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SHORT COMMUNICATIONS

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NITROGEN FERTILIZATION AND PLANT DENSITY LEVELS IN RELATION TO YIELD, ITS ATTRIBUTES AND QUALITY OF TORIA

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ABSTRACT

Significantly higher seed yield of toria (*Brassica campestris var: toria*) variety T-9 was recorded when the crop was fertilized with 90 kg N/ha. Increased number of branches and siliquae per plant and 1000-seed weight resulted in increased seed yield under higher level of nitrogen fertilization. Varying plant density levels did not differ significantly for the seed yield during 1978-79 but during 1979-80, 4.33 lakh plants per hectare reduced the yield significantly over 2.22 and 1.66 lakh plants per hectare. Oil content in seeds decreased and protein content increased with the increase in rates of nitrogen application. Higher protein content in seeds was recorded at lower level of plant density.

Key words : Indian rape; Toria; *Brassica campestris var. toria*; plant density; quality; nitrogen.

INTRODUCTION

Along with the Himalayan region, Indian rape (*Brassica campestris.* var. *toria*) is extensively grown and contribute substantially to the economy of farmers in this region. At farmer's field often inadequate fertilization supplemented with uneven plant stand per unit area causes great variations, which limits in full realization of potential yield levels. Amongst the various *Brassica* species *toria* has been reported to be the heavy feeder and positive response to nitrogen fertilization has been reported by many workers (Dalal *et al.*, 1962; Saxena and Singh, 1968 and Wankhede *et al.*, 1970), Similarly, differential response to plant population levels have been noticed by Singh *et al.* (1971). Since nitrogen fertilization and plant population levels affect the production of the crop to a greater extent, the present investigation was carried out to study the variations in yield, its attributes and quality of the Indian rape.

MATERIALS AND METHODS

Field experiments were conducted on a silty clay loam soil (pH 7.2, organic matter 2.35 per cent at a soil depth 0-15 cm, available P_2O_5 62.3 and available K_2O 246.5 kg/ha) during the winter seasons of 1978-79 and 1979-80 at the Crop Research Centre located at 29^{0}N and 79.3^{0}E with humid sub-tropical climate. T-9 variety of toria was planted on October 4 during both the years in a factorial R.B.D. taking combinations of 5 rates of nitrogen application (0, 30, 60, 90 and 120 kg/ha) and 3 levels of plant density (3.33, 2.22 and 1.66 lakh plants/ha). The plant density levels were maintained by planting the crop in 20, 30 and 40 cm apart rows, respectively and thinned to keep

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TABLE 1. Influence of nitrogen rates and plant density levels on seed yield and yield attributes.

Treatments	Number of branches per plant		Number of siliquae per plant		Number of seeds per siliqua		1000-seed weight (g)		Seed yield per plant (g)		Seed yield (q/ha)	
	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80
Nitrogen rates (kg/ha)												
0	11.7	12.0	127.3	142.6	2.8	11.1	2.42	2.81	5.31	5.55	6.79	7.59
30	12.4	12.3	132.8	150.9	13.5	11.7	2.45	3.06	5.83	5.38	10.17	10.36
60	15.9	13.9	145.8	158.6	13.2	12.0	2.50	2.88	6.20	6.12	10.81	11.91
90	17.4	15.4	164.8	233.9	15.0	13.5	2.64	3.15	6.95	6.27	13.48	14.79
120	16.1	16.1	156.7	175.4	14.4	14.0	2.61	3.18	7.17	7.24	13.79	15.08
S. Em. ±	0.25	0.28	1.73	29.60	0.32	0.13	0.04	0.05	0.10	0.13	0.37	0.19
C.D. (P=0.05)	0.74	0.81	4.96	—	0.93	0.37	0.12	0.15	0.29	0.37	1.06	0.56
Plant density levels (lakh/ha)												
3.33	13.9	12.3	139.0	147.8	13.8	12.0	2.52	2.82	6.04	5.65	10.69	11.43
2.22	13.7	13.8	144.9	162.1	13.6	12.5	2.52	3.08	6.15	6.15	11.12	12.03
1.66	16.1	15.6	152.6	207.0	13.8	12.8	2.54	3.14	6.72	6.54	11.32	12.41
S.Em. ±	0.20	0.22	1.34	22.9	0.25	0.10	0.03	0.04	0.07	0.10	0.28	0.15
C.D. (P=0.05)	0.57	0.63	3.84	—	—	0.29	—	0.12	0.22	0.29	—	0.45

one plant/hill at a distance of 14 cm. The crop was uniformly fertilized with 60 kg P_2O_5/ha at the time of sowing. As per the treatment 2/3 quantity of nitrogen was applied as basal dressing and remaining 1/3 quantity was top dressed at 50 per cent flowering stage. The crop was grown under irrigated conditions keeping individual plot size of 5 m×3.6m. Estimation of protein content in seeds was made by determining nitrogen content using microkjeldahl's method (Jackson, 1967) and multiplying by a constant factor of 6.25 and has been reported in per cent. Seed samples collected for protein content were also used for oil determination using Soxhlet's extraction method taking petroleum ether as solvent.

RESULTS AND DISCUSSION

Effect of nitrogen :

The application of nitrogen increased seed yield of *toria* but the level of significance reached at 90 kg N/ha in both years (Table 1), whereas 120 kg N/ha did not increase the seed yield of *toria* during both the years. The per cent increase in seed yield with the application of 30, 60 and 90 kg N/ha was 45.9, 55.1 and 93.4 and 36.5, 56.9, and 94.9 per cent over control during 1978-79 and 1979-80, respectively. Response of *toria* to nitrogen fertilization have also been reported by Maini *et al.* (1956) and Dhindsa *et al.* (1973).

The number of branches per plant significantly increased upto 90 kgN/ha during both the years (Table 1). Increased rates of nitrogen also resulted in more number of siliquae/plant but application of nitrogen beyond 90 kg N/ha adversely affected the number. Significantly more number of seeds per siliqua was also recorded at 90 kg N/ha. Nitrogen fertilization also increased the 1000-seed weight which increased with the increase in nitrogen rates, but differences between 90 and 120 kg N/ha were not significant. Number of seeds per siliqua and 1000-seed weight were higher under higher rates of nitrogen because of the higher translocation of food material for the formation of seeds (Bhan and Singh, 1973). The increase in various yield contributing characters with the increasing levels of nitrogen was due to the vigorous vegetative growth of the crop under the high level of nitrogen fertilization which resulted inadequate supply of photosynthates for the formation of branches, siliquae and development of seeds. Similarly, increase in yield attributes with nitrogen fertilization have been reported by Shastry and Kumar (1981) in mustard. All these yield contributing characters had additive effect on the seed yield per plant and ultimately the seed yield/ha. Number of siliquae per plant had positive relationship with nitrogen rates (R^2 = 0.83 and R^2 = 0.98) during both the years (Fig. 1).

Effect of plant density :

The plant density levels also affected seed yield but effect was pronounced during 1979-80 only. The seed yield was higher at plant density level of 1.66 lakh/ha, but did not differ significantly from the yield obtained at the density of 2.22 lakh/ha. The higher plant density level invariably had lower values of yield contributing characters

(Kumar and Rahman, 1978). The seed yield under higher plant density level reduced significantly, because of the decrease in number of branches/plant, number of siliquae/plant and 1000 seed weight (Table 1).

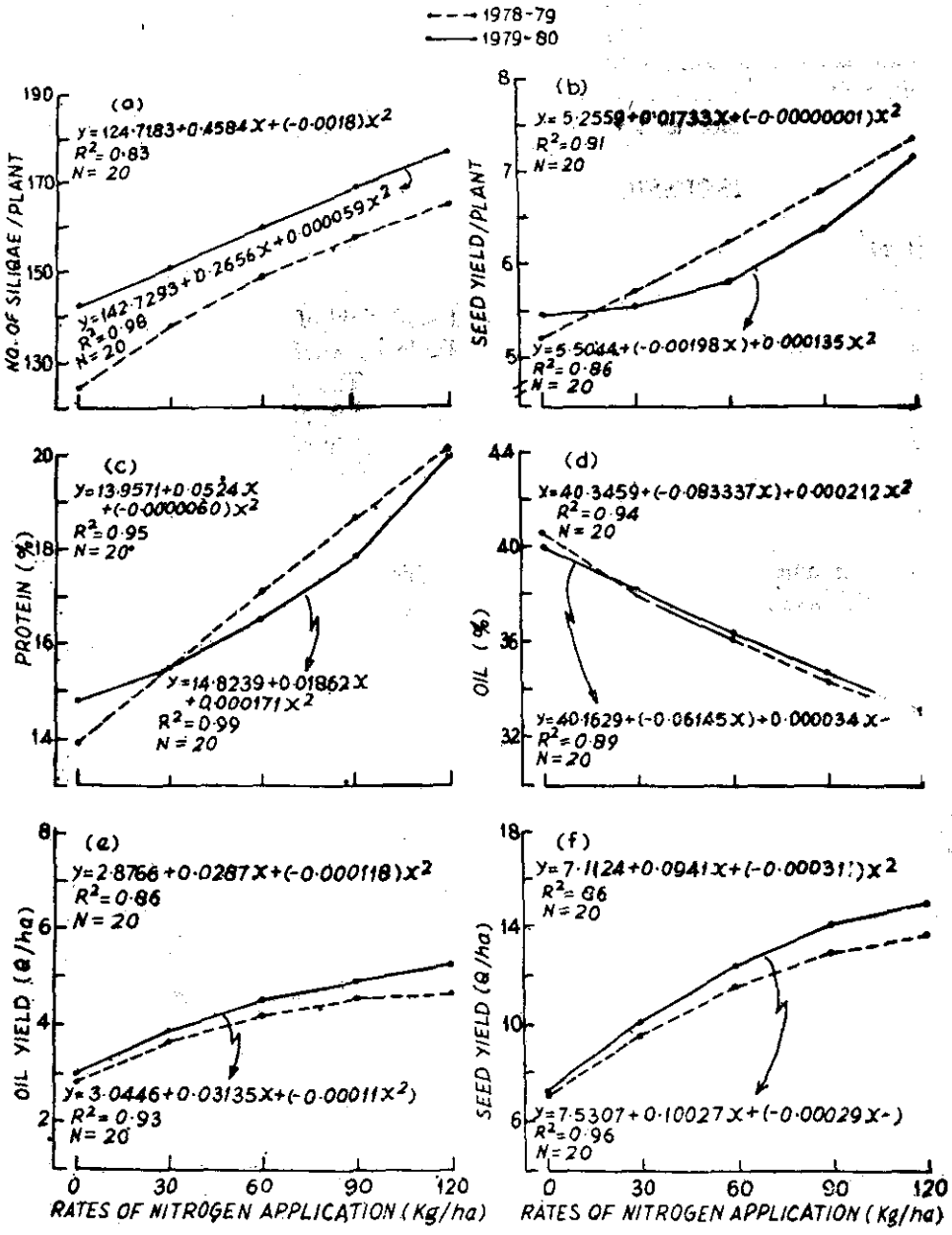

Fig. 1 : Relationship between yield and quality parameters and nitrogen rates

Interaction effect :

The interaction effect of nitrogen and plant density on seed yield was significant during 1979-80 (Table 2). The application of 90 kg. N/ha and plant density level of 2.22 lakh/ha resulted in higher seed yield. However, at 1.66 lakh plants/ha, the higher levels of nitrogen did not show difference. Plant density levels of 2.22 and 1.66 lakh/ha did not have significant difference at 90 and 120 kg N/ha.

TABLE 2. **Interaction effect of nitrogen rates and plant density levels on seed yield (q/ha) of toria** *(1979-80)*

Nitrogen rates (kg/ha)	Seed yield (q/ha)			
	Plant density (lakh/ha)			
	3.33	2.22	1.66	Mean seed yield (q/ha)
0	7.10	7.51	8.15	7.59
30	9.89	10.22	10.96	10.36
60	11.58	12.03	12.31	11.97
90	13.09	15.70	15.58	14.79
120	15.50	14.71	15.03	15.08
Mean seed yield (q/ha)	*11.43*	*12.03*	*12.41*	*11.96*

Oil content :

The oil content in seeds decreased with the increase in the nitrogen levels, significantly (Table 3). Inverse relationship between oil and protein contnet in seeds was reported by Bhatty (1964). However, the oil yield remained low at lower nitrogen rates because oil yield is the resultant of seed yield and oil content and the seed yield was higher under the high rates of nitrogen fertilization which resulted in higher oil yield. The plant population levels affected the oil content significantly only during 1979-80. Higher oil content was recorded at plant density level of 3.33 lakh/ha but remained at par with 2.22 lakh/ha.

Protein content :

Protein per cent in seeds increased with the increase in the rates of nitrogen application (Table 3). Since nitrogen plays an important role in the synthesis of amino

acids which constitute building blocks of protein, it resulted in higher protein content in seeds at higher rates of nitrogen application. At lower plant density level the protein content was higher during both the years which may be attributed to the fact that more number of primary and secondary branches were formed even at later stages which had higher contribution in total protein content because of higher number of younger seeds. Similar findings indicating the higher protein content in younger seeds have been also reported by Maini *et al.*, (1965).

TABLE 3. Effect of nitrogen rates and plant density levels on oil and protein content in seeds and oil yield in toria.

Treatments	Oil content (%)		Protein content (%)		Oil yield
	1978–79	1979–80	1978–79	1979–80	1979–80
Nitrogen rates (kg/ha)					
0	40.37	40.16	13.95	14.73	2.81
30	37.89	38.18	15.55	15.76	3.85
60	36.40	36.07	17.38	16.46	3.93
90	34.34	34.44	18.12	17.82	4.62
120	33.50	33.43	20.31	19.58	4.61
S. Em. ±	0.31	0.19	0.14	0.05	0.13
C.D. (P=0.05)	0.89	0.56	0.41	0.15	0.37
Plant density levels (lakh/ha)					
33.33	36.57	36.96	16.61	16.58	3.83
2.22	36.54	36.36	16.99	16.80	4.00
1.66	36.39	36.05	17.08	17.24	4.05
S. Em. ±	0.24	0.15	0.11	0.04	0.10
C.D. (P=0.05)	—	0.45	0.33	0.12	—

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A COMPARATIVE ASSESSMENT OF THE HARVEST INDEX AND OTHER ECONOMIC ATTRIBUTES IN THREE CULTIVATED SPECIES OF *BRASSICA*

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ABSTRCT

The mean, range and genetic variance were studied for harvest index and 15 other attributes in three cultivated *Brassica* species. The estimates of heritability and expected genetic advance were also worked out. Exploitable extent of genetic variance does exist for harvest index in Pahadi *rai* (*B. rugosa*) only. The heritability for this character was observed to be high in *B. campestris* and *B. juncea*. It was comparatively low in *B. rugosa*. The plant height and biological biomass yield in all three *Brassica* species and siliquae/plant in *B. campestris* showed considerably high variability with their high heritabilities and genetic advance. It is suggested that economic yield could still be improved through proper selection for biological yield in all these economically important species.

Key words : Harvest index; *Brassica, B. rugosa; B. juncea; B. campestris.*

INTRODUCTION

Harvest index is usually considered to be quite important in determining the expression of seed yeild and has been reported to be positively associated with this economically important attribute in various crops (Syme, 1970; Singh and Stoskopf, 1971; Nass, 1973; Varshney and Singh, 1982). Though, it ts important however, not much is known about the extent of its variability and heritability in economically important crop species of rapeseed and mustard in India. In the present investigation, therefore, an attempt has been made to obtain some of these basic biometrical informations which could be meaningfully utilized in the genetic imrovement of seed yield in these crops.

MATERIALS AND METHODS

Materials for the present investigation comprised of 15 genetic stocks of three species of *Brassica* i.e., *B. campestris L.B. juncea* (L.) Czern & Coss, and *B. rugosa* Roxb. The selection number studies in *B. campestries* were T9 C3, YS 151, YS6, and BSP, -1, Varuna, BR40, T6342, PR-21, Yellow Rai, in *B. juncea* and FS902, FS908, FS 919, S2 and S4, in *B. rugosa*. These were grown in a R.B.D. with four replications at Pantnagar. Each plot consisted of 5 rows each of 5m. The spacing between rows and plants were 30cm and 10cm, respectively. The observations were reported on plant height (cm), number of primary branches/plant, secondary branches/plant, siliquae/ main shoot, siliquae/plant, seeds/ siliquae, 1000-seed weight (g), economic yield/plant (g) ,biological yield/plant (g) and oil content (%) using 10 random plants from each plot in every replications. Days to 75% maturity were recorded on plot basis. Besides these characters, the leaf area and leaf dry weight, after 42 and 65 days of crop growth

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were also recorded on 10 leaves. These leaves were collected from the mid height of the same ten plants. The harvest index was determined as the ratio of economic yield and biological yield and expressed in percentage (Donald, 1962). Coefficients of variability were estimated according to Burton (1952). Heritability in broad sense and genetic advance under selection for these characters were calculated according to Allard (1960).

RESULTS AND DISCUSSION

The range, mean, standard error, phenotypic and genotypic coefficient of variation of the various characters studied have been given in Table 1. The analysis of variance reveals highly significant differences among treatments for all the characters. A wide range for harvest index was observed in all three *Brassica* species. The difference in harvest index of *B. rugosa* with that of *B. juncea* and *B. campestris* was quite high. A wide range was also observed for the characters, days to maturity, leaf dry weight at 42 days, plant height, primary branches / plant, secondary branches/palnt, siliquae/main shoot, biological yield/plant and oil content in all the three species of *Brassica*. However, the range for leaf area at 42 and 65 days and leaf dry wieght at 65 days was low in both *B. campestris* and *B. rugosa*. Substantial range was observed for siliquae/plant in *B. campestris* and *B. rugosa*., however, it was low in *B. juncea*. For seeds/siliqua and 1000-seed weight the range was low in *B. campestris* but it was quite high in other two *Brassica* species. A wide range was observed for economic yield/plant in *B. campestris* and *B. juncea* whereas it was low in *B. rugosa*.

It is difficult to compare the range of various characters because it is not unit free so the phenotypic and genotypic coefficients of variability were calculated and compared for various characters. Not withstanding the results of range observed for days to maturity and oil content, the phenotypic and genotypic coefficients of variability (pcv and gcv) were very low but these were little influenced by environmental factors. Both pcv and gcv were high for leaf area and leaf dry weight at 42 and 65 days in all the three *Brassica* species. Environmental factors played important role in the expression of these traits because the values of pcv and gcv are not very close together. Exploitable coefficient of variability was observed in all the three *Brassica* species for plant height, primary branches/plant, secondary branches/plant and biological yield/plant and environmental factors did not influence the expression of these characters. A worthwhile improvement could be achieved for such characters through simple selection. Low variability was observed for seeds / siliqua, 1000-seed weight and harvest index both in *B. campestris* and *B. juncea*, however, it was high in *B. rugosa*. Exploitable amount of variability was observed for siliquae/plant in *B. campestris* and *B. rugosa* but it was low in *B. juncea*. Substantial amount of genetic variability exists for economic yield/plant in *B. campestris* and *B. juncea* but it was low in *B. rugosa*. The characters which had high phenotypic variability with more environmental variation are unpredictable and selection based only on phenotypic variation may not lead substantial improvement of these traits. Similar results were also observed by Yadava (1973) and Katiyar *et al.* (1976) in mustard.

TABLE 1. The range, mean, phenotypic and genotypic coefficient of variation for various economic attributes in three Brassicas, *B. campestris* (S1) *B. juncea* (S2) and *B. rugosa* (S3).

Characters 1		Range 2	Mean ± S.E. 3	P.C.V. 4	G.C.V. 5
Days to 75% maturity	S1	108.50 - 117.50	112.05 ± 0.45	3.61	3.51
	S2	121.50 - 127.00	124.40 ± 0.71	2.09	5.09
	S3	148.50 - 157.00	152.55 ± 0.74	2.21	1.98
Leaf area at 42 days (cm^2)	S1	61.44 - 95.22	76.21 ± 6.32	22.63	15.31
	S2	104.86 - 150.75	133.99 ± 12.86	21.75	10.00
	S3	119.15 - 187.82	144.56 ± 13.36	24.25	16.02
Leaf area at 65 days (cm^2)	S1	44.47 - 59.25	53.12 ± 4.92	19.64	6.69
	S2	88.57 - 103.80	93.06 ± 9.21	18.64	6.77
	S3	199.72 - 375.80	259.31 ± 27.00	31.70	23.86
Leaf dry weight at 42 days (g)	S1	0.16 - 0.30	0.22 ± 0.03	29.52	4.74
	S2	0.38 - 0.57	0.50 ± 0.06	**26.12**	10.27
	S3	0.42 - 0.66	0.51 ± 0.04	**21.67**	9.83
Leaf dry weight at 65 days (g)	S1	0.11 - 0.20	0.16 ± 0.03	**38.52**	19.89
	S2	0.25 - 0.37	0.31 ± 0.04	**21.04**	6.13
	S3	0.69 - 1.35	0.90 ± 0.12	**36.61**	24.83
Plant height (cm)	S1	100.70 - 148.85	120.67 ± 1.89	17.20	**16.91**
	S2	129.70 - 206.05	157.46 ± 3.95	19.36	**18.70**
	S3	163.65 - 244.42	218.92 ± 3.85	14.96	**14.54**
Primary branches / plant	S1	3.57 - 5.90	5.11 ± 0.13	19.01	**18.25**
	S2	4.12 - 7.46	5.23 ± 0.27	26.23	**24.13**
	S3	4.95 - 8.02	6.59 ± 0.43	21.55	**17.21**
Secondary branches / plant	S1	0.67 - 6.97	4.13 ± 0.33	78.50	**76.79**
	S2	7.75 - 10.90	9.46 ± 0.49	15.75	**11.91**
	S3	7.12 - 10.47	8.77 ± 0.54	20.61	**16.59**

Table 1. Contd.

