. The further increase of levels did not result any significant increase of pod yields. The differences in pod yields due to Mo levels were also significant in both the years. The average maximum pod yield of 25.73 q/ha and 17.34 q/ha were obtained due to soil application of 0.8 kg/ha, Mo which was significantly superior to the rest of the Mo levels during 1977 and but it was at

Table 1 : Pod yield (kg/ha) of groundnut as influenced by levels of P and Mo

	0 ppm Mo (control)		0.8 kg Mo soil application		5 ppm Mo foliar application		10 ppm Mo foliar application		Mean	
	1977	1978	1977	1978	1977	1978	1977	1978	1977	1978
P_0	1943	1276	2064	1389	1978	1328	2040	1353	2006	1337
P_{40}	2609	1728	2734	1840	2665	1776	2708	1815	2679	1760
P_{80}	2639	1740	2744	1848	2674	1798	2710	1820	2692	1802
P_{120}	2678	1753	2751	1863	2673	1805	2716	1825	2705	1815
Mean	2467	1624	2573	1734	2498	1677	2544	1704	—	—

	1977	1978	
C. D. for P levels	29	23	
C. D. for Mo levels	27	30	
C. D.	N S	N S	NS = Non significant

Table 2 : Yield contributing characters of groundnut as influenced under different treatments

Treatment	No. of branches		Two seeded pod/plant		One seeded pod/plant		Infilled pods per/plant	
	1977	1978	1977	1978	1977	1978	1977	1978
Phosphorus levels (kg/ha)								
0	4.21	4.67	7.07	5.85	1.73	1.03	4.18	5.78
40	4.54	5.17	8.58	7.02	1.24	0.78	3.49	5.08
80	4.64	5.28	8.63	7.05	1.19	0.73	3.34	4.95
120	4.70	5.34	8.65	7.06	1.16	0.70	3.24	4.95
CD at 5%	0.13	0.19	0.38	0.14	0.06	0.07	0.20	0.23
Molybdenum levels								
0 ppm Mo (Foliar)	4.20	4.90	7.83	6.39	1.51	0.93	4.10	5.59
' ' 5 ppm	4.40	5.05	8.12	6.67	1.34	0.81	3.75	5.28
' ' 10 ppm	4.74	5.21	8.39	6.90	1.25	0.76	3.29	4.98
0.8 kg soil application	4.75	5.29	8.58	7.02	1.21	0.74	3.10	4.94
CD at 5%	0.21	0.11	0.43	0.12	0.06	0.06	0.14	0.28

Table 2 : (Contd.)

100 kernel weight (g)		Shelling (%)		Plant height		Pod yield/ plant (g)	
1977	1978	1977	1978	1977	1978	1977	1978
34.3	32.0	71.1	70.2	31.6	24.6	5.51	5.37
36.9	34.8	73.2	72.4	32.0	26.5	6.88	6.55
37.2	35.2	73.6	72.7	31.9	26.0	7.00	6.58
36.9	35.2	73.3	72.7	31.9	26.0	6.95	6.60
0.7	0.4	0.5	0.3	0.72	0.24	0.25	0.13
35.8	33.7	72.4	71.7	30.5	25.2	5.92	6.00
36.2	34.3	72.7	71.9	31.0	25.7	6.41	6.24
36.5	34.5	72.9	72.1	32.4	26.0	6.91	6.38
36.8	34.7	73.2	72.4	32.6	26.2	7.08	6.48
0.5	0.4	0.5	0.2	0.97	0.34	0.27	0.14

par with 10 ppm foliar application during 1978. Foliar application of 5 ppm Mo was also significantly superior to 0 ppm Mo in both the years. The interaction between P and Mo levels was not found significant in both the years. This explains that there is no relationship between the availability of soil Mo with successive increase in P application.

The yield contributing characters like plant height, number of branches, filled and unfilled pods/plant, 100 kernel weight, shelling percentage and pod yield/plant were also influenced similar to that of pod yield, due to application of different levels of P and Mo (Table 2). Plant height was increased due to applied P upto 40 kg/ha and subsequently it declined at higher doses like 80 and 120 kg/ha while gradual increase in number of branches upto 120 kg P_2O_5/ha were observed. Soil application of 0.8 kg/ha molybdenum and foliar application of 10 ppm were at par with each other and significantly increased plant height and number of branches over the rest of Mo levels. The mean increase in two seeded pods per plant was 21.4 and 21.0% due to application of 40 kg P_2O_5/ha over control during both the seasons respectively. But further increase in P level did not improve this character significantly. Similarly one seeded pods per plant decreased gradually with successive increase in P levels but the trend was similar to that of two seeded pods per plant. The highest number of two seeded pods, lowest number of one seeded pods and unfilled pods per plant were recorded under 0.8 kg soil application of Mo followed by 10 ppm foliar application of Mo which were at par with each other and significantly superior to the rest of Mo levels during both the seasons. The mean increase in 100 kernel weight and shelling percentage was 7.6, 3.0 and 8.8, 3.1 per cent respectively due to 40 kg P_2O_5 /ha during 1977 and 1978 respectively. Similarly both these attributes were also significantly influenced with 0.8 kg soil application of Mo. The pod yield per plant also followed the similar trend to that of pod yield due to phosphorus and molybdenum levels.

The similar trends obtained for yield contributing characters and as well as pod yields, conclusively proved that the application of 40 kg/ha phosphorus combined with 0.8 kg/ha soil application or 10 ppm foliar application of molybdenum seems to be optimum for getting higher pod yields of groundnut. These findings are in agreement with the findings of Misra and Singh (1977), Yadahalli *et al.* (1970) and Takkar and Randhawa (1978).

The yield and yield attributes influenced due to zinc and gypsum at varying levels of phosphorus are presented in Table 3. The pod yield of groundnut significantly influenced due to treatments. The highest pod yield of 20.68 q/ha was obtained due to application of phosphorus along with gypsum and zinc sulphate (T_5) and the increase was about 20.2 % over control (only phosphorus application). Similarly phosphorus application alone has also

Table 3 : **Yield contributing characters and pod yield of groundnut as influenced by different treatments**

Treatment	Plant height (cm)	No. of branches	Two seeded pods/plant	One seeded pods/plant	Unfilled pods/plant	100 kernel weight (g)	Shelling (%)	Pod yield kg/ha
T_1 0 kg P_2O_5	23.7	4.3	5.9	1 3	6.4	31 0	70 5	1330
T_2 40kg P_2O_5/ha	25 8	4.9	6.5	1.1	4.9	34.6	72.8	1720
T_3 40kg P_2O_5/ha +gypsum	28.2	5 4	7.6	0 8	4.4	35.7	73 1	1857
T_4 40kg P_2O_5/ha + zinc sulphate	26.6	5.2	8 1	0 7	3.8	36.8	74 0	1913
T_5 40kg P_2O_5/ha + zinc sulphate +gypsum	29 0	6 1	8.8	0.5	3.6	38.0	74.6	2068
C. D. at 5%	0.59	0.23	0.38	0.15	0.53	0.78	0.82	39

increased pod yield about 29.3% over contol (T_1). Further it was observed that individual application of zinc sulphate or gypsum along with phosphorus was also significantly different from each other and increased the pod yield to the extent of 8.0% and 11.2% respectively.

The gypsum application along with phosphorus had significantly improved the sound seeds per plant, 100 kernel weight and shelling percentage due to better filling of pods. These results are in agreement with the findings of Hamid (1980). Application of zinc sulphate has much influence on growth characters such as plant height and number of branches Therefore, combined application of these two nutrients along with phosphorus had significantly improved all the yield attributing characters and in turn produced more pod yield of groundnut. Similar results were also reported by Hallock and Garren (1968).

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5 Harvest index and ideotype analysis in Indian mustard

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ABSTRACT

Harvest index of 420 germplasm of Indian mustard (*Brassica juncea* (L) Czern and Coss) were evaluated during the period from 1980—81 to 1982—83 at Pulses and Oilseeds Research Station, Berhampore. The range of variation of co-efficient of variability was from 9.4 to 38.4 per cent. On the basis of the deviation of harvest index values from the mean, the germplasm could be classified into five different groups. Progressive increase in respect of 1000 seed weight and yield per plant were observed from groups with low harvest index to those with high harvest index. However, in respect of number of primary branches per plant the trend was reverse.

Plants with two primary branches were considered to be ideal for optimum translocation of dry matter. Allowing more vegetative growth only reduced the harvest index without any significant increase in yield.

Key words : *Brassica*; harvest index; ideotype; Indian mustard

INTRODUCTION

Increase in grain yield in many crops has been observed to be a result of achieving more efficient distribution of dry matter into the economic part. In fact, the major break through in cereal grain yield has been due almost entirely to the improvement of source to sink relationship without an increase in total dry matter production (Singh and Stoskopf, 1971 ; Donald and Hamblin, 1976). The harvest index as referred by Donald (1962) forms a useful measure of such relationship. In mustard, as compared to other crops relatively little effort has been directed towards evaluation of cultivars on the basis of harvest index.

The present investigation reports the harvest index status of mustard as observed in a large collection of germplasm, its relationship to seed yield and its attributing traits and ideal plant model for achieving higher harvest index in mustard.

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MATERIALS AND METHODS

Studies on harvest index:

Four hundred twenty germplasm were grown at the Pulses and Oilseeds Research Station, Berhampore during 1980-81 to 1982-83. Each entry was in single row of 5m length. Ten plants were randomly selected at maturity and data were recorded on number of primary branches per plant, number of siliquae per plant, 1000 seed weight, the biological yield per plant and seed yield per plant. The harvest index was then determined as the ratio of seed yield to biological yield and expressed as percentage.

The data averaged over years were subjected to statistical analysis for the estimates of mean, variance, C. V. etc. Grouping of germplasm on the basis of harvest index values was done on the following manners :

1) Very Low (VL) : The entries showing harvest index values two or more S. D. unit below the mean.

2) Low (L) : The entries showing harvest index one S. D. unit below the mean.

3) Medium (MID) : The entries having harvest index around the mean within S. E. limit.

4) Moderately High (MH) : The entries exceeding mean by one S, D. unit.

5) High (H) : The entries exceeding the mean by two or more S. D. unit.

Studies on ideotype:

This experiment was conducted with three strains *viz.*, Seeta, Varuna and Pusa Bold under field condition in RBD with three replications during 1980-81 to 1982–83. Control over branching was exerted by nipping the axillary growth at the bud stage (Islam and Sedgley, 1981). Seven different types of restrictions in branching were imposed on each strain and performances of these types were tested against freely growing type, considered as control, in respect of four characters *viz.*, number of siliquae per plant, 1000 seed weight, yield per plant and harvest index. Thus there were in all eight treatments including control.

1) $M_1P_0S_0$: Plants bearing only main shoot throughout.

2) $M_1P_1S_0$: Plants bearing only main shoot and only one primary branch throughout.

3) M_1P_1 Sall : Plants bearing main shoot, one primary branch with all the secondary branches throughout.

4) $M_1P_2S_0$: Plants bearing main shoot and two primary branches. throughout.

5) M_1P_2 Sall : Plants bearing main shoot, two primary branches with all the secondary branches throughout.

6) $M_1P_3S_0$: Plants bearing main shoot and three primary branches.

7) M_1P_3 Sall : Plants bearing main shoot, three primary branches with all the secondary branches.

8) Control : Branching freely throughout.

The data averaged over years were subjected to statistical analysis.

RESULTS

Studies on harvest index :

The data presented in Table 1 revealed that the harvest index of the germplasm ranged from 9.4 to 38.4 per cent with a mean value of 20.81 per cent. The variability as reflected by C. V. was, however, observed to be very low for harvest index. The maximum variability was observed in case of yield per plant (44.91) followed by number of siliquae per plant 40.72. 1000 seed weight had comparatively low C. V. values.

The mean with regard to yield per plant, 1000 seed weight, number of primary branches per plant and number of siliquae per plant, of five different groups constituted on the basis of harvest index values are presented in Table 2 and the expression of these characters as influenced by harvest index is given in Fig. 1. The strains worthy of mentioning in high harvest index group are IB-90, IB-1793, IB-367, R-75-2 etc.

It may be seen from Table 2 and Fig. 1 that there had been steady increase in yield per plant and seed weight with the increase of harvest index values. Number of primary branches per plant, on the other hand, was observed to be reduced with the increase of harvest index values.

Table 1 : Variability in *Rai* in respect of harvest index, yield, seed weight number of siliquae and number of primary branches

	No. of siliquae/ plant	No. of primary branches/ plant	1000 seed weight (g)	Yield/ plant (g)	Harvest index (%)
Range	71-578	2.8-9.2	1.5-5 2	0.5-5.2	9.40-38.40
Mean	220.07	4.76	2.92	4.32	20.81
Variance	8032.47	1.06	0.06	3.76	16.42
S. D.	89.62	1.03	0.24	1.94	4.05
C. V.	40.72	21.64	8.22	44.91	3.90
S. E.	±4.39	±0.05	±0.01	±0.09	±0 20

Table 2 : Mean performances of germplasm broadly grouped under very low, low medium, moderately high and high on the basis of harvest index values

	Very low	Low	Medium	Moderately high	High
No. of primary branches per plant	6.6	4.7	5.0	5.1	3.9
No. of siliquae per plant	130.0	186.0	257.0	262.0	236.0
1000 seed weight (g)	2.0	2.1	2.4	2.4	3.1
Yield per plant (g)	2.1	2.2	5.1	5.6	5.1

The correlation co-efficient as presented in Table 3 further exhibited that harvest index had significantly positive association with seed yield and seed weight and significantly negative association with primary branches. Somewhat different picture was, however, observed in respect to number of siliquae per plant. Siliquae number per plant indicating a steady rise with the increase of harvest index values from very low to medium/moderately high, was observed to show a gradual decline with very high harvest index values. Its association with harvest index as computed over the groups was, however, observed to be weakly positive.

Table 3 : Correlation co-efficients among harvest index and yield components

	Primary branches per plant	Siliquae per plant	1000 seed weight	Seed yield per plant
Harvest index	—0.6698**	0.438	0.826**	0.848**
Primary branches per plant		0.383	—0.507*	0.603**
Siliquae per plant			—0.337	0.569**
1000 seed weight				0.270

** Significant at 1% level

* Significant at 5% level

Studies on ideotypes :

Treatment differences were significant for all the characters under study in all the three varieties. Data presented in Table 4 revealed that in all the three varieties harvest index was maximum at plant bearing main shoot and two primary branches with all the secondary branches. So far, the seed yield per plant is concerned, no significant differences were observed among the treatments 5, 7 and control in all the three varieties.

Although number of siliquae per plant was observed to be numerically highest in control for all the three varieties, the treatment 5 did not differ significantly with the control in any of the varieties in this regard. 1000 seed weight on the other hand, however, indicated the highest value in treatment 1 for all the varieties. Increase in number of siliquae and branches per plant resulted in reduction of seed weight and the minimum seed weight was recorded in control for all the varieties under study.

Table 4 : Performances of Pusa bold, Varuna and **Seeta** under different types of branching

Variety		Treatment	Harvest index	1000 seed wt.(g)	No. of siliquae/ plant	Grain yield/ plant (g)
Pusa bold	1.	$M_1P_0S_0$	*17.56*	*7.69*	*64*	*4.55*
	2.	$M_1P_1S_0$	19.78	7.85	106	6.08
	3.	M_1P_1Sall	25.23	6.80	150	8.49
	4.	$M_1P_2S_0$	22.16	7.55	136	6.95
	5.	M_1P_2Sall	28.28	6.89	173	9.20
	6.	$M_1P_3S_0$	20.23	6.44	163	7.37
	7.	M_1P_3Sall	25.34	5.98	180	9.00
	8.	Control	23.11	5.56	205	8.92
		S. E.	1.400	0.292	15.91	0.567
		C. D. (5%)	4.674	0.976	51.97	1.892
Varuna	1.	$M_1P_0S_0$	17.8	5.04	66	2.64
	2.	$M_1P_1S_0$	17.5	4.47	105	3.74
	3.	$M_1P_1S_0$	24.15	4.63	160	5.38
	4.	$M_1P_2S_0$	21.75	4.48	128	5.22
	5.	M_1P_2Sall	28.15	4.20	222	6.84
	6.	$M_1P_3S_0$	22.97	4.10	205	6.24
	7.	M_1P_3Sall	25.83	3.92	231	7.12
	8.	Control	22.74	3.73	269	7.25
		S. E.	1.292	0.135	24.72	0.577
		C. D. (5%)	4.560	0.45	82.43	1.925
Seeta	1.	$M_1P_0S_0$	24.49	3.60	68	2.99
	2.	$M_1P_1S_0$	23.80	3.29	102	3.33
	3.	M_1P_1 Sall	28.78	2.65	173	4.67
	4.	$M_1P_2S_0$	25.85	2.99	131	3.78
	5.	M_1P_2Sall	31.19	2.96	229	5.98
	6.	$M_1P_3S_0$	29.54	2.80	156	4.69
	7.	M_1P_3Sall	*29.16*	*2.60*	*262*	*6.06*
	8.	Control	23.11	2.40	290	6.99
		S. E.	1.076	0.138	27.62	0.504
		C. D. (5%)	3.591	0.464	92.12	1.812

DISCUSSION

Since the economic part of the crop under study is seed, the harvest index provides useful measure of yield efficiency. The harvest index values obtained in this study represented a poor distribution of assimilate into the economic part of the plant. A more or less similar values in *Brassica* spp. were also reported by Thurling (1974), Mehrotra *et al.* (1976), and Varshney and Singh (1982).

The observation worth mentioning in this study is existence of very low co-efficient of variability for harvest index in such a large collection in spite of the fact that characters like yield, number of primary branches, number of siliquae per plant had high C. V. values. Thus it appears that improvement of harvest index with an ultimate object of improvement of yield will be difficult by utilising the existing variability in the growth habit.

Analysis in the expression of yield and its attributes as affected by harvest index (Fig. 1) revealed that with the increase of harvest index, seed weight and yield also increased. Correlation analysis also elucidated the same trend of interrelationship in the sense that harvest index had highly significant positive correlation with seed yield and seed weight (Table 3). A positive correlation between yield and harvest index in *Brassica* spp. was also reported by Varshney and Singh (1982), Methrotra (1976), Thurling (1974) and others. The relationship, therefore, indicates possibility of improving harvest index by increasing seed weight and yield. But, at the same time, it is interesting to observe that two direct contributors of yield *viz.*, number of primary branches and siliquae per plant were reduced with the increase of harvest index (Fig. 1). Of these two characters, again, number of primary branches exhibited highly significant negative correlation with harvest index.

It may, thus, be assumed at this stage that reduction in the number of primary branches may help in achieving higher harvest index. The situation, therefore, demands developing such a plant model in which restriction in number of primary branches can be imposed without any effect on yield.

The observations and contention on the basis of the results obtained in harvest index are also corroborated by the results recorded in ideotypes. Perusal of data presented in table 4 will show that treatment numder 5 (two primary with all the secondary branches), recorded highest harvest index, which was significantly superior over control in all the varieties. Corresponding yield per plant was statistically at par with the control. It will thus appear that certain level of vegetative growth is necessary to facilitate translocation of optimum dry matter to the sink beyond which the growth becomes unfruitful.