1.	2.	3.	4.	5.
No. of siliquae/ main shoot.	S1 38.70 - 49.05	42.09 ± 1.97	12.51	8.32
	S2 38.92 - 45.40	42.05 ± 1.76	10.03	5.51
	S3 36.44 - 41.50	38.89 ± 0.79	6.68	5.32
No. of siliquae / plant.	S1 96.50 - 198.55	173.19 ± 7.77	26.17	24.59
	S2 226.97 - 286.57	249.61 ± 15.03	14.12	7.36
	S3 181.30 - 280.72	243.48 ± 12.49	17.64	14.32
No. of seeds/siliqua	S1 19.29 - 10.72	9.88 ± 0.33	8.33	4.96
	S2 7.63 - 10.64	9.48 ± 0.29	13.01	11.45
	S3 5.45 - 9.51	7.5 ± 0.36	21.36	19.11
1000 seed weight (g)	S1 2.12 - 2.32	2.26 ± 0.02	5.30	2.60
	S2 2.55 - 3.39	2.87 ± 0.09	13.14	9.92
	S3 1.36 - 2.03	1.73 ± 0.05	16.52	13.85
Economic yield/plant (g)	S1 6.23 - 11.40	8.73 ± 0.22	27.26	26.77
	S2 9.75 - 13.28	10.25 ± 0.26	17.63	16.91
	S3 2.63 - 3.15	2.81 ± 0.06	11.64	9.85
Biological yield / plant (g)	S1 23.72 - 38.31	29.99 ± 1.31	24.43	22.82
	S2 26.07 - 43.71	34.06 ± 1.35	20.33	18.73
	S3 17.86 - 33.33	26.01 ± 1.34	23.41	21.04
Harvest index (%)	S1 26.07 - 32.52	29.03 ± 0.75	10.38	9.00
	S2 27.50 - 33.50	30.38 ± 0.65	9.40	8.37
	S3 9.10 - 14.90	11.24 ± 0.64	22.85	18.91
Oil content (%)	S1 40.37 - 45.00	42.75 ± 0.39	5.43	5.12
	S2 38.37 - 42.37	40.00 ± 0.27	4.09	3.86
	S3 39.62 - 45.50	42.27 ± 0.26	6.24	6.12

The estimates of broad sense heritability and expected genetic advance under selection have been given in Table 2. Heritability in broad sense fails to indicate genetic progress, therefore, the heritability with genetic advance is important in deciding the suitable breeding methodology. The high heritability as well as high genetic advance was observed for plant height and biological yield/plant in three *Brassica* species and for siliquae/plant only in *B. campestris*. The presence of wide variability with high heritability and gentic advance indicated that for these traits considerable amount of improvment could be obtained by simple selection procedures. High heritability was also observed for hearvest index in both *B. campestris* and *B. juncea* but camparatively low in *B. rugosa* however, genetic advance was low for this trait in all three *Brassica* species. Similarly for yield and other yield contributing characters the high heritability with low genetic advance or low heritability with high genetic advance was observed in these *Brassica* species except plant height and biological yield in all three *Brassicas* and siliquae/plant in *B. campestris*. Such results indicate that no worthwhile genetic improvement could be obtained under simple selection schemes for these traits. For improving economic yield, selection may be applied on biological yield as it has high positive correlation with economic yield (Varshney, 1980) as well as wide variability with high heritability and high genetic advance exist for biological biomass in present set of material.

TABLE 2. Heritability and Genetic advance for various economic attributes in *B. campestris* L. (S1), *B. juncea* (L). Czern and Coss (S2) and B. *rugosa* (S3).

Characters	Heritability			Genetic advance		
	S1	S2	S3	S1	S2	S3
1. Days to 75% maturity	94.42	76.88	80.63	7.87	4.71	5.60
2. Leaf area at 42days (cm^2)	46.10	21.34	42.68	16.38	12.81	31.17
3. Leaf area at 65days (cm^2)	11.54	13.20	56.56	2.48	4.72	95.84
4. Leaf dry weight at 42days(g)	54.43	14.70	45.11	0.07	0.04	0.10
5. Leaf dry weight at 65days(g)	26.37	4.95	46.26	0.03	0.01	0.32
6. Plant height (cm)	96.70	93.28	94.48	41.33	58.58	63.75
7. Primary branches/plant	92.23	84.62	63.76	1.85	2.39	1.87
8. Secondary branches/Plant	95.72	57.21	64.84	6.39	1.76	2.42
9. Siliquae/main shoot	44.19	30.17	63.28	4.79	2.62	3.39
10. Siliquae/plant	88.17	26.95	65.95	82.38	19.64	58.33
11. Seeds/siliqua	35.43	77.46	80.08	0.60	1.97	2.67
12. 1000 seed weight (g)	16.60	56.98	70.35	0.05	0.44	0.41
13. Economic yield/plant(g)	96.43	91.91	71.63	4.73	3.42	0.48
14. Biological yield/plant(g)	87.18	84.81	80.76	13.16	12.10	10.13
15. Harvest index(%)	75.09	79.35	73.56	4.66	4.67	3.76
16. Oil content (%)	88.71	88.94	96.11	4.24	2.99	5.23

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PRODUCTIVITY OF MUSTARD GROWN UNDER DIFFERENT CROPPING SEQUENCES

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ABSTRACT

An experiment was carried out for two seasons during 1982-83 and 1983-84 in the Gangetic plains of West Bengal to study the effects of different preceding *kharif* crops, *viz.* rice (*Oryza sativa* L.), maize (*Zea mays* L.), jute (*Chorchorus olitorius* L.), black gram (*Vigna radiatus* Linn), cowpea (*Vigna unguiculata* L. Savi ex Hassk) and groundnut (*Arachis hypogea* L.) on the productivity of mustard (*Brassica juncea* L. Czern and Coss). Legumes (blackgram, cowpea and groundnut) showed better residual effect on the yield components and yield of succeeding mustard crops than that of other crops. Number of primary branches/plant, number of seeds/siliqua, number of siliqua/plant, 1000 grain weight and finally yield of oilseeds increased when mustard were grown after legumes. Highest yield of mustard (1.6 t/ha) was obtained from cowpea (fodder) - mustard sequence followed by groundnut-mustard (1.3 to 1.5 t/ha) and blackgram-mustard sequence (1.2-1.4 t/ha). Lowest yield of mustard was obtained from maize-mustard sequence (0.9-1.1 t/ha)

Key words: Mustard based cropping sequence with cereals, legumes, fibres.

INTRODUCTION

The average yield of mustard (*Brassica juncea* L. Czern and Coss) in India is usually low because most of the crop is grown as a mixed crop with wheat (*Tirticum aestivum L.*) in north-western region or after the harvest of rice on the residual moisture in the north-eastern region. Furthermore, the crop is not sown in time and it is not adequately fertilized and protected. Because of an acute shortage of edible oil, the price of oilseed has increased and there has been now scope to give importance to this crop. The objective in this study is to evaluate the productivity of mustard when sown in right time, as a main crop in sequence with other *kharif* (Jun-Sep) growing crops or in otherwords in a mustard based cropping system.

MATERIALS AND METHODS

Field experiments were conducted in the University Farm, Kalyani for two successive years, 1982-83 and 1983-84. The farm is situated at 23°N latitude and 89°E longitude at an altitude of 9.75 m above sea level The experimental soil had sandy clay loam texture having neutral soil reaction containing 0.66% total nitrogen, 34 and 110 kg/ha P_2O_5 and K_2O, respectively. The six sequences tried with mustard were (i) mustard-maize for fodder (*Zea mays* cv. 'Adecuba' in 1982 and cv. 'African giant' in 1983), (ii) mustard-rice (*Oryza sativa* L. cv. 'Rasi'), (iii) mustard-jute (*Chorchorus olitorius* L. cv. 'JRO-632' in 1982 'Rupali' in 1983), (iv) mustard-blackgram (*Vigna radiatus* cv. 'T 9'), (v) mustard-cowpea (*Vigna unguiculata* L. cv. HFC-42-1 in 1982 and EC-4216 in 1983) and (vi) mustard-groundnut (*Arachis hypogea* L. cv. 'Polachi'). Except

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jute rest of the *kharif* crops were sown in the last week of June and jute was sown in the middle of April. After harvesting the *kharif* crops mustard was sown in the first week of November (Table 1). The experiment was conducted in RBD with four replications of 5m × 6m plots. Maize, blackgram, cowpea, rice, jute, groundnut and mustard were established at seed rates of 20, 12, 25, 80, 5, 80 and 6 kg/ha, respectively with a row distance of 20 cm in rice, jute, blackgram, and cowpea. 30 cm in groundnut and mustard and 60 cm in maize. Recommended dose of fertilizers were used in both *kharif* and *rabi* crops (Table 1). A low dose of nitrogen was given to mustard to make the best use of the residual fertility of the previous crops. In addition to pre-sowing irrigation, two more irrigations were applied to mustard crops. Except one irrigation in jute no irrigation was applied in *kharif* crops. Plant protection measures were taken as and when required. Among the *kharif* crops maize and cowpea were harvested as fodder (maize at milk stage 65-70 days after sowing (DAS) and cowpea at 75-80 DAS). The growth attributes of mustard *viz.* stand establishment, number of siliqua/plant, number of seeds/siliqua and 1000 seed weight were recorded in addition to yield estimations. The soil samples were analysed twice once before the sowing of *kharif* crops and other before the sowing of mustard for total nitrogen content of the experimental soil by Kjeldahl's method (Jackson, 1967).

TABLE 1. Dates of sowing, dates of harvesting, spacing with seed rate in bracket and the fertilizer doses of the crops.

Crops	Dates of sowing		Dates of harvesting		spacing	Fertilizer dose in kg/ha		
	1982–83	1983–84	1982–83	1983–84	(seed rate)	N	P_2O_5	K_2O
Kharif crops								
Rice	29.6.82	22.6.83	8.10.82	7.10.83	20×10cm² (80 kg/ha)	60	30	30
Maize	22.6.82	22 6.83	31 8.82	3.9.82	60×30cm² (20 kg/ha)	100	50	50
Jute	26.4.82	12.3.83	5.10.82	13.9.83	20×7cm² (5 kg/ha)	60	40	40
Blackgram	26.6.82	26.6.83	19.9.82	21.9.83	20×10cm² (12 kg/ha)	20	60	30
Cowpea	18.6.82	26.6.83	3.9.82	9.9.83	20×10cm² (20 kg/ha)	20	60	30
Groundnut	24.6.82	24.6.83	8.10.82	18.10.83	30×15cm² (80 kg/ha)	20	60	30
Rabi crops								
Mustard	10.11.82	2 11.83	15.3.83	3.3.84	30×10cm² (6 kg/ha)	40	40	40

RESULTS AND DISCUSSION

Yields of kharif crops

Green forage yields in terms of dry weight of maize and cowpea have been summarised in Table 2. Low yields of maize and cowpea for fodder in 1982 were due to use of the varieties 'Ade-cuba' and 'HFC-42-1', respectively. Higher yield in black gram (12.2 q/ha) in 1983 was due to higher amount of precipitation (55.9 cm) receivied during the rainy months (June to October) than that of in 1982 (40.7 cm).

TABLE 2. Dry matter * and grain yield (g/ha) of different *kharif* crop (average of 4 replications)

Crops	Yield (q/ha) 1982–83	1983–84
Maize (Fodder)	90.2 ± 11 06	3550. ± 32.79
Cowpea (Fodder)	66.9 ± 3 84	265.0 ± 39.05
Rice (Grain)	27.8 ± 2. 89	28.9 ± 1.93
Jute (Fibre)	15.3 ± 2.88	16.1 ± 1.06
Blackgram (Grain)	5.9 ± 1.39	12.2 ± 0.60
Groundnut (Grain) *(unshelled)*	19.2 ± 1.89	19.5 ± 2.25

* For fodder crops only

Yield components and productivity of mustard

The maximum number of inflorescence bearing primary branches/plant in the base crop of mustard (Table 3) was obtained (9/plant) when it followed groundnut in 1982-83 and cowpea (5.9/plant) in 1983-84. The crop established after (1982-83) and rice (1983-84) recorded the least number of branches (5.8/plant in 1982-83 and 4.7/plant in 1983-94). The number of siliqua/m^2 recorded at the time of harvest was significantly more where mustard crop followed leguminous crops than those following cereal or fibre crop. Roy (1979) reported that number of siliqua/m^2 ranged from 2, 615 (control) to 5,855 (at 120 kg N/ha) in variety 'Varuna' under irrigated condition.

The number of seeds/siliqua in the first year (Table 3) did not differ significantly between treatments ranging from 7.0 to 9.6/siliqua. But in 1983-84 the treatment differences were statistically significant. The maximum number of seeds/siliqua were recorded when mustard was grown after groundnut and the least when the crop followed rice. In

TABLE 3. Number of primary branches/plant, number of siliqua/m2, number of seeds/siliqua, 1000 seed weight in g and seed yield in q/ha of mustard as influenced by the residual effect of preceding *kharif* crops.

Preceding *kharif* crops	No. of Primary branches/plant		No. of siliqua/ m2		No. of seeds/ siliqua		1000 seed wt. in g		Seed yield in q/ha	
	1982–83	1983–84	1982–83	1983–84	1982–83	1983–83	1982.83	1983–84	1982–83	1983–84
Maize (F)	6.7	5.4	4025	4066	7.0	11.1	4.2721	5.7312	**8.6**	**11.1**
Rice	6.3	4.7	3425	4118	8.4	11.1	4.1204	6 0711	**8.7**	**11.4**
Jute	5.8	5.6	4075	4096	9.6	12.5	3.9912	6.1915	**10.2**	**14.7**
Blackgram	8.0	5.8	5425	4564	8.5	12.2	4.3122	6.3304	**11.8**	**15.1**
Cowpea (F)	8.4	5.9	6950	4794	8.0	13.4	4.6231	6.3216	**16.2**	**16.4**
Groundnut	9.1	5.7	6125	4905	8.7	13.5	4.3816	6.4513	12.9	15.5
Mean	7.38	5.52	5004	4424	8.37	12.30	4.2834	6.1829	11.40	14.03
S Em (±)	1.75	0.34	707	200	1.09	1.13	0.3460	0.0540	**1.34**	**1.04**
C D at P = 0.05	3.72	0.71	1491	245		2.40		0.1150	2.86	2.22

1983-84, only 1000 seed weight of mustard grown under different sequences differed significantly (Table 3). The highest test weight (6.45 g) was recorded when the crop followed groundnut and the lowest (4.12 g) when it followed rice.

The yield (Table 3) of mustard ranged from 860 to 1620 kg/ha in 1982-83 and 1111 to 1640 kg/ha in 1983-84. In both the years maximum yield of mustard was recorded when it was grown after cowpea (1620 kg/ha in 1982-83 and 1604 kg/ha in 1983-84). The yield of mustard was statistically at par where it followed groundnut, black gram or jute. Lowest yield in both the years were recorded when mustard followed maize (Table 3). De and Giri (1978) reported that in Delhi best yields of mustard are obtained when it follows cowpea crop as fodder as compared to other crops.

Thus, it may be concluded that mustard as a *rabi* main crop sown in the first week of November, gives the best yield when it follows leguminous crops (groundnut and blackgram for grains and cowpea for fodder) in *kharif*.

The nitrogen status of soil

From the data summarised in Table 4, it is apparent that plots which had legumes like groundnut, cowpea or blackgram, maintained high total nitrogen (0.11 to 0.12%) in soil in both the years. The lowest total nitrogen content was recorded in plots having jute. Jute-mustard sequence reduced badly the total nitrogen content of the soil. Thind *et al.* (1979), Biswas *et al.* (1967), and Sharma and Singh (1970) reported that growing of leguminous crops like groundnut etc. in the crop rotation had a beneficial effect on the soil nitrogen than that under any of the cereal crop rotation.

TABLE 4. Total nitrogen content of soil after the harvest of *kharif* and *rabi* crops.

Treatments	Total nitrogen percentage (W W)			
	After harvest of *Kharif* crops		After harvest of mustard	
	1982-83	1983-84	1982-83	1983-84
Maize (F)	0.050	0.046	0.044	0.041
Rice	0.053	0.049	0.044	0.041
Jute	0.045	0.042	0.036	0.034
Blackgram	0.121	0.112	0.062	0.058
Cowpea (F)	0.123	0.114	0.057	0.053
Groundnut	0.127	0.117	0.064	0.059
S Em (±)	0.0143	0.0132	0.0062	0.0058
C D at P = 0.05	0.0291	0.0269	0.0132	0.0123

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GENETIC VARIABILITY, HERITABILITY AND DROUGHT INDEX ANALYSIS IN *BRASSICA* SPECIES

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ABSTRACT

Screening of 27 genotypes of 7 cultivated species of genus *Brassica* under four environments of fields and drought plots indicated significant differences among the genotypes for different quantitative characters. The expression of plant height, siliquae per plant, siliqua length and seed yield were significantly reduced under drought conditions. However, primary and secondary branches and seeds per siliqua were not influenced much by drought conditions. 1000 seed weight increased under drought as compared to irrigated conditions.

Genetic variability was maximum for secondary branches followed by seed yield, siliquae per plant and seed weight in all the environments. Broad sense heritability was higher for secondary branches, seed weight and seeds per siliqua in all the environments. As judged by heritability and genetic gain through selection, seed yield and secondary branches under drought and secondary branches, seed weight and seeds per siliqua under irrigated conditions could be improved through selection. Based on seed yield, its attributes and drought index, *B. juncea* cv. RH 7513, RH 30 and RH 785 and *B. carinata* var. HC 2 were indentified as most promising genotypes for drought conditions.

Key words : Genetic variability; heritability; drought index; *Brassica* species.

INTRODUCTION

There is no general agreement as to what should be the optimum environment for selecting the genotypes for drought tolerance. However, Hurd (1969, 1971, 1976), in wheat, Levitt (1951) in various crop plants and Richards (1978) and Richards and Thurling (1978) in repeseed advocated the adequacy of drought water deficit environment for affecting seed yield improvement for that condition. In the present study, efforts have been made to screen various genotypes of *Brassica* species under both irrigated and water deficit conditions with a view to examine the extent of genetic variability, heritability and genetic advances for seed yield and other related characters and to analyse the effect of drought environment on the expression of these attributes. Such information would enable breeders in developing suitable genotypes of *Brassica* species for water deficit conditions.

MATERIALS AND METHODS

The experiemntal material for the present study comprised 27 genotypes of 7 *Brassica* species (Table 1).

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TABLE 1. **Genotypes and their origin.**

Species/Genotype	Origin	Species/genotype	Origin
B. campestris L.		*B. napus* L.	
BSH 1	India	EC 129126	Poland
Span	Canada	Regent	Canada
Torch	Canada	Gulliver	Sweden
Bell	Sweden	HNS 3	selections from
		HNS 1	Canadian base
		HNS 2	material, Regent
B. juncea L.		*B. carinata*	
Prakash	India		
RH 30	India	BC 2	India
Varuna 80	India	HC 2	USSR
Lethbridge 22 A	Canada		
RYS 80	India		
Blaze	Canada	*B. chinensis* L.	
RH 785	India		
Domo	Canada	Local	India
RC 781	India		
RH 781	India	*B. tournefortii* L.	
		Local	India
RIK 78-6-1	India	*B. alba* L.	
RH 7513	India	Local	India

The above genotypes were screened under four environments namely: E1 - Irrigated thrice, in field having loam soil; E2 - Only pre-sowing irrigation, in field having loam soil; E3 - newly constructed drought plots (30 × 6 m) filled with dune sand, presowing 3.2 cm absoulte water at 45 cm wetting of soil, later on irrigation witheld and E4 - Drought plot (30 × 6m) filled with dune sand, presowing 2.1 cm absolute water at 309 cm wetting of soil, lateron irrigation witheld. The experiment was conducted in R.B.D. with two replications in each environment during, 1982-83 at Haryana Agricultural University. Hissar. Each entry was represented by four rows each of 1.5 m length. Row to row and plant to plant distances within rows were kept at 30 and 15 cm, respe-

ctively. Only two middle rows of each entry were considered to record the observations on 10 plants for plant height (cm), primary and secondary branches per plant (No), total siliquea per plant (No), siliqua length (cm), seeds per siliqua (No), seed yield per plant (g) and 1000-seed weight (g) in all the environments. The data for above observations were analysed for the analysis of variance, range of variability, genotypic coefficient of variability (GCV), phenotypic coefficent of variability (PCV), heritability (Broad sense) and genetic advance (CA) as percent of mean.