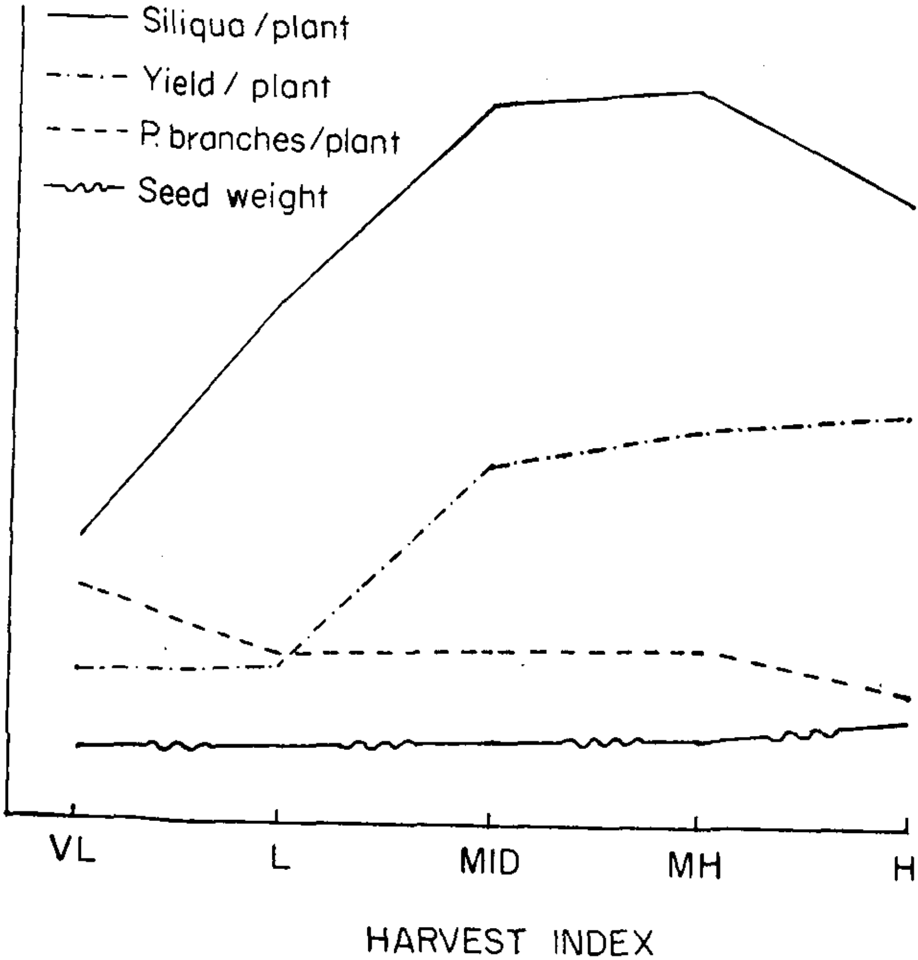

Fig. 1 : Yield, siliquae number, seed weight and primary branches as **influenced** by harvest index

Islam and Sedgley (1981) working with wheat also pleaded for reduction in number of uneconomic tillers for achieving high harvest index. The present investigation also elucidates that bearing of primary branches beyond two is uneconomical, since it fails to bring about significant increase in yield.

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Effect of aphid infestation on oil yield attributes in *Brassica*

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ABSTRACT

Twenty six cruciferous species including six artificially synthesized amphidiploids of *Brassica* were screened for aphid infestation and fecundity in 1973—74 and 1974—75. On the basis of these observations they were classified into resistant, tolerant and susceptible groups. None of the species was immune to aphid attack, however, degree of aphid infestation and fecundity in three groups varied considerably. Per cent loss over control due to aphids were 17.3, 27.4 and 53.5 and 21.4, 30.8 and 59.8 in seed yield, 14.9, 20.3 and 29.7 and 7.3, 14.3 and 27.3 in seed weight and 6.6, 8.6 and 14.4 and 7.3, 13.0 and 23.7 in oil content of resistant, tolerant and susceptible groups in 1973—74 and 1974-75 respectively.

The study revealed that the most reliable estimate in screening for aphid resistance would be the measure of per cent loss in the important economical characters such as, seed yield, oil content, seed weight etc. Future lines of research in breeding for resistant in crucifers is suggested.

Key words: Aphid infestation; aphid fecundity; resistant; tolerant; susceptible; cruciferous species

INTRODUCTION

Of the various domesticated crucifers, rape and mustard are important oilseed crops of greater significance to our country's economy. Among the factors responsible for the low productivity of these crops in India, the lack of aphid resistant varieties is an important one, as in years of severe aphid infestation, the crop is completely damaged. A number of insecticides are no doubt effective in controlling aphids and minimizing the damage to the crop but their extensive use besides causing environmental pollution pose health hazards to general life, as the produce is consumed directly as vegetables, condiments and edible oil by human beings and as fodder by animals. Further, the control of aphids has often been found difficult due to inadequate knowledge in handling of the cumbersome insecticides and their spraying equipments thus making it

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beyond the reach of ordinary farmers. Under these circumstances, control of aphids by breeding of resistant varieties has obvious advantages. Unfortunately, there is no known variety in this vast group of domesticated crucifers which could be best suited under aphid infested condition. In the present study, therefore, an attempt was made to preliminary screen the aphid resistant/tolerant strains from the available germplasm of crucifers.

MATERIALS AND METHODS

The material comprised of 26 cruciferous species including some of the artificially synthesized stable amphidiploids of digenomic *Brassica*. These were grown in randomised block design at the farm of Indian Agricultural Research Institute, New Delhi during the crop seasons of 1973-74 and 1974-75 under natural aphid infested conditions. The material was grown in four replications, keeping one as control, which was sprayed with the insecticide (Metacystox, 0.1%) thrice during the crop season.

All plants of a species were thoroughly screened for aphid infestation and were classified into four non-overlapping categories *viz.* killed, highly attacked (HA) slightly attacked (SA) and non-attacked (NA) plants. Two rounds of observations i.e. 110 and 130 days in 1973—74 and three 85,100 and 115 days after sowing in 1974—75 were taken covering the peak period of aphid infestation.

For assessing the multiplication rate or fecundity of aphids fifteen random plants from each species, previously ensured for the absence of aphids, were taken and 5-6th instar aphids (after 5th moulting) reared in the laboratory were put on the inflorescence of these plants and the racemes covered with muslin cloth bag to prevent inside aphids getting out and outside aphids getting in. After 25 days, when aphids multiplied sufficiently, racemes were cut along with cloth bags. Progenies of aphids whether dead or alive were counted and multiplication rate was computed for each species.

To find out the effect of aphid infestation on economical characters, per cent loss in seed yield, seed weight and oil content of each species was estimated over the control. Oil content was assessed using Pulsed Nuclear Magnetic Resonance Spectrometer (NMR) following the method of Tiwari *et al.* (1974).

RESULTS

On the basis of aphid infestation and fecundity the material was classified into three groups as follows :

Resistant	Tolerant	Susceptible
B. carinata	*B japonica*	*Camelina sativa*
B. integrifolia	*B. nigra*	*B. narinosa*
B. hirta	*B. amarifolia*	*B. pekinensis*
B. alba	*B. napus*	*B. chinensis*
Eruca sativa	*B. juncea*	*B. campestris* var. yellow *sarson*.
Crambe abyssinica	*B. rapa*	*B. campestris* var. brown *sarson*.
	B. oleracia	*B. campestris* var *toria*.
	B. tournefortii	
	Raphanus sativus	
	B. chinensis × *B. nigra*	(Stable amphidiploid, n=18)
	B. pekinensis × *B. nigra*	(,, ,, n=18)
	B. japonica × *B. nigra*	(,, ,, n=18)
	B. narinosa × *B nigra*	(,, ,, n=18)
	B. campestris × *B. oleracea*	(,, ,, n=19)
	B. chinensis × *B. oleracea*	(,, ,, n=19)

Aphid infestation : Appearance of aphid under natural field condition in northern India has often been observed around the last week of December in every year. However, its appearance is mostly determined by the environmental conditions of the area. In the year 1974-75 aphid infestation was visible little earlier than 1973-74. Initially aphids made their pockets on terminal portion of main recemes at pre-flowering stage on susceptible species such as *B. chinensis, B. pekinensis, B. narinosa, Camelina sativa* etc. Resistant species were the last preferred by the aphids and with low intensity. However, none of the species was immune to aphid attack. There was no killed plant in initial observations in any of the groups but later when infestation was at its peak the resistant, tolerant and susceptible groups were clearly distinguishable from each other. Mortality and highly attacked plant percentage were the highest in susceptable species in both the years (Tables 1 and 2). However, *B. alba* and *B. hirta* from the tolerant group were the exceptions where more than 50 per cent of the plants were severely infested by the aphids.

Table 1 : Per cent aphid infestation and fecundity on three groups of Cruciferous species (1973-74)

Group	% aphid infestation after days of sowing 100 days				130 days				Fecundity of aphids
	Killed	HA	SA	NA	Killed	HA	SA	NA	
Resistant	Nil	3.6	8.4	87.9	2.0	21.3	52.2	24.4	138.6
Tolerant	,,	4.0	13.0	83.0	12.7	30.0	48.7	8.6	301.6
Susceptible	,,	18.2	19.0	62.8	20.1	28.3	38.0	13.6	476.3
Range	—	1.8-40.4	1.8-34.9	26.1-98.1	1.2-26.9	5.6-66.3	6.5-80.6	0.0-21.7	69.3-568.5
C. D. (5%)	—	4.08	3.25	5.62	2.70	6.16	6.57	5.64	99.10

HA-highly attacked, SA-slightly attacked and NA-not attacked.

Fecundity of aphid : Highly significant differences were observed with regard to aphid fecundity between and within resistant, tolerant and susceptible groups in both the years. The rate of aphid multiplication was maximum on susceptible than resistant and tolerant groups (Tables 1 and 2). The mean fecundity rate of aphids was more for the majority of crucifers in 1974-75 than in 1973-74. The least aphid multiplication rate was observed on *Crambe abyssinica* (63.3) and *Eruca sativa* (127.0) and the highest on *B. campestris* var. *toria* (568.5) and *Camelina sativa* (754.0) in 1973-74 and 1974-75 respectively.

Effect of aphid infestation on quantitative characters

Seed yield : Highly significant differences were observed within and between the groups of cruciferous species with regard to mean seed yield during both the years (Table 3). The overall range of variation varied from 30.8 in *Raphanus sativus* to 1031.4 g in *B. pekinensis* in 1973-74 and 33.0 in *B. campestris* to 603.0 g in *B. carinata* in year 1974-75. Groupwise mean for seed yield was the highest in susceptible group and the lowest in resistant in 1973-74 but reverse was the case in 1974-75.

There was wide variation in per cent loss of seed yield caused by the aphids. It ranged from 7.0 in *Crambe abyssinica* to 75.2 per cent in *Camelina sativa* and

Table 2 : Per cent aphid infestation and fecundity on three groups of Cruciferous species (1974-75)

Group	% aphid infestation after days of sowing: 85 days				100 days				115 days				Fecundity of aphids
	Killed	HA	SA	NA	Killed	HA	SA	NA	Killed	HA	SA	NA	
Resistant	Nil	Nil	2.6	97.4	Nil	Nil	11.8	88.2	1.6	8.9	32.5	56.9	225.0
Tolerant	Nil	Nil	16.8	83.2	Nil	14.3	30.3	55.4	16.3	23.8	38.8	21.4	515 0
Susceptible	Nil	Nil	29.9	70.2	Nil	34.7	24.1	40.8	34.7	18.3	28.8	18.2	706.0
Range		—	0.0-34.2	65.0-40.0	—	0.0-45.6	6.5-42.4	26.7-93.5	0.0-52.2	0.0-30.9	12.5-51.8	9.8-82.1	127.0-754.0
C. D. (5%)		—	3.34	3.62	—	5.28	3.3	6.99	3.94	3.18	3.37	7.04	126.7

HA-highly attacked, SA-slightly attacked and NA-not attacked

9.9 in *Eruca sativa* to 78.1 per cent in *B. chinensis* in 1973-74 and 1974-75 respectively (Table 4). Loss in seed yield was found to be increased in second year than the first year in all the crucifers studied. Maximum loss was recorded in susceptible than resistant and tolerant species in both years.

Table 3 : Mean seed yield, seed weight and oil content of three groups of Cruciferous species (under aphid infested conditions)

Group	Mean of Character					
	Seed yield[1] (g)		1000 seed weight (g)		Oil content (%)	
	1973-74	1974-75	1973-74	1974-75	1973-74	1974-75
Resistant	465.5	354.2	3.0	3.5	28.0	27.5
Tolerant	403.7	184.7	2.5	2.7	34.0	30.8
Susceptible	524.4	79.6	1.9	2.1	32.3	30.2
Range	30.8 — 1031.4	33.0 — 603.0	1.1 — 6.4	1.3 — 6.0	15.3 — 42.4	12.1 — 38.4
C. D. (5%)	65.6	51.7	0.43	0.38	3.16	3.39

[1]Based on 3 × 5 m rows

Table 4 : Per cent loss over control due to aphid infestation in seed yield, seed weight and oil content of three groups of Cruciferous species

Group	Per cent loss in character					
	Seed yield		1000-seed weight		Oil content	
	1973-74	1974-75	1973-74	1974-75	1973-74	1974-75
Resistant	17.3	21.4	14.9	7.3	6.6	7.3
Tolerant	27.4	30.8	20.3	14.3	8.6	13.8
Susceptible	53.5	59.8	29.7	27.3	14.4	23.7
Range	7.0-75.2	9.1-78.1	2.9-50.0	2.9-37.1	1.2-22.9	3.0-27.4
C. D. (5%)	5.62	5.84	4.18	2.96	1.56	2.21

1000 seed weight : Significantly high mean seed weight was observed in resistant and tolerant than susceptible groups in both the years. The per cent loss in seed weight due to aphid attack was observed to be maximum in susceptible group. The least reduction in seed weight was recorded in *Eruca sativa* (2.9%) and the highest in *Camelina sativa* (50.0%) and *B. pekinensis* (47.1%) in 1973-74 and 1974-75 respectively.

Oil content : The range of variation for mean oil content varied from 15.3 in *Crambe abyssinica* to 42.2 per cent in the amphidiploid *B. chinensis* x *B. oleracea* in 1973-74 and 12.1 in *B. tournefortii* to 38.4 per cent in the amphidiploid of *B. campestris* x *B. oleracea* in 1974-75 (Table 4). The three groups differed significantly from each other.

Maximum loss in oil content due to aphid attack was recorded in *B. campestries* var. *toria* (22.9 and 27.4%) and the minimum in *Eruca sativa* (1.2 and 3.0 %) in both years. Significant differences were observed within and between the groups in relation to loss of oil content. The susceptible group sustained severe losses in oil content whereas resistant and tolerant suffered a little.

Correlation coefficient : Seed yield, seed weight and oil content of Cruciferous species were found to be negatively correlated with aphid fecundity and their correlation coefficient values were —0.19, —0.20 and —0.22 respectively.

DISCUSSION

The growth habit of the plant of various species differed in respect of number of branches, size of the leaves, plant type and maturity which provided differential amount of feeding area to the aphids. Therefore, degree of aphid infestation and fecundity varied substantially on them. However, none of the species was found immune to aphid attack. Susceptible species provided better nutritional conditions and more feeding area to the aphids for their growth and development which resulted in high rate of aphid multiplication on them. Initially aphids preferred the apical portions of the plant but later on they colonised all the parts readily if population pressure demanded. Further more, the plants of susceptible species appeared to be more succulent and less woody compared io *B. carinata, B. integrifolia* from resistant and *B. japonica, B. nigra* and *B. juncea* from tolerant group especially during the later stages of plant growth which coincided with the peak period of aphid infestation. The nature of resistance in *Eruca sativa* seemed to be either due to fiberous nature as suggested by Kundu and Pant, (1967) or due to antibiotic and toxic effect of the plant sap (Virtanen, 1965; Tjallingii, 1976) on the aphids. The woody and fiberous plants may produce a mechanical hinderance to aphids in penetrating their rostrum deep down to the phloem level which is the ideal place of their feeding (Bliss *et al.* 1973; Botha *et al.* 1975).

The digenomic species of *Brassica* such as *B. napus*, *B. juncea*, *B. amarifolia*, *B. carinata* and all the artificially synthesized amphidiploides included in the present study have common relationship, as the genomes of *B. nigra* and *B. oleracea* in some or the other way are involved in all these species. Thus the aphid tolerant factors present in *B. nigra* and *B. oleracea* are also involved in all the above mentioned digenomic species. Therefore, aphid tolerance in these species might have come through the genome of *B. nigra* or *B. oleracea*. This is further suggested by the most resistant species, *B. carinata*, the genomic constitution of which includes both the aphid tolerant genomes of *B. nigra* and *B. oleracea*.

Higher aphid infestation and fecundity were generally associated with severe damage of the plant. However, *B. alba*, *B. hirta*, *B. napus*, *B. rapa* and *Raphanus sativus* were the exceptions. These species although supported large population of aphids, yet showed less damage to quantitative characters. The higher reduction in enconomical characters of susceptible species compared to resistant and tolerant seemed to be due to the feeding of large number of aphids on them, resulting the plant stunted in growth and reduced in productivity (Dixon and Logan, 1973; Nath and Saba, 1974). Plant sap may contain several other biochemical constituents besides protein, amino acids and sugars that are the raw material of seed formation and oil synthesis. Thus the excessive drainage of plant sap (Dixon and Logan, 1973) from the susceptible species led to a drastic reduction in economical characters of the plant.

Though, per cent reduction in economical characters generally was high in susceptible species compared to resistant and tolerant species in both years, but mean seed yield and oil content of susceptible group was more than the resistant group in 1973-74. The intensity of aphids was not severe in 1973-74, therefore, susceptible species did not sustain much damage while the resistant species could not exhibit their full potential of resistance over susceptible. Secondly, most of the species under susceptible category happened to be good yielder and high in oil content whereas resistant group comprised of crucifers (*B. hirta*, *B. alba* and *Crambe abyssinica*) that are traditionally not grown on account of low seed yield and low oil content.

Among the three quantitative characters studied, seed yield seemed to be more sensitive character to aphid attack as aphid infestation caused severe injury to the leaf, branch, flowering stalk and pod of the plant and these were directly associated with seed yield. Therefore, high reduction in seed yield was obtained than seed weight and oil content of the plant.

Insect resistance in crop plants could be measured in terms of percentage of damage to the foliage or fruiting parts, general vigour of the plant, reduction of stand and yield reduction. It could also be measured in terms of the number of eggs oviposited by the insect aggregation, food preference, food utilization, growth rate, mortality and longevity. The present study indicated that the best and more reliable method of screening for aphid resistance would be to measure the resistance in terms of per cent loss caused by the aphids in seed yield and oil content, as these were the ultimate products of the plant.

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9 Analysis of combining ability in sunflower

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ABSTRACT

The nature and magnitude of combining ability effects in 27 crosses of sunflower in respect of yield and its components were studied in a line x tester cross experiment involving 9 inbred lines and 3 testers. The results revealed that the nature of gene action was predominently additive for yield, hull content and oil content while it was non-additive for days to flowering, capitulum diameter, days to 75 per cent maturity, number of filled seeds per capitulum and test weight.

Key words : Combining ability; sunflower; *Helinthus annuus;* Line × tester analysis

INTRODUCTION

The present study was undertaken to test promising inbreds of sunflower for their combining ability using a line × tester analysis.

MATERIALS AND METHODS

Nine inbred lines *viz.*, CMS-2, CMS-124, RM-62, HS-53, EC. 113045, Karilic 11 8, 323, Kransnodorets, Ammavirec were used as female parents. The three testers EC. 68415, Salyut, and Hebbal composite were used as male parents. Male sterility was induced by using 100 ppm gibberelic acid (Seetharam and Kusumakumari, 1975).

In all 27 hybrids were produced. Hybrids alongwith their parents were evaluated in a completely randomised block design with three replications. The spacing was 60 cm between rows and 30 cm between plants. Data were recorded on days to flowering, capitulum diameter, days to 75 per cent maturity, number of filled seeds per capitulum, plant yield, test weight (100 seed weight) hull content and oil content.

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Analysis of variance, general and specific combining ability effects and variances were worked out based on procedures developed by Kempthorne (1953) and as given by Singh and Chaudhari (1977).

RESULTS AND DISCUSSION

The analysis of variance revealed that differences between treatments (crosses and parents) were significantly different for all the characters (Table 1). Significant differences were observed between crosses for some characters but not for days to 75 per cent maturity, number of filled seeds, plant yield and oil content. Males did not differ significantly except for the character, test weight. Significant differences among females were observed for the characters, days to flowering and hull content. The variance due to parents *vs* crosses which is a measure of heterosis, accounted for a major portion of variation in all the traits except test weight and hull content showing thereby the presence of considerable amount of heterosis in respect of various economic characters.

Both female and male × female components contributed to the differences in respect of days to flowering. For test weight, males and males × females contributed to differences in hybrids. Females contributed to differences in hybrids for the character, hull content. For the rest of the characters the differences in hybrids was due to combined effects of all the components (males, females and males × females). Setty and Singh (1977) reported similarly with respect to the character, plant yield.

The estimates of general and specific combining ability effects of the male and female parents are presented in Table 2 and 3.

Variances due to general combining ability (gca) and specific combining ability (sca) (Table 1) indicated that the nature of gene action was predominently non-additive in respect of days to flowering, capitulum diameter, days to 75 per cent maturity, number of filled seeds per capitulum and test weight. While it was additive for the remaining characters. Putt (1966) reported predominent role of additive gene action for days to maturity and oil content. Setty and Singh (1977) observed non-additive gene action to be more important for days to 50 per cent flowering, capitulum diameter, hull content and additive gene action for maturity. Rao and Singh (1977) reported additive genetic variance for maturity, capitulum diameter, 1000 seed weight, hull content and oil content.

From the estimates of gca effects presented in Table 2, it may be seen that three lines *viz.* 323, CMS-124 and HS-53 had significant negative effects for days to flowering. CMS-2 had significant positive effect for capitulam diameter. Krasnodarets had significant negative effects for days to 75 per cent

Table 1 : Analysis of variance for eight characters in sunflower

Source	Degrees of freedom	No. of days taken to flowering	Capitulum diameter	Days to 75% maturity	No. of filled seeds per capitulum	Plant yield	Test weight	Hull content	Oil content
Replication	2	6.02	1.22	15.39	65683.84	227.42	0.90	4.04	2.62
Treatments	38	67.83**	10.25**	22.72**	56145.12**	302.48**	1.47**	85.04**	64.25*
Parents	11	68.81**	21.96**	36.69**	102363.05**	654.02**	2.69**	115.31**	78.18
Parents *vs* crosses	1	550.90**	13.11**	156.54**	53546.73*	673.30**	0.13	2.92	553 40**
Crosses	26	40.83**	5.18**	9.65	32845.16	139.49	1.00**	75.39**	39.54
Females	8	94.54*	8.48	9.45	38136.78	186.34	0.90	229.43**	62.59
Males	2	17.00	3.67	23.46	11993.29	172.41	3.52*	3.21	25.70
Males × Females	16	29.96**	3.72	9.24	32805.83	112.45	0.74*	7.39	29.75
Error	76	9.51	2.44	6.46	24757.09	116 29	0.36	22.63	40.92
Coefficient of variance %		4.87	10.63	3.00	22.57	29.30	11.55	16.19	15.00
S. E. (±)		2.52	1.27	2.07	128.47	8.80	0.49	3.88	5.22
gca		0.389	0.030	0.023	0.811	0.558	0.006	1.403	0.202
sca		6.816	0.427	0.926	2682.909	—	0.127	—	—

* Significant at 5%

** Significant ot 1%

Table 2. General combining ability effects of female parents

Parents	No. of days to flowering	Capitulum diameter	Days to 75% maturity	No. of filled seeds/ capitulum	Plant yield	Test weight	Hull content	Oil content
CMS—2	6.40**	1.50**	0.94	—5.05	4.51	0.24	12.90**	—4.79*
CMS—124	—2.51*	—0.41	—0.73	—8.29	—1.09	0.05	—2.48	3.19
RM—62	2.26*	0.99	0.72	144.91*	7.64*	0.36	0.95	0.79
HS—53	—3.09**	—0.07	—1.28	12.51	—0.56	—0.03	—3.81*	2.79
EC. 113045	2.09*	0.34	0.83	—2.22	—1.04	0.11	0.11	—0.64
Karlic—11.8	1.33	—1.16*	—0.17	—11.93	—2.17	—0.44*	—1.11	—0.78
323	—3.24**	—0.85	0.94	—53.33	—3.29	—0.09	—2.30	1.49
Krasnodorets	—1.91	0.79	—1.73*	4.96	3.48	0.46*	—1.79	—3.12
Armavirec	—1.35	—1.55**	0.49	—98.15	—7.48*	—0.43*	—2.47	1.12
EC. 68415	0.87	0.31	0.12	22.15	0.16	—0.09	0.25	0.43
Salyut	—0.19	—0.41	—0.99*	—19.80	—2.60	—0.30*	0.15	—1.12
Hebbal composite	—0.68	—0.09	0.86	—2.35	2.45	0.40**	—0.39**	0.69
C. D.								
Females at 5%	2.05	1.04	1.69	104.32	7.15	0.39	3.16	4.24
1%	2.72	1.38	2.24	138.67	9.50	0.52	4.19	5.64
Males at 5%	1.18	0.59	0.97	60.25	4.13	0.23	1.82	2.45
1%	1.57	0.79	1.29	80.06	5.49	0.30	2.42	3.25

* Significant at 5%

** Significant at 1 %

Table 3. Specific combining ability effects of the hybrids

Cross 1	No. of days taken to flowering 2	Capitulum diameter 3	Days to 75% maturity 4	No. of filled seeds/ capitulum 5	Plant yield 6	Test weight 7	Hull Content 8	Oil Content 9
CMS—2 x EC. 68415	3.49	—1.40	2.10	—120.46	—8.59	—0.49	1.39	—3.34
CMS—12 x ,,	2.22	0.21	—0.57	74.12	4.28	—0.17	0.41	3.19
RM—62 x ,,	—0.72	—1.12	—0.01	—98.96	—1.79	0.34	0.69	—0.83
HS—53 x ,,	2.04	—0.01	0.32	—78.71	—5.19	—0.14	1.07	—0.12
EC. 113045 x ,,	0.22	1.20	0.54	55.21	0.59	0.38	—2.01	—1.44
Karlic 11.8 x ,,	—6.82**	0.83	—1.22	112.05	8.67	0.70*	—1.34	3.92
323 x ,,	—2.71	0.13	—2.24	66.21	3.12	0.26	—1.81	1.94
Krasnodorets x ,,	0.02	—0.33	—0.57	—40.26	—3.82	—0.32	0.09	—4.08
Armavirec x ,,	2.25	0.48	1.54	30.81	—3.27	—1.50	1.23	—0.76
CMS—2 x Salyut	—2.36	0.50	—0.79	12.10	—0.27	0.12	1.23	—0.50
CMS—124 x ,,	—1.72	—0.82	1.88	—57.28	—2.79	0.13	—1.05	—2.49
RM—62 x ,,	1.02	0.92	0.43	121.29	0.72	0.41	0.26	1.77
HS—53 ,,	—0.99	—1.49	1.43	—129.59	—2.59	0.19	0.03	—0.66
EC. 113045 x ,,	0.51	0.69	—0.01	14.03	0.44	0.28	0.62	1.63

* Significant at 5%

** Significant at 1%

Table 3 : (Contd.)

1	2	3	4	5	6	7	8	9
Karlic 11.8 x ,,	6.12**	—0.01	—1.35	—54.46	—3.34	—0.45	—0.90	—2.92
323 x ,,	1.61	—0.67	0.88	5.35	—3.06	—0.72*	—0.59	3.14
Krasnodorets x ,,	0.15	—0.79	1.21	47.65	5.11	0.54	0.25	—0.54
Armavirec x ,,	—4.34*	0.08	—2.68	40.93	5.78	0.31	—1.63	0.56
CMS—2 x Hebbal Composite	—1.14	0.89	—1.31	108.36	8.87	0.38	—2.62	3.83
CMS—124 x ,,	—0.50	0.61	—1.31	—16.84	—1.48	0.04	0.64	—0.70
RM—62 x ,,	—0.30	0.19	—0.42	—22.33	1.07	0.06	—0.95	—0.94
HS—53 x ,,	—1.05	1.49	—1.75	208.31*	7.78	—0.06	—1.09	0.77
EC. 113045 x ,,	—0.74	—1.89*	0.47	—69.23	—7.04	—0.67	1.39	—0.19
Karlic 11 8 x ,,	0.69	—0.83	2.47	—57.59	—5.34	—0.25	0.44	—1.01
323 x	1.09	0.55	1.36	—71.55	—0.06	0.46	2.39	—5.06
Krasnodorets x ,,	—0.17	—0.46	—0.64	—7.39	—1 29	—0.22	—0.33	4.28
Armavirec x ,,	2.09	—0.56	1.14	—71.73	—2.51	0.25	0.13	—1.32
C. D. at 5%	3.54	1.79	2.92	180.15	12.39	0.68	5.47	7.35
1%	4.71	2.38	3.88	240.19	16.46	0.91	7.26	9.77

* Significant at 5%
** Significant at 1%

Table 4. Mean values for different characters under study in respect of hybrids and parents

Characters	No. of days to flower	Capitulum diameter (cm)	Days to 75% maturity	No. of filled seeds	Plant yield (g)	Test weight (g)	Hull content (%)	Oil content (%)
	1	2	3	4	5	6	7	8
CMS-2 x EC. 68415	75.49	15.32	88.66	617.77	34.45	4.78	43.78	34.72
GMS-2 x Salyut	68.66	16.50	84.66	708.38	40.02	5.18	43.51	36.01
CMS-2 x HC	69.30	17.40	86.00	822.09	54.21	6.15	39.13	42.15
CMS—124 x EC. 68415	65.30	15.01	84.33	825.70	41.73	4.91	27.41	49.23
CMS—124 x Salyut	60.30	13.27	85.67	652.34	31.90	5.01	25.85	42.00
CMS—124 x HC	61.03	15.19	84.33	710.23	38.26	5.62	25.00	45.60
RM—62 x Salyut	67.80	16.41	85.67	967.53	44.14	4.78	30.58	43.86
RM—62 x HC	66.00	16.20	86.67	841.36	49.54	5.96	28.84	42 96
HS—53 x EC. 68415	64.53	15.14	84.67	677.09	32.79	4.87	23.36	45.52
HS—53 x Salyut	60.43	12.93	84.67	584.24	32.64	5.00	25.60	43.44
HS—53 x HC	59.90	16.41	83.33	939.60	48.05	5.45	23.93	46.67
EC. 113045 x EC 68415	67.91	16.76	87.00	796.27	44.10	5.30	27.59	40.76
EC. 113045 x Salyut	67.13	15.53	84.33	713.13	35.18	4.99	30.11	42.29
EC. 113045 x HC	65.40	13.44	87.67	647.33	32.76	4.76	30.34	42.27
Karlic 11.8 x EC. 68415	60.11	14.89	84.33	843.41	45.04	5.30	27.04	45.94
Karlic 11.8 x Salyut	71.97	13.33	83.00	634.95	30.28	3.94	29.18	37.60
Karlic 11.8 x HC	66.07	13.01	88.67	649.26	33.33	4.84	28. 18	41.32
323 X EC. 68415	59.65	14.50	84.33	756.16	38.40	5.19	25.38	46.26
323 X Salyut	62.90	12.97	86.33	753.34	29.44	4.02	26.49	45.92
323 X HC	61.90	14.69	88.67	593.90	37.48	5.89	28.94	32.52

Table 4 : (Contd.)

	1	2	3	4	5	6	7	8
Krasnodorets x EC. 68415	63.70	15.67	83.33	707.98	38.20	5.18	27.78	35.64
RM—62 x EC. 68415	67.13	15.09	85.33	789.23	44.40	5.74	31.13	42.80
Krasnodorets x Salyut	62.76	16.07	84.00	753.93	14.38	5.82	27.83	37.64
Krasnodorets x HC	61.97	15.32	84.00	716.35	43.02	5.77	26.71	44.61
Armavirec x EC. 68415	66.49	14.54	87.67	675.94	27.79	5.89	28.52	44.64
Armavirec x Salyut	58.83	13.42	82.33	644.10	34.09	4.71	25.28	42.90
Armavirec x HC	64.79	13.28	88.00	548.90	30.85	5.35	26.51	42.83
Parents								
Females CMS—2	66.53	12.20	84.67	516.89	25.21	4.99	44.36	31.67
CMS—124	58.50	14.86	83.67	514.33	24.99	5.55	29.05	31.70
RM—62	64.95	16.12	84.67	664.60	31.06	4.69	38.92	31.06
HS—53	54.53	10.78	82.67	509.75	22.58	4.22	29.35	35.75
EC—113045	63.03	14.46	85.33	767.45	37.48	4.91	29.35	35.75
Karlic 11.8	51.57	8.41	72.33	290.09	7.88	3.07	28.53	29.05
323	56.30	12.58	83.67	631.70	26.07	4.46	22.75	43·72
Krasnodorets	66.89	15.34	87.00	583.98	30.23	4.94	30.29	42.45
Armavirec	57.03	14.63	81.33	660.33	32.60	5.25	28.03	37.87
Males EC. 68415	60.20	17.58	83.67	965.55	54.39	6.39	23.40	42.92
Salyut	55.23	16.08	83.67	691.36	44.24	6.51	25.12	42.16
Hebbal composite	61.42	17.04	83.33	915.63	51.51	5.76	27.49	41.02

HC = Hebbal composite

maturity. RM-62 showed significant effects for number of filled seeds and plant yield. Krasnodorets showed positive effect for test weight and HS-53 had negative effect for hull content. The line CMS-125 had high positive effect for the character, oil content. Among males, Hebbal Composite was good combiner in respect of days to flowering, test weight, hull content and plant yield. Salyut was a good, combiner for earliness and EC. 68415 was a good combiner for the other characters,

Estimates for specific combining ability effects revealed that the number of cross combinations showing high *sca* are rather limited. No one cross exhibited high specific combining ability effect simultaneously for all the characters studied. Nevertheless a few cross combinations showed moderate to high specific combining ability for certain characters. The hybrid Karlic-11.8 x EC. 68415 was good combiner for days to flowering. HS-53 x Hebbal composite was good combiner for capitulum diameter and for number of filled seeds per capitulum. Armavirec x Salyut was good combiner for days to 75 per cent maturity. CMS-2 x Hebbal composite, Karlic 11.8 x EC. 68415 had good *sca* effects for plant yield. The hybrids Karlic-11.8 x EC.68415, CMS-2 x Hebbal composite and Krasnodorets x Hebbal composite had high *sca* effects for test weight, hull content and oil content respectively.

In general the performance of lines was not related to their performance in crosses with the testers This suggests that selection based upon parental performance alone would not necessarily reflect the ability to produce superior combinations when crossed with similar lines. In the present study Krasnodorets was a good combiner for days to 75 per cent maturity and test weight, RM-62 was good for number of filled seeds and plant yield, 323 was good for capitulum diameter and days to flowering. The line EC. 113045 has good mean performance with respect to number of filled seeds per capitulum and plant yield. Karlic-11.8 performed well with all the testers (Table 4). These lines could be used in the future breeding programme.

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8 Induction of foliar movements by thermal radiation in groundnut

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ABSTRACT

Unlike circadian rhythm regulated nictinastic foliar movements, diurnal foliar closure and reopening were found to be easily induceable by manipulation of heat radiation load. Foliar closure was induced in adequately watered plants with slight change in water potential when the leaf temperatures increased and the relative humidity droppd around their leaves. Water stressed plants however, respond faster by closure and reopening with varying thermal loads. Although, stomatal closure accompanied foliar closure stomatal opening was not accompanying normal foliar exposure. Cuticular transpiration under increasing thermal radiation has apparent significance.

Key words : Foliar movements; thermnal radiation; groundnut; *Arachis hypogaea*

INTRODUCTION

The nictinastic foliar movements exhibited by the members of the family Leguminosae were known since before Charles Darwin (Darwin, 1881). These circadian movements are regulated by the physiological clock and are not easily manipulated over short time intervals (Buinning, 1967). Mid-day foliar movements (*parahelionasty*) under conditions of high incoming solar radiation and water stress in the arid regions is known as an adaptive mechanism for avoida nce of radiation interception and xerophytism (Neger, 1913; Oppenheimer, 1960; Begg, 1980; Ramesh Babu, *et al.* 1983). Since the day time solar radiation at the canopy level fluctuates over a wide range, particularly due to the rotation of the earth and the cloud cover (Gates, 1962) they exhibit parahelionasty (Dubetz, 1969), these plants also exhhibit movements of foliage for

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optimal interception of radiation for photosynthesis (Diaphotonasty) under favourable conditions (Begg, 1980). Thus the leguminaceous plants have foliage responding by closing and opening sensitive to varying thermal loads and water stress during day hours. Cultivated groundnut (*Arachis hypogaea* L.) similarly exhibits foliar closure under moisture stress during mid day hours (Ramesh Babu *et al.* 1983; Ramesh Babu and Rao, 1984). The inducability of foliar movements by experimental manipulation of thermal loads under normal and moisture stressed conditions over short time intervals is described in this paper.

MATERIALS AND METHODS

Long wave thermal radiation was produced by a hemispherical steel plate (90 cm in diameter). This simulator of artificial sky was held above the plants at 35 to 45 cm from the level of the leaves. Holes around the centre of the plate provided a vent for warm air escape and the plants were never in convective or conductive heat exchange with the simulator. The simulator plate was heated with a 1000 W/h resistance electric heater element encased in glass braiding placed on the outer surface and was maintained at 200°C to 220°C over the plants of Virginia bunch cv. Kadiri 2 of 14 to 17 days grown in plots of 3 × 2 m at 30 × 10 cm spacing. Thermal load produced in this manner is estimated to be in the range of 2000 W/m^2. Shading from direct solar radiation was provided by the same simulator with the heater turned off and was tilted to the south by about 25°. These plants were raised from seed sown after irrigation of plots at 5 cm/ha. The plots received 30 N, 10 P and 25 K kg/ha as urea, superphosphate and muriate of potash prior to irrigation for sowing. Following a 50 mm cumulative Class A pan evaporation some plots received irrigation at 50 mm/ha (T_1) and others received none (T_2). During the period of experimental simulation of thermal radiation the soil water potentials in these plots at rooting depths were at, less than —0.3 and —8.0 bars in the T_1 and T_2 plots respectively.