RESULTS AND DISCUSSION

The analysis of variance for eight characters in four environments have been presented in table 2. The perusal of this table revealed highly significant differences among the genotypes for all the characters in all the environments. It signifies the adequacy of the material chosen for the present study.

TABLE 2. Analysis of variance for seed yield and other characters under field and simulated water stress conditions.

Character	MEAN SQUARES			
	E_1	E_2	E_3	E_4
Plant height	3109.650 **	3894.754 **	3097.755 **	2646.051 **
Primary branches per plant	10 657 **	10.300 **	10.759 **	6.251 **
Secondary branches per plant	60.377 **	212.120 **	166.061 **	130.154 **
Siliquae per plant	49277.897 **	84452.318 **	38395.335 **	38257.740 **
Siliqua length	1.101 **	1.229 **	0.868 **	0.9868 **
Seeds per siliqua	28.988 **	31.740 **	18.480 **	24.026 **
Seed yield per plant	76.369 **	96.940 **	63.622 **	52.136 **
1000 seed weight	2.509 **	2.670 **	1.998 **	2.001 **

** Significant at P = 0.01

The expression of the characters like plant height, siliquae per plant, seed yield and siliqua length was considerably reduced under drought conditions, whereas other characters were not much affected by the drought (Table 3a and 3b) *B. tournefortii Lc. Jangali rai* was the dwarfest genotype in all the environments. *B. juncea* L. cv. RIK-7-86-1 and RC 781 possessed lowest number of primary branches whereas *B. napus* L.cv. HNS 3, Gulilver and Regent had the lowest number of secondary branches, *B. carinate*

L. var. HC 2 possessed highest number of primary and secondary branches and siliquae per plant. *B. alba L.* had minimum and *B. napus* L. cv. HNS 1 the maximum values of siliqua length and seeds per siliqua in most of the environments. *B. juncea* L. var. RH 7513 and RH 785 registered highest seed yield and RH 30 the highest seed weight in all the environments.

Drought environments did not affect the expression of genetic variability for siliquae number, siliqua length and secondary branches as judged by the values of GCV. However, for seed yield and plant height there was increase in genetic variability under drought environments. The characters for which there was decrease in genetic variability under drought environments were primary branches, seeds per siliquae and seed weight. As judged from the magnitude of the differences in GCV and PCV values, there was pronounced effect of soil environment on the expression of plant height, primary and secondary branches, siliquae per plant and seed yield. The characters which were not influenced by soil environment were siliquae length, seeds per siliqua and seed weight. Heritability in broad sense over all the evnironments was higher for secondary branches, seed weight, plant height, seeds per siliqua and seed yield. Generally, the heritability estimates were low under drought environments for all the characters except seed yield. Genetic gains as percent of mean were higher under drought for the characters seed yield and secondary branches. It was however, of the same order under drought and irrigated conditions for siliquae per plant and siliqua length and least for seed weight and seeds per siliqua under drought. The gains through selection based on all the environments were heigher for plant height, seed yield and seed weight.

Considerably higher variability among the genotypes for all the characters could be attributed to the differences at species levels. The variability in *B. juncea* was desirable as this is an important *Brassica* species for this region. The differences in seed yield in this species varied from 5.34 g (*Blaze*) to 21.26 g (Varuna). The differences in seed yield could largely be attributed to the differences in branching, siliquae number, seeds per siliqau and seed weight. Morgan (1974) reported the varietal differences in rape seed due to siliqua number and seeds per siliqua. Greater genetic variability for seed and its components has already been reported by Yadava and Singh (1977). Consideration of GCV, PCV, heritability (BS) and GA indicted that secondary branches, seed yield, seeds per siliqua and seed weight were most likely to be improved in all the evnironments through selection. Siliqua length, seeds per siliqua and seed weigh had higher GCV and less influence of soil environment on their expression and are therefore, desirable for improvement under both irrigated and drought conditions. Drought environments accelerated the genetic variability for seed yield and plant height and resulted in move heritability and genetic advances. Similar observations have been made by Richards (1978) in rapeseed and Hurd (1969, 1971, 1976) in wheat.

The data presented in table 4 for seed yield and its components and drought index (seed yield under drought environments divided by seed yield under irrigated environments) indicated that *B. napus* cv. Gulliver; *B. juncea* cv. Blaza and *B. alba* local registered highest values of drought index but at a very low productivity levels. Levitt (1951) advocated the utility of this parameter for selecting drought tolerant genotypes.

TABLE 3a. Genetic variability and heritability for plant height, primary and secondary branches and siliquae per plant among 27 genotypes of seven *Brassica* species evaluated under four different environments.

Character	Environment	General Mean	Range of variation Minimum	Range of variation Maximum	GCV	PCV	Heritability (per cent)	Ganetic advance (per cent)
Plant height (cm)	E_1	184.9 ±6.01	116.3 (Jangali rai)	258.0 (RC 781)	0.2106	0.2158	95.29	42.28
	E_2	190.6 ±9.63	116.0 (do)	269.0 (Domo)	0.2260	0.2369	91.00	44.30
	E_3	148.75± 9.07	120.3 (do)	214.4 (RIK 78-6-1)	0.2575	0.2715	89.92	50.83
	E_4	148.33±10.63	117.4 (do)	215.2 (do)	0.2345	0.2555	84.25	44.20
Primary branches per plant	E_1	8.06± 0.36	4.60 (RIK 78-6-11)	14.00 (HC 2)	0.2828	0.2899	95.18	55.31
	E_2	8.43± 0.54	5.50 (RC 781)	15.00 (do)	0.5763	0.6453	89.21	50.59
	E_3	8.05± 0.57	5.10 (do)	14.30 (di)	0.2794	0.2968	88.61	54.40
	E_4	7.80± 0.75	5.40 (RIK 87-6-1)	12.10 (do)	0.2214	0.2345	88.97	43.03
Secondary branches per plant	E_1	11.03± 0.75	1.70 (HNS 3)	20.90 (do)	0.4933	0.5028	96.25	9.45
	E_2	13.57± 1.69	4.20 (Gulliver)	55.00 (do)	0.7513	0.7691	94.75	150.40
	E_3	12.34± 1.35	5.50 (Regent)	47.20 (do)	0.7275	0.7465	95.73	147.67
	E_4	13.60± 1.28	2.10 (do)	38.90 (do)	0.5814	0.5963	95.07	116.70
Siliqua per plant	E_1	388.9 ±37.1	95.0 (BSH 1)	878.0 (do)	0.3922	0.4147	89.44	76.02
	E_2	454.3 ±75.0	188.0 (Gulliver)	886.0 (do)	0.4211	0.4815	76.49	75.33
	E_3	318.1 ±75.0	151.0 (EC 126791)	900.0 (do)	0.4165	0.4539	84.19	78.54
	E_4	345.6 ±38.1	137.0 (Regent)	665.0 (BC 2)	0.3849	0.4153	85.90	73.57

E_1 Irrigated; E_2 Non-irrigated; R_3 Water stress I; E4 Water stress II.

TABLE 3b. **Genetic variability and heritability for siliqua length, seeds per siliqua, seed yield and 1000 seed weight in 27 genotypes of seven *Brassica* sepcies evaluated under four diffierent environments.**

Character	Environment	General mean	Range of variation Mainimum	Maximum	GCV	PCV	Heritability (percent)	Geneti advance (percent)
Siliqua length (cm)	E_1	3.72±0.144	2.00 (B. *alba*)	5.05 (HNS 1)	0.1955	0.2031	92.64	38.49
	E_2	3.75±0.245	1.30 (RC 781)	5.20 (do)	0.1988	0.2189	82.34	36.89
	E_3	3.39±0.178	2.80 (do)	4.20 (do)	0.1870	0.2014	86.27	36.05
	E_4	3.54±0.195	1.80 (*B. alba*)	4.70 (Regent)	0.1908	0.2061	85.69	36.52
Seeds per siliqua	E_1	13.07±0.559	3.40 (do)	19.95 (HNS 1)	0.2882	0.2943	95.90	58.14
	E_2	14.42±0.685	2.60 (do)	19.80 (do)	0.2721	0.2803	94.25	54.23
	E_3	13.01±0.779	4.00 (do)	19.5 (Span)	0.2258	0.2395	87.67	43.71
	E_4	13.54±0.651	3.2 (do)	18.3 (HNS 1)	0.2514	0.2605	86.75	46.14
Seed yield (g) per plant	E_1	11.41±1.85	1.20 (ECI 129 126)	26.67 (RH 7513)	0.5165	0.5653	83.43	96.66
	E_2	13.37±2.03	2.36 (do)	24.67 (do)	0.4982	0.5424	84.36	93.86
	E_3	9.04±1.13	0.60 (do)	24.50 (RH 785)	0.6116	0.6365	92.35	120.63
	E_4	9.31±0.83	1.55 (do)	21.71 (RH 7513)	0.5419	0.556	94.85	108.73
100 seed weight (g)	E_1	2.85±0.146	1.53 (HNS 2)	5.53 (RH 30)	0.3903	0.3969	96.71	79.19
	E_2	2.88±0.190	1.39 (EC 129 126)	5.47 (do)	0.3957	0.4066	94.75	78.47
	E_3	3.54±0.203	1.80 (do)	5.65 (do)	0.2765	0.2882	92.03	54.91
	E_4	2.970±0.190	1.90 (Gulliver)	5.90 (do)	0.3306	0.3427	93.05	65.66

E_1 Irrigated; R_2 Non irrigated; E_3 water stress I; E_4 Water stress II.

From practical view point the consideration of high average yield and higher drought index revealed that *B. juncea* cv. RH 7513, RH 30 and RH 785 and *B. carinata* var. HC 2 were best suited for irrigated as well as drought conditions. *B. juncea* cv. Varuna registered highest average seed yield but its drought index was less as compared to above mentioned genotypes. The study further revealed that seed yield higher seed weight and higher number of branching accompanied with drought index need special consideration for developing suitable genotypes of *Brassica* species for drought/water deficit conditions. Identification of parental lines based on above characteristics in hybridization programme and selection for seed yield in segregating generations under drought/water deficit conditions apperas to be a suitable breeding approach in these crops.

TABLE 4. Mean performance of 27 genotypes of seven *Brassica* species for seed yield and its component characters averaged over four environments of fields and water stress conditions.

Genotype	Seed yield per plant (g)	Drought index *	Siliquae per plant	Seeds per siliqua	1000 seed weight (g)	Secondary branches per plant
B. campestris						
BSH 1	12.16	0.89	213.5	15.7	4.07	11.1
span	11.08	0.50	426.5	17.3	2.16	13.9
Torch	12.81	0.70	440.3	15.2	1.92	14.7
Bell	10.78	0.76	284.0	18.1	2.56	11.7
B. juncea						
Prakash	15.60	0.86	443.0	12.3	2.88	21.1
RH 30	17.53	0.87	300.8	11.5	5.64	11.9
Varuna	21.26	0.58	431.3	12.6	4.50	17.7
Lathbridge 22A	9.51	0.58	473.8	11.9	4.03	23.2
RYS 80	13.45	0.59	389.8	11.4	3.97	12.5
Blaze	5.34	1.27	332.3	10.1	2.22	19.0
RH 785	16.44	0.99	374.5	13.0	3.50	16.0
Domo	9.13	0.52	505.8	12.8	2.03	28.3
RC 781	8.88	0.53	448.3	13.2	2.54	21.1
RH 781	15.65	0.82	374.5	12.1	4.41	14.3
RIK 78-6-1	10.02	0.37	361.0	8.8	4.17	11.9
RH 7513	21.85	0.70	532.3	11.5	3.76	19.1
B. napus						
EC 129126	1.43	0.60	183.3	13.4	1.71	7.3
Regent	5.53	0.51	286.5	18.3	2.58	7.1
Gulliver	4.54	1.31	245.5	15.7	2.28	4.8
HNS 3	5.24	0.67	286.5	15.9	2.38	6.7
HNS 1	6.62	0.54	249.5	18.5	2.69	8.4
HNS 2	4.18	0.69	245.0	17.2	1.89	6.6
B. carinata						
BC 2	13.59	0.88	505.8	11.4	3.57	34.1
HC 2	18.77	0.79	814.3	15.5	2.61	50.5
B. chinensis	9.69	0.93	344.3	15.7	2.59	8.9
B. tournefortii	8.67	0.96	317.3	13.4	2.70	22.6
B. alba	3.96	1.18	364.8	3.3	4.83	9.9

$$* \text{ Drought index} = \frac{\text{Seed yield under drought conditions}}{\text{Seed yield under irrigated conditions}}$$

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LINE X TESTER ANALYSIS OF COMBINING ABILITY IN CASTOR

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ABSTRACT

Combining ability for seed and its attributes was studied in line x tester analysis involving 4 pistillate lines and 15 monoecious pollen parents in castor. The estimated components of general and specific combining ability (gca and sca) variances showed the preponderrance of non-additive gene action for yield per plant and capsules in main spike, whereas additive gene action was predominant for nodes upto main spike, length of main spike, effective spikes per plant and 100 seed weight. Among the female parents VP-1 was good general combiner for yield per plant and 100 seed weight, JP-58 for capsules in main spike and variety 240 for nodes upto main spike and effective spike per plant. Among the males 63 Mo for nodes upto main spike and plant height, SPS-43-3 for length of main spike and 100 seed weight, T-4 for capsules in main spike, Bhagya for effective branches per plant and VI-4 for yield per plant were found good general combiners. The high yielding parents were also the good general combiners and thus parental selection can also be done on the basis of *per se* performance.

Key words : Castor; *Ricinus communis L.*; Combining ability; Line × tester analysis.

INTRODUCTION

Hybrid vigour in castor (*Ricinus communis* L.) have been extensively explored for enhencing the yield. A number of male and female (pistillate) lines are now available to evolve castor hybrids. However, selection of suitable parents is important for the development of productive hybrids. The information on the inheritance of yield and combining ability is usefull for future breeding programme. Hence a line x tester analysis was under taken to obtain information on the above parents.

MATERIAL AND METHODS.

Four pistillate lines (VP-1, JP-58, JSP-10 R and 240) and 15 pollen parents selected on the basis of genetic diversity were crossed adopting line x tester mating. The resulting 60 hybrids with their parents were planted in a randomized compect block design with two replications at Castor Research Project, Sardar Krishinagar during 1981-82. Each plot consisted single row of 15 plants with an inter and intra row spacing of 90 cm × 60 cm. Observations on five randomly selected plants were recorded for number of nodes upto main spike, height upto main spike, length of main spike, capsules on main spike, effective branches per plant, 100 seed weight and yield per plant. The data were analysed according to the method suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

The differences among the crosses were significant (Table 1) for all the characters, indicating the presence of genetic diversity among the genetic lines selected for study. The differences in the general combining ability (gca) effects of males and females

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

Source of variance	D.F.	Nodes upto main spike	Plant height up to main spike(cm)	Length of main spike (cm)	Number of capsules in main spike	Effective spike per plant	100 seeds weight (g)	Yield per plant (g)
Replication	1	0.01	1715.35**	458.64**	1645.76**	18.72*	7.35*	4979.41**
Crosses	59	7.81**	363.85**	70.41**	270.35**	15.19**	22.39**	378.48**
Males effects (M)	14	19.30**	946.63**	174.56**	416.19**	36.68**	76.81**	608.32**
Females efiects (F)	3	33.44**	415.93	48.12	806.87**	56.98**	40.34**	893.83
F × M interaction	42	2.13*	156.87	37.28	183.41*	5.05*	2.98**	265.05*
Error	59	1.43	125.86	29.93	100.80	2.67	1.20	164.10
Variance components								
gca (males)		2.12	97.59	17.16	29.09	3.95	9.22	42.90
gca (females)		1.04	8.63	0.36	20.78	1.73	1.25	20.96
gca (pooled)		1.27	27.12	3.89	22.53	2.20	2.93	25.58
sca		0.35	15.50	3.67	41.30	1.19	0.89	50.47

Whare * Significant at P = 0.05

** Significant at P 0.01

TABLE 2. **Estimates of g.c.a. effects with mean performance of 19 parents (15 + 4) for various characters in Castor**

	Nodes up to main spike		Plant height upto main spike (dm)		Length of main spike (cm)		Number of capsules in main spike		Effective branches/plant		100-seed weight (g)		Yield per plant (g)	
	g.c.a. effect	Mean	g.c.a. effect	Mean	g.c.a. effect	Mean	g.c.a. effect	Mean	g.c.a. effect	Mean	g.c.a. effect	Mean	g.c.a. effect	Mean
Females														
VP 1	0.073	15.9	2.58	41.8	0.23	49.9	-5.13*	62.4	-0.76*	8.3	1.46**	26.0	7.60*	81.0
JP-58	0.593*	18 5	-3.10	32.5	0.57	35.8	6.52**	48.9	-1.20**	4.5	-0.41*	20.6	-3.13	56.0
JSP-10R	0.846**	20.6	-3.28	37.1	-1.83	32.6	-3.02	38.6	0.06	4.6	0.26	25.4	-4.66*	60.5
240	-1.506**	14.4	3.80	51.3	1.03	27.7	1.62	42.2	1.92*	11.3	-1.30**	23.4	0.17	70.5
SE gca	0.22	—	2.04	—	1.00	—	1 83	—	0.30	—	0.20	—	2.34	—
SE (gi—gj)	0.31	—	2.98	—	1.41	—	2 59	—	0.42	—	0.28	—	3.31	—
Males														
VI-9	-1.93**	15.00	-16 06**	63.0	-3.21*	36.1	-0 65	48.0	-0.13	5.8	0.16	27.3	6.31	77.5
JI-35	1.10*	20.30	10.12*	92.5	3.53	34.1	8.49*	47.4	-0.16	6.4	0 85*	25.3	8.44	76.5
SPS-43-3	1.75**	21.40	8.24*	93.2	9.06*	61.0	7.89*	67.8	-2.73**	4.6	5.68**	37.8	2.19	99.5
VH-28-2	0.60	15.20	6.32	64.7	0.36	29.5	5.73	28.2	0.14	7.9	0.27	22.9	5.94	57.5
J-1	0.58	21.3	1.62	76.5	-2.01	43.4	-2.78	53.6	1.00	8.1	0.75	22.6	7.44	73.0
37500	0.63	17.0	8.62*	90.2	2.03	48.9	1.94	50.2	-2.23**	4.3	3.81**	38 2	1.69	65.5
63 Mo	-3.88**	11.8	-19.98**	38.5	-9.31**	29.0	-14.66**	31.7	2.71**	9.2	-2.05**	17 4	-15 06**	50.5
Bhagya	-0.60	13.3	-2.13	50.5	-4.76*	29.2	-12.81**	34.0	2.94**	9.7	-2.18**	24 9	-13.44**	74.0
Aruna	-0.60	14 6	0.57	57.0	-0 09	35.6	0.96	43.0	0.36	8.3	-4.53**	17.0	10.68*	60.5
1-4-13	0.42	19.4	0.52	54.7	2.56	42.1	-0 36	56.9	-0.01	4.6	-1.55*	24.7	0.19	61.0
VI-4	0.50	20.3	8.57*	11.7	2.78	42.1	1.59	67.0	1.26*	5.2	0.81*	26.6	12.31**	84.0
VI-14	-0.10	17.2	-5.28	78.7	-2.16	44.2	-1.43	37.2	1.79**	13.8*	2.75**	22.6	3.81	80.0
VH-57-1-4	-0.12	13.7	-6.52	57.8	-1.44	40.9	-6.08	39.4	-1.06	8.8	-1.70*	23.0	-8.31	73.0
VH-61-2-5	-1.05*	16 7	-13.52**	61.5	-4.04*	38.2	0 79	44.6	1.83**	5.0	-0.86*	25.0	-7.43	76.5
T-4	2.75**	24.0	19.27**	150.5	6.75**	58.7	11.24**	95.8	-4.51**	2.3	6.51**	45.5	6.56	90.0
SE gca	0 42	—	3.94	—	1.93	—	3.55	—	0.58	—	0.39	—	4.53	—
SE (gi-gj)	0 59	—	5.61	—	2.72	—	5.02	—	0.82	—	0.55	—	6.40	—

** Significant at P=0.01

* Significant at P=0.05

TABLE 3. Specific combining ability and mean performance of selected hybrids for various characters in castor.

Crosses	Nodes upto main spike	Plant height upto main spike (cm)	Length of main spike (cm)	Number of capsules in main spike	Effective spike per plant	100 seed weight (g)	Yield per plant (g)
VP-1 × VI-9	-0.64 (15.2)+	-14 00 (41.4)	1 65 (41.8)	7.66 (56.6)	0 99 (8.1)	-0.10 (27.7)	6 02 (109)
V-1 × JI-35	0 03 (18.9)	16.42* (98.0)	9.40* (56 1)	27.85** (85.6)	2.81** (9.9)	0.62 (29.5)	14 39 (120)
JP-58 × Aruna	-1.29 (16.4)	6.15 (72.5)	0.78 (44 4)	11.96** (74.1)	0.83 (8 0)	0.91 (22.1)	23.76** (100)
JP-58 × VI-4	1.01 (19.8)	10.15 (84.5)	3.11 (49.6)	12.83 (61.4)	0 03 (8.1)	1.35 (26.2)	11.76 (110)
240 × VH-28-2	-0.49 (16.2)	4.7 (83.8)	0.47 (45.r)	10.03 (72.1)	2.43* (12.5)	0.70 (24.4)	11.33 (107)
240 × VI-14	-0.79 (15.3)	2.19 (69.6)	3.20 (45.2)	3.76 (52.8)	0.98 (12.7)	1.74 (23 8)	17.46 (111)

Whare * Significant at P = 0.05

** Significatn at P = 0.01

were significant for all the characters except plant height upto main spike and length of main spike in females. The variance due to specific combining ability (sca) was significant only for nodes upto main spike, capsules in main spike, effective spike per plant, 100 seed weight and seed yield per plant.