Air temperatures were recorded by copper-constantinum thermocouples, placed at 3 cm intervals from the leaf level upwards to 3 cm below the simulator surface. The temperatures of the leaves under the simulator and of plants outside were measured with thermocouple leaf clips. Air relative humidity was measured using hygrometer.

Leaf water potentials were measured with a scholander pressure bomb apparatus and the phloem exudate at low pressurisation was ignored. Stomatal diffusive resistances were measured with a LiCor autoporometer LI 65 and a LI 206 sensor on the adaxial and abaxial surfaces separately. The total resistance of these two parallel resistances was computed by summing up the reciprocal of resistance (conductance) of the two surfaces (Turner, 1970).

Averages of 4 measurements of the total conductance was reconverted to mean resistance by the reciprocal of the average conductance.

Estimation of changes in the angle at the base of opposite leaflets were made as described by Ramesh Babu *et al.* (1983).

Solar and sky radiation were measured with a pyranometer sensor (Sr. No. PY 2165) held level on a levelling fixture and with LiCor integrating radiometer LI 188.

Transpiration rates were estimated by the cut leaf method. All the experiments presented were repeated with identical qualitative changes on four different days during the December to April growing season of 1982-83.

RESULTS

Induction of foliar closure

Both the normally watered (T_1) and water stressed plants (T_2) have normally fully open leaflets from about 7-00 a. m. Water stressed plants exhibit closure beyond 10-00 a. m. The thermal radiation simulation for induction of foliar closure was, therefore, produced during 8-00 and 9-30 a. m. that is a period of maximal foliar opening during the forenoon. Within 10 minutes of increased I.R. thermal radiation load, visually obvious foliar closure occurred in the water stressed plants. During this period the angle between the leaflets was reduced to 105°. The normal plants (irrigated) also exhibited closure to 90.5° in 25 minutes of simulated heat although their leaf temperatures were about 105°C higher than those of the moisture stressed plants. This slow response of these plants could be due to their larger leaf water content and higher transpiration rate.

Leaflets of moisture stressed plants exhibited complete closure by reduction of 159° in the angle between the leaflets in 40 minutes, with simultaneously increasing stomatal diffusive resistances and decreasing transpiration (Table 1). The leaf temperatures of plants exposed to increase I.R. thermal load were 5.5°C higher than the plants exposed to normal sky. Irrigated plants at —5.0 bars leaf water potentials, transpired at 39 mg dm^2 min^{-1} were also 5.5°C warmer with their leaflets closed to 29° under the heat radiating artificial sky. Interestingly watered plants continued to transpire inspite of high stomatal resistances presumably through the cuticle (Ramesh Babu and Rao, 1984). Under increased thermal load they exhibit 12.5 mg dm^2 min^{-1} increase of transpiration as stomatal resistance increased to 12.2 Scm^{-1}. This unusual and consistant condition can only be explained by vapour efflux through (1) bundle sheeths extensions that follow the entire course of leaf vasculature and (2) the cuticular permeability of

Table 1 : The effect of simulated thermal radiation and induction of foliar closure in moisture stressed groundnut plants

	Initial condition	Complete closure	Reopening
Time of day	8 00 a.m.	8.40 a m	9.20 a.m.
Solar radiation Cal. cm^2 min^{-1}	0.43 ± 0.1	0.50 ± 0.01	0.53 ± 0.01
Air temperature °C	21.0	26.0	28.0
Leaf temperature °C			
External plants	22.0 ± 0.5	26.5 ± 0.41	28.0 ± 0.79
Plants under simulator	22.5 ± 0.4	32.0 ± 1.41	29.0 ± 0.89
Relative humidity %			
External plants	95.0 ± 1.6	90.0 ± 0.79	87.0 ± 1.58
Under simulator	95.0 ± 2.6	75.0 ± 1.50	85.0 ± 2.16
Angle between leaflets in degrees			
External plants	166.5 ± 5.1	163.0 ± 2.55	158.0 ± 2.00
Under simulator	172.5 ± 3.3	13.5 ± 2.70	155.0 ± 3.80
Leaf water potential bars			
External plants	−9.0 ± 1.2	−9.5 ± 0.49	−10.0 ± 0.50
Under simulator	−9.0 ± 1.3	−11.0 ± 1.00	−11.0 ± 0.49
Stomatal resistance Scm^{-1}			
External plants	2.7 ± 0.2	3.8 ± 0.40	7.2 ± 0.20
Under simulatcr	2.5 ± 0.2	15.8 ± 0.80	17.9 ± 1.10
Transpiration rate mg dm^2 min^{-1}			
External plants	10.8 ± 0.8	15.2 ± 0.92	15.8 ± 0.75
Under simulator	8.8 ± 0.8	1.9 ± 0.53	2.3 ∓ 0.65

the leaves as was already reported (Ramesh Babu and Rao, 1984). The stomatal closure accompanied foliar closure and stomatal opening was not observed to accompany foliar opening that was observed after the removal of thermal radiation simulation. Significant changes in the per cent relative humidity around the leaves and increasing leaf temperatures were noticeable during the foliar closure.

Foliar reopening like the closure was faster in the moisture stressed plants and near complete opening was consistently recorded within 60 minutes of removal of I.R. radiation simulation and exposure to a normal sky. The normal plants (irrigated) response of opening was slower as they were not as open as the stressed plants even after a lapse of 90 min. (Table 2).

Water potentials of the plants changed only slightly (—1.5 and —0.5 bars in 40 and 55 min. in the stressed and irrigated plants respectively) during the I.R. simulation period and in relation to those of the open canopy conditions.

Induction of foliar opening

Foliar opening was induced by reduction of solar radiation load by shading thereby the thermal load to groundnut plants that exhibit maximum foliar closure at noon hours (Ramesh Babu *et al.* 1983). The shade produced 85 to 87.8 per cent reduction in the direct radiation load. The moisture stressed plants foliage showed opening in 35 min from 24.6° to 126.5° with simultaneously decreasing transpiration and increasing stomatal diffusive resistances (Table 3).

The adequately watered plants showed a lesser response in 35 min. of shading as they showed only 30.7° of opening. The foliage of these plants was relatively open at the beginning and were exposed to radiation (at 64.8° to 67.5° of opening). Similar to the moisture stressed plants, transpiration rate decreased considerably and the plants water potentials showed elevation by 1.0 bar. Leaf temperatures were 3.0 and 2.5° C cooler under the shade in the stressed and normal plants, respectively. The plants in the open canopy were 2.0 to 2.5° C warmer than the air temperature at 12-20 and 12-30 p.m. in the stressed and normal plants, respectively. Stomatal resistances in the irrigated plants decreased under the shaded condition (Table 4).

To relate the intensity of radiation load with the foliar response four different levels of radiation loads (59%, 39%, 17% and 14% of the incident radiation) were produced (Table 5) over the moisture stressed plants. The bulk air temperatures remained nearly constant. The fastest response could be observed with more than 85% reduction of the incident radiation load as indicated earlier. The moisture stressed plants exhibit noticeable change in their foliar

Table 2: The effect of simulated thermal radiation and induction of foliar closure in adequately watered groundnut plants

	Initial condition	Complete closure	Reopening
Time of day	8.00 a.m	8.55 a.m.	10.25 a.m.
Solar Radiation Cal. cm^{2} min^{-1}	0.43 ± 0.01	0.56 ± 0.02	1.20 ± 0.01
Air temperature °C	21.2	26.0	29.5
Leaf temperature °C			
External plants	22.8 ± 0.4	24.0 ± 0.8	25.5 ± 0.5
Plants under simulator	22.5 ± 0.3	29.5 ± 0.7	31.5 ± 0.5
Relative humidity %			
External plants	90 ∓ 1.5	85 ± 1.5	80 ± 1.5
Under simulator	90 ± 3.0	58 ± 3.7	75 ± 2.4
Angle between leaflets			
External plants	140.0 ± 5.1	135.5 ± 8.5	138.5 ± 5.4
Under simulator	138.0 ± 6.2	29.0 ± 2.6	88.0 ± 6.7
Leaf water potentials bars			
External plants	—4.5 ± 0.2	—5.0 ± 0.4	—5.0 ± 0.3
Under simulator	—4.5 ± 0.2	—5.5 ± 0.4	—5.0 ± 0.3
Stomatal resistance S cm^{-1}			
External plants	2.0 ± 0.2	2.8 ± 0.2	2.6 ± 0.3
Under simulator	1.8 ± 0.3	12.2 ± 1.2	13.5 ± 1.4
Transpiration rate mg dm^{2} min^{-1}			
External plants	26.8 ± 3.0	29.3 ± 2.8	38.2 ± 2.0
Under simulator	26.8 ∓ 1.4	39.3 ± 1.0	30.9 ± 0.7

Table 3 : The effect of reduction of solar radiation load and foliar opening in moisture stressed groundnut plants

	Initial foliar condition	Foliar opening
Time of day	11.55 a. m.	12.30 p.m.
Solar radiation Cal. cm^2 min^{-1}	1.07 ± 0.02	1.23 ± 0.01
Radiation below shade Cal. cm^2 min^{-1}	0.16 ± 0.01	0.17 ± 0.01
Air temperature °C	33.0	33.5
Air temperature °C under shade	31.0 ± 0.7	33.0 ± 0.8
Leaf temperature °C		
External plants	34.0 ± 1.2	35.0 ± 1.6
Under shade	30.0 ± 1.3	32.0 ± 1.1
Relative humidity %		
External plants	50.0 ± 1.2	50.0 ± 1.5
Uunder shade	56.0 ± 1.6	51.0 ± 1.8
Angle between leaflets --degrees		
External plants	20.6 ± 2.3	25.5 ± 2.1
Under shade	21.2 ± 1.8	126.5 ± 6 5
Leaf water potentials—bars		
External plants	—14.5 ± 0.3	—14.5 ± 0.4
Under shade	—14.5 ± 0.3	—14.0 ± 0.3
Stomatal resistances S cm^{-1}		
External plants	14.5 ± 2.1	14.5 ± 2.1
Under shade	14.5 ± 2.1	25.2 ± 2.3
Transpiration rate mg cm^2 min^{-1}		
External plants	45.3 ± 0.6	56.4 ± 1.1
Under shade	45.3 ± 0.6	22.8 ± 0.3

Table 4 : The effect of reduction of solar radiation load and foliar opening in adequately watered groundnut plants

	Initial foliar condition	Foliar opening
Time of day	11.45 a.m.	12.20 p.m.
Solar radiation Cal. cm^2 min^{-1}	1.27 ± 0.01	1.15 ± 0.01
Radiation below shade		
Cal. cm^2 min^{-1}	0.18 ± 0.01	0.14 ± 0.01
Air temperature °C	31.0	32.5
Under shade	30.0	30.5
Leaf temperature °C		
External plants	32.0 ± 1.5	32.5 ± 1.6
Under shade	29.5 ± 1.7	30.5 ± 1.2
Relative humidity %		
External plants	58.0 ± 0.8	51.0 ± 0.5
Under shade	59.0 ± 1.2	55.0 ± 1.5
Angle between leaflets—degrees		
External plants	64.8 ± 3.8	67.5 ± 4.1
Under shade	64.8 ± 3.8	98.5 ± 6.3
Leaf water potentials — bars		
External plants	10.6 ± 0.25	10.25 ± 0.33
Under shade	10.6 ± 0.25	9.5 ± 0.41
Stomatal resistances S cm^{-1}		
External plants	6.7 ± 0.3	5.9 ± 0.4
Under shade	6.7 ± 0.3	1.7 ± 0.2
Transpiration rate mg dm^2 min^{-1}		
External plants	109.6 ± 2.2	96.2 ± 1.8
Under shade	109.6 ± 2.2	47.1 ± 1.1

Table 5: The effect of graded reduction of solar radiation load and foliar opening in moisture stressed groundnut plants

Treatment	Open	Single layer polyethylene cover	Mosquito net single layer	Double layer mosquito net	Triple layer mosquito net
Solar radiation Cal. cm^2 min^{-1}	1.23 ± 0.01				
Radiation below cover Cal. cm^2 min^{-1}		0.72 ± 0.01	0.48 ± 0.02	0.21 ± 0.01	0.17 ± 0.01
Air temperature °C	35.5	35.0	35.5	35.0	35.0
Leaf temperature °C	36.5 ± 0.87	34.5 ± 0.35	34.0 ± 0.85	33.0 ± 0.82	33.0 ± 0.80
Relative humidity percent	56.0	58.0	58.0	62.0	68.0
Time lapse min.	—	100	75	60	45
Angle between leaflets in degrees	21.0 ± 2.2	51.4 ± 4.6	73.2 ± 5.0	86.7 ± 5.8	103.0 ± 9.1
Leaf water potentials in bars	−14.3 ± 0.3	−15.0 ± 0.5	−14.0 ± 0.3	−14.0 ± 0.4	−13.5 ± 0.3
Stomatal resistance S cm^{-1}	14.3 ± 0.3	14.7 ± 0.2	14.2 ± 0.3	14.0 ± 0.2	14.0 ± 0.2
Transpiration rate mg cm^2 min^{-1}	70.6 ± 2.2	55.8 ± 1.7	34.2 ± 1.7	23.2 ± 2.2	18.0 ± 1.6

condition with a 100 min. time lapse at about 60% of the incident radiation level. The leaf angle and transpiration rate exhibit a direct proportionality to irradiation and their temperatures were 0.5 to 2.0° C lower to the air temperatures. Significantly the stomatal resistances showed no changes in the time frame mentioned. Here again the role of extra stomatal route of tranpiration is significantly indicated.

DISCUSSION

Members of the family Leguminosae common to the arid and semiarid regions characterized by high incoming solar short wave and thermal radiation balance, experience wide thermal regimen in day and night cycle. From dusk to dawn the net negative thermal radiation balance and heat loss from leaves inevitably coincides with the dark periods of the minimum essential duration. These set off the rhythm phenomena which last for several days (Bunning, 1967) and plants adapt with circadian rhythm regulated closure for avoidance of heat loss Darwin, 1881). As pointed out, with varying radiation inputs during the day hours the observed cycles of closure and reopening provide the plants with the necessary opportunity for sensing the thermal load with reference to their internal moisture status for regulation of the extent of exposure to the radiation load. The plants growing under moisture stress show higher degree of closure and opening capability over short intervals of time (Ramesh Babu *et al*. 1983).

It is not possible to discriminate between the effects of thermal and water stress as increased thermal load induces water stress. However, water stress alone does not produce foliar closure during the day hours. Even the severely stressed plants below —60 bars leaf water potentials exhibit normal foliar opening in the morning hours when the the incoming radiation levels are low (Ramesh Babu *et al*. 1983, Ramesh Babu and Rao, 1984 and Ramesh Babu *et al*. 1984). The irrigated plants were less responsive with only —0.5 bar lowering of leaf water potential during their foliar closure. Their higher transpiration rate that provides leaf cooling when compared with the water stressed plants, the stressed plants exhibit faster foliar responses with their lower transpiration rate and relatively higher leaf temperatures. This lends to the interpretation that the simulated closure could be due to the combined effects of thermal and water stress of which the thermal stress may have a prominent role. The increasing transpiration rate under conditions of increasing stomatal resistance of the adequately watered plants under increased thermal load (Table 2) could be essentially through the cuticle which in many crop plants were known to be appreciably permeable to account for 18 to 90 per cent of total transpiration (Pallas and Bertrand, 1966) and inaccuracies in transpiration measurements occur when the cuticular losses enter the picture (Crafts, 1968). This again may explain the changes in leaf angle and transpiration rates that were in direct proportion to the irradiance while stomatal resistances remained unchanged in Table 5 (Vaadia *et al.* 1961). The cuticular conductance of vapour however is less well recognised in the recent literature on crop plants.

The avoidance of radiation interception by foliar closure in groundnuts confers additional functional advantages by reducing vapour pressure deficit between the upper photosynthetically active surfaces as well as increasing the bounday layer resistances for vapour loss and heat gain by convective heat transferences (Gates, 1962) to these sensitive upper leaf surfaces. Simultaneously the lower surfaces are exposed to the exterior environment. The lower surfaces of the groundnut leaves have radiation reflectant properties with a higher stomatal resistances due to anatomical pecularities contiguous with the lower epidermis(Ramesh Babu and Rao, 1984 and Yarbrough, 1957). The groundnut foliage also exhibit movements at the axil of the pinnay compound leaves for interception of solar radiation when the intensities of the same are low in the morning (7-00 a.m. to 10-00 a. m.) and evening (4-00 p. m. to 6-00 p.m.) hours (Dubetz, 1969 and Ramesh Babu *et al.* 1983). These movements are by a twisting movement of the compound leaf to either the east or west along with a decrease or increase of the angle between the rachis and the stem depending upon the insertion point of the leaf on the stem relative to the sun, These reversible movements are known to be caused by turgor changes in the 'motor' cells situated at the pulvinar bases of leaflets and the bases of petioles. Differential turgor changes are caused by varying membrane permeabilities and the movement of potassium thereby effecting osmotic potential changes in the 'motor' cells (Begg, 1980; Sutcliffe, 1978). Phytochrome is indicated to be the sensory pigment (Begg, 1980). However, the precise signal generation due to incident radiation, leaf water status and temperature and its transmission are not well understood.

It may be concluded that the groundnuts like other leguminaceous species are thermo sensitive with well evolved mechanism for not only avoidance of thermal stress but are equally adapt to intercept light under favourable thermal load conditions during the day hours and avoid heat loss by foliar closure during nights. However, when the annual species are grown under adequate water supplies their adaptability was observed to be declining or lost altogether in their pod filling phenophase rendering them susceptible to water stress and consequent losses of yields (Ramesh Babu *et al.*, 1984).

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Studies on spore germination and infection of *Alternaria brassicae* of rapeseed and mustard

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Alternaria leaf blight of rapesed and mustard caused by *Alternaria brassicae* (Berk.) Sacc. is a common and serious disease. Environmental optima for spore germination and subsequent infection were studied to obtain information on pathogen factors in the epidemic devolopment of the disease.

Experiments on the effects of temperature on spore germination and infection were carried out in an incubator with temperature variation of $\pm$ 1°C. Variable light intensities were created in a temperature controlled (24-26°C) growth room fitted with florescent tube lights by adjusting the distance between the seedlings grown in plastic pots and the source of light. Inoculated seedlings were exposed for 24 h to different light intensities and then transferred to green house. Different relative humidity percentages were obtained in desiccators by using mixture of conc. H_2SO_4 and water (Buxton and Mellenby, 1934). The slides carrying *A. brasscae* spores were incubated at 25 $\pm$ 1°C in such desiccators. To maintain leaf wetness, spray inoculated plants raised in plastic pots were covered with polythene bags and incubated at desired temperature for desired duration in an incubator. After desired hours of exposure, replicate pots were removed to green house for observation till the appearance of symptoms. About 200 spores from 7-day old cultures per treatment with three replications were used for germination. A spore having germ tube length of more than its width was considered as germinated spore. For use of leaf extracts and leaf exudates, leaves were collected from two months old field grown plants. Leaf extract was prepared by grinding 2 g. of leaf pieces from each cultivar in 100 ml of distilled water in a sterilized pestle and mortar. For each drop of spore suspension one drop of leaf extract was used. Leaf exudates were obtained from different cultivars by incubating thoroughly washed leaf pieces in plates lined with moist blotting sheets for 24 h. Exudates were collected with sterilized pipette in a sterilized test tube. One drop of leaf exudate was used for each drop of spore suspension.

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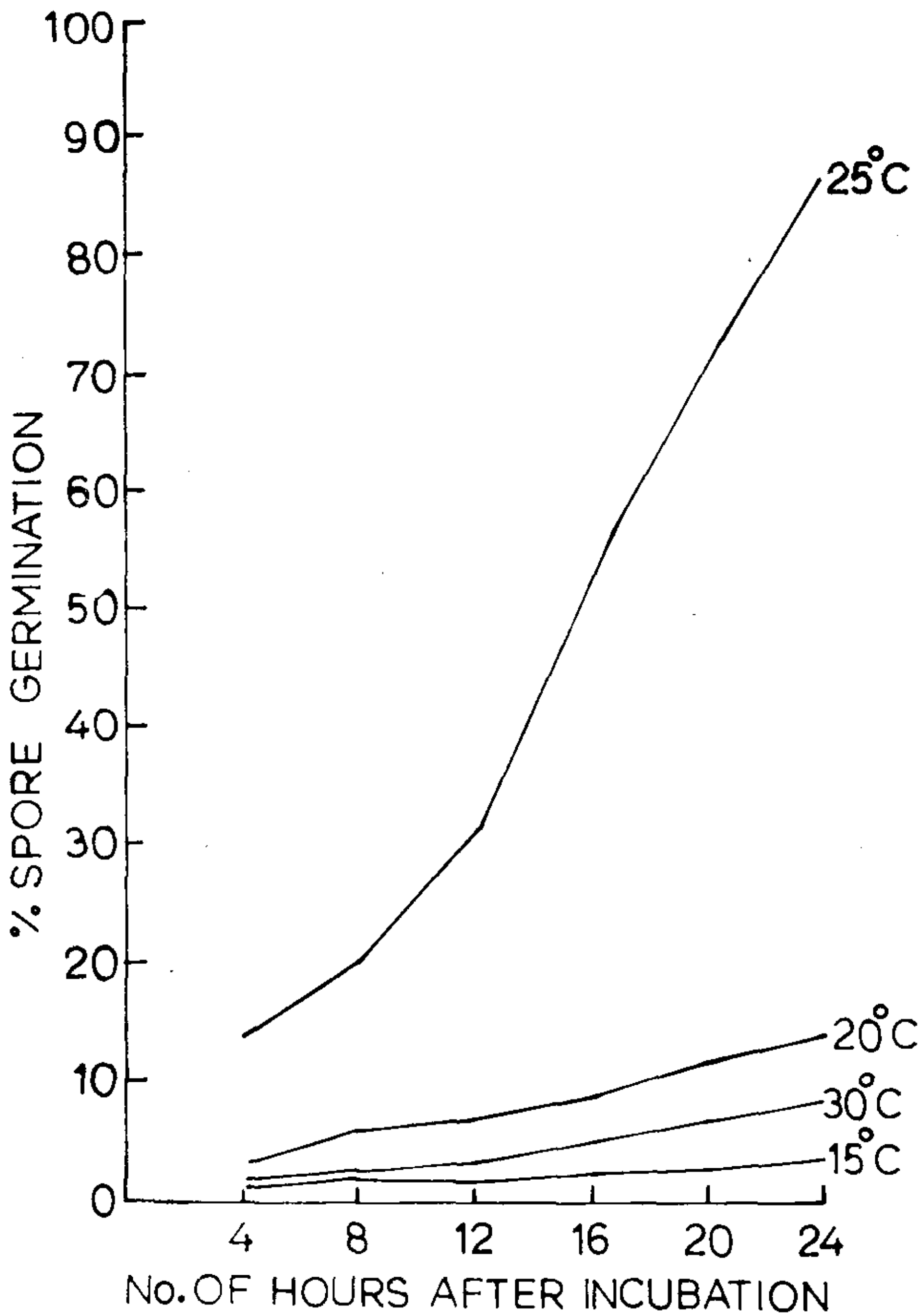

Fig. 1 : Influnce of temperature on spore germination of *A. brassicae*

Optimum temperature for spore germination was 25°C (Fig. 1). Spore germination reduced significantly at temperatures lower or higher than 25°C. Spore germination started at 4 h of incubation and reached to the peak level, for all the tamperatures at about 24 h. Experiments on interaction of temperature and leaf wet ness were carried out with a susceptible cultivars. Data on influence of leaf wetness on disease intensity at various temperatures showed that a leaf wetness period of 16-24 h was necessary for high infection at the critical temperature of 25°C. Temperature regimes higher or lower than 25°C, however, caused reduction in disease intensity by affecting both size and number of spots even at optimum period of leaf wetness. Studies on the influence of light intensity on conidial germination had deleterious effect on spore germination and subsequent infection (Table 2). Both number and size of lesions were reduced at direct exposure to strong light intensity. Conidial germination at optimum temperature (25°C) was directly dependent on per cent relative humidity of the atmosphere. Relative humidity around 90 per cent gave maximum spore germination. Lower relative humidity values caused drastic reduction in spore germination. A period around 24 h was necessary to attain highest spore germination percentage at 90 per cent RH. Leaf extracts of 8 cultivars of *Brassica* sp. were generally inhibitory to spore germination under other conditions remaining optimum (Table 3). Leaf extracts and exudates of both susceptible and resistant cultivars were inhibitory but inhibitory effects of resistant cultivars (Tower and RC-781) were more pronounced. However, leaf exudates from all the 8 cultivars were more inhibitory than exudates.

Optimum and cardinal temperature, humidity requirements of *A. brassicae* for conidial germination *in vitro* were normal and comparable to that of most other tropical necrotrophic leaf pathogens which show adaptation to high ambient humidity (80-95% RH) and moderate temperature (20-25°C) conditions. Intensity of disease development, under *in vitro* conditions also had similar optima. Period of leaf wetness was found to be critical in this respect. Strong light intensits had inhibitory effects on conidial germination and infection percentages but an indirect effect of light through desiccation due to heat can not be discounted. Darkness or low light intensity would favour infection and it is possible that infections in nature proceed under dark conditons. Gupta *et al.* (1972) had earlier shown that alternate periods of darkness and light favours conidial germination in *A. brassicae.* Inhibition effects of leaf exudates and extracts, particularly of the resistant cultivars, to conidial germination would suggest the possibility of presence of some principle(s) in *Brassica* sp. which might participate in natural defence. The principle(s) may be common and normal constituent of *Brassica* sp., concentrations and or reactions during interaction of which may differ in susceptible and resistant cultivars determining the differential response. Benyon and Brown (1969) had earlier shown the presence of antagonistic principle in the leaves of wallflower against *A. brassicae.*

Table 1 : Influence of temperature and leaf wetness on infection of *A. brassicae*

Temperature	*Disease intensity after hours of leaf wetness											
	4		8		12		16		20		24	
(°C)	No. of lesion/ leaf	Size (mm)	No. of lesion/ leaf	Size (mm)	No, of lesion/ leaf	Size (mm)	No. of lesion/ leaf	Size (mm)	No. of lesion/ leaf	Size (mm)	No. of lesion/ leaf	Size (mm)
15	0.1	0.1	0.3	0.2	0.5	0.6	0.6	0.5	0.7	0.7	0.7	0.7
20	0.9	1.0	1.2	1.4	1.6	1.7	1.5	1.9	1.6	1.6	1.7	1.5
25	3.6	5.0	4.2	8.1	6.0	13.9	6.8	14.3	7.0	14.6	7.4	15.2
30	0,2	1.5	0.4	1.3	0.8	1.9	0.6	1.5	0,7	1.7	0.8	1.6

*Average of 10 leaves

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Short Communications

10 Variability studies of some quantitative characters in sesamum

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The entire success of plant breeding programme in sesamum (*Sesamum indicum* L) or any other crop largely depends on the wide range of variability in that crop. Environment has a profound influence upon the economically important characters which are quantitatively inherited. Hence, it is difficult to decide upon whether the observed variability is heritable or due to environment. It is, therefore, necessary to partition the observed variability into its heritable and non-heritable components. Not much work has been done in respect of sesamum. Thus the present investigation was conducted to assess the genotypic variability in seed yield and quantitative components contributing to yield in sesamum so as to assist the plant breeder in forming a basis for selection.

Thirty one genotypes of sesamum belonging to different agro-climatic regions were grown in a randomised block design with four replications during the *kharif* season of 1974 at Regional Research Station, Dharwad. Each plot consisted of one row with 30 plants. The row to row and plant to plant spacing within a row were 30 cm and 15 cm respectively. Observations were recorded on ten random plants for plant height (cm), number of nodes on the main branch, number of capsules on the main branch, number of capsules on the other branches and seed yield per plant (g), in each replication. The main values of each line were subjected to statistical analysis. Genotypic coefficients of variation were estimated according to the method outlined by Burton (1952). The method suggested by Hansan *et al.* (1956) was used for estimating the heritability of different characters. Expected genetic advance was estimated as per the formula suggested by Lush (1949) and Johnson *et al.* (1955).

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The data revealed that the varietal differences for the six quantitative characters studied were highly significant.

The range, mean and SE values are furnished in Table 1. It is seen from the table that the range was wide for plant height, while limited range was noticed in respect of yield. It is also clear that the wide range in case of plant height is followed by the highest SE value and the limited range of yield by the least SE value. It is observed from Table 2 that the phenotypic and genotypic variances were also high for plant height and low for the seed yield/plant. It is also evident that the characters *viz.,* plant height, number of capsules on the main branch and number of nodes on the main branch were influenced by the environment to a very little extent as compared to other characters. The genotypic coefficients of variation, heritability (%) and genetic advance (expressed in per cent of mean) are presented in Table 3.

Number of branches and number of capsules on the main branch had high genotypic coefficients of variation. High heritability estimates were observed for plant height, number of capsules on the main branch and number of branches. Similar results have been reported in sesamum by Mohanty and Sinha (1965). The high heritability values for number of branches are also followed by high genetic advance. But in case of plant height, the expected genetic advance was not in proportion to the high heritability value observed. So it was evident that the higher estimates of heritability need not be associated

Table 1: Phenotypic variability in the six quantitative characters

Character	Range	Mean	SE(±)
Plant height (cm)	44.00—128.00	80.14	3.00
Number of branches	4.62— 27.45	14.67	1.60
Number of nodes on the main branch	5.17— 24.35	13.38	2.97
Number of capsules on the main branches	9.50— 17.90	13.30	0.93
Number of capsules on the other branches	1.70— 9.80	3.13	0.57
Seed yield per plant (gm)	0.25— 2.50	1.04	0.20

Table 2 : **Estimates of phenotypic, genotypic and error variances for the six quantitative characters**

Character	Phenotypic variance	Genotypic variance	Error variance
Plant height (cm)	492.56	483 62	9.06
Number of branches	30.97	28 38	2.59
Number of nodes on the main branch	22.93	14.06	8.87
Number of capsules on the main branch	2.73	1.86	0.86
Number of capsules on the other branches	2 42	2.08	0.33
Seed yield per plant (g)	0.15	0.10	0.04

Table 3: Estimates of genotypic coefficient of variation, heritability per cent and genetic advance for the six quantitative characters

Character	Genotypic coefficient of variation	Heritability per cent	Genetic advance in per cent of mean
Plant height (cm)	27.49	98.19	55.99
Number of branches	46.00	85.95	88.18
Number of nodes on the main branch	10.22	68.13	17.44
Number of capsules on the main branch	35.58	91.63	71.64
Number of capsules on the other branches	27.95	61.31	45.22
Seed yield per plant (g)	30.77	66.67	71.62

with higher values of genetic advance. This was in conformity with the finding of Johnson *et al.* (1955). In the present study, the heritability estimate for seed yield per plant was found to be low Low heritability estimates for yield have also been reported in other crops e. g. sorghum (Swarup and Chaugle, 1962), rice (Panwar and Gupta, 1967) and groundnut (Dixit *et al.* 1970). Thus the present study revealed that there is a lot of scope for improvement of some economic traits like number of capsules on the main branch and number of branches.

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Table 2 : **Influence** of light intensity on *A. brassicae* **infection.**

Light intensity	Disease intensity* Per cent spore germination after 24 h	No. of lesions/ leaf	Size of lesions/leaf (in mm)
0 lux	78	7.0	19.40
1000 lux	63	6.2	15.50
2000 lux	60	5.9	13.80
5000 lux	49	3.8	8.20

* Average of 20 leaves

Table 3: **Effect** of leaf exudates and leaf extracts from different **cultivars of** rapeseed and mustard on spore germination of *A. brassicae.*

Cultivars	% spore germination after 24 hours of incubation* Leaf exudates	Leaf extracts
Tower	40	26
RC—781	49	29
YRT—3	66	47
CSR—448	61	44
CSR—741	58	45
CSR—142	62	46
RH—30	71	49
Prakash		
Control (water)	88	91

*** Average of 200 spores incubated at 25°C.**

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Effect of *Azotobacter* and *Azospirillum* on performance of *Sesamum indicum*

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The nitrogen fixing potential of the associative symbiont, *Azotobacter* sp. and *Azospirillum* sp. in cereal crops and grasses has been well studied by several workers. But the information on the effect of inoculation of *Azospirillum* sp. and *Azotobacter* sp. on the yield of oil seed crops (Ankineedu *et al.*, 1983) especially like sesamum is almost meagre. Oblisami *et al.* (1976) reported upto 8 per cent increase in yield of sunflower by *Azotobacter* treatment in combination with 45 kg N/ha. The increase in cotton seed by the use of *Azotobacter* was noticed by Chowdappan *et al.* (1977). Konde *et al.* (1978) reported that azotobacterisation had a favourable effect on the yield of sunflower. Thangaraju *et al.* (1982) studied the response of sesamum to *Azospirillum* inoculation under different moisture regimes. With this object in view, field studies were taken up to study the effect of *Azotobacter* and *Azospirillum* on the performance of *Sesamum indicum* L. especially in increasing its yield potential as well as saving in its nutrient requirement.

Field experiments were conducted at the Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore, during 1980 to 1982 with the following treatment combinations, to study the effect of growth regulators and bacterial cultures on the performance of sesame variety Co. 1.

T_1 = Control (30 kg N/ha + 20 kg P_2O_5/ha)

T_2 = Control + NAA @ 10 ppm at flower initiation stage

T_3 = Control + Cytozyme @ 100 ppm at ,, ,, ,,

T_4 = Control + Cycocal 80 ml/ha at ,, ,, ,,

T_5 = Control + *Azotobacter* 600 g/ha

T_6 = Control + *Azospirillum* 600 g/ha

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T_7 = 15 kg N/ha + 20 kg P_2O_5/ha + *Azotobacter* 600 g/ha

T_8 = 15 kg N/ha + 20 kg P_2O_5/ha + *Azospirillum* 600 g/ha

Five field experiments were conducted in all during the monsoon and summer seasons with Co. 1 as test crop.

Biometric observations such as number of capsules end branches per plant and plant height were recorded. The differences observed for number of capsules and branches per plant and plant height were not statistically significant. However, number of branches per plant and plant height in the treatments, *Azotobacter* and *Azospirillum* at 15 kg N + 20 kg P_2O_5 per hectare were the highest *viz.* 11.5, 11.7 and 104 cm, 105 cm in kharif 1982 and 17, 18 and 127 cm, 128 cm in summer 1982 respectively. Reddy (1981) reported that the treatments *Azotcbacter, Azospirillum* and the combination of both (*Azotobacter* and *Azospirillum*) significantly increased the plant height, number tillers etc. in pearl millet.

The statistical analysis of yield data Table 1) revealed that the treatments 30 kg N+ 20 kg P_2O_5 + *Azotcbacter* 600 g per hectare recorded 25 to 45 per cent increased seed yield over control. The same trend was noticed in case of shoot yield also. The economics of treatmental influence revealed that the treatment 15 kg N+ 20 P_2O_5 plus *Azospirillum* 600 g per hectare has given the highest income over control in both rainfed and summer seasons during 1980—81 and 1981—82 (Table 3). It confirms the results reported by Subba Rao (1981) that *Azosopirillum* inoculation to sorghum variety CSH 5 found to increase crop yield at Coimbatore and Udaipur (36.6 per cent and 22.6 per cent increase respectively) over corresponding control. Similarly, Thangaraju (1982) found that the response of sesamum to *Azospirillum* inoculation was more pronounced in rainfed rather than under irrigated condition and the seed yields were increased from 9.9 to 91.6 per cent in irrigated and from 15 1 to 157.7 per cent in rainfed conditions over the corresponding control. Purushothman *et al.* (1979) reported that with 75 per cent of fertilizer nitrogen and *Azospirillum* incoculation on pearl millet (variety Co, 6) recorded 7968 kg/ha of grain yield while with 100 per cent fertilizer nitrogen, the yield was only 6586 kg/ha. Purushothaman and Gunasekaran (1980) reported significant increase of grain and straw yield of pearl millet due to *Azospirillum* inoculation.

With regard to oil content there was not much variation due to treatment difference (49.0 to 50.0 per cent).