Estimate of variance, gca (males) was higher than those due to gca (females) for all the traits, indicating greater diversity among the males as compared to females for their combining ability. The estimates of sca variance were considerably higher than gca (pooled) for yield and capsules in main spike, indicating preponderance of non-additive gene action in the inheritance of these traits. These results are in agreement with those of Kandaswami (1977). Singh and Yadava (1981) and Singh and Srivastava (1982), who also observed the importance of both the gene actions nd preponderance of non-additive gene actions for yield in castor. However, for plant height upto main spike and length of main spike only additive gene action was important and for nodes upto main spike, effective spike per plant and 100 seed weight both the types of gene actions were involved with the preponderance of additive gene action. Hooks *et al.* (1971) also reported the preponderance of additive gene action for days to flower and nodes upto main spike in castor.

The gca effect indicated that among the females, VP-1 was good general combiner for yield per plant and 100 seed weight. JP-58 for number of capsules in main spike and female 240 for nodes upto main spike and effective spike per plant were other good general combiners. General combiners identified among the males were VI-9 and 63 Mo, for nodes upto main spike and plant height upto main spike, SPS-43-3 and T-4 for length of main spike, T-4, JI-35 and SPS-43-3 for number of capsules in main spike; 63 Mo, Bhagya, VI-4 and VI-14 for effective spike per plant, SPS-43-3,37500 and T-4 for 100 seed weight and VI-4 and JI-35 for yield per plant.

The specific combinations as indicated by significant sca effects were JI-58 × Aruna for yield per plant, VP-1 × 37500 for 100 seed weight, VP-1 × JI-35, 240 × J-1 and 240 × VH-28-2 for effective branches per plant, VP-1 × JI-35 for number of capsules in main spike, 240 × SPS-43-3 for length of main spike, VP-1 × VH-57-1-4 for plant height upto main spike and 240 × VI-4 for nodes upto main spike. Specific cross combination, JP-58 × Aruna for yield per plant and VP-1 × JI-35 for effective branches per plant involved low general combiners. It may arise due to epistatic gene action.

Though the cross JP-58 × Aruna showed significant sca for yield, its *per se* performance was not very high (Table 3) under such circumstances crosses with higher *per se* performance should be considered. In this context, cross VP-1 × JI-35 deserves merit since it showed higher *per se* performance and sca effect for important yield attributes like length of main spike, number of capsules in main spike and effective branches per plant along with considerably high sca estimate for yield. The female parent of this cross (VP-1) as an established 'S' type pistillate line, which can be maintained by reverted selfing or sibbing with heterozygous segregants. The hybrid seed production can be achieved by planting female line with double seed rate along with male line in ratio of 3:1, keeping necessary isolation. Thirty to fourty percent *monoecious* plants appeared in the

rows of female line can be rouged out after appearence of main spike on the basis of shape of male and female flowers before anthesis. Hence this cross should be considered for the commercial exploitation of heterosis in castor.

The parent with higher *per se* performance (Table 2) were also found to be good general combiners for most of traits indicating that *per se* performance of parents can effectively be used as a selection criterion while selecting the parents. Since non-additive component was predominent for the inheritance of yield and number of capsules in main spike, the exploitation of heterosis would be effective for the improvement of yield in castor.

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PHENOTYPIC STABILITY OF DIFFERENT POPULATIONS IN INDIAN MUSTARD

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ABSTRACT

Sixty eight homogeneous and heterogeneous genotypes of Indian mustard were evaluated for stability of seed yield in eight pertinent environments. Significance of linear component of genotype-environment interaction suggested that the prediction for most of the genotypes appeared to be feasible. The significance of pooled deviation indicated that populations differed with respect to their stability. The homogeneous populations exhibited the highest response indicating that homogeneous population were less buffered than the heterogeneous populations. Heterozygous-heterogeneous (F_2) and homozygous-heterogeneous (mixtures) populations respresenting high genetic variability expressed relatively more stability over homozygous-homogeneous (parental) and heterozygous-homogeneous (F_1). populations. Three crosses namely P. Rai 1011 × RH 30, RH 7513 × RH 30 and RH 7513 × RLM 198 are the desirable crosses and can be used to develop lines with high stability.

Key words: Raya; Indian Mustard; Stability

INTRODUCTION

Wide adaptability is an important feature of an improved cultivar. It can be achieved either by individual buffering or by population buffering. A relationship has been found between the stability and degree of heterozygosity, but there are evidences which suggest that both are governed by the different genetic systems. Jones (1958) reported that single crosses were more stable than inbred lines, and double crosses than single crosses in maize. Chaudhary and Paroda (1979) reported that heterozygous-heterogeneous (F_2 and F_3) and homozygous-heterogeneous (mixtures) populations were more stable than homozygous-homogeneous (parental) and heterozygous-homogeneous (F_1) populations in wheat. Such type of studies are not reported in Indian mustard. Keeping this in view, an attempt has been made to find out the relationship of homogeneous (parental and F_1) and heterogeneous (F_2, F_3 and parental mixtures) populations in Indian mustard with their stability parameters.

MATERIAL AND METHODS

The experimental material consisted of 15 F_1s, 15 F_2s, 15 F_3s and 15 binary mixtures developed in a 5 × 3, line × tester system of mating and their eight parents, F_1 s of 15 crosses constituted heterozygous-homogeneous populations. F_2 and F_3 to these crosses constituted heterozygous-heterogeneous populations, whereas, parental mixtures represented the homozygous-heterogeneous populations. All these 56 populations were grown in a R.B.D. with two replications in eight pertinent environments. These environments were created with four levels of nitrogeneous fertilizer (0 kg, 50 kg, 100 kg, 150 kg N/ha) and two spacing (30 × 10 cm and 45 × 10 cm). Each populati-

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ons was grown in a single row of 6 m. The analysis was done for seed yield according to the analysis proposed by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Pooled analysis of variance (Table 1) revealed the presence of genetic variability in the material under investigation. Highly significant mean square due to environment (linear) indicated differences between environments and their considerable influence over the seed yield. Linear component of genotype-environment interaction was significant, therefore, prediction for most of the genotypes appeared to be feasible. Significance of pooled deviation indicated that population differed considerably with respect to their stability.

TABLE 1. Pooled analysis of variance for seed yield.

Source of Variation	d.f.	M.S.
Strains	67	199.32 **
Environments	7	2187.71 **
Strain × Env.	469	66.98 **
Env. + (Strain × Env.)	476	98.18 **
Env. Linear	1	15313.95 **
Strain × Env. Linear	67	81.83 **
Pooled deviation	508	63.56 **
Pooled error	536	9.54

**Significant at P = 0.01

Considering mean rank values of the linear response (regression coefficients) of the homogeneous populations (parents and F_1 s) and heterogenous populations (F_2s, F_3 s and mixtures), the homogeneous populations exhibited the highest response and the heterogeneous populations showed less response indicating that the homogeneous populations were less buffered especially to poor environment than the heterogeneous populations (Table 2).

The non linear response (deviation from regression coefficients) and their mean ranks were presented in Table 3. It became evident from the table that the heterogeneous populations had a better expression of stability than the homogeneous populations. Among the heterogeneous populations, F_2 populations representing maximum genetic variability due to segregation and recombination, appeared to be most stable, and therefore, revealed that heterozygous-heterogenous (F_2) populations had an clear advantage

TABLE 2. Regression Coefficients of Parents, F_1s, F_2s, F_3s and binary mixtures alongwith their ranking patterns.

Crosses	P_1	P_2	F_1	F_2	F_3	Mixture
P. Rai 1011 × RH 30	1.12 (5)	1.47 (6)	0.53 (2)	0.72 (4)	0.47 (1)	0.62 (3)
R.H. 7513 × RH 30	1.07 (4)	1.47 (6)	0.72 (3)	1.26 (5)	0.48 (2)	0.12 (1)
RLM 29 × RH 30	1.19 (2)	1.47 (4)	1.35 (3)	1.98 (6)	1.73 (5)	0.75 (1)
RLM 82 × RH 30	1.08 (3)	1.47 (4)	1.53 (5)	2.07 (6)	0.86 (2)	0.34 (1)
RLM 514 × RH 30	2.11 (6)	1.47 (4)	1.45 (3)	1.13 (2)	1.56 (5)	0.79 (1)
P. Rai 1011 × RLM 198	1.12 (4)	1.46 (5)	1.11 (3)	2.15 (6)	0.30 (1)	0.85 (2)
RH 7513 × RLM 198	1.07 (2)	1.46 (6)	0.16 (2)	0.67 (4)	-0.56 (1)	0.38 (3)
RLM 29 × RLM 198	1.19 (4)	1.46 (5)	0.85 (2)	0.68 (1)	1.47 (6)	1.16 (3)
RLM 82 × RLM 198	1.08 (2)	1.46 (5)	1.11 (3)	1.15 (4)	1.61 (6)	0.57 (1)
RLM 514 × RLM 198	2.11 (4)	1.46 (2)	2.10 (3)	1.15 (1)	1.46 (2)	1.46 (2)
P. Rai 1011 × Varuna	1.12 (4)	1.20 (5)	1.37 (6)	0.29 (2)	0.08 (1)	0.66 (3)
RH 7513 × Varuna	1.17 (4)	1.20 (5)	2.12 (6)	0.40 (3)	0.04 (1)	0.16 (2)
RLM 29 × Varuna	1.19 (3)	1.20 (4)	1.51 (6)	0.43 (1)	1.30 (5)	0.81 (2)
RLM 82 × Varuna	1.08 (4)	1.20 (5)	1.31 (6)	0.91 (3)	0.61 (2)	0.46 (1)
RLM 514 × Varuna	2.11 (5)	1.20 (4)	1.13 (3)	0.59 (6)	2.26 (6)	0.80 (2)
Mean Rank	3.73	4.67	3.73	3.27	3.07	1.87

Values in parenthesis indicate ranking of regression coefficient.

due to population buffering to exhibit relatively more stability over other populations like homozygous - homogeneous ($P_1 + P_2$), heterozygous-homogeneous (F_1) and homozygous-heterogeneous (mixtures) populations. Heterozygousity in F_1 did not appear to be of specific advantage for the better expression of stability. Therefore, superiority of F_2 populations, revealed that the maximum expression of genetic variability led to better expression of stability owing to population buffering. This was further supported as the mixed population had better stability in comparison to their parental and F_1 populations.

In the present study none of the cross has high yield with high stability. However, three crosses namely Pant Rai 1011 × RH 30, RH 7513 × RH 30 and RH 7513 × RLM 198 showed heterosis both for regression coefficient (b-value) and deviation from regression (S^2d) but these crosses are low yielder. These crosses also transmitted their high stability parameters to their offspring in F_2 and F_3, thus lines with high stability can be

TABLE 3. **Deviation from regression of parents, F_1s, F_2s, F_3s and mixtures alongwith their ranking pattern.**

Crosses	F_1	F_2	F_1	F_2	F_3	Mixtures
P. Rai 1011 × RH 30	23.59* (4)	87.90** (6)	4.62 (1)	23.15** (3)	32.96** (5)	10.38 (2)
RH 7513 × RH 30	33.29** (3)	87.90** (6)	12.73 (1)	16.58 (2)	44.96** (5)	41.49** (4)
RLM 29 × RH 30	18.04 (3)	87.90** (5)	107.52** (6)	74.40** (4)	9.95 (1)	13.34 (2)
RLM 82 × RH 30	69.05** (4)	87.90** (5)	30.54** (1)	59.03** (3)	137.08** (6)	31.22** (2)
RLM 514 × RH 30	93.86** (6)	87.90** (5)	37.85** (1)	39.10** (2)	86.97** (4)	81.20** (3)
Pant Rai 1011 × TLM 198	23.59** (4)	34.87** (5)	23.40* (3)	12.71 (1)	20.31* (2)	35.69** (6)
R.H. 7513 × RLM 198	33.29** (4)	34.87** (5)	32.55 (3)	4.60 (2)	144.01** (6)	−3.23 (1)
RLM 29 × RLM 198	18.04 (3)	34.87** (5)	30.10** (4)	4.61 (2)	94.91** (6)	1.29 (1)
RLM 82 × RLM 198	69.05** (4)	34.87** (3)	22.95** (2)	−3.29 (1)	119.96** (6)	78.92** (5)
RLM 514 × RLM 198	93.86** (5)	34.87** (2)	131.03** (6)	27.85** (1)	53.52** (4)	38.23** (3)
P. Rai 1011 × Varuna	23.59* (2)	44.08** (4)	229.23** (6)	105.36** (5)	27.06** (3)	9.83 (1)
RH 7513 × Varuna	33.29** (4)	44.08** (5)	432.94** (6)	20.30* (3)	13.41 (2)	−0.12 (1)
RLM 29 × Varuna	18.04 (1)	44.08** (5)	19.78 (2)	36.80** (4)	86.89** (6)	24.12* (3)
RLM 82 × Varuna	69.05** (6)	44.08** (4)	17.29 (2)	16.86 (1)	59.71** (5)	36.74** (3)
RLM 514 × Varuna	93.86** (5)	44.08** (3)	126.65 (6)	37.39** (2)	74.05** (4)	28.49** (1)
Mean Rank	3.87	4.53	**3.33**	**2.40**	4.33	2.53

Value in parenthesis indicates ranking of the S^2di

developed. Whereas five crosses namely RLM 29 × RH 30, RLM 514 × RLM 198, RH 7513 × Varuna, RLN 29 × Varuna and RLM 514 × Varuna exhibited heterosis and better mean performance in F_2 and F_3 generations but with poor stability. These crosses can be utilised to develop pure lines with high yield. Gupta *et al.* (1983) reported that determination of stability of performance was under a separate genetic control. Therefore, in the present material, lines thus developed with high mean and lines with high stability can be utilised to develop lines, with high mean and high stability by *inter se* crossing.

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INHERITANCE OF FREE FATTY ACIDS IN INDIAN MUSTARD

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ABSTRACT

Nine genotypes of Indian mustard representing a wide spectrum with respect to morphological and biochemical attributes were crossed in half diallelic fashion to study the inheritance of free fatty acids. Both additive and non-additive genetic components were observed to be operative for its inheritance. Three parents namely, RH-30, RH-785 and RH-780 showed the significant negative (desirable) gca effects and use of these parents in future breeding programme is advocated. 10 cross combinations were isolated possessing the desirable negative sca effects for free fatty acids. Selection in early segregating generations for high-yield and low free fatty acids could be most appropriate for simultaneous exploitation of additive and non-additive genetic components.

Key words : Inheritance; Combining ability; Genetic architecture; Indian mustard

INTRODUCTION

Indian mustard (*Brassica juncea*, L. Czern & coss) is an important oil yielding crop among the oilseeds grown in India, China and Pakistan. But the excess amount of free fatty acids in its oil, affects the keeping quality. These free fatty acids undergo autoxidation at the point of unsaturation and are degraded into lower fatty acids resulting into rancidity of oil. These free fatty acids are produced as a result of hydrolysis of triglycerides by lipase enzyme under adequate moisture and temperature. Therefore, we need to have a genotype possessing lesser amount of free fatty acids ($<1\%$ in oil). But, unfortunately no systematic efforts have been made to know the nature and magnitude of genetic components involved in the inheritance of free fatty acids in Indian mustard. The present study was attempted to have a look into the genetic architecture of free fatty acids, which would facilitate the choice of superior parents and in the formulation of an effective and efficient breeding methodology suited for Indian mustard.

MATERIALS AND METHODS

Nine genotypes namely: RH-30, Prakash, yellow rai K-1, RH-785, RC-1426, RC-1425, RH-780, RC-423 and RC-781 of Indian mustard (*Brassica juncea*, L. Czern and Coss) grown at the farm of Haryana Agricultural University, Hissar were utilized to hybridize in all possible combinations (excluding reciprocals). Thirtysix F_1s alongwith the 9 parents were grown in a R.B.D. consisting of three replications. Each progeny represented by a single row of 6 m with 15 cm plant to plant distance. 45 cm space was kept between the rows. At the time of maturity, bulk seed sample of each progeny was collected from all the replications to have the estimation of percentage free fatty acids as per specification outlined in AOAC (1961).

The data recorded for free fatty acids were subjected to angular transformation for further statistical analysis. Combining ability variances and effects were estimated

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TABLE 1. Mean values of parents (diagonal) and F_1 crosses (above diagonal) with respect to free fatty acids in Indian mustard.

Parents	RH_{-30}	Prakash	Yellow Rai K_{-1}	RH_{-785}	RC_{-1426}	RC_{-1425}	RH_{-780}	RC_{-423}	RC_{-781}
RH_{-30}	0.467	0.510	0.467	0.510	0.523	0.517	0.507	0.653	0.513
Prakash		0.513	0.510	0.603	0.513	0.507	0.467	0.447	0.550
Yellow Rai K_{-1}			0.547	0.510	0.523	0.517	0.560	0.653	0.463
RH_{-785}				0.567	0.610	0.580	0.560	0.513	0.463
RC_{-1426}					0.453	0.550	0.547	0.510	0.523
RC_{-1425}						0.510	0.543	0.637	0.443
RH_{-780}							0.550	0.596	0.587
RC_{-423}								0.537	0.527
RC_{-781}									0.450

as per method suggested by Griffing (1956) method 2 model 1. The estimation of genetic components alongwith different ratios was done as per Hayman (1954).

RESULTS AND DISCUSSION

The analysis of variance for simple R.B.D. indicated the presence of sufficient amount of genetic variability with respect to free fatty acids among the progenies under study. The mean values pertaining to parents and crosses have been presented in Table 1. Before the analysis of diallel cross is carried out it is very much desirable to test the assumptions underlying this technique i.e. test for homogenity of arrays and regression coefficient test for Wr. Vr against unity. Non-significant values recorded for both these tests indicated that further analysis can be carried out reliably.

The estimates of genetic components with respect to free fatty acids have been presented in table 2. The additive genetic component (D) and dominance component (H_1) were significant. However, the magnitude of H_1 was much higher than the corresponding D component indicating thereby the preponderance of non additive genetic component for the inheritance of free fatty acids in Indian mustard. The ratio $(H_1 / D)^{1/2}$ which measures the degree of dominance also showed the presence of over dominance. The symmeterical distribution of positive and negative alleles in parents given by ratio $H_2/4H_1$, was observed to be deviating from the theoretical value (0.25), thereby indicating the asymmeterical distributions of alleles in parents. The ratio $(4DH_1)^{1/2} + F/(4\ DH_1)^{1/2}$-F, measuring the proportion of dominant and recessive genes in parents, indicated that for every one recessive gene there were three dominant genes involved for the inheritance of free fatty acids in Indian mustard. The ratio h^2/H_2, which measures the number of alleles or allele group exhibiting dominance was observed to be very low. This might have been under estimated because of the presence of complementary interaction (Mather and Jinks, 1971) or due to the asymmeterical distribution of positive and negative alleles in parents. The lower value recorded for the ratio indicated that no valid interpretation about gene groups exhibiting dominance could be made. The heritability (n.s.) was of lower order.

TABLE 2. Estimates of genetic components and their ratios for free fatty acids in Indian mustard.

Components	D	H_1	H_2	h^2	F	E
	0.0098*	0.0035*	0.0205	0.0050	0.0152	0.004
	±0.0031	±0.0067	±0.0058	±0.0039	±0.0071	±0.0010

Contd :-

Ratios	$(H_1/D)1/2$	$H_2/4H_1$	$\frac{(4DH_1)1/2+F}{(4DH_1)1/2-F}$	h^2/H_2	Heritability (N.S.)
	1.70	0.18	2.67	0.23	39.68

* denotes significance at P — 0.05

The mean sum of squares due to general and specific combining ability were significant for the characters under study (Table 3). Since the mean squares due to general and specific combining ability do not provide the clear picture regarding the relative magnitude of additive and non-additive genetic component, therefore, the unbiased variances due to both general (6^2g) and specific (6^2s) combining ability alongwith the ratio $6^2s/6^2g$ were calculated. The magnitude of 6^2s was approximately 9 times higher than the corresponding 6^2g revealing thereby the preponderance of non additive genetic components.

TABLE 3. Analysis of variance for combining ability with respect to freefatty acids in Indian mustard.

Source	d.f.	Mean sum of squares
General combining ability	8	0.0078 *
Specific combining ability	35	0.0060 *
Error	88	0.00045
6^2g	0.0067	
6^2s	0.00575	
$6^2s/6^2g$	8.58	

* denotes significance at P = 0.05

The excess amount of free fatty acids in mustard oil reduces its keeping quality, therefore, parents or cross combinations possessing negative gca or sca effects, respectively would be most desirable. Three parents namely, RH-30, RH-785 and RH-780 showed significant negative gca effects (Table 4). Use of these parents in future breeding programme is advocated. Three parents selected on the basis of gca effects and array means were the same but were different when selected on the basis of gca effeccts and *per se* performance, therefore, array means could effectively be utilized to isolate the desirable parents.