During the rainfed season of 1980, the treatment, control plus cytozyme @ 100 ppm recorded the maximum uptake of nitrogen, phosphorus and potash in

Table 1: The seed and shoot yield of Co. 1 sesamum during the year 1980—1982

Treatment particulars	Yield (kg/ha) 1980		Yield kg/ha (1981)				Yield during 1982 in kg/ha			
	Rainfed		Summer		Rainfed		Summer		Rainfed	
	Seed	Shoot	Seed	Shoot	Seed	Shoot	Seed	Shoot	Seed	Shoot
1. Control (N+P) fertiliser	272	612	502	1506	119	1543	114	1220	139	1477
2. Control+NAA 10 ppm at flower initiation	258	561	504	1512	130	1660	238	1100	169	1111
3. Control+ cytozyme 100 ppm at flower initiation	313	705	556	1668	142	1720	288	1340	174	1344
4. Control+ cycocel 80 ml/ha at flower initiation	309	695	524	1572	151	1528	270	1425	172	1455
5. Control+ *Azotobacter* 600 g/ha	336	756	679	2037	151	1835	288	1330	196	1366
6. Control+ *Azospirillum* 600 g/ha	347	781	665	1995	159	1786	300	1640	192	1744
7. 50% N+full P+*Azotobacter* 600 g per ha	218	491	628	1884	174	2407	291	1650	186	1455
8. 50% N+ full P+*Azospirillum* 600 g/ha	335	755	677	2031	182	2277	326	1722	219	1355
C. D.	132.9	332.5	15.74	83.97	NS	NS	NS	NS	NS	0.2707

NS = Non Significant

Table 2 : Uptake of N, P and K nutrients in Co. 1 variety

Treatment particulars	Rainfed 1980 uptake in kg/ha			Summer 1981 uptake in kg/ha		
	N	P	K	N	P	K
1. Control (N+P fertilizers)	7.5	3.0	2.1	10.34	11.30	18.07
2. Control + NAA 10 ppm at flower initiation	7.2	3.3	1.9	8.32	5.85	24.17
3. Control+Cytozyme 100 ppm at flower initiation	10.3	4.1	3.2	15.18	8.34	18.85
4. Control+Cycocel 80 ml/ha at flower initiation	6.2	4.1	1.6	16.51	10.48	19.65
5. Control+*Azotobacter* 600 g/ha	7.9	4.1	2.2	18.33	12.77	31.57
6. Control+*Azospirillum* at 600 g/ha	8.6	3.6	2.1	19.35	10.57	29.53
7. 50% N+full P+*Azotobacter* 600 g/ha	6.5	3.5	1.5	16.96	8.85	20.72
8. 50% N+Full P+*Azospirillum* 600 g/ha	6.8	3.5	1.8	22.75	11.24	27.42
C. D.	0.97	0.79	0.42	—	—	—

Table 2 : (Contd)

Rainfed 1981 uptake in kg/ha			Summer 1982 uptake in kg/ha			Rainfed 1982 uptake in kg/ha		
N	P	K	N	P	K	N	P	K
2.62	1.31	0.86	4.62	2.25	1.58	2.57	1.36	0.83
2.72	1.56	0.87	4.74	2.48	2.61	3.47	1.41	1.77
4.54	1.99	1.25	8.61	4.30	3.96	3.99	1.52	2.17
2.88	2.12	1.06	4.91	3.78	3.65	3.41	1.17	2.33
3 79	1.97	1.09	7.11	3.44	3.44	4.41	1.43	2.35
3 50	1.91	1.12	6.45	3.00	3.84	4.12	1.11	2.26
4.88	2.27	1.36	8.41	4.06	3.49	4.72	1.13	2.40
4.19	2.19	1.26	7.34	3.26	3.75	5.13	2.14	2.58

Table 3 : Economics of treatment influence on sesamum

Treatment particulars	1980 Rainfed		1981 Summer	
	%Increase in yield over control	Income from the treatment over control Rs.	%Increase in yield over control	Income from the treatment over control Rs.
1. Control (N+P fertilisers)	—	—	—	—
2. Control+NAA 10 ppm	—5.15	—402	0.40	—325
3. Control+Cyto-zymo 100 ppm	15.07	—177	10.76	—133
4. Control+cycocel 80 ml/ha	13.24	—192	4.38	—234
5. Control+*Azospi-rillum* 600 g/ha	23.53	186	35.26	525
6. Control *Azospi-rillum* 600 g/ha	27.57	219	32.47	483
7. 50% N+full P+ *Azospirillum* 600 **g/ha**	91.56	138	25.10	438
8. 50% N+full P+ *Azospirillum* 600 **g/ha**	23.16	249	34.86	585

Table 3. (Cond.)

1981 Rainfed		1982 Summer		1982 Rainfed	
%increase in yield over control	Income from the treatment over control Rs.	%increase in yield over control	Income from the treatment over control Rs.	%increase in yield over control	Income from the treatment over control Rs.
—	—	—	—	—	—
9.2	—327	5.78	—301.50	21.58	—225.00
19.3	—231	28.00	— 16.50	25.18	—142.50
26.9	—204	20.00	— 97.50	25.50	—138.00
26.9	90	28.00	277.50	41.00	250.50
33.6	114	33.33	381.50	38.13	232.50
46.2	225	29.33	357.00	35.25	280.50
52.9	249	44.89	514.50	57.55	420.00

sesame. But in the year 1981 (rainfed season) the treatment 15 kg N plus 20 kg P plus *Azotobacter* 600 g/ha give the maximum uptake of N, P and K followed by the treatment control plus cytozyme (100 ppm) and 15 kg N plus 20 kg P plus *Azospirillum* 600 g/ha. In the year 1982 also (rainfed season) the treatment 15 kg N plus 20 kg P_2O_5 plus *Azospirillum* 600 g/ ha gave the maximum uptake of nutrients (N, P and K). In summer seasons of 1981 and 1982 the treatment 15 kg N plus 20 kg P plus *Azospirillum* 600 g/ha and control plus Cytozyme @ 100 ppm gave the maximum uptake of nutrients respectively (table 2).

In general, it is seen that the *Azospirillum* with 50 per cent N and full P_2O_5 contributed to maximum uptake of major nutrients in summer seasons and it followed the treatment control plus cytozyme @ 100 ppm in rainfed seasons of 1981-82. Pal and Malik (1981) conducted field experiments with sorghum CSH-5 and found that *Azospirillum* sp. contributed to the nitrogen uptake by crop in the range from 5.8 to 19.6 kg/ha. The results of high uptake values indicated a high N utilisation applied through *Azospirillum* sp. and in turn P and K. In the case of cytozyme treatment, cytozyme being a chemical containig some biochemical enzyme which enhanced the utilisation of applied nitrogen and in turn phosphorus and potash.

It is concluded that field experiments conducted during 1980—81 in both rainfed and summer seasons to study the effect of growth regulators and bacterial cultures like *Azotobacter* and *Azospirillum* on the performance of sesamum (variety Co. 1) revealed that 15 kg N plus 50 kg P_2O_5 plus 600 g *Azospirillum* per hectare gave an increased yield of 23 to 35 per cent and an additional profit of Rs. 249.00 to 585.00 per hectare over control. The uptake value of N, P and K in seeds of sesamum revealed that in general both cytozyme @ 100 ppm and 15 kg N plus 20 kg P_2O_5 plus 600 g *Azospirillum* per hectare contributed the high uptake of nutrients.

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A note on double cropping studies with kharif oilseed crops

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Groundnut is the major oilseed crop grown during *Kharif* under assured rainfall tract of Dharwad. Others are soybean, niger, sesamum, sunflower and castor. Except castor other oil seed crops are of short duration enabling to grow subsequent *rabi* crops like safflower, bengal gram, wheat and jowar. Therefore, a field experiment was conducted to compare the performance of various double cropping sequences under transition tract of Dharwad. The experiment was laid out in randomised block design in medium black clay loam soil at Regional Research Station, Dharwad from 1977-78 to 1979-80. There were nine double cropping sequences (Table 1). Recommended package of practices were adopted for all the crops. Gross income was computed based on prevailing market prices of different produces.

The results are furnished in table 1. Groundnut-jowar sequence gave the highest yields (3514 and 1567 kg/ha) followed by groundnut-bengal gram sequence (3803 and 832 kg/ha). Niger-jowar sequence gave the lowest yields (433 and 347 kg/ha). Among all the crop sequences tried, performance of *rabi* jowar after *kharif* niger was very poor compared to its performance after groundnut. Decreased yields of barley were also noticed after *kharif* sesamum by Warsi *et al.* (1980). The maximum net profit (Rs. 6921.40/ha) was obtained by groundnut-safflower sequence but resulted in lower net return per rupee spent (Rs. 1.37). However, the maximum net return per rupee spent was obtained by sesamum- safflower sequence (Rs. 2.95). Sole crop of castor recorded higher net profit compared to niger-jowar sequence. It is concluded that the groundnut-safflower or groundnut- bengal gram sequences proved to be the most remunerative under assured rainfall tract of Dharwad.

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Table 1: Yield and economics of different cropping sequences (average of 1977—78, 1978—79 and 1979—80)

Treatments	Yield of *kharif* oilseed crop & rabi crop (kg/ha)	Total gross income (Rs/ha)	Total net profit.	Net return/rupee spent.
1. Groundnut in *khrif* + safflower in *rabi*	3638 799	11971.40	6921.40	1.37
2. Groundnut in *kharif* + Rabi jowar in *rabi*	3514 1567	11135.50	6185 50	1.25
3. Groundnut in *kharif* + Bengalgram in *rabi*	3800 832	11330.40	6380.40	1.29
4. Groundnut in *kharif* + wheat in *rabi*	3619 834	10465.30	5515.30	1.11
5. Castor	1731	3462.00	2325.00	2.04
6. Soybean in *kharif* + safflower in *rabi*	1256 794	5998.40	1998.40	0.50
7. Sesamum in *kharif* + safflower in *rabi*	746 951	7899.60	5899.60	2.95
8. Sunflower in *kharif* + wheat in *rabi*	2103 851	5021.80	3121.80	1.64
9. Niger in *kharif* + Rabi jowar in *rabi*	433 347	2252.53	352.50	0.19

Market rates adopted	Rs/ kg	Market rates adopted	Rs/kg
Groundnut	2.50	Niger	4.00
Castor	2.00	Wheat	1.70
Sunflower	1.70	Bengalgram	2.20
Sesamum	6.00	Safflower	3.60
Soybean	2.50	Rabi jowar	1.50

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13 CGS. 101 - an insect resistant groundnut culture

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Reports on insect resistant groundnut cultivars are rare from India although quite a few have appeared from U.S.A. (Young *et al.*, 1972; Campbell *et al.*, 1975; Johnson *et al.*, 1977; Wynne *et al.*, 1977; Campbell and Wynne, 1980). A natural insect resistant variant, possibly of mutant origin, was isolated at the Project Coordinating Unit (Groundnut) of the All India Coordinated Research Project on Oilseeds at the Panjabrao Krishi Vidyapeeth, Akola. This report briefly describes the characters of this cultivar.

During *Kharif*, 1980 a variant was observed in GO 343, a Spanish Bunch culture, grown in the germplasm bank. The variant was entirely different from the rest of the plants by possessing thick and leathery leaflets. The foliage gave waxy coated greyish look. The plant had four primary branches similar to GO 343; but it differed very much from GO 343 in pod characters. The variant possessed long and slender pods bearing 3—4 kernels compared with 2-seeded medium size pods in GO 343. In the testa colour also the variant differed from the parent culture. While GO 343 had rose testa, the variant possessed purple testa.

There was a heavy attack of jassids (*Empoaca* sp.) on the entire groundnut crop, including the germplasm lines, during *Kharif* 1980. All the germplasm cultures showed varying degree of hopper burn, while the variant did not show any symptom of damage. The variant was harvested separately and multiplied under the culture No. CGS 101.

CGS 101 was entered during *Kharif*, 1982 in the trial on "Advanced screening of promising varieties against pests" under the All India Coordianated Research Project on Oilseeds. At Jalgaon centre the material was screened against leaf-miner (*Aproaerema modicella* Deventer). CGS 101, and two other ICRISAT groundnut cultures *viz.*, ICG 5037 (Nc Ac 2154) and ICG 8109 (Nc Ac 17011), showed least damage due to this pest. These cultures showed 82 to

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93 per cent less infestation to leaf-miner as compared with the check, "Phule Pragati" (Anonymous, 1983). CGS 101 holds good promise for leaf-miner resistance also in addition to jassids, both of which are major pests of groundnut in India.

Thickness of the leaf-let in CGS 101 was compared with the popularly grown Spanish *Bunch* groundnut varieties of Maharashtra State *viz.*, Phule Pragati (JL 24), SB XI and AK 12-24. For this purpose, leaf-lets from the top pair of the third leaf on the main axis were sampled. In each replication four such leaf-lets were used for measuring thickness. The thickness of leaf was measured under microscope with the help of ocular micrometer by taking the T. S. of leaf and measuring the thickness of lamina excluding the mid-rib. The mean values (in microns) are presented in Table 1. From this data it can be seen that the thickness of leaf-let in CGS 101 which was 363.1 μ was significantly greater than the leaf-let thickness in the varieties, Phule Pragati (302.9 μ), SB XI (274.5 μ) and AK 12-24 (312.2 μ).

Further studies are under progress to confirm the resistance of CGS 101 to the pest complex occurring on groundnut.

Table 1 : Thickness of leaf-let in microns (μ) in CGS 101 and 3 other varieties

Culture/variety	Mean leaf-let thickness (μ)	% thickness of CGS 101 over others
CGS 101	363.1	—
JL 24 (Phule Pragati)	302.9	16.60
SB XI	274.5	24.39
AK 12-24	312.2	14.01
G. M.	313.17	
S. Em.	7.99	
C. D. (1%)	33.28	
C. V. %	6.24	

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Association of some morphological determinants with seed yield in toria

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Yield is a complex character and dependent on a number of component traits. Keeping this in view the present study was undertaken to know the association of seed yield with its contributing characters in toria *Brassica campestris* L. var. *toria*). The experimental material of 20 genotypes of *toria* were grown in a randomized block design consisting of three replications at the research farm of Haryana Agricultural University, Hissar during *rabi* 1979—80. Each genotype was represented by 10 rows plot of 6 meter length with a spacing of 30 × 15 cm between and within rows respectively. Ten plants were selected in each replication and data on different quantitative traits e.g. seed yield, primary branches, secondary branches, days to flowering, days to maturity, plant height, 1000 seed weight, total siliquae, seeds per siliqua, siliqua length and oil content were measured. Oil content was estimated with the help of NMR. The data recorded for these triats were subjected to analysis for correlation and path coefficient as per Aljibouri *et al.* (1958) and Dewey and Lu (1959) respectively.

The analysis of variance revealed highly significant differences among genotypes for yield and its component traits. The magnitude of genotypic correlation coefficients were found to be higher than their corresponding phenotypic correlation coefficients for most of the characters (table 1). The higher genotypic correlation coefficient forms a sound base for their practical implication. These results were in confirmation with those of Gupta (1972) in *Brassica juncea*. Seed yield was observed to have a positive and significant correlation with primary branches. Similar relationship has been reported by Singh *et al.* (1969) and Gupta (1972) in *Brassica juncea*. Further seed yield was positively

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Table 1 : Genotypic (above diagonal) and phenotypic (below diagonal) correlations between seed yield and its components and oil content in *toria*

Characters	Seed yield	Primary branches	Secondary branches	Days to 1st flowering	Days to 50 per cent flowering
Seed yield	—	0.48	0.17	0.56	0.52
Primary branches	0.45*	—	0.34	0.62	0.57
Secondary branches	0.17	0.33	—	0.27	0.26
Days to Ist flowering	0.49*	0.56*	0.24	—	0.99
Days to 50 per-cent flowering	0.46*	0.52*	0.22	0.97*	
Days to maturity	0.45*	0.41	0.32	0.70*	0.68*
Plant height	0.51*	0.30	—0.07	0.58*	0.54*
1000 seed weight	0.13	—0.13	0.00	0.13	0.11
Total siliquae	0.38	0.51*	0.42	0.54*	0.53*
Siliqua length	0.37	0.05	0.05	0.23	0.21
Seeds per siliqua	0.18	0.53*	0.32	0.35	0.33
Oil content	0.37	0.33	0.26	0.44	0.46*

* Significant at P=0.05

Table 1. : (Cond.)

Days to maturity	Plant height	1000 seed weight	Total siliquae	Siliqua length	Seeds for siliqua	'Oil content
0.48	0.53	0.16	0.39	0.39	0.20	0.67
0.47	0.32	—0.13	0.54	0.05	0.64	0.60
0.33	—0.05	0.02	0.43	0.04	0.38	0.45
0.81	0.60	0.18	0.59	0.26	0.48	0.96
0.81	0.57	0.19	0.59	0.25	0.46	0.92
—	0.49	0.15	0.31	0.56	0.30	0.90
0.44	—	0.32	0.29	0.43	0.42	0.28
0.14	0.29	—	0.41	0.13	0.00	—0.18
0.28	0.28	0.37	0.11	—0.11	0.41	0.18
0.52*	0.39	0.14	—0.11	—	0.20	0.64
0.26	0.36	—0.03	0.37	0.18	—	0.35
0.43	0.13	—0.07	0.15	0.28	0.26	—

Table 2 : Direct (diagonal) and indirect (off diagonal) influence of different yield components and oil content at genotypic level on seed yield in *toria*

Characters	Primary branches	Secondary branches	Days to Ist flowering	Days to 50 per cent flowering	Days to maturity
Primary branches	0.39*	0.12	0.52	0.12	—0.56
Secondary branches	0.13	0.35*	0.23	0.06	—0.41
Days to Ist flowering	0.24	0.10	0.84*	0.21	—1.00
Days to 50 per cent flowering	0.22	0.09	0.82	0.21*	—1.00
Days to maturity	0.17	0.02	0.11	0.12	0.22*
Plant height	0.12	—0.02	0.51	—0.12	—0.61
1000 seed weight	—0.05	0.01	0.15	0.04	—0.19
Total siliquae	0.21	0.15	0.49	0.13	—0.39
Siliqua length	0 02	0.01	0.22	0.05	—0.69
Seeds per siliqua	0.25	0.13	0.41	0.10	—0.37
Oil content	0.23	0.16	0.80	0.20	—1.12

Residual effect = 0.273

Table 2 : (Contd.)

Plant height	1000 seed weight	Total siliquae	Siliqua length	Seeds per siliqua	Oil content	Genotypic correlation with seed yield
0.10	0.07	0.02	0.04	—0.41	0.07	0.48
—0.02	0.00	0.02	0.03	—0.24	0.02	0.17
0.20	0.00	0.03	0.20	—0.31	0.05	0.56
0.19	0.00	0.03	0.19	—0.29	0.05	0.52
0.19	—0.10	0.11	0.02	—0.19	0.05	0.48
0.33*	0.00	0.01	0.32	—0.27	0.02	0.53
0.10	—0.01*	0.02	0.10	0.00	—0.01	0.16
0.10	0.00	0.04*	—0.08	—0.27	0.01	0.39
0.14	0.00	—0.01	0.75*	—0.13	0.03	0.39
0.14	0.00	0.02	0.15	—0.65*	0.02	0.20
0.09	0.00	0.01	0.48	—0.23	0.05*	0.67

and significantly associated with days to flowering (i. e., days to 1st flowering and 50 per cent flowering), days to maturity and plant height confirming the results of Singh *et al.* (1969) and Yadava (1973) in Indian mustard.

Some of the component characters also showed positive and significant correlation among themselves. In the present study primary branches exhibited significant positive association with days to 1st flowerig, days to 50 per cent flowering, total siliquae and seeds per siliqua supporting the results of Singh *et al.* (1969) in *Brassica juncea*; *Banerjee et al.* (1969) in yellow *sarson*; Singh and Singh (1974) in brown *sarscn*. Days to flowering (1st flowering, 50 per cent flowering) were significantly correlated with days to maturity, plant height and total siliquae (Singh *et al.* 1969; Gupta 1972 in *Brassica juncea*). Days to maturity was positively and significantly correlated with siliqua length.

The genotypic correlations were partitioned into direct effect of each component and its indirect contribution through other yield components (Table 2). The results indicated that all the characters except 1000 seed weight and seeds per siliqua had positive direct effect on seed yield. Days to first flowering possessed high positive association with seed yield, whereas, path coefficient analysis also revealed its importance as it recorded highest direct effect. Also, the plant height, primary branches, secondary branches, days to 50 per cent flowering, days to maturity and siliqua length had high positive direct effect. Likewise, Chauhan and Singh (1977), Labana *et al.* (1977) and Singh *et al.* (1975) reported secondary branches as an important character whereas Kumar and Yadava (1979) emphasized plant height as an important yield determinent. The two components traits, namely, 1000 seed weight and seeds per siliqua were observed to exhibit the positive association with seed yield but on the contrary, path coefficient analysis revealed them to be unimportant as they exhibited negative direct effect on seed yield. These results were not in accordance to Tak (1976); Shivahara *et al.* (1977); and Kumar and Yadava (1979) as they observed positive and appreciably high positive direct effect of 1000 seed weight and seeds per siliqua on seed yield. The low residual effect factor (i.e., 0.273) indicated that the component characters under study were responsible for 73 per cent of variability in the seed yield. Further, regarding indirect effect, it was observed that days to first flowering was the most important character because it added positively to seed yield through all the characters whereas days to maturity, 1000 seed weight and seeds per siliqua had negative indirect influence on seed yield through most of the characters. It was also observed that those traits which had high direct influence on seed yield also affected indirectly via other component characters. The positive association of 100 seed weight with seed yield was masked by its own direct and indirect effects mainly through days to maturity and primary branches. Similarly, the strong negative direct influence of seeds per siliqua on seed yield was counter balanced by very high positive influence observed indirectly through all the characters under study except for days to maturity and 1000 seed weight. Further, a situation also arose, such as in case of total siliquae and oil content, where the high correlation values were associated with very low direct effects. In both these characters seed yield was affected because of high negative indirect influence through days to maturity and seeds per siliqua.

The results of present study indicated that most important factors responsible for seed yield were primary branches, days to flowering, maturity and plant height which could reliably be used as a selection criterion for a better plant type of *toria*.

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Germination of raya under salt stress soil conditions

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Rapeseed and mustard occupy prominent place being next in importance to groundnut both in area and production meeting the fat requirements of about 50% population in North, Central and Eastern India. Low production of oil seed crop plants resulted in the import of 1.041 million tonnes of edible oils costing 5334 million rupees in 1978-79 to meet the internal demands of the country (Swaminathan, 1980). Increased production may be achieved by increasing the acreage of the crop or by increasing the yield per unit area. Salt affected lands of the Indo-Gangetic planes which is estimated to be about 3.5 million hectares may be brought under raya cultivation after reclamation as raya has been found to be more tolerant than other oil yielding plants in *rabi* (Singh *et al.*, 1974). Plant stand is a limiting factor in salt affected soil. Therefore, germination of a variety is of prime importance in such soil conditions. In order to know the germination behaviour of some raya (*Brassica juncea* Linn) varieties under different levels of saline and sodic conditions, the present experiment was carried out.

Six genetically improved cultivars (Prakash, Pusa bold, Varuna, RH 7811, T M 7 and TM 12) of raya were sown in soils of different grades of sodicity (pH2 9.0, 9.2 and 9.6) and salinity (ECe 5, 10 and 15 mmhos/cm) against normal soil ($pH_2$8.0, ECe 2.4 mmhos/cm). Sodicity levels were created artificially by adding differential quantities of $NaHCO_3$ in normal soil. Saline soil was prepared by saturating normal soil with salt solutions of different concentrations containing NaCl: $CaCl_2$:Na_2SO_4 in the ratio of 7:2:1. One hundred fully matured and healthy seeds were sown on November 25, 1983, in each pot containing 20 kg graded soils. Each treatment was replicated four times. Pots were covered with rice straw to maintain the soil moisture at field moisture capacity level. Visual observations on germination initiation and 50 per cent germination over all varieties were taken. Germination of different varieties under various levels of soil stress were recorded at the end of 10 and 20 days period. Average germination per cent for each variety under different soil stress was calculated and presented in the tables. From the germination data,

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per cent reduction in stress over normal was calculated and presented in tables in parenthesis. Per cent Germination data of different varieties under stress were statistically analysed.

Germination was recorded as emergence of cotyledons out of soil. Five days after sowing germination was initiated in normal and in soil of pH_2 9.0 while it took six days in soil of pH_2 9.2. Germination was started eight days after sowing in soil of pH_2 9.6. Singh *et al.* (1979) reported delayed germination with increase in ESP levels. Similar results were also observed in the present study. Germination was initiated 8, 11 and 15 days after sowing in soils of ECe 5, 10 and 15 mmhos/cm respectively. Therefore, it is seen that germination initiation was delayed both in sodic and saline soil conditions but more in saline condition than in sodic condition.

Visual observations indicated that 50 per cent germination took place 7, 8 and 11 days after sowing in normal, $pH_2$9.0 and $pH_2$9.2, respectively. Germination could not attain 50 per cent level within 20 days time in soils of pH_2 9.6. In saline soils of ECe 5 mmhos/cm, varieties could attain 50 per cent germination in sixteen days after sowing. However, no varieties could attain 50 per cent germination in other soil salinity levels. This indicates decrease in the rate of germination with increase in sodicity and salinity and the rate slowed down more in saline than in sodic media.

Germination of seeds for each soil level and for each variety and their percentage of reduction in stress over normal at 10 days and 20 days after sowing are presented in Table 1 and 2, respectively. In case of sodic soils ten days after sowing (Table 1), germination percentage decreased with the increase of sodicity level in all varieties except in Prakash and Varuna at pH_2 9.2. Pusa bold at pH_2 9.0 showed increased germination per cent over normal. The percentage of reduction in stress over normal showed increase with the increase of sodicity level with the exception of Prakash, Pusa bold and Varuna which showed different trend in germination percentage. All the varieties showed higher percentage of germination in all sodicity levels after 20 days as compared to 10 days after sowing (Table 2). Further, all the varieties showed reduced germination percentage over normal in all sodicity levels and the percentage of reduction was increased with the increase of sodicity levels. It is further seen that with the exception of TM 7 all the varieties showed less than 50 per cent reduction in germination over normal at soil of $pH_2$9.2. Pusa bold is least affected (26.6%) at this level of sodicity (pH_2 9.2).

The mustard varieties in different salinity levels after 10 days of sowing (Table 1) showed very poor germination and very high per cent reduction of

Table 1 : Average seed germination per cent and the per cent reduction in stress over normal (in parenthesis) after 10 days of sowing under different soil stress conditions.

Varieties	Per cent germination						
	Sodicity (pH_2)			Normal	Salinity (ECe mmhos/cm)		
	9.0	9.2	9.6		5	10	15
Prakash	41.5	53.8	2.0	74.0	—	—	—
	(43.9)	(27.4)	(97.3)		(100.0)	(100.0)	(100.0)
Pusa bold	66.5	59.8	13.8	62.0	0.3	—	—
	(7.3)	(3.6)	(77.8)		(99.6)	(100.0)	(100.0)
Varuna	31.3	33.8	24.3	68.3	1.3	—	—
	(54.2)	(50.6)	(64.5)		(98.2)	(100.0)	(100.0)
RH 7811	75.8	52.5	5.8	89.0	6.5	—	—
	(14.9)	(41.0)	(93.5)		(92.7)	(100.0)	(100.0)
TM 7	56.8	11.8	—	72.0	0.5	—	—
	(21.2)	(83.7)	(100.0)		(99.3)	(100.0)	(100.0)
TM 12	62.3	24.3	5.3	77.3	2.3	—	—
	(19.4)	(68.6)	(93.2)		(97.1)	(100.0)	(100.0)

Table 2 : Average seed germination per cent and the per cent reduction in stress over normal (in parenthesis) after 20 days of sowing under different soil stress conditions

Varieties	Per cent Germination						
	Sodicity (pH_2)			Normal	Salinity (ECe mmhos/cm)		
	9.0	9.2	9.6		5	10	15
Prakash	66.5 (18.4)	56.3 (31.0)	19.0 (76.7)	**81.5**	64.0 (21.5)	26.0 (68.1)	1.8 (97.0)
Pusa bold	71.0 (16.0)	62.0 (26.6)	36.0 (57.4)	**84.5**	79.0 (6.5)	19.0 (77.5)	2.0 (97.6)
Varuna	73.3 (18.4)	53.5 (40.4)	42.0 (53.2)	**89.8**	71.3 (20.6)	35.3 (60.7)	3.5 (96.1)
RH 7811	81.0 (15.8)	64.5 (33.0)	26.5 (72.5)	**96.3**	70.3 (27.0)	38.5 (60.0)	2.0 (97.9)
TM 7	71.0 (20.7)	36.8 (58.9)	24.8 (72.4)	**89.5**	68.5 (23.5)	32.3 (64.0)	3.5 (96.1)
TM 12	76.0 (11.6)	45.0 (47.7)	21.5 (75.0)	**86.0**	44.8 (48.0)	26.0 (69.8)	15.5 (82.0)

C. D. (5%) variety = 4.89; C. D. (5%) level = 5.29; C. D. (5%) N x L = 12.93

germination at 5 ECe and also showed no germination at all in 10 and 15 ECe soil. However, after 20 days of sowing (Table 2) germination percentages were increased in comparison to 10 days after sowing but the germination per cent was reduced and the per cent reduction in stress over normal were increased with the increase of salinity levels. Reduced and delayed germination under saline environmental conditions were also reported by Rai (1977) and Paliwal and Maliwal (1982). All the varieties showed less than 50 per cent reduction over normal in 5 ECe and more than 50 per cent reduction was noted in 10 and 15 ECe. Pusa bold was least affected in 5 ECe. Further, it is seen that the salinity affected more than the soil sodicity at the germination stage.

Germination percentage of the varieties after 20 days of sowing was statistically analysed taking the different sodicity and salinity levels alongwith normal soil as main treatments. The analysis showed significant differences *amongst the varieties, levels and variety x level interaction.*

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Intercropping sorghum with groundnut under rainfed conditions

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Sorghum *(Sorghum bicolor* L.) is mostly grown under rainfed conditions. With the introduction of high yielding short duration varieties of sorghum and oilseeds with different types of canopy architecture, it is now possible to design suitable intercropping systems. Keeping this in view and since no precise information is available on suitable associate crops for different planting patterns in rainfed cropping of sorghum for assessing total grain production and economical returns per unit area, the studies were carried out on the planting pattern and intercropping sorghum with groundnut (*Arachis hypogaea* L.) under rainfed conditions on medium black soils in the Oilseeds Research Farm, Jalgaon during *Kharif* 1979 to 1981.

The experiment was conducted in a randomised block design with three replications on medium black soil. Nine treatment combinations comprising of three planting patterns *viz.*, normal (45 x 15 cm), paired row (30-60 x 15 cm) and skip row after every two rows (45-90 x 10 cm) of sorghum with three cropping systems *viz.* one row of groundnut, two rows of groundnut and entire sorghum, were adopted. The intercrop as well as sorghum were sown at optimum moisture condition simultaneously on June 28, June 19, and July 1, during 1979, 1980 and 1981 respectively. The crops were sown by hand dibbling so as to obtain equal population in all the treatments. A recommended doses of NPK (75:62:62 kg/ha) were applied to sorghum while fertilizers were applied at the rate of 20 kg N+40 kg P_2O_5/ha to groundnut on area basis at seeding only. An additional rows of intercrop were accomodated by changing crop geometry by keeping the plant population of sorghum constant in all the planting patterns. A sorghum variety CSH 5 and Phule pragati (JL 24) a bunch groundnut variety were used in the experiment. Total rainfall received during the period, 1979, 1980 and 1981 from sowing to harvesting of the crop were 742.5 mm, 550 mm and 764 mm respectively. It was good enough to support all *Kharif* crops during rainy months in all the years. The yields from net plots of 5.40 x 5.10 m were recorded.

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Grain yields : There were significant differences among the various treatments during first two years and also on pooling the data for over three seasons (Table 1). Among the planting patterns tried, sorghum yield was either at par with or slightly superior to that of a normal planting pattern. It was slightly improved when sorghum was planted in paired rows or one row skipped planting pattern. Intercropping of groundnut did not affect the grain yield of sorghum significantly. However, the sorghum yields were slightly reduced when groundnut was intercropped, but when judged from the point of veiw of total productivity of the cropping systems sorghum planted in paired rows plus one row of groundnut gave the highest productivity (4492 kg/ha) followed by skip row planting of sorghum plus one row of groundnut (4462 kg/ha). In general, the total productivity of the intercropping systems was higher than the sole cropping of sorghum. The results of this investigation indicated that the intercropping of groundnut did not reduce the yield of sorghum considerably. Therefore, the yield of groundnut as an intercrop was a bonus. However, there is a scope for the selection of intercrops when sorghum planted in wide row pattern (paired or skip row) as the wide row pattern did not affect the yield of sorghum. These findings are similar to those reported by Singh (1979) and Tarhelkar and Rao (1979) and as observed at Dhule, Digraj and Rahuri (Anonymous 1981) contrary to our observations, at Kolhapur (Anonymous 1981) the grain and fodder yields of sorghum were more in sole planting than paired system without intercrop. However, when intercrop of groundnut was introduced the yield of sorghum was increased by about 7 q/ha and 3 q/ha over paired and solid planting respectively. Whereas Jalgaon (Anonymous 1981) sunflower yields were found to reduce in the association with groundnut as an intercrop while Singh and Singh (1977) reported that intercropping of groundnut did not affect the seed yield of principal crop adversely. Similar observations were also reported by Pandey *et al.* (1981). Kalra and Gangwar (1981) reported that intercropping of red gram with groundnut under paired row planting was more remunerative than intercropping with soybean, greengram or sorghum.

Monetary returns : Among the planting patterns, the significantly highest monetary returns (Rs. 6126.00/ha) were obtained from skip row planting pattern which were at par with paired row planting and both these patterns were significantly superior to normal planting pattern. The intercropping system also affected the monetary return significantly but the increase in the returns was marginal. The highest returns were obtained from sorghum plus one row of groundnut (Rs. 6181.00/ha) followed by sorghum plus two rows of groundnut (Rs. 6146.00/ha). These findings are similar to those observed by Pandey *et al.* (1981), Desai and Goyal (1980), at Dhule, Digraj and Rahuri (Anonymous 1981) and Kalra and Gangwar (1980). The highest net profit of Rs. 3488.00/ha was obtained from skip row planting of sorghum plus one row of groundnut. The highest return on every rupee invested was with paired row planting of sorghum

Table 1 : Yields and monetary returns of the principal and intercrop in different treatments

Treatments	1979				1980			
	Sorghum		Groundnut		Sorghum		Groundnut	
	Grain kg/ha	Fodder kg/ha	Dry pods kg/ha	Creepers kg/ha	Grain kg/ha	Fodder kg/ha	Dry pods kg/ha	Creepers kg/ha
S (NP)	4092	7044	—	—	4230	6306	—	—
S (PP)	4324	6548	—	—	4342	6354	—	—
S (SRP)	4297	6554	—	—	4382	6118	—	—
S (NP) $+G_1$	4194	7062	132	708	4037	6693	13	508
S (PP) $+G_1$	4448	6627	235	460	4309	6330	12	333
S (SRP) G_1	4300	6584	257	696	4351	5973	10	266
S (NP) $+G_2$	4217	7111	243	1991	3540	6221	13	690
S (PP) $+G_2$	4438	7032	299	1307	3480	6106	23	575
S (SRP) $+G_2$	4297	6657	301	1532	4194	5459	15	672
S. E. ± / ha	56.00	119.00	—	—	79.52	—	—	—
C. D. at 5%	169.00	358.00	—	—	238.93	—	—	—
C. V. %	2.40	—	—	—	2.76	—	—	—

S = Sorghum ; NP = Normal planting (45 x 15 cm) ; PP = Paired planting (30-60 x 15 cm) ; SRP = skip row planting (45 – 99 x 10 cm) ; G_1 = One row of groundnut ; G_2 = Two rows of groundnut

Table 1 : (Contd.)

1981				Avarage grain yield kg/ha	Total mean Productivity kg/ha	Av. monetary returns Rs/ha	Net Profit Rs/ha	Cost benefit ratio
Sorghum		Groundnut						
Grain kg/ha	Fodder kg/ha	Dry pods kg/ha	Creepers kg/ha					
4323	6656	—	—	4215	4215	5627	3127	1:2 21
4680	6626	—	—	4449	4449	5878	3378	1:2.35
4563	6414	—	—	4414	4414	5816	3316	1:2.33
4580	6656	13	799	4270	4323	6062	2815	1:2.15
4459	6324	12	496	4405	4492	6244	3470	1:2.17
4434	6596	34	847	4362	4462	6237	3488	1:2.27
4529	6929	12	421	4095	4185	6024	2230	1:1.54
4627	6112	18	468	4182	4295	6088	2841	1:1.87
4522	6051	53	1028	4338	4460	6326	3328	1:2.11
68.66	—	—	—	110.20	—	97.70	—	—
N. S.	—	—	—	311.60	—	292.00	—	—
1.42	—	—	—	—	—	—	—	—

N. S. = Non-significant

with no intercrop (Rs. 2.35). In general, the cost benefit **ratio decreased with** the intercropping of groundnut.

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17 A note on character association in *Linum*

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In order to exploit the segregating generations of interspecific hybrids through selection, it is desirable to examine the pattern of character association among them. Keeping this objective in view, 12 species of *Linum, viz., L. usitatissimum, L. angustifolium, L. ctatharitricum, L. creoetans, L. floccosum, L. gallicum, L. hirsutum, L. lewissi, L. pellescence, L. perenne, L. strictum* and *L. tenue* and 13 crosses among them (eleven crosses with *L. usitatissimum* and 2 other crosses, *L. catharitricum* x *L. hirsutum* and *L. strictum* x *L. lewissi*) were grown in a randomized block design with 3 replications. Data were recorded on 10 competitive and randomly selected plants for days to flowering, plant height, tiller number, number of capsules per plant, number of seeds per capsule, size of capsule, seed yield and pollen diameter. After usual analysis of variance and covariance, phenotypic and genotypic correlations (Croxton and Cowden, 1964) and path coefficient values (Dewey and Lu, 1959) for the characters were worked out.

Genotypic correlations were, in general, greater than the corresponding phenotypic correlations (Table 1). This indicated that though there was a strong inherant association between the various characters studied, the phenotypic expression of the correlations was depressed under the influence of environment. Grain yield, a character of major importance, was positively correlated with capsule size, seeds per capsule, capsules per plant and pollen diameter, whereas, tillers per plant and days to flowering showed negative correlations. Plant height showed nonsignificant correlation with yield. Capsules per plant was positively correlated with capsule size, seeds per capsule and pollen diameter. Negative correlation was found between capsules per plant and days to flowering. Capsule size was positively correlated with pollen diameter and negatively with days to flowering and tillers per plant. Similarly, seeds per capsule was positively correlated with pollen diameter and tillers per plant whereas, negatively correlated with days to flowering. Contrarily, days to flowering showed positive correlations with tillers per plant and pollen diameter. Some of these

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Table 1. Genotypic (above diagonal) and phenotypic (below diagonal) correlations in *Linum*

Characters	Capsule size	Seeds per capsule	Capsules per plant	Grain yield	Days to flowering	Plant height	Tillers per plant	Pollen diameter
Capsule size	1.000	0.373	0.904	0.720	—0.610	—0.315	—0.659	0.580
Seeds per capsule	0.141*	1.000	0.603	0.397	—0.474	—0.167	0.684	0.419
Capsules per plant	0.851*	0.280	1.000	0.759	—0.883	—0.283	0.078	0.466
Grain yield	0.685*	0.201	0.723*	1.000	—0.923	—0.190	—0.807	0.584
Days to flowering	—0.460*	—0.185	—0.412	—0.917	1.000	—0.249	0.721	0.655
Plant height	—0.003	0.074	—0.059	0.080	—0.351	1.000	—0.113	0.341
Tillers per plant	—0.456*	0.272	0.124	—0.871*	0.357	0.010	1.000	0.280
Pollen diameter	0.213	0.576*	0.167	0.259	0.576*	0.288	0.105	1.000

* Significant at 5%

Table 2. Direct (diagonal) and indirect effects of yield components on yield in *Linum*

Characters	Capsule size	Seeds per capsule	Capsules per plant	Days to flowering	Plant height	Tillers per plant	Pollen diameter	r_g with yield
Capsule size	0.367	0.035	0.647	—0.133	—0.085	0 021	—0.132	0.720
Seeds per capsule	0.137	0.094	0.431	—0.103	—0.045	—0.022	—0.095	0.397
Capsules per plant	0.332	0.457	0.715	—0.192	—0.077	0.030	—0.106	0.759
Days to flowering	—0.224	—0.044	—0.632	0.218	—0.068	—0.024	—0.149	—0.923
Plant height	—0.115	—0.016	—0.203	—0.054	0.271	0.004	—0.077	—0.190
Tillers per plant	—0.242	0.064	—0.659	0.157	—0.031	—0.032	—0.064	—0.807
Pollen diameter	0.213	0.039	0.333	0.143	0.092	—0.009	—0.227	0.584

Residual effect = 0.217

results are in agreement of those of Chandra and Makhija (1978), Patil *et al.* (1980), Gupta and Godawat (1981) and Chawla and Singh (1983). The present investigation, thus revealed that high yielding plants should have more and larger capsules with more seeds.