Out of 36 crosses under study, only 10 crosses namely, RH-30 × Yellow rai K-1, RH-30 × RC-1425, Prakash × Yellow rai K-1, Prakash × RC-1425, Prakash × RH-780, Prakash × RC-781, RH-785 × RC-1425, RC-1426 × RH-780, RC-1426 × RC-423 and RC-1426 × RC-781 exhibited negative significant sca effects. The highest negative sca effects were recorded for cross combination Prakash × RC-1425. It was also observed that ranking of cross combinations on the basis of *per se* performance and effects were not same or in other words crosses having high *per se* performance did not necessarily have high sca effects. Since *per se* performance is a realized value whereas sca affect is an estimate, measured as the deviation of F_1 over parental performance.

TABLE 4. **Estimates of general (diagonal) and specific (above diagonal) combining ability effects with respect to free fatty acids in Indian mustard.**

Parents	RH_{-30}	Prakash	Yellow Rai K_{-1}	RH_{-785}	RC_{-1426}	RC_{-1425}	RH_{-780}	RC_{-423}	RC_{-781}
RH_{-30}	-0.031*	0.046*	0.095*	0.039	0.090*	0.063*	0.007	0.048	0.035
Prakash		-0.011	-0.154*	0.106*	0.007*	0.046*	-0.079*	0.039	-0.085*
Yellow rai K_{-1}			0.017*	-0.042	-0.024	-0.011	0.033	0.148*	0.150*
RH_{-785}				-0.023*	-0.004	-0.051*	0.070*	0.010*	-0.033
RC_{-1426}					0.045*	0.020	-0.049*	-0.064*	0.012
RC_{-1425}						0.028*	-0.002	0.023	-0.058*
RH_{-780}							-0.019*	0.007	0.066
RC_{-423}								0.013*	0.034
RC_{-781}									0.015*

S.E. (gi) = 0.006 S.E. (gi-gj) = 0.009 S.E. (sij-sik) 0.028

*denotes significance at P = 0.05

Therefore, sca effects for a particular cross may be low or high. It was concluded from the present study that sca effects may not always lead to the correct choice of cross combination and, therefore, the selection of a particular cross combination on the basis of *per se* performance seems to be more reliable.

The combining ability and genetic component analysis have shown the preponderance of non-additive genetic variance (non fixable) towards the inheritiance of free fatty acid in Indian mustard. However, the importance of additive (fixable) genetic variance can not be ruled out. Therefore, a breeding methodology utilising the fixable and non-fixable components of genetic variances would be most desirable for the further enhancement of genetic material in hand. It seems that selection in early segregating generations for high yield and low free fatty acid could be most appropriate for the simultaneous exploitation of additive and non-additive genetic components.

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PRELIMINARY INVESTIGATIONS ON SOME CHEMICAL CONSTITUENTS OF POD SHEEL IN RELATION TO RESISTANCE OF GROUNDNUT CULTIVARS AGAINST TERMITES

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ABSTRACT

Twenty one cultivars of groundnut were selected for biochemical analysis of shell flour of pods to study the varietal differences in cultivars - Susceptible and resistant to termites, *Microtermes* and *Odontoterms* sp. infestation. Crude fibre, showed positive correlation with termite damage (%) .Fat and starch contents varied from 1 to 6% and 3 to 11% respectively but were insignificantly correlated to termite damage. The contents of eight minerals - K, Na, Mg, Ca, Fe, Cu, Mn and Zn were estimated and zinc and manganese showed negative relationship with termite damage.

Key words : Biochemical components ,*Arachis hypogea*, termite damage, susceptibility.

INTRODUCTION

Termites of the genera *Micotermes* sp. and *Odontotermes* sp. are the major soil pests in India and Africa. These may cause 5-50% economic loss in groundnut in India (Kushal and Deshpande, 1967). The aspects of biology, crop loss and chemical control of termites were studied in detail by other researchers. Termite control is at present largely dependent of the use of chemicals. The chemical factors involved in imparting resistance to host plants in relation to insect damage were established in other crops by many scientists. Beck (1956) showed the influence of nutritional factors on larval development of European corn borer *Pyrausta nubilalis*. Tingey (1985) reviewed the contribution of biochemical components gainst Cicadellidae in cotton, soybean and potato.

The work on the role of chemical constituents in groundnut resistance to termite infestation is scanty. Therefore, an attempt was made to estimate some chemical constituents of pod shells of 21 groundnut cultivars.

MATERIAL AND METHODS

Groundnut varieties ranging from highly susceptible to highly resistant were grown in the field during 1982-83 in *Kharif* season at ICRISAT centre Patancheru, A.P. The cultivars were planted in 4 rows of 4 m long with 60 cm × 15 cm spacing in 3 replications. The pods of approximately same maturity were selected. They were sun dried and shelled seeds were removed. Pod shells were kept in oven at 60°C for 24 hrs to remove moisture. They were ground in willy mill and sieved through 40 mesh. The pod shell flour was kept in air tight polythene bags and used for various chemical analysis.

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The crude fibre and lignin contents were estimated by acid and alkali hydrolysis as described in A.O.A.C. (1965). The method of Dubois *et al.* (1965) was followed for starch estimation. The oil content was determined by Shoxlet method.

The major and minor elements namely calcium (Ca), magnessium (Mg), potassium (K), sodium (Na), Zinc (Zn), manganese (Mn), iron (Fe) and copper (Cu) were estimated in an Atomic Absorption Spectrophotometer AA 1200 (Piper, 1966).

RESULTS AND DISCUSSION

Crude fibre indicated the amount of cellulose present in the peanut hulls. All susceptible varieties namely TMV-2, Robut 33-1, NcAc 2232, NcAc 2144 showed high crude fibre content (Table 1). Resistant varieties namely RMP-40 and Ah-7663 possessed less amount of crude fibre in hulls. The correlation coefficient (r=0.61) of crude fibre with termite attack (Table 2) was significant. As termites are cellulose eating insects they might prefered the varieties of high fibre content.

The values obtained for lignin were in accordance with those reported by Albrecht (1979). Like crude fibre lignin also showed positive significant correlation (r =0.55) with termite damage. The high lignin content of pod shells of susceptible cultivars might be associated with the wood eating habit of termites; otherwise lignin is supposed to confer resistance to plants from the attack of leaf hoppers, leaf defoliators and stem borers.

The correlation coefficient of oil content (r = 0.45) to termite damage was not significant. The resistant cultivars RMP 40, NcAc 2230 and NcAc 17888 showed high oil content while TMV-2, Robut 33-1, GNL and NcAc 2214 (Susceptible) showed less oil content. A clear trend was however, not found across varieties whereas Akhtar & Jabeen (1983) reported antitermite effect of essential oils.

Starch ranged from 3-11% and no significant correlation with termite damage was observed. Similar results were reported by Pandey and Pandey (1984).

The ash content was found to be 2-7 % depending on the amount of various minerals present in hulls. The mineral content. (Table 3) indicated that potassium and calcium were relatively dominant, while zinc and manganese were in very low levels. NcAc 22407 a highly resistant cultivar, showed low percentage of manganese and relatively high percentage of zinc. Magnessium, sodium and calcium did not vary significantly between the cultivars of groundnut. Collins and Post (1981) estimated minerals in toasted peanut hulls and the present values tally generally with those estimates.

In order to determine the correlation between these minerals and termite damage (%) of the cultivars a stepwise linear regression analysis was done (Table 4). The most significant variable was manganese followed by zinc, copper and iron respectively. The element - Mg, Na, K and Ca did not seem to contribute significantly to the termite damage of pods.

TABLE 1. Estimation of chemical components in pod shell flour of 21 cultivars of groundnut.

S.No.	Cultivar	Termite damage(%)	Fat (%)	Starch (%)	CF (%)	Lig (%)	Ash (%)
1.	NC Ac 2230	8.8	6.80	7.20	65.56	33.40	3.89
2.	NC Ac 343	3.1	2.00	7.70	60.07	25.72	5.33
3.	NC Ac 2243T	3.2	2.40	4.91	65.27	29.65	4.14
4.	M 13	8.1	4.10	5.29	63.97	24.63	5.87
5.	NC Ac 17880	7.6	6.70	11.25	73.00	36.49	6.47
6.	RMP 40	5.5	8.25	11.25	48.21	19.57	7.32
7.	ICG 885	6.1	3.20	6.30	60.76	—	7.35
8.	TMV 2	32.5	1.45	4.10	70.05	34.75	2.97
9.	NC Ac 2144	22.4	1.95	5.85	70.53	31.10	6.49
10.	NC Ac 2242	17.1	1.95	6.86	70.97	32.29	3.24
11.	Robut 33-1	27.5	1.18	4.28	74.07	33.12	2.69
12.	NC Ac 1709	12.9	1.08	3.62	67.42	29.73	4.60
13.	NC Ac 10033	2.6	2.50	5.06	66.94	25.23	2.68
14.	NC Ac 7215	12.34	2.00	7.76	65.56	23.27	6.82
15.	GNL	27.5	1.77	7.15	74.28	29.98	—
16.	NC Ac 2240B	5.7	—	7.99	—	—	—
17.	NC Ac 2124	13.0	—	8.55	70.96	28.91	—
18.	NC Ac 2240T	0.5	—	10.80	—	—	—
19.	FESR 386	5.7	—	9.45	66.43	28.73	—
20.	NC Ac 2232	20.5	—	8.21	70.07	33.49	—
21.	Ah 7663	3.47	—	—	48.80	20.04	—
	G. Mean	11.77	3.16	7.18	66.05	28.85	4.92
	S. Em.	5.13	±0.03	±0.29	+2.05	±1.07	±2.57
	CV %	23.91	1.0	4.1	0.3	3.7	5.2

CF = Crude fibre; Lig = Lignin

TABLE 3. Mineral content in the pod shells of *A. hypogaea* and % termite damage recorded in 21 groundnut cultivars.

S.No.	Cultivar	Content of minerals in shells							
		Fe	Cu	Zn	Mn	Ca	Mg	Na	K
		ppm				%			
1.	GNL	825.00	19.30	24.00	42.50	0.45	0.15	0.27	1.25
2.	NC Ac 2142	600.00	19.30	21.00	30.50	0.56	0.11	0.21	1.30
3.	FESR 386	720.00	11.30	15.00	36.00	0.29	0.13	0.15	1.50
4.	NC Ac 2240T	530.00	11.30	21.00	34.50	0.31	0.11	0.18	1.12
5.	NC Ac 2240B	430.00	10.00	16.50	34.00	0.30	0.10	0.15	1.32
6.	NC Ac 2232	875.00	24.00	29.50	37.00	0.35	0.09	0.20	1.17
7.	Ah 7663	575.00	19.30	20.00	30.00	0.31	0.10	0.16	1.61
8.	TMV 2	688.21	8.51	9.56	74.40	0.36	0.13	0.07	0.53
9.	M—13	664.18	9.31	18.09	38.63	0.38	0.27	0.18	1.03
10.	NC Ac 10033	780.00	9.47	17.19	42.79	0.41	0.18	0.06	1.31
11.	NC Ac 2243T	846.35	11.11	18.51	42.93	0.36	0.17	0.15	1.03
12.	NC Ac 7215	859.38	8.63	18.84	56.71	0.30	0.19	0.06	1.62
13.	NC Ac 2242	707.11	8.81	8.65	36.15	0.33	0.17	0.19	0.45
14.	Robut 33—1	635.16	7.77	15.86	53.54	0.30	0.12	0.06	0.45
15.	NC Ac 2230	1028.21	10.40	24.62	56.47	0.66	0.19	0.10	0.70
16.	NC Ac 2144	797.29	9.33	24.74	40.06	0.46	0.20	0.14	1.14
17.	NC Ac 17880	848.41	9.35	26.04	44.12	0.47	0.23	0.10	1.49
18.	PMP 40	584.19	8.27	30.07	40.94	0.34	0.25	0.07	1.64
19.	ICG 885	742.10	9.46	22.79	48.48	0.43	0.26	0.11	1.76
20.	NC Ac 343	715.41	10.03	24.20	58.37	0.31	0.17	0.06	1.43
21.	NC Ac 1705	693.41	8.05	12.79	39.88	0.39	0.17	0.08	0.84
	Mean	726.16	11.49	19.95	43.89	0.38	0.16	0.12	1.21
	SEmt	30.94	1.71	1.53	1.82	0.05	0.31	0.29	0.21
	CV %	6.02	21.07	10.84	5.87	20.62	26.53	32.49	24.90

TABLE 2. Correlation and regression analysis of chemical components in pod shell flour of 21 *groundnut cultivars and* % *termite damage.*

Variable	*Correlation* coefficient	Standard error of estimate	Regression equation
Crude fibre	0.61**	0.243	-38.1 - 0.771 X
Lignin	0.55*	0.398	-17.3 - 1.0 X
Starch	-0.40	0.875	24.64 - 1.643 X
Fat	-0.45	1.080	19.60 - 1.99 X
Ash	-0.34	1.48	21.71 - 1.91 X

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

TABLE 4. Stepwise linear regression analysis of pod shell minerals and % termite damage in 21 cultivars of groundnut.

	Regression (coefficients)	Standard error
Constant	-12.120	6.040
Mn	0.72*	6.040
Zn	-0.467 *	0.160
u	0.720	0.220
Fe	70 017	0.007

* Significant at P = 0.05

The termite damage appeared to be negatively correlated with zinc while manganese was positively correlated to termite damage. Slama and Sharlby (1973) reported deterrent feeding effect of zinc on the larvae of *Spodoptera littoralis* Boised. It is evident that zinc produce deleterious effect on insect feeding and therefore, termites may eat the varieties of groundnut containing more zinc content.

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EFFICACY AND ECONOMICS OF SOME MANAGEMENT PRACTICES OF FUNGAL DISEASES OF GROUNDNUT

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ABSTRACT

Carbendazim plus TMTD seed treatment protected the seed and seedling diseases and reduced leaf spots and rust of groundnut. Similarly, spray applications of carbendazim plus mancozeb substantially reduced the foliar diseases and protected the plants from the soil-borne pathogens causing delayed mortality. Phosphorus as super phosphate (16%P) at 40 kg/ha reduced the late mortality due to *Macrophomina phaseolina* and to some extent foliar diseases. Reduce diseased levels due to all the three management strategies resulted in improved yields and the cost-benefit ratios were high in two spray treatment over four spray applications.
Key words: Management practices on diseases, Leaf spots; Rust

INTRODUCTION

Fungal diseases of groundnut; seed and plant mortality induced by *Aspergillus niger*, *Sclerotium rolfsii*, *Macrophomina phaseolina*, rust (*Puccinia arachidis*) *and* leaf spots (*Cercospora arachidicola* and *Phaeoisariopsis personata*) are of economic significance in many groundnut growing areas of the country (Subrahmanyam *et al.*, 1980). Individual foliar fungal diseases can be controlled by fungicidal sprays (Mayee and Beheti, 1983; Mayee *et al.*, 1985 b; Sondage *et al.*, 1985) and by addition of phosphatic fertilizers (Mayee *et al.*, 1985 a). Seed and soil-borne diseases can be avoided by chemical seed treatment (Mayee *et al.*, 1985 a). The present study was undertaken with a view to finding out the efficicacy and economics of different management practices either alone or in combination.

MATERIALS AND METHODS

Effects of seed treatment, spray application and addition of phosphatic fertilizer at three levels (Table 1) were tested on the development of various diseases of groundnut in a field experiment during rainy season of 1984 and 1985. The residual levels of phosphorus in top 15 cm of soil in the experimental field was 30 kg total P/ha. Carbendazim + TMTD (2 g each/kg seed) and carboxin + TMTD (2 g each/kg seed) along with untreated control were compared as seed treatment. Carbendazim (0.05%) + mancozeb (0.2%) tank mixture was sprayed two and four times at 12 days interval beginning from 35 days after planting. Three levels of phosphorus (0, 40 and 80 kg/ha) were administered in the form of single superphosphate by broadcasting the total quantity in respective plots prior to sowing. Groundnut variety JL-24 (highly susceptible to all the diseases) was grown under standard grower's practices except for the P treatments at O, 40 and 80 kg/ha in the respective plots of these treatments.

The combination of 27 treatments including suitable controls were arranged in 3^3 partial confounding design (Cox, 1958) with two replications. Individual plots measured 4.5 m × 4.5 m spaced at 30 cm × 15 cm with a 3.9 m × 4.2 m segment within each plot for observations.

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Rust and leaf spots inoculations were performed between 25 and 27 days after planting as per the procedure described earlier (Ghuge *et al.*, 1981; Sondge *et al.*, 1985). The experiment was taken on a plot where high incidences of *S. rolfsii*, *A. niger* and *M. phaseolina* were recorded in two previous seasons. Observations were recorded on emergence, final plant stand, total green leaves retained by the plant. The severity of rust and leaf spots was evaluated as per the per cent severity chart (Subrahmanyam *et al.*, 1983) on twenty random plants in each plot. Average apparent infection rates were calculated according to the logistic equation of Vanderplank (1963). The plots were harvested 107 days after planting and the dry pod yield, 100-kernel weight and remaining food weight recorded.

RESULTS

Foliar spray applications of carbendazim and mancozeb reduced rust and leaf spot severities and brought down their epidemic progress from 0.089 units per day to 0.045 units per day for rust and from 0.065 to 0.045 units per day for leaf spots. Phosphorus addition to soil at 80 kg/ha decreased severity of both diseases and seed treatment reduced rust but not leaf spots (Table 1). Phosphorus application and spray treatments

TABLE 1. Management practices in relation to disease severities on groundnut cv. JL--24.

Treatment	Disease evaluation				
	Final Rust Severity (%)	Final Leaf spot Severity (%)	Mortality[1] (%) (7 DAP)	Mortality[2] (%) (102 DAP)	Compound leaves/plant (102 DAP)
I. Seed Treatment					
Control	59.2^{d}	37.5^{bc}	22.9^{b}	6.7^{d}	11.9^{b}
Carbendazim+TMTD	55.2^{c}	36.4^{b}	16.0^{a}	2.4^{b}	12.2^{b}
Carboxin+TMTD	56.5^{c}	38.4^{bc}	25.3^{c}	2.3^{ab}	9.7^{b}
II. Phosphorus Addition					
Control	59.5^{d}	39.2^{c}	20.4^{b}	5.0^{b}	11.3^{b}
P 40 kg/ha	57.9^{d}	38.8^{c}	20.9^{b}	4.3^{bc}	11.5^{b}
P 80 kg/ha	53.8^{c}	34.4^{b}	23.0^{b}	1.6^{ab}	11.0^{b}
III. Spray Application					
Control	88.7^{e}	52.0^{d}	22.1^{b}	6.2^{d}	5.8^{a}
Two-spray	44.6^{b}	34.0^{b}	21.4^{b}	2.4^{ab}	10.8^{b}
Three-spray	38.0^{a}	26.0^{a}	21.1^{a}	0.8^{a}	17.3^{c}

[1]due to *Sclerotium rolfsii* and *Aspergillus niger*

[2]due to *Macrophomina phaseolina* (*Fusarium* sp. occasionally present)
(DAP refers to days after planting)

did not influence the early pre and post-emergence mortality due to *Sclerotium rolfsii* and *Asperigillus niger* but markedly reduced the mortality occurring late in the season mainly due to dry stem rot induced by *Macrophomina phaseolina*. Carbendazim + TMTD treatment was highly effective in preventing the early mortality. Retention of green foliage at harvest was more in foliar spray but not in others.

TABLE 2. Influence of management practices on the yield and economics of groundnut cv. JL-24.

	Treatment	Yield		Cost: Benefit Ratio
		100-kernel weight (g)	Pod yield (kg/ha)	
I	Seed Treatment			
	Control	34.5[b]	1309[b]	
	Carbendazim + TMTD	35.5[b]	1430[b]	1:4.6
	Carboxin + TMTD	35.3[b]	1405[b]	1:3.8
II	Phosphorus Addition			
	Control	34.5[b]	1373[b]	
	40 kg P/ha	35.5[b]	1373[b]	1:1.5
	80 kg P/ha	35.9[b]	1379[b]	1:0.9
III	Spray Application			
	Control	31.4[a]	1063[a]	
	Two-sprays	34.7[b]	1416[b]	1:5.5
	Four-sprays	39.3[c]	1665[c]	1:4.4

From the data in Table 2, it is observed that spray treatments significantly enhanced the pod yield and 100-kernel weight. Increases in pod yield in seed treatments and added phosphorus plots over their respective controls were not significant. Highest pod yield was obtained in four-spray treatment which was superior to two-spray treatment. The interactions between seed treatment, phosphorus application and sprays were not significant. The treatments were cost efficient except with phosphorus at 80kg/ha. Highest cost benefit ratio (1:5.5) was obtained in two-spray schedule followed by seed treatment with carbendazim + TMTD (1:4.6).