The capsules per plant showing the highest genetic correlation with yield (0.759) was mainly due to direct effect (0.715) and partly due to indirect effect via capsule size. Similarly, capsule size having second highest genetic correlation with yield (0.720) was also due to indirect effect via capsules per plant (0.647) and its direct effect (0.367). Identical results were reported in the inter-relationship of seed per capsule with yield (0.397) because, this character also contributed to yield via indirect effects of capsules per plant (0.431) and seeds per capsule (0.137). Significant association of pollen diameter with yield (0.584) in path analysis revealed that capsules per plant (0.333) and capsule size (0.213) are important attributes in contrast to other characters. Thus positive correlation of yield with capsule size, seeds per capsule, capsules per plant and pollen diameter are mainly due to capsules per plant and capsule size. Negative correlation of yield with days to flowering (0.923) was due to direct effect (0.213). Similarly, plant height, negatively correlated with yield was also contributing via direct effect (0.271). Negative inter-relationship between tillers per plant and yield (−0.807) contributed to yield via days to flowering. Thus path analysis revealed that capsule size and capsules per plant are major components of yield in *Linum*. However, Singh (1980), Chawla and Singh (1983) and Kapoor and Chawla (1983) have also reported similar results in *Linum usitatissimum*.

The general picture that emerged out from the study of correlations and path analysis showed that for developing a high yielding plant through interspecific hybridization, one has to develop selection indices to incorporate capsule size and capsules per plant in order to improve yield.

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A note on the relative tolerance of linseed varieties and species to alkalinity conditions

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With a view to assess the tolerance potential of 139 linseed *(Linum usitatissimum)* varieties and also of 2 *Linum* species *grandiflorum* and *gallicum*, seeds were sown in well prepared alkaline plots on November 29, 1983 at CSAU A & T Kanpur, Alkaline Research Farm, Dileepnagar, Kanpur. Each entry was represented by one 4.5 m long row marked 30 cm apart. At the time of sowing, physical analyses of the soil samples of the experimental site exhibited 49.2% sand, 25.2% silt and 21.1% clay and the soil was rated as sandy clay loam. At crop harvest, the pH values of composit sample of the top 15 cm soil for each of the plot (4.5 x 0.3 m) were determined in 1:2.5, soil : water suspension, separately. It varied between 8.27 to 8.97.

The experimental plots were fertilized with N, P_2O_5 and K_2O @ 40, 20, 20, Kg/ha, respectively as basal and 2 irrigations were applied during the course of crop growth. For recording observations, 5 competitive plants from each entry were tagged and 5 capsules from each of the tagged plants were selected, ramdomly. The number of seeds/capsule were counted and the ovule fertility percentage was worked out. Here it may be pointed out that a linseed capsule is composed of 5 locules and each locule possesses 2 ovules which ultimately develops into seed. This provides a reliable estimate of the ovule fertility by counting the number of seed set per copsule.

The data presented in table 1 revealed that the ovule fertility varied between 54.4 to 23.2 per cent. Out of 141 varieties/species evaluated, 9 groups could be formed. Four varieties namely RL 23—1, Bengal—34, EC 9832 and CI 1315 exhibited >90 per cent ovule fertility and appeared resistant to the prevailing alkaline conditions in the rhizosphere of these varieties. Under normal growing conditions in linseed, ovule fertility is reported to be around 90 per cent (Rai and Das, 1982). The minimum ovule fertility was recorded in Mauranipur-2 (54.4%)

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Table 1 : Clustering of linseed varieties based on their ovule fertility under alkalinity conditions

Cluster No.	No. of varieties	Ovule fertility percentage (range)	Varieties
1	2	3	4
1	2	54.4—55.0	Mauranipur—2, 53—9—b
2	8	55—60	No. 46—6, Dharwar-1, Syndonag 1—3, Neelum, IC—1282, NP -89, CP—33, Mostatha
3	14	60—65	Irland, Ragn-5, H-660, No—31, EC—41607, Bengal—64, Wera, T—477, *Linum gallicum* Linga, EC—41520, IC-32616, EC-41678, 64/1
4	14	65—70	IC—32615, IC-47574, Jaishri—2, Himanchal—1, Aubrel-10, EC-41627, R-76, FR-11, 19/59, 35/1, NC-1963, H 603, S—65-13, UPG-25
5	29	70—75	B-67, Bodokhankhani, Wardha-2, LS—3, LS—44, A-2-1, H-43-3, 5/5—65—1, No.-41, No.-45 NP-3, UP-8-A, EC-41601. EC—54431, R—6, R—10, R-157, Bengal-50, Bengal—52, Varanda, Jovenipuram, EC—13223, CI—795, Kota—16, R—2 12/60—1/2, EC-41483, Kota-10, LCM—926
6	31	75—80	EC—41525, IC-47580, CI—1639, CI—1856, Kota—5, 11/47-3/—3, Mukta,OR-8—44,T—28,T—61—

Table 1 : (Contd.)

1	2	3	4
			P—72—2, N-3, Azar, Punjab—T—4, EC-41595, EC—41597, EC—41619, EC—41624, IC—17, R—4, Bengal-58, Bengal—70, No-497, Labhandi, UPI-8, RR-9, R—966, LH—1, LH—2, Jaishi-5—6, CI-41539,
7	21	80—85	*L. grandiflorum*, LCM-1020, B—56—13, NP (RR) 521, FR—7, Punjab local, EC—41584, EC—41585,EC-41596, Looma,Niwada, Sabour(yellow),Sethi-1,Sheymil-1, Massents, Bisam-70, EC—41484, EC—22529, Kota—11, IC-49448
8	18	85—90	EC—6160, EC—41540, EC—41577, R—7, RL—9—2, Rys—9, ICAR—1, LS—4, A—12—1—2, A—19—2—1, 5—253, Bengal—6, Bengal—461513, Syndonag—20, Sahdoor—76, Jaishi—1—3, Maldas, Gugorachochi
9	4	90.0—93.2	EC—9832, CI—1315, RL—23—1, Bengal—34

-a local variety of Bundelkhand region of U.P. This variety alongwith culture 53—9—b was considered as the most susceptible to alkalinity conditions. In total, as many as 49 varieties/species showed ovule fertility below 75 per cent. Similar studies conducted under salinity conditions have also revealed vast variability with regard to ovule fertility (17.88 to 79.52%) in linseed (Rai and Sinha, 1980).

The present initial study has clearly indicated that the varieties which have exhibited normal ovule fertility and thereby a high degree of resistance to alkaline conditions may be utilized as potential donors for evolving salt resistant varieties. However, before their utilization at a large scale is contemplated, it is necessary to know the reaction of these varieties to different cations and anions as differential genetic system in other crop plants are on record and it is suggested that the varieties are to be tailor made to suit specific salinity/alkalinity situations prevailing in a particular zone (Rai and Sinha, 1978).

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Mutations in plant architecture induced by gamma rays in niger

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Niger (*Guizotia abyssinica* Cass.) is a member of compositae grown in India and Pakistan as minor oilseed crop (Anon. 1969). India with an annual area of about 6 lakh hectares and production of about 1.5 lakh tonnes is the chief producer of this crop. The avarage yield of this crop in India is only about 265 kg per ha. This low yield of niger is probably hindering its spread into more fertile soils where other crops are more remunerative. However, niger should be considered primarily as a valuable oilseed crop especially in those areas where oilseed crops are few. In fact in India it is a tribal crop.

Although crop improvement programmes in niger have been intensified in the past decade, not much headway has been made and information with regard to the genetic variability in this crop for different plant types, phyllotaxy etc. is not available. Very little work has been done on the taxonomy of niger and according to Baagoe (1974) practically there are no recognised varieties of cultivated niger.

Considering the low amount of genetic variability available in niger, it was thought a useful approach to adopt induced mutation technique for the induction of genetic variability. In this paper we are reporting the results of some pioneer efforts made in inducing mutations of plant architecture through the use of gamma rays.

The variety used for the study was IGP-76, a popular variety in India which matures in 105 days and has an yield potential of 1400 kg per ha. For the induction of mutations, a physical mutagen, gamma rays was used. The source of the mutagen was the gamma source available at the Division of Genetics, Indian Agricultural Research Institute, New Delhi. 10 g each of dry seeds (approximately 2500 seeds) of the above variety was irradiated with 20 and 30 KR doses of gamma rays and the M_1 generation alongwith control was grown

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during the *rabi* season of 1980 at the Farm of the Directorate of Oilseeds Research, Rajendranagar, Hyderabad, under rainfed conditions. The M_2 M_3 and M_4 generations were raised during the *kharif* seasons of 1981, 1982 and 1983 respectively. In the M_2 generation mutations for different plant types especially with regard to branching habit were isolated from both 20 and 30 KR treatments.

Mutations affecting branching pattern :

Mutants with both increased and decreased branching were observed in the M_2 generation. Mutants with increased branching were of two types. One type showed branching in very acute angle from the third basal node and the plant appeared very compact occupying less space. In these mutants the number of capitulam per plant was found to be substantially increased and an average of 100 capitulae per plant were observed as compared to an average of 73 capitulae per plant in the control. In the other type of mutants also the branching started from the third node from the base but the angle of branching from the main stem was less acute and the plants appeared unwieldy occupying more space. This type of branching induced more of secondary branches also and consequently there was an overwhelming increase in the number of capitulae showing an average of 242 capitulae per plant which was very much higher as compared to the control and the compact branching types. One of the loose branching types recorded as high as 329 capitulam per plant. But as far as synchrony in flowering and maturity was concerned the compact branching types were more synchronous and the flowering was completed within a span of 20 days, whereas in some of the loose branching types, it continued even after 50 days. In general, the loose branching types took more time for maturity (130—135 days) in comparison to the parent variety (110 days) as well as the compact branching types (115—120 days).

In the third category the branching usually started from the tenth node from the bsae and the number of branches produced were few. The average number of capitulae in such mutants was 61. The plants also were shorter than the parental variety. But in this case the plants showed better synchrony with regard to flowering and maturity. Some of them matured even in 100 days.

Mutations affecting phyllotaxy :

Mutations for altered phyllotaxy were noticed in M_4 generation in two mutant families. One of them showed a whorled phyllotaxy where 6-9 leaves were observed at each node. The mutant was a late maturing type and showed shy branching and flowering. The leaves were unsually broad measuring 5—8 cm in diameter. The leaves were unusually broad measuring 5-8 cm in diameter. The mainstem of the plant was very thick.

The other mutant with altered phyllotaxy had three leaves at each node placed at equal distance around the stem. Every leaf axil produced a branch and consequently there were three primary branches at each node. The mutant had a weak main stem with thin branches and matured alongwith the rest of the cultures.

Weiss (1983) reported that from the Indian seed grown for demonstration purpose one plant was able to produce 82 heads over a 26 day period. According to him a plant may produce 30-40 flower heads under suitable conditions: exceptionally, twice this number. In the present studies the parential variety IGP-76 on an average recorded 73 capitulae per plant. The number of capitulae in the mutants isolated for increased branching showed a two to three fold increased branching as conpared to the control. In a particular mutant isolated from 30 KR treatment, the increase was almost five fold. If the figures given by Weiss (1983) (30-40 flower heads per plant) are taken as a standard, the increase is more than eight fold. It is quite evident from the stady that gamma rays as a mutagen was very efficient in inducing this enormous variability which is not previously recorded in this crop for this character.

The first report of a mutant with altered phyllotaxy came from Janoria and Verma (1978) who observed a natural whorled in the cultivar "Ootacamund". The mutants recorded an average seed yield increase of 10 per cent over the parent. In the present study although the induced mutants recovered for altered phyllotaxy did not appear to be of mnch significance, the fact that gamma rays were capable of inducing this variability in niger is of value and gives support to the use of mutation technique for the induction of variability in this crop.

Although mutants with the three types of branching discussed above were recovered from both the doses of gamma rays applied, mutants with altered phyllotaxy were recovered only from 30 KR treatment. Even the frequency of mutations with increased branching was also higher with 30 KR gamma irradiation. Thus between 29 and 30 KR doses of gamma rays applied the latter was found to be more efficient in inducing the above mutations. The encouraging results presented in this communication reveal that there is a great scope for the induced mutation technique in the niger crop improvement programmes.

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Response of groundnut to nitrogen fertilizer and plant densities in relation to rhizobial inoculation

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In recent past, a declining trend of pod yields was observed in *Kharif* groundnut. Inadequate fertilization, low plant population and non-use of *rhizobial* culture were among the principle factors of low yield (Anonymous, 1979). To quantify the optimum plant population, nitrogen fertilizer under the conditions of seed inoculation of *Rhizobium*, a field experiment was conducted at College Farm, Hyderabad in *Kharif*, 1982.

The soil was sandy loam with pH 7.8, low in available nitrogen (232 kg/ha), medium in available phosphorus (23 kg P_2O_5/ha) and high in available potassium (295 kg K_2O/ha). The treatments consisted of two plant populations (3.33 and 5.0 lakhs/ha), and three levels of nitrogen (0,20 and 40 kg/ha) with and without *Rhizobial* inoculation. The treatment were replicated four times in randomised block design with factorial concept. Requisite amount of nitrogen in the form of urea was applied to the respective treatmental plots. Seed was inoculated with *Rhizobium* inoculum (NC—92) obtained from ICRISAT, Patancheru. A uniform dose of 50 kg P_2O_5/ha in the form of singal superphosphate was applied. The variety, TMV—2 was sown on 24th June and the crop duration was 108 days.

The effect of different treatments on growth and yield of groundnut are presented in table 1. Varying plant population and nitrogen levels exhibited significant influence. However, considerable variation was not brought out due to *Rhizobial* inoculation over non-inoculation. Number of branches/plant, filled pods/plant, 1000-kernel weight, shelling percentage, and yield per hectare were significantly more with plant population of 3.33 lakhs/ha. However, the plant height and haulms yield per hectare were significantly higher with plant population of 5.0 lakhs/ha. The pod yield of 1383 kg/ha with 3.33 lakh population/ha was more by 30.4 per cent compared to 5.0 lakh population/ha. Reduced pod yield with 5.0 lakh population/ha could be due to

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Table 1 : Effect of plant populations, nitrogen levels and *Rhizobium* inoculation on growth and yield of groundnut

Treatment	Plant height (cm)	Branches per plant	Mature pods/ plant	1000-kernal weight (g)	Shelling percentage(%)	Pod yield (kg/ha)	Haulms yield (kg/ha)
Populations							
5.0 lakh plants/ha	30.94	5.73	6.80	215.78	65.92	1060	2435
3.33 lakh plants/ha	28.09	6.62	10.00	272.70	69.82	1383	2216
C. D. at 5%	1.181	0.347	0.215	6.268	0.533	53.4	64.5
Nitrogen							
0 kg N/ha (Control)	24.60	4.60	4.60	221.60	64.52	682	1837
20 kg N/ha	31.05	6.69	10.10	254.30	69.31	1472	2542
40 kg N/ha	32.89	7.24	10.50	256.90	69.78	1512	2597
C. D. at 5%	1.447	0.425	0.264	7.677	0.654	65.4	79.0
Inoculation							
Control (uninoculated)	30.11	6.29	8.5	245.20	68.17	1233	2358
Rhizobium	28.92	6.07	8.3	243.30	67.58	1211	2294
C. D. at 5%	N S	N S	N S	N S	N S	N S	N S

N S = Non significant

severe mutual competition for resources like light, soil moisture and nutrients that reduced branches/plant, filled pods/plant, kernel weight and shelling per cent. Similar observations were also made by Enyi (1971) and Mao and Hsu (1975).

Significant increase in growth in terms of plant height, production of branches, and yield per hectare was observed with increasing levels of nitrogen. The significant increase in pod yield per hectare compared to no nitrogen (control) was in the order of 115.8 and 121.7 per cent with 20 and 40 kg N/ha respectively. The rate of out turn in pod yield was maximum from 0 to 20 kg N/ha rather than from 20 to 40 kg N/ha indicating higher response to nitrogen at lower rate of application. Considerable response to nitrogen application might be due to poor status of soil nitrogen. Similar response of groundnut to nitrogen application has been reported by Jayadevan and Sreedharan (1976) and Choudary *et al.* (1977). The use of *Rhizobial* inoculation did not benefit in improving the pod yields. The non-responsiveness of *Rhizobial* inoculation may be due to slight alkaline condition of the soil (pH 6.8) impairing the activity of both native and inoculated *Rhizobium* bacteria, or due to the non-responsiveness of the variety used (TMV-2).

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Aerial infection of *Macrophomina phaseolina* on castor

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During the survey of oilseeds diseases in *Kharif* 1983, a severe aerial infection of *Macrophomina phaseolina* (Tassi) Goid on castor (*Ricinus communis* L.) was observed in and around Hyderabad. 60 – 80 per cent plants were killed in M.M. Kunta Operational Project area. Disease was observed to cause severe damage after 45 days of planting.

On the adult plants, the primary infection starts as a small brown depressed lesion on or around the nodes. The lesions increase in size by both up and downward extension of the infection causing 2 to 20 cm necrotic area. Several lesions often coalesce and girdle the stem causing wilt and leaf drop leaving a bare yellowish stalk, which ultimately become black. In severe infection, entire branch or the entire top of the plant withers away. Pycnidia are formed on the infected tissue. The wilting of leaves starts at the apex and progresses downwards. Pith region shows brown discolouration due to formation of sclerotia. Sclerotia are rarely produced on the outer surface of the lesions. Infected capsules become discoloured and drop off easily. Pycnidia are produced on the outer surface of the capsule and sclerotia are produced inside. In the immature seed, mycelium and sclerotia are observed under the seed coat. Microscopic examination of infected stems shows the presence of the fungus in all infected tissues particularly in the epidermis and cortex. Pycnidia are produced embedded in the epidermis and sclerotia are formed in the ray cells and xylem.

Repeated isolation on PDA from the infected tissue confirmed the involvement of *Macrophomina phaseolina* (Tassi) Goid as causal organism. The identification of the fungus was confirmed by the Commonwealth Mycological Institute (IMI 285644). The Pathogenicity of the isolated *M. phaseolina* was confirmed on one month old seedlings of castor grown in pots.

The seedling infection of castor caused by *M. phaseolina* is well known (Bilgrami *et al.*, 1979). The aerial infection causing die back type of symptoms

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constitutes a new record in India. However, review of literature reveals that similar kind of symptoms were observed by Rieuf (1953) from Morocco.

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CONTENTS

Volume 1, 1984

CONTENTS

Number 1, June 1984

CONTENTS

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