DISCUSSION

Disease management technology in groundnut is fairly well developed in recent years but emphasis has been on the use of fungicidal chemicals (Mayee *et al.*, 1985 a). Carbendazim, carboxin and thiram (TMTD) are recommended for seed treatments aga-

inst seed and soil-borne disease while spray application for control rust and leaf spots are highly economical (Mayee *et al.*, 1985 b; Sondge *et al.*, 1985). Phosphorus application is beneficial for reducing foliar diseases (Mayee *et al.*, 1985 a). The present study support these finding and highlights the supplementary utility of seed treatments in protection against foliar diseases and phosphorus and spray applications in protection against the seed and soil-borne diseases. The influence of phosphorus in the present study appeared less pronounced than was earlier (Mayee et *al.*, 1985 a) may be because of high levels of initial phosphorus. The interactions between the management factors could not be observed. Although this calls for more sustained studies with longer time series data, it indicates that adoption of any one strategy in the resource constraint management shall give maximum returns.

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CORRELATION BETWEEN YIELD AND YIELD COMPONENTS IN SESAME

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ABSTRACT

Correlation between yield and six other characters *viz.*, days to 50 per cent flowering, days to maturity, plant height, branches per plant, capsules per plant and 1000 seed weight was studied in 125 variants (25 parents and 100 hybrids) of sesame (*Sesamum indicum L.*) Three characters *viz.*, plant height, number of branches per plant had highly significant and positive correlation with yield. They also had significant and positive intercorrelation among themselves. As such, improvement of these three important component characters by proper choice of parents and hybridization and simultaneous improvement of these characters by adopting recurrent selection technique would result in the improvement of yield in sesame in the materials studied.

Key words : Correlation; Yield components; Sesame; *Sesamum indicum* L.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the important oilseed crops. It is rich in oil (53.53 per cent) and protein (26.25 per cent). Sesame oil is noted for its stability and quality. Though India occupies first place in area of this crop with 25 lakhs hectares (39.5 per cent of world area), it stands only second in production with 5 lakhs tonnes of seeds (24 per cent in world production) as per FAO statistics (Anon., 1983). The reason for low production in India is mainly due to the low per hectare yield.The average per hectare yield of this crop in India is only 200 kg while the world average per hectare yield is 329 kg. So, production of this important oilseed crop has to be stepped up by evolving high yielding varieties. For evolving high yielding varieties, the plant breeders must know the relationship between yield contributing characters and their association with yield. With this main objective, correlation study was taken up in sesame.

MATERIALS AND METHODS

A total of 20 lines (female parents) of different geographical origin and 5 testers (male parents) of high yielding and well adapted varieties of sesame (Table 1) were crossed in a line × tester model during February to May, 1983 to generate materials with wide variability. The 25 parents and the 100 hybrids (totally 125 variants) were raised in R.B.D. with three replications during July to October, 1983 at Oilseeds Experiment Station, Tindivanam. The meterials were studied for seven characters *viz.*, days to 50 per cent flowering, days to maturity, plant height, branches per plant, capsules per plant, 1000 seed weight and yield per plant for finding out the correlation of various characters with yield.

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TABLE 1. Name and Origin of sesame lines

	Name of the material	Type No.	Origin	Code No. given for easy reference
1.	Malun-3028	Si. 53	Burma	L1
2.	Nagpur white	Si. 66	Nagpur	L2
3.	Sambalpur	Si. 71	Sambalpur	L3
4.	Patna	Si. 242	Patna	L4
5.	Gaya	Si. 244	Gaya	L5
6.	Jessore Dacca	Si. 251	Pakistan	L6
7.	Sajjankonda-Faridpur	Si. 255	Dacca	L7
8.	Mukurdi Nigeria-I	Si. 770	Nigeria	L8
9.	Hannet-Burma E-27-47	Si. 972	Hannet	L9
10.	Dusi	Si. 1159	Dusi	L10
11.	Si. 244/2	Si. 1225	Japan	L11
12.	Oss. 117/1 Killeis	Si. 1248	Greece	L12
13.	S.R.S. Karimnagar No. 180	Si. 1460	Mysore	L13
14.	E.C. 20765 No. 1	Si. 1484	Sudan	L14
15.	Bombay S. 23	Si. 1669	Bombay	L15
16.	U.S.A.	Si. 1770	U.S.A.	L16
17.	Type-13	Si. 2176	Kanpur	L17
18.	Till No. 1	Si. 3115	Ludhiana	L18
19.	R.T. 1	Si. 3214	Assam	L19
20.	68/20	Si. 3296	Andhra Pradesh	L20
21.	TMV 2	TMV 2	Tamil Nadu	T 1
22.	TMV 3	TMV 3	Tamil Ndau	T 2
23.	TMV 4	TMV 4	Tamil Nadu	T 3
24.	TMV 5	TMV 5	Tamil Nadu	T 4
25.	TMV 6	TMV 6	Tamil Nadu	T 5

RESULTS AND DISCUSSION

The data on days to 50 per cent flowering, days to maturity, plant height, branches per plant, capsules per plant, 1000 seed weight and yield per plant were analysed statistically and found to be highly significant. The range and mean of the 125 variants for the characters studied are presented in Table 2. Wide variability was noticed among

TABLE 2. Range and mean of the 125 variants for the characters studied

	Particulars	Characters studied						
		Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Branches per plant	Capsules per plant	1000 seed weight (g)	Yield per plant (g)
1.	Range	40.00–52.33	85.00–95.66	77.36–135.13	2.06–11.46	32.93–107.66	2.13–3.50	1.73–9.60
2.	General mean	47.63	93.55	116.81	7.63	78.22	2.75	6.41
3.	S.E.	0.64	0.87	3.29	0.92	9.44	0.23	1.22
4.	S.E.D.	0.91	1.24	4.66	1.30	13.35	0.32	1.73
5.	C.D.	1.78	2.43	9.13	2.55	26.16	0.63	3.39

the materials studied for all the haracters. Days to 50 per cent flowering ranged from 40 (L 18) to 52.33 (T1). Days to maturity ranged from 85 (L18) to 95.66 (L11 × T2). Plant height ranged from 77.36 cm (L18) to 135.13 cm (L19 × T5). Branches per plant ranged from 3.06 (L15) to 11.46 (L9 × T2). Capsules per plant ranged from 32.93 (L15) to 107.66 (L3 × T3). The 1000 seed weight ranged from 2.13 grams (L10 × T5) to 3.50 (L16 × T3). Yield per plant ranged from 1.73 grams (L15) to 9.60 grams (L20 × T4). Since there is wide variability among the different characters there is scope for selection in the materials for improving the different characters. The characters which are positively or negatively correlated to yield should be known to the breeder so as to select the good materials and to reject the unwanted materials. Therefore, correlation between yield and other characters was worked out (Table 3).

TABLE 3. Correlation Coefficient of yield and yield components

	Days to 50% flowering	Days to maturity	Plant height (cm)	Branches per plant	Capsules per plant	1000 seed weight (g)	Yield per plant (g)
Days to 50% flowering	—	0.4613*	0.3147*	0.1486	0.0949	–0.0624	0.0385
Days to maturity		—	0.3997**	0.1423	0.2066*	0.0783	0.0402
Plant height (cm)			—	0.3496**	0.5688**	0.0059	0.5949**
Branches per plant				—	0.7307**	0.0963	0.5344**
Capsules per plant					—	0.0936	0.6908**
1000-seed weight (g)						—	0.1092

* Significant at P = 0.05

** Significant at P = 0.01

Days to 50 per cent flowering had significant and positive correlation with days to maturity and plant height. Days to maturity had significant and positive correlation with days to 50 per cent flowering, plant height and capsules per plant. Plant height had significant and positive correlation with days to 50 per cent flowering, days to maturity, branches per plant, capsules per plant and yield per plant. Shrivas and Singh (1978) reported similar results in sesame. Branches per plant had significant and positive correlation with plant height, capsules per plant and yield per plant. Similar results were reported in sesame by Sikka and Gupta (1949). Capsules per plant had significant and positive correlation with days to maturity, plant height, branches per plant and yield per plant. Capsules per plant had high correlation with yield according to Krishnamurthy *et al.* (1964). In the present study, 1000 seed weight had no significant and positive association with yield and other characters. As such, 1000 seed weight did not seem to be a decisive factor for determining yield in sesame in the materials studied. Varisai Muhammed and Stephen Dorairaj (1964) reported that among capsule number, capsule size and 1000 seed weight, the character 1000 seed weight did not seem to be a decisive factor for determining yield in sesame. According to Yadava (1980) and Janardhanam *et al.* (1982), 1000 seed weight had direct effect on yield in sesame.

In the present study, three characters *viz.*, plant height, number of branches per plant and number of capsules per plant were found to be the important yield contributing factors in sesame. These three characters had significant and positive correlation with yield. These three component characters also possessed significant and positive intercorrelation among themselves. As such, selection for the improvement of these three characters would ultimately result in the improvement of yield in sesame.

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GENE EFFECTS FOR DAYS TO FLOWERING, MATURITY AND SEED YIELD IN INDIAN MUSTARD UNDER TWO ENVIRONMENTS

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ABSTRACT

Genetic control of three traits in six population parameter model indicated both additive and dominance gene effects to be important under normal sown conditions for days to flowering and seed yield. However, under late sown conditions additive effects were important for days to maturity. Under both normal and late sown conditions, genetic control of days to flowering was predominantly under additive gene effects. Simple selection could, therefore. be effective to improve the flowering period in any of the two environments whereas, selection for yield will be more effective under normal sown conditions only.

Key words : Indian mustard; additive effects; dominance effects, epistasis; environment; *Brassica juncea.*

INTRODUCTION

Indian mustard (*Brassica juncea* L. Czren & Coss) is gorwn both as mixed and pure crops in irrigated and rainfed areas of the northern parts of the country. This crop has shown promise under the normal (October) as well as late (November) sown conditions. Although there is ample informations on genetic control of maturity traits under normal sown conditions (Chauhan and Singh, 1979; Singh *et al.*, 1981) but genetic information under late sown conditions is limited (Singh and Singh, 1983). The present study was, therefore, aimed for generating the information on genetic control of seed yield and maturity traits in Indian mustard grown under both normal and late sown conditions so as to formulate suitable breeding strategy for evolving superior genotypes for late sown conditions.

MATERIALS AND METHODS

The experimental material for the present study comprised a set of basic six generations (P_1, P_2, F_1, F_2, B_1 and B_2) in respect of two crosses namely, Varuna × EC-126743 and Prakash × EC-126743. Of these, Varuna and Prakash are released cultivars, whereas EC-126743 is a Russian introduction which is characterized by high oil content in seeds, resistance to *Alternaria* leaf blight and white rust, yellow seed coat and vary late maturity. The experiment was conducted in a RBD with three replications under two environments i.e. normal (E_1, 25th October, 1983) and late (E_2, 10th November, 1983) sowings. Each non-segregating generations as well as back crosses were sown in two rows whereas F_2,s were sown each in six rows of 6 m. The distances between rows and plants within row were maintained at 30 and 15 cm respectively. Ten competitive plants in non-segregating generations (parents and F_1's) 30, plants in F_2 and 15 plants in each of the backcross generations of the two crosses were sampled at

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random. The observations on these plants were recorded for days to flowering, days to maturity and seed yield.

The estimates of gene effects were derived from the generation mean analysis of Hayman (1958) following the scaling test of Cavalli (1952) and Hayman and Mather (1955).

RESULTS AND DISCUSSION

On the three parameter model, the weighted least square estimates of mean (m), additive (d) and dominance (h), components were obtained. There was a general agreement between individual scaling and joint scaling tests (Table 2). The failure of this model was attributed mainly to the presence of epistasis.

For days to flowering, significant additive and dominance gene effects were observed in the cross, Prakash × EC-126743 over both the environments. Additive effects (d) were larger in magnitude than the dominance effects (h) indicating fixable nature of this character (Table 1).

For days to maturity, only the cross, Prakash × EC-126743 in E_1 showed the adequacy of three parameter model. Estimates of gene effects indicated that additive gene effects were important for the inheritance of this trait (Table 3).

Both additive (d) and dominance (h) gene effects were found to be significant with the preponderance of additive effects in the inheritance of seed yield in E_2.

Based on six-parameter model, days to flowering exhibited both additive and dominance main effects as well as interacting effects of (i) and (l) in E_2 in cross, Varuna × EC-126743. Similar results on genetic control of days to flowering under normal sowings were reported by (Yadava *et al.*, 1976; Singh *et al.*, 1981). Whereas in E_1, non-allelic interactions were not detected even on six-parameter model. This indicated the presence of G × E interactions. For days to maturity, mainly additive and espistatic effects of (i), (j) and (l) were responsible. Magnitude of (i) type interaction was higher than other interactions This revealed the feasibility for the improvement of this trait.

For seed yield, the cross, Varuna × EC-126743 indicated additive gene effect to be significant with interaction of (j) type in E_1 whereas for Prakash × EC-126743 in the same environment both additive and dominance components were significant and magnitude of dominance effect was greater than that of additive effect with (i) and (l) type of interaction Under normal sown conditions, similar results were also reported by Singh *et al.* (1981) and Ramdhari and Yadava, (1983).

Based on the studies on the genetic control of these traits, it was found that there is varying genetic control in the varying genetic material for days to maturity and seed yield over two environments. However, for days to flowering, similar genetic control was operative under normal and late sown conditions. Based on genetic analy-

TABLE 1. Mean performance of the six generations of two crosses for days to flowering, days to maturity and seed yield in two environments.

Character	Environment	Cross	P_1	P_2	F_1	F_2	B_1	B_2
Days to flowering	E_1	Varuna × EC-126743	53.87 ±0.158	98.02 ±0.232	66.10 ±0.198	67.81 ±0.157	55.58 ±0.144	66.88 ±0.256
	E_2	Varuna × EC-126743	45.97 ±0.128	95.07 ±0.218	60.80 ±0.201	60.37 ±0.201	47.51 ±0.206	61.62 ±0.226
	E_1	Prakash × EC-126746	60.23 ±0.294	98.02 ±0.199	71.63 ±0.358	62.03 ±0.379	60.59 ±0.232	68.38 ±0.573
	E_2	Prakash × EC-126743	53.60 ±0.183	95.73 ±0.261	63.36 ±0.358	60.91 ±0.214	55.51 ±0.214	63.06 ±0.323
Days to maturity	E_1	Varuna × EC-126743	146.4 ±0.177	157.1 ±0.239	148.6 ±0.142	148.8 ±0.238	148.0 ±.1061	157.0 ±0.208
	E_2	Varuna × CE-126743	140.0 ±0.175	155.2 ±0.175	139.6 ±0.201	143.3 ±0.248	145.0 ±0.178	153 6 ±0.201
	E_1	Prakash × EC-126743	150.1 ±0.174	157.5 ±0.193	151.3 ±0.222	150.5 ±0.096	151.7 ±0.219	155.1 ±0.195
	E_2	Prakash × EC-126743	148.3 ±0.151	155.6 ±0.201	148 2 ±0.116	148.1 ±0.197	148.8 ±0.145	153.7 ±0.183
Seed yield (g/plant)	E_1	Varuna × EC-126743	36.67 ±0.325	17.18 ±0.246	29.40 ±0.294	19.06 ±0.601	23.22 ±0.219	19.50 ±0.235
	E_2	Varuna × EC-126743	17.87 ±0.341	6.340 ±0.216	18.83 ±0.246	14.91 ±0.402	18.78 ±0.263	15.55 ±0.543
	E_1	Prakash × EC-126743	31.51 ±0.313	15.50 ±0.294	25.18 ±0.189	13.27 ±0.467	29.76 ±0.312	22.20 ±0.245
	E_2	Prakash × EC-126743	20.37 ±0.259	6.393 ±0.141	17.59 ±0.263	11.45 ±0.412	15.84 ±0.242	15.14 ±0.303

TABLE 2. Scaling tests and estimation of components of generation means on three parameters model in two crosses for days to maturity and seed yield in two environments.

Character	Environment	Cross	Gene effects (m)	Gene effects (d)	Gene effects (h)	Joint scaling test (3 d.f.)	Scaling tests A	Scaling tests B	Scaling tests C	Scaling tests D
Days to flowering	E_1	Varuna × EC-126743	67.80 ±0.717	−13.91** ±0.713	−12.52** ±1.283	9.659*	1.190 ±2.379	5.240 ±3.814	−17.73** ±6.522	6.840 ±3.569
	E_2	Varuna × EC-126743	60.97 ±0.652	−14.97** ±0.651	−10.18** ±1.189	7.906*	−1.750 ±3.049	−3.630 ±3.420	17.84* ±9.030	11.61* ±4.327
	E_1	Prakash × EC-126743	62.86 ±0.933	−9.701** ±0.931	−9.039** ±2.074	1.261	−0.680 ±5.025	−4.600 ±7.240	−15.10 ±15.06	−4.910 ±8.274
	E_2	Prakash × EC-126743	60.99 ±0.843	−8.104* ±0.875	−7.589** ±1.875	4.731	0.120 ±3.624	5.030 ±4.971	−12.41 ±10.58	−8.780 ±5.492
Days to maturity	E_1	Varuna × EC-126743	147.6 ±0.744	−5.027** ±0.739	−1.901 ±1.124	11.81**	0.700 ±2.493	10.30** ±3.185	−3.800 ±9.230	−7.400 ±4.854
	E_2	Varuna × EC-126743	143.7 ±0.641	−4.593** ±0.634	−10.47** ±1.242	19.02**	3.480 ±2.796	12.51** ±3.063	−8.110 ±9.750	−12.05* ±5.035
	E_1	Prakash × EC-126743	151.2 ±0.661	−1.128* ±0.568	−0.078 ±1.317	1.117	1.990 ±3.319	0.370 ±3.070	−2.980 ±4.596	−2.670 ±2.675
	E_1	Prakash × EC-126743	148.5 ±0.631	−6.043** ±0.629	−6.097** ±0.935	15.40**	−4.260 ±2.220	7.240** ±2.764	−14.98* ±6.715	−8.980* ±4.057
Seed yield	E_1	Varuna × EC-126743	27.14 ±1.018	19.46** ±0.984	−3.240 ±1.894	171.4**	−19.63** ±3.805	−7.580* ±3.787	−36.40 ±25.15	−4.600 ±11.61
	E_2	Varuna × EC-126743	12.22 ±1.017	5.758** ±1.018	6.826** ±1.731	0.687	0.874 ±4.215	5.830 ±7.507	−2.230 ±15.64	−4.517 ±9.637
	E_1	Prakash × EC-126743	23.69 ±1.158	7.831** ±1.152	1.649 ±1.630	7.862*	2.830 ±4.747	3.720 ±3.801	−44.29* ±18.03	−25.42** ±9.256
	E_2	Prakash × EC-126743	12.96 ±0.762	6.390** ±0.758	4.226** ±1.581	6.122	−6.280 ±3.607	6.297 ±4.223	−16.14 ±15.71	−8.030 ±8.254

TABLE 3. Estimates of components of generation means on six-parameters model in two crosses for days to flowering, days to maturity and seed yield in two environments.

Character	Environment	Cross	Genetic control				
			(d)	(h)	(i)	(j)	(l)
Days to flowering	E_1	Varuna × EC-126743	-11.30 ** ±1.967	1.395 ±7.260	13.68 ±7.137	3.215 ±2.113	-9.630 ±10.22
	E_2	Varuna × EC-126743	-14.11 ** ±2.050	-33.44 ** ±8.746	-23.22 ** ±8.653	0.840 ±2.160	28 60* ±11.48
Days to maturity	E_1	Varuna × EC-126743	9.000** 1.766	12.50 ±9.770	14 80 ±9.708	-4.800** ±1.845	-25.80** ±11.70
	E_2	Varuna × EC-126743	-8.650** ±1.799	12.56 ±10.15	24.10 * 10.07	-4.515** ±1.750	-40.09** ±12.12
	E_2	Prakash × EC-126743	-10.90** ±1.570	12 07 ±8.160	17.96* ±8.110	-5.750** ±1.710	-20.94** ±9.940
Seed yield	E_1	Varuna × EC-126743	3.770* ±1.570	11 67 ±23.31	9.200 ±23.23	-6.025* ±2.430	18.01 ±24.71
	E_1	Prakash × EC-126743	7.560** ±2.660	52.51** ±18.58	50.84** ±18.51	-0.445 ±2.950	-53.39* ±20.93

sis of seed yield, it was found that its improvement for late sown conditions can be made by the method which capitalize on both additive and dominance gene effects. Along with high yield, early maturity may be worth consideration for developing genotypes suitable for late sown conditions, as there was a preponderance of additive gene effects for earliness. This attribute could be improved by simple selection procedures in any of the two environments, whereas seed yield would be more amenable for its improvement through selection under early sown conditions only.

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THE EFFECT OF SOWING DATE, SEED RATE AND FERTILIZER ON SEED YIELD OF NIGER IN THE CENTRAL HIGHLAND OF ETHIOPIA

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ABSTRACT

An indigenous, full term niger (*Guizotia abyssinica* Cass) variety was planted for three growing seasons at Holetta and Ghinchi, Ethiopia, at three dates using four seed rates and two levels of fertilizer. The location and year greatly affected seed yield. Higher yields across sites and years were associated with moderate or no rains during flowering and seed filling periods. Reduction in yields were observed when planting was delayed beyond early July. The number of days required to reach maturity was also decreased with late planting. Seed rates of 5-20 kg/ha were the least important factor for seed yield. The lowest rate of 5 kg/ha produced higher yield when planted early, whereas the 10-15 kg/ha had an advantage with late planting. Yield was better under fertilized conditions and the response was greater when planting was delayed.

Key words: Niger; *Guizotia abyssinica*; sowing date; seed rate; fertilizer, Ethiopia.

INTRODUCTION

Niger, the most important oil crop in Ethiopia, is widely grown on heavy, poorly drained soils. Approximately 50% of the total oil production in the country is from niger. This crop is known to be an excellent competitor with weeds and produces a fine quality oil.

In Ethiopia, niger is sown between May and September, depending on soil type, length of growing season and annual precipitation (Belayneh, 1985). Experimental results from India and Ethiopia indicate that early planting at onset of the rains resulted in highest niger seed yield (Singh and Nakhtore, 1980; Belayneh, 1985). Frost damage to seed is a real risk with late planting in some parts of Ethiopia. Hence the planting must be manipulated to avoid frost.

In general, higher plant population increased seed yield over the lower population (Patil and Joshi, 1978; Patil, 1979). On the other hand, more dense stands caused mutual sharing of plants and resulted in less yield per hectare (Patil and Patil, 1981). A seed rate of about 15 kg/ha was best when niger was planted at row width of 30cm both in India and Ethiopia (Bhardwaj and Gupta, 1977 and Belayneh, 1985).

The effect of fertilizer on niger seed yield has been studied with variable results. Bhardwaj and Gupta (1977) reported no significant increase in seed yield with fertilizer application.

The effects of seed rate, fertilizer and time of planting in niger have usually been investigated as single factors in a single year, or at single site (Singh and Nahtore, 1980;

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Singh *et al.* 1980; Belayneh, 1985). The present study, therefore, was conducted to explain the relationship between planting date, seed rate and fertilizer application on seed yields of niger using data from several years at two locations in the central highlands of Ethiopia.

MATERIALS AND METHODS

The trial including three sowing dates at fortnightly intervals starting with the expected onset of steady rain, two levels of fertilizer (no application and 23/23 N/P_2O_5 kg/ha) and four seed rates (5, 10, 15 and 20 kg/ha) was carried out for three seasons both at Holetta (1976, 1977 and 1978) and Ghinchi (1976, 1977 and 1979). An indigenous *niger variety named local Ghinchi* was used at both locations.

The soils of the Holetta trial site was dark grey clay-Eutric Gleysol. The Ghinchi site is characterized by a very heavy dark clay Vertisol that forms deep cracks in the dry season and drains extremely poor in the rainy season.

Holetta and Ghinchi are located at altitudes of 2380 and 2200 meters a.s.l., latitudes of about 9:0 and 9:30 degrees north and longitude of about 38:30 and 38:90 degrees east, respectively. Monthly averages of the daily maximum and minimum temperature and rainfall at Holetta for the relevant experimental periods are given in Table 1.

Split-split plot design with sowing dates as main plots, seed rates as subplots and fertilizer as sub-sub plots was used. Each sub-sub plot consisted of six 5-meter rows spaced at 30 cm. The net plot size was $6m^2$. The treatmentsd were replicated thrice. On the basis of previous results 23:23 kg/ha of $N:P_2O_5$ was considered sufficient to meet the need of the crop and was broadcasted at planting.

The centre four rows were used for data collection and yield determination. The data of each site were analysed separately, then both locations were combined into a single analysis with the sites included as a fixed effect factor.

In 1977, poor yield of niger was obtained at Holetta, partly due to the heavy rains in October resulting in poor seed setting and increased shattering. Consequently, it was not considered for analysis.

RESULTS AND DISCUSSION

Site effiects :

The location and year affected yield of niger more than did any other factor (Table 2). Site seed yields varied from 123 kg/ha at Ghinchi in 1976 to 795 kg/ha at Ghinchi in 1979. At Holetta, moderately low yields were recorded in both 1976 and 1978 with a maximum of 380 kg/ha in 1976.

TABLE 1. Monthly rainfall, rainy days and average temperature at Holetta (1976-1979).

Month	Total rainfall in mm and number of rainy days (in parenthesis)				Average temperature °(C)							
					1976		1977		1978		1979	
	1976	1977	1978	1979	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
June	123.4 (19)	113.1 (23)	180.9 (24)	141.3 (19)	22.3	5.1	21.4	8.0	21.9	8.2	23.4	8.0
July	169.2 (28)	276.1 (24)	305.9 (25)	214.6 (31)	19.2	7.5	18.7	9.4	18.5	10.2	19.8	10.2
August	331.3 (27)	248.6 (28)	217.1 (29)	243.1 (26)	18.7	8.4	19.8	9.5	18.3	9.2	19.7	9.2
September	83.1 (17)	197.7 (20)	150.6 (27)	106.5 (20)	20.6	7.6	19.4	7.9	19.5	8.8	20.0	8.3
October	4.0 (4)	126.0 (13)	54.4 (4)	8.8 (3)	22.0	4.5	20.9	8.1	21.3	6.2	22.5	5.5
November	62.9 (6)	30.2 (3)	0 (0)	0.3 (1)	20.9	4.8	21.1	4.9	21.6	1.4	22.4	1.5
December	— —	0 (0)	3.0 (4)	0 (0)	—	—	21.9	2.2	23.0	4.0	24.1	2.8

TABLE 2. Effects of site, sowing dates, seeding rates and fertilizer on yield and yield characters of niger.

a. Site

	Yield kg/ha	Height (cm)	Days to Flower	Days to Mature
Ghinchi-76	123	NA	93	166
Ghinchi-77	517	NA	96	177
Ghinchi-79	795	87	91	144
Holetta-76	380	94	99	168
Holetta-78	323	102	108	170
LSD (0.05)	27	9	3.2	5.86

b. Sowing Dates

1st	483	109	104	176
2week delay	432	91	96	164
4week delay	366	82	92	156
LSD (0.05)	21	8.2	2.5	3.1

c. Seeding Rates

5 kg/ha	433	103	97	167
10 kg/ha	438	89	98	164
15 kg/ha	430	92	97	165
20 kg/ha	408	91	97	163
LSD (0.05)	13	NS	NS	2.2

d. Fertilizer

None	372	87	99	167
23/23 N/P_2O_5 kg/ha	483	101	96	164
LSD (0.05)	8	3.36	1.5	1.2
Character Mean	257	94	97	165

Rainfall and temperature data (Table 1) can explain some of this variation. Since Holetta and Ghinchi are 45 km apart, weather trends recorded at Holetta can be indicative of Ghinchi. Highest precipitation usually occurs in July and August when the crop is in the vegetative phase, with progressively declining rainfall in September and October, the time of flowering and early seed filling stage. In November, the crop approaches maturity, and rainfall during this month may have a profound effect on final yields. In 1976, heavy rains in November led to heavy shattering losses and very low

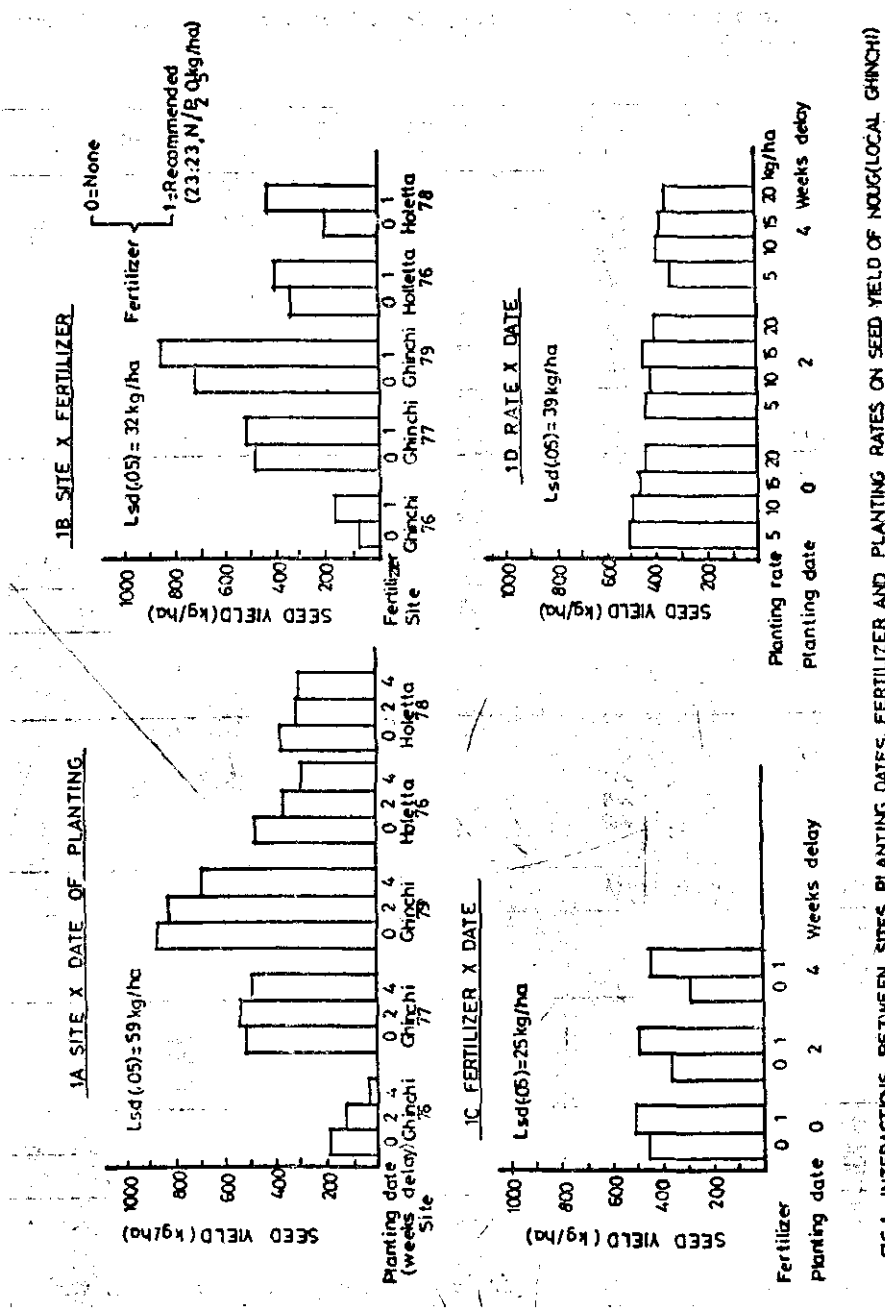

FIG.1 INTERACTIONS BETWEEN SITES, PLANTING DATES, FERTILIZER AND PLANTING RATES ON SEED YIELD OF NOUG(LOCAL GHINCHI)

yield at Ghinchi. Moderate yields were recorded in 1978 when November rains were moderate, with high yields in 1979 when there were no rains in November.

At Holetta, due to higher elevation and cooler season, the growth cycle is lower. Therefore, November rains had less effect at this site. The higher air temperature recorded in Sept.-Nov. of 1979 (Table 1) are indicative of more sunny days during flowering and seed formation. Increased bee activity and hence greater cross-pollination in a self-incompatible crop such as niger may also have helped to produce the higher yields at Ghinchi in that year. A similar effect of sunny flowering period on seed yield has been reported by Patil and Joshi (1978). It is interesting to note that the high yielding crop at Ghinchi in 1979 had the shortest grain filling period and the shortest plant height.

Seeding Dates :

Planting with the onset of rains in mid to late June produced the highest seed yield at all sites except Ghinchi in 1977 (Fig. la, Table 2b). June rainfall in 1977 was unusually low (Table 1), which might have caused the first and second planting at Ghinchi to produce equal yields. The third planting produced lowest yields at all sites. Field research in India by Singh and Nakhtore (1980) showed a similar increase in seed yield with early planting.

Seed Rate :

Seeding rates from 5 to 20 kg/ha had only a slight effect on the seed yields of niger (Table 2c). Across sites, the highest seeding rate produced significantly lower yields. This finding was in conformity with a report of Patil and Patil (1981). A consistent high yield response was obtained at all sites with early planting at the lowest seeding rate of 5 kg/ha (Fig. ld). When planting was delayed, the rate of 10 or even 15 kg/ha appeared to be optimum. Higher seed rates resulted in faster maturity but had no effect on the days to flower.

Fertilizer Applications :

The application of the recommended fertilizer produced higher seed yields at all sites (Fig. lb), increasing the mean yield from 372 to 483 kg/ha (Table 2d). This increase in seed yield with nirtogen and phosphorous application is in agreement with the findings of Bhosal and Patil (1979) and Kachapur *et al.* (1979). The fertilizer effect more pronounced when sowing was delayed. Hence, application of recommended nitrogen and phosphorous fertilizer is likely to be more profitable when planting is delayed than with early planting. Application of fertilizer hastened flowering and maturity as compared to the control (Table 2d).

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STUDIES ON HETEROSIS IN INTER- AND INTRA-SUBSPECIES CROSSES OF GROUNDNUT

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ABSTRACT

The extent of heterosis over midparent and better parent was studied through a half diallel involving eight genotypes of subspecies, *hypogea* and *fastigiata* of the species, *Arachis hypogaea*.

Desirable significant negative heterosis over better parent was observed for days to 50% flowering in spanish × spanish crosses and for days to maturity in spanish × valencia crosses. Significant heterosis in negative direction for number of aerial pegs, number of immature pods was also evident in most of the crosses. Breeding programme involving spanish and valencia under subspecies *fastigiata* would be rewarding. Spanish × spanish also exhibited high heterotic effect for number of mature pods per plant over midparent as well as better parent.

Heterosis over midparent for pod yield per plant ranged from 34.72 to 57.28% and the cross GAUG-1 × Chico (spanish × spanish) recorded the highest value.

Heterosis was of low magnitude in case of 100 seed weight and shelling per cent over either midparent or better parent.

Key words : Heterosis; *Arachis hypogaea*; inter and intra subspecies crosses.

INTRODUCTION

In the absence of male sterile line, the possibility of exploitation of heterosis in groundnut appears to be remote at present. The alternative, therefore, left to the breeders is to take up these promising crosses having high heterosis which in turn may produce desirable transgressive segregants in avdanced generation. Very little information is available on the heterosis of various morphoagronomic traits, its magnitude and direction in groundnut (Hasan and Srivastava, 1966; Wynne *et al.*, 1970; Deshmukh *et al.*, 1985). The present investigation was undertaken to know the extent as well as direction of heterosis for yield and its attributes involving inter- and intra-subspecific crosses in groundnut.

MATERIALS AND METHODS

Eight diverse parents representing different botanical groups viz, GAUG-1, Chico, Pollachi-1 (spanish, var. *valgaris*), NcAc 927, PI 118989-3B (valencia var. *fastigiata*) under subspecies *fastigiata* and GNLM, TG-1, Florigiant (virginia, var. *hypogaea*) under subspecies *hypogaea* were chosen and mated in all possible combinations. The parents and their 28 F_1's were grown in a RCBD with 3 replications at the Centre's Experimental Farm during the summer, 1983. Seeds were dibbled by adopting a spacing of 20 cm and 60 cm within and between rows, respectively. Plot size was 3 rows of 2 m length each. Recommended cultural parctices were followed to raise a healthy crop.

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Observations on 5 randomly selected plants were recorded for (i) days to 50% flowering, (ii) height of main stem (cm), (iii) number of primary branches, (iv) length of primary branches (cm), (v) days to maturity, (vi) number of aerial pegs, (vii) number of mature pods per plant, (viii) number of immature pods per plant, (ix) pod yield per plant (g) (x) 100 seed weight (g) and (xi) shelling per cent. The heterotic effects were computed as percentage increase or decrease of F_1's over midparent (relative heterosis) as well as better parent (heterobeltiosis).

RESULTS AND DISCUSSION

Significant differences among the parents and the F_1 hybrids were observed for all the characters. Performance of hybrids as compared to over all mid parental values and better parent for eleven characters is presented in Table 1. The salient features for each of the characters are discussed below.

TABLE 1. Mean performance of heterosis (in percentage) over midparent (MP) and better parent (BP) for different characters in groundnut.

	Days to 50% flowering		Height of main stem		No. of primary branches	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
1×2	-1.38	2.88	2.23	-6.82	2.64	-8.35
1×3	-6.74	1.12	6.61	-16.20	0.09	-28.57
1×4	-0.88	7.69	3.88	2.47	4.17	-10.71
1×5	1.75	11.54	28.28	-9.07	-1.06	-12.06
1×6	-2.42	-1.94	2.52	-5.28	3.70	0.00
1×7	-2.88	-2.88	9.42	4.46	-1.89	-7.14
1×8	-3.36	10.57	-8.40	-30.75	4.46	-5.75
2×3	-0.99	12.36	-23.42	-35.08	15.79	0.00
2×4	1.28	5.31	4.38	-4.53	19.05	13.64
2×5	2.95	7.96	0.33	-24.37	7.59	-13.33
2×6	9.26	14.36	-14.36	-27.30	-2.50	-10.00
2×7	-1.37	2.88	1.70	-3.14	-19.15	-24.00
2×8	1.21	10.62	-17.64	-33.19	2.82	-16.09
3×4	1.42	20.22	7.03	-15.69	48.11	33.30
3×5	0.47	20.22	10.02	-4.83	3.84	-25.00
3×6	3.12	12.24	-3.68	-28.48	14.29	-7.69
3×7	-3.68	4.49	-5.58	-23.08	7.32	-12.00
3×8	-1.34	23.60	-22.19	-26.28	-1.57	-28.16
4×5	4.88	5.74	14.52	-18.64	7.14	-16.67
4×6	4.89	14.56	-1.77	-9.57	13.04	0.00
4×7	0.88	9.61	-4.91	-8.88	4.00	-6.40
4×8	4.69	9.84	-1.63	-25.44	19.71	-5.75
5×6	3.96	14.56	-4.75	-35.51	0.00	-13.88
5×7	3.51	13.46	-17.51	-39.61	-12.79	-26.11
5×8	7.75	12.10	-17.07	-24.71	6.21	4.44
6×7	-2.42	-1.94	-4.16	-15.14	-9.80	-11.55
6×8	-0.42	14.56	-13.54	-38.10	16.79	1.15
7×8	0.00	14.42	5.64	-17.43	13.71	-2.30
SE±	0.89	1.02	0.74	0.87	0.45	0.54

TAALE 1 Contd.

	Length of primary branches		Days to maturity		No. of aerial pegs	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
1×2	6.19	-1.06	-0.14	2.36	23.40	97.96
1×3	7.14	-16.28	3.47	11.19	-45.80	-62.70
1×4	2.94	-0.68	-1.40	3.50	-25.40	-21.33
1×5	3.47	-1.47	-1.12	3.83	22.95	69.86
1×6	0.30	-7.47	0.00	1.18	-22.08	-36.65
1×7	7.15	-6.29	0.73	1.18	-21.16	-14.94
1×8	-1.39	-5.97	0.00	5.60	29.92	71.14
2×3	25.37	-38.45	7.53	18.64	38.34	151.02
2×4	2.40	-7.70	-1.50	0.84	-4.65	-13.52
2×5	-1.88	-12.63	-0.14	2.24	-3.39	-10.44
2×6	-12.76	-24.55	-0.71	0.57	10.39	-14.06
2×7	-6.98	-12.68	-1.15	0.88	0.63	-34.63
2×8	-9.19	-19.02	1.50	4.49	22.06	23.13
3×4	2.87	-21.84	4.19	17.97	-20.58	69.39
3×5	2.05	-23.18	4.79	18.64	12.41	110.20
3×6	5.93	-22.02	5.92	15.25	9.68	48.98
3×7	-9.61	-29.14	6.44	14.91	-9.09	90.41
3×8	-7.61	-30.39	4.43	18.98	20.00	104.98
4×5	-4.90	-6.18	0.54	0.54	0.21	30.77
4×6	-2.42	-6.86	0.28	0.45	-37.95	1.43
4×7	-10.89	-14.69	0.14	4.68	-40.35	-55.07
4×8	-11.26	-12.33	0.53	1.07	2.78	-23.08
5×6	-24.90	-27.36	0.00	3.75	0.29	-23.30
5×7	-21.65	-25.97	-2.10	2.33	1.97	-39.24
5×8	-0.77	-0.93	0.53	1.07	0.67	-19.53
6×7	-3.49	-11.62	-2.18	-1.46	-8.18	-43.60
6×8	-12.52	-15.52	-1.10	3.17	26.45	-14.81
7×8	-4.19	-9.33	0.69	4.38	15.62	-18.84
SE±	0.88	1.03	0.13	0.14	0.16	0.78

TABLE 1. Contd.

	No. of mature pods per plant		No. of immature pods per plant		Pod yield per plant	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
1×2	-11.15	-12.23	18.50	97.96	0.32	-17.77
1×3	50.85	26.19	-18.30	6.12	57.28	24.44
1×4	7.98	-19.62	12.23	21.33	54.94	30.70
1×5	-8.71	-27.09	2.19	69.86	6.67	-20.62
1×6	28.23	26.58	1.28	36.65	21.49	2.45
1×7	20.42	16.93	-23.83	14.94	33.03	33.03
1×8	-14.98	-33.65	18.95	71.14	-10.93	-30.70
2×3	-14.63	-27.87	5.90	151.02	-23.17	-47.21
2×4	7.46	-19.25	-24.68	13.52	-2.84	-30.07
2×5	8.38	-12.64	-10.76	10.44	-12.55	-42.71
2×6	2.52	0.00	-27.73	-14.01	-4.12	-7.43
2×7	-0.44	-2.15	-39.47	32.62	2.26	-16.18
2×8	11.68	-12.06	9.60	23.13	-4.89	-35.54

3×4	−18.55	−29.58	18.57	69.39	−31.51	−36.59
3×5	−31.13	−35.00	−10.82	110.20	−23.26	−29.79
3×6	−27.39	−39.89	−19.78	48.98	−34.72	−54.24
3×7	28.47	10.12	−9.56	90.41	25.81	−0.29
3×8	0.09	0.00	2.04	104.98	20.73	17.73
4×5	11.34	1.41	−12.82	30.77	43.67	22.58
4×6	0.18	−25.95	−17.59	1.43	2.98	−24.22
4×7	−6.85	−29.17	−25.53	2.53	3.79	−12.45
4×8	−1.33	−7.50	−5.88	−23.08	0.80	−8.82
5×6	−3.63	−23.77	−35.24	−23.30	−9.83	−39.89
5×7	−19.49	−34.23	−43.53	−39.24	−10.84	−33.78
5×8	−14.29	−6.90	−28.09	−19.52	1.19	−5.22
6×7	1.99	−2.19	−68.45	−43.60	1.85	−14.52
6×8	−16.25	−35.25	−19.07	−14.81	−24.12	−47.58
7×8	6.57	−15.00	−21.77	−18.84	6.67	−17.01
SE±	0.72	0.87	0.60	0.78	0.65	0.75

TABLE 1. Contd.

	100 seed weight		Shelling per cent	
	M.P.	B.P.	M.P.	B.P.
1×2	1.11	−5.49	2.10	−1.98
1×3	0.83	−6.20	1.65	−0.68
1×4	3.00	−0.19	−2.53	−7.07
1×5	−1.83	−5.89	−4.37	−10.89
1×6	−0.11	−6.67	0.39	−3.12
1×7	−1.07	−4.14	2.43	1.79
1×8	−1.83	−3.21	−13.01	−13.28
2×3	−3.50	−15.65	−1.19	−7.23
2×4	4.06	0.27	−7.78	−2.49
2×5	7.38	−3.48	−0.23	−3.26
2×6	7.85	7.79	−2.29	−2.82
2×7	3.71	−5.84	−3.31	−7.73
2×8	7.21	−1.08	−8.24	−11.65
3×4	−1.56	−11.06	0.62	−6.16
3×5	−2.50	−5.52	3.99	−5.14
3×6	−3.66	−5.84	1.57	−4.14
3×7	−1.55	−5.62	2.46	0.73
3×8	0.56	−6.28	−2.46	−4.99
4×5	2.61	−4.56	−3.16	−5.44
4×6	−1.60	−5.24	−1.94	−3.20
4×7	1.96	−4.17	−7.37	−12.21
4×8	0.35	−4.17	−7.43	−11.53
5×6	0.48	−9.73	−0.63	−4.21
5×7	−0.67	−7.76	−0.41	−7.72
5×8	−4.43	−7.13	−6.43	−12.53
6×7	−9.59	−0.57	1.40	−2.73
6×8	0.13	−7.66	−7.05	−10.03
7×8	1.80	−3.51	−3.55	−4.57
SE±	0.52	0.61	0.70	0.81

1. GAUG-1; 2. TG-1; 3. Chico; 4. NcAc 927; 5. GNLM; 6. PI 118989-3B; 7. Pollachi-1; 8. Florigiant.

Days to 50% flowering :

Twenty hybrids showed intermediate behaviour with a tendency towards lateness. None of the hybrids involving Chico (earliest parent) except those with GAUG-1 and Pollachi-1 showed earliness towards Chico.

Six cross combinations out of 29 showed desirable significant negative heterosis over midparent and the majority of these were spanish × spanish crosses. Interestingly none of the hybrids showed significant negative heterosis over better parent (flowering earlier) except the cross GAUG-1 × Pollachi-1 (spanish × spanish) which indicated overdominance for earliness. The extent of desirable negative heterosis for this trait was, however, low and ranged from -2.42 to -6.74 per cent.

Height of main stem :

Heterosis over midparent showed two distinct trends. Almost 50% of the F_1 hybrids exhibited significant positive heterosis while the rest showed negative trend. The highest values of both positive and negative heterosis were 28.28 and - 22.19% respectively. Heterosis on the basis of better parent (taller) was negative for all the hybrids except GAUG-1 × Pollachi-1 (spanish × spanish) and GAUG-1 × NcAc 927 (spanish × valencia). The magnitude of nagative heterosis ranged from -3.14% (TG-1 × Pollachi-1) to -39.61% (GNLM × Pollachi-1).

Number of primary branches :

Most of the hybrids showed positive heterosis over midparent and the cross, Chico × NcAc 927 (spanish × valencia) exhibited highest positive heterosis (48.11%). Majority of the hybrids, however, exhibited negative heterosis when compared with their respective better parents. The crosses showing significant positive heterosis over the better parents in the order of merit were: Chico × NcAc 927 (33.30), TG-1 × NcAc 927 (13.64) and GNLM × Florigiant (4.44). This may be an indication of effects due to everdominance.

Length of primary branches :

The values of heterosis over midparent ranged from 24.90% (GNLM × PI 118989-3B) to 25.37% (TG-1 × Chico). When compared with their respective better parents none of the hybrid showed positive heterosis except GAUG-1 × Pollachi-1 (spanish × spanish) indicating a general absence of the over-dominance for this trait.

Days to maturity :

Heterosis over midparent ranged from -0.69 to 7.53 per cent. Out of 9 crosses showing desirable significant negative heterosis, 6 crosses involved medium × late parents and 3 involved medium × medium parents. The only hybrid, PI 118989-3B × Polla-

chi-1 (valencia × spanish) showed desirable significant negative heterosis over better (early maturing) parents indicating over-dominance for earliness.

Number of aerial pegs :

Highest desirable negative heterosis over midparent as well as better parent exhibited by GAUG-1 × Chico (spanish × spanish) was at the extent of -45.80 and -62.70%, respectively followed by NcAc 927 × Pollachi-1 (valencia × spanish) (-40.35 over midparent and -55.07 over better parent). Amongst 11 crosses showing significant negative heterosis over midparent, 8 of them also showed significant negative heterosis over their respective better parents. The result indicated the possibility of developing variety devoid of wasteful aerial pegs through judicious breeding programme involving spanish and valencia botancial varieties of subspecies *fastigiata*.

Number of mature pods per plant :

Out of 28 F_1 hybrids, 12 combinations showed significant positive heterosis over midparent. The high heterotic crosses in order to merit were GAUG-1 × Chico (50.85%), Chico × Pollachi-1 (28.47%), GAUG-1 × PI 118989-3B (28.23%) and GAUG-1 × Pollachi-1 (20.42%). All these four combinations except last but one were spanish × spanish and also exhibited significant positive heterosis over their respective better parents. The significant positive heterosis over better parent was, however, low and ranged between 10.12 to 26.28 per cent. Raju *et al.* (1979), however, reported high heterosis for this trait in a cross involving virginia × spanish and moderate heterosis in a virginia × virginia cross.

Number of immature pods per plant :

Most of the crosses showed significant desired negative heterosis over midparent. The extent of negative heterosis was between -5.88 to -48.45. The parent TG-1 bearing highest number of immature pods per plant in cross combination with another high immature pod bearing parent, GNLM and with two moderate parents viz., PI 118989-3B and Pollachi-1, produced less number immature pods in hybrid then the better parent resulting in expression of desired significant negative heterosis. A number of hybrids with GNLM also showed significant negative heterosis over the better parent. PI 118989-3B × Pollachi-1 (valencia × spanish) showed highest negative heterosis (-43.68%) over better parent for this trait. The hybrids showing negative heterosis over the better parent invariably showed the negative heterosis over midparental value also.

Pod yield per plant :

Heterosis over midparent ranged from -34.72% to -57.28%. Out of 28 hybrids, 13 exhibited significant positive heterosis. The highest value of heterosis was observed in the hybrids, GAUG-1 × Chico followed by GAUG-1 × NcAc 927 (54.94%), NcAc 927 × GNLM (43.67%) and GAUG-1 × Pollachi - 1(33.03%). Heterosis when calculated on the basis of respective better parent the hybrids in majority of the cases exhibited

negative heterosis. Significant positive heterosis over better parent for this trait was exhibited by the 6 hybrids most of which either belonged to spanish × spanish or spanish × valencia combinations. Isleib and Wynne (1980) also reported that parents of subspecies *fastigiata* generally have greater heterotic responses than parents from subspecies *hypogaea*.

100 Seed weight :

In most of the cases significant positive heterosis over midparent was observed for this trait. The magnitude of heterosis, however, was low, the highest being 7.85 percent in TG-1 × PI 118989-3B (virginia × valencia). This hybrid being a cross between low and high kernel weight, alone showed significant positive heterosis over the better parent. Garet (1976) observed heterosis from the inter subspecific crosses involving virginia × spanish parents. Layrisse *et al.* (1980) also found that high heterosis for pod yield and 100 seed weight was associated with the cross involving the parents of different centres of diversity.

Shelling per cent :

Heterosis over midparent ranged from 4.0 to 13.0 percent. Out of 28 hybrids only 7 exhibited significant positive heterosis, although the magnitude was low. The highest heterosis for shelling per cent was exhibited by the hybrid, Chico × GNLM. As compared to the better parents, almost all the F_1 hybrids except GAUG-1 × Pollachi-1 (spanish × spanish) showed significantly negative heterosis.

From the foregoing discussion it can be seen that, in general, the heterosis was towards the desirable direction in each of the characters studied. Out of the eleven characters reported here, heterosis was positive and significant in majority of the crosses in the case of number of primary branches, number of mature pods, pod yield and 100 seed weight. All these attributes are directly related to the yield. On the other hand, heterosis was generally negative in the case of days to 50% flowering, days to maturity, number of aerial pegs and number of immature pods. The negative trend in these attributes is desirable from the point of economic importance. Thus in the present investigation the trend of heterosis was found to be both positive and negative but, in any case in the desirable direction. The trend is, therefore, encouraging and gives confidence to the breeder with the possibility of selecting the desirable transgressive segregants from the segregating populations.

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DISSIPATION OF CARBOFURAN IN *SESAMUM INDICUM* LINN.

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ABSTRACT

Carbofuran 3G applied to the soil in sesamum rows at the rate of 0.5 kg a.i. /ha persisted in soil for 35 and 42 days in sole crop of sesamum and sesamum intercropped with pigeonpea during 1983 and 1984 respectively, whereas residue was detected upto 28 days and 35 days in sesamum intercropped with groundnut during 1983 and 1984 respectively. The corresponding residues in plant samples were reduced below detectable level in 42 days and 49 days during 1983 and 1984 respectively. In sesamum sole crop, sesamum + groundnut and sesamum + pigeonpea, respectively, half life values in soil, were 8.47, 6.28 and 6.53 days and waiting periods were 53.92, 40.72 and 42.78 days during 1983 while during 1984, half life values were worked out to be 10.31, 6 30 and 7.56 and waiting periods 64.30, 41.57 and 47.94 days. Similarly, in plants, half life values ranged from 5.81 days to 10.20 days during 1983 and 7.10 days to 12.92 days during 1984; whereas waiting periods ranged from 42.07 to 65.86 days during 1983 and from 47.55 to 79.42 days in 1984. Oil and oil cake samples from both the year contained no detectable carbofuran residue.

Key words: Residue; carbofuran; intercropping; *Sesamum indicum*; *Arachis hypogeae*; *Cajanas cajan*

INTRODUCTION

Carbofuran (2,3-dihydro-2, 2-dimethyl-7-benzofuranyl-N-methyl carbamate) is a highly potent systemic insecticide for controlling crop pests. Although residues of carbofuran, on several crops have been determined in India and abroad (Agnihotrudu and Mithyantha, 1978), very little information on this aspect in sesamum is available. The present study was undertaken to evaluate insecticidal schedule of carbofuran for the control of pests of sesamume, specially jassids causing phyllody disease from point of view of persistence of toxic residue in soil, plant and seed.

MATERIALS AND METHODS

The experiments were conducted at Water Technology Centre, IARI, New Delhi farm during *kharif* 1983 and 1984. Carbofuran obtained from M/s. Rallis India Ltd., New Delhi was applied @ 0.5 kg a.i. /ha to soil in rows of sesamum (*Sesamum indicum*, L) at the time of sowing. Soil samples were drawn at random and after mixing, drying and grinding, 100g samples were used for extraction and estimation of residues at 0(4 h), 7, 14, 21, 28, 35 and 42 days after treatment. Plant samples of 50g were taken for extraction and estimation at 14, 21, 28, 42 and 49 days after sowing (treatment).

The colorimetric method described by Gupta and Dewan (1971) was used for preparation of standard curve for chemical assay and the same alongwith regression equation is given in Fig. Carbofuran resides were extracted from soil samples by acid hydrolysis method (Cook *et al.*, 1986).

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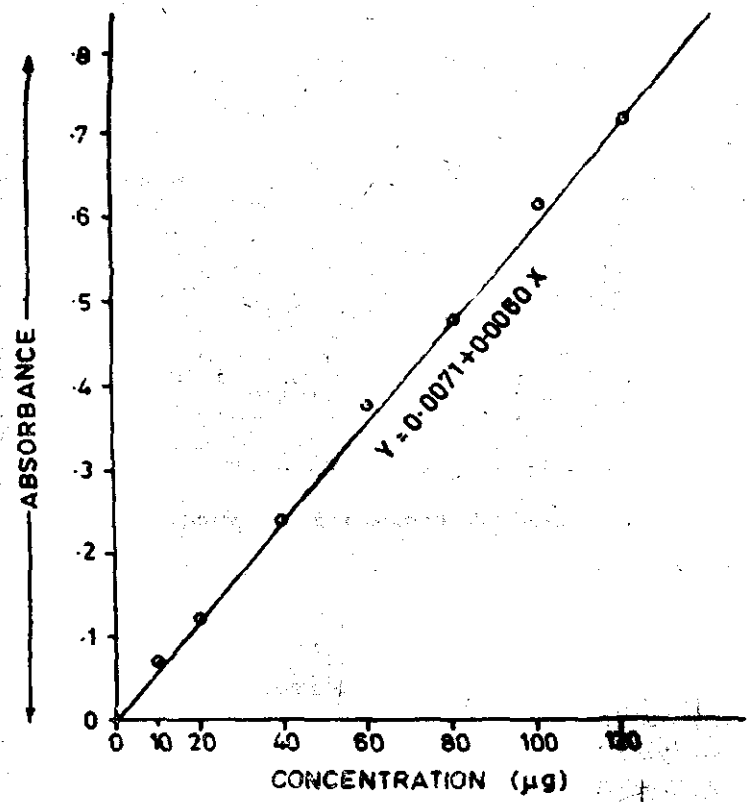

FIG. STANDARD CALIBRATION CURVE FOR CARBOFURAN

Plant smaples were extracted in acetone using a warring blender and filtering through Buchner funnel under pressure. The extracts were concentrated to 10 ml in Kuderna Danish Evaporator assembly with a drop of propylene glycol in it. The concentrated samples were separated in dichloromethane and cleaned with the help of activated charcoal.:

Residues in soil and plant samples were estimated from a 5 ml aliquot drawn from dichloromethane solution by rapid colorimetric procedure of Gupta and Dewan (1971) and taking into consideration the recovery factor. Soil and plant samples were individually fortified with 5 and 10 μgml^{-1} of carbofuran separately. The samples were analysed according to the above mentioned prccedure of extraction, clean up and estimation. Recoveries of carbofuran in soil and sesamum leaves varies from 88.6 to 89.2 per cent and 86.8 to 87.5 per cent respectively (Table 1).

Residue half life (RL_{50}) values and safety intervals (T_{tol}) values were calculated using the formula given by Hoskins (1961).

TABLE 1. Recovery of Carbofuran from fortified samples.

Substrate fortified	Insecticide added ($\mu g\ ml^{-1}$)	Insecticide recovered $\mu g\ ml^{-1}$	Recovery %	Mean recovery %	Recovery factor
Soil	5	4.43	88.6	88.9	1.13
	10	8.92	89.2		
Sesamum leaves	5	4.34	86.8	87.15	1.15
	10	8.75	87.5		

RESULTS AND DISCUSSIONS

Persistence in soil and plants

During *kharif*, 1983, the initial deposits in soil were 9.04 μgml^{-1} and the residue persisted upto 35 days, while during *kharif*, 1984 it was detected upto 42 days with initial deposit of 9.23 μgml^{-1}. However, when seasmum was grown alongwith groundnut, carbofuran was detected in soil upto 28 days and 35 days after application during 1983 and 1984, respectively. The percent reduction in soil over intial deposit was 93.86 and 93.93 at 35 and 42 days after application during 1983 and 1984 respectively when sesamum was grown as sole crop. In soil, where sesamum was grown with groundnut, the reduction of carbofuran over initial deposit was observed to be 95.61 and 95.78 per cent at 28 and 35 days after application, while in sesamum and pigeonpea cropping system 97.85 and 99.89 per cent reduction was recorded at 35 and 42 days after application during 1983 and 1984, respectively (Table 2). This result is in full agreement with Gupta and Dewan (1974) and Sahu and Agnihotri (1983).

Fourteen days after application of carbofuran, plant contained 3.45, 2.68 and 3.06 μgml^{-1} residues during 1983 and 3.83, 3.06 and 3.25 μgml^{-1} residues during 1984 in sesamum sole crop, sesamum + groundnut and sesamum + pigeonpea, respectively, thereafter, these declined with time to 0.76 $\mu g\ ml^{-1}$ in sole crop, 0.38 μgml^{-1} in sesamum + pigeonpea on 35 and 42 days after application during both the years. The residue in sesamum plant intercropped with groundnut at 35 and 42 days after application was found to be 0.19 and 0.16 μgml^{-1} during 1983 and 1984, respectively. The per cent reduction in carbofuran over initial deposit was 77.97, 92.91 and 87.58 at 35 days after application in sole crop of sesamum, sesamum + groundnut and sesamum + pigeonpea, respectively during 1983 while during 1984, reduction in carbofuran varied from 80.16 to 94.77 per cent over initial deposit at 42 days after application in all the three cropping systems (Table 3).

TABLE 2. Residue of carbofuran in soil under different cropping system during *kharif* 1983 and 1984.

Stage of sampling (days after treatment)	SE				SE + GN				SE + PP			
	Mean residue* of carbofuran ($\mu g\ ml^{-1}$)		Reduction of residue over initial deposit (%)		Mean residue* of carbofuran ($\mu g\ ml^{-1}$)		Reduction of residue over initial deposit (%)		Mean residue* of carbofuran ($\mu g\ ml^{-1}$)		Reduction of residue over initial deposit (%)	
	1983	1984	1983	1984	1983	1984	1983	1984	9183	1984	1983	1984
0 (4 hrs)	9.04	9.23	—	—	8.66	9.01	—	—	8.85	9.54	—	—
7	4.71	4.89	47.90	47.02	4.14	4.14	52.19	54.05	4.33	4.52	51.07	52.62
14	2.45	2.63	72.90	71.50	2.07	2.07	76.10	77.02	2.25	2.10	74.58	77.99
21	1.31	1.51	85.51	83.64	0.94	1.13	89.14	87.46	1.13	0.98	87.23	91.06
28	0.75	0.94	91.76	89.81	0.38	0.56	95.61	93.78	0.56	0.48	93.67	94.96
35	0.56	0.75	93.86	91.87	BDL	0.38	—	95.78	0.19	0.18	97.85	98.11
42	BDL	0.56	—	93.93	BDL	BDL	—	—	BDL	0.10	—	99.89
49	BDL	BDL	—	—	BDL	BDL	—	—	BDL	BDL	—	—

* Figures are average of two replications; SE = Sesamum sole crop; SE + GN = Sesamum + groundnut; SE + PP = Sesamum + pigeonpea; BDL = Below Detectable level.

TABLE 3. **Residue of carbofuran in sesamum plants under different cropping systems during *kharif* 1983 and 1984.**

Stage of sampling (days after treatment)	SE				SE + GN				SE + PP			
	*Mean residue of carbofuran ($\mu g\ ml^{-1}$)		Reduction of residue over initial deposite (%)		*Mean residue of carbofuran ($\mu g\ ml^{-1}$)		Reduction of residue over initial deposit (%)		*Mean residue of carbofuran ($\mu g\ ml^{-1}$)		Reduction of residue over initial deposit (%)	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
14	3.45	3.83	—	—	2.68	3.06	—	—	3.06	3.25	—	—
21	1.91	1.91	44.64	50.13	1.15	1.15	57.09	62.42	1.53	1.83	50.00	43.69
28	1.53	1.53	55.63	60.05	0.76	0.66	71.64	78.32	1.14	1.15	62.74	64.61
35	0.76	1.15	77.97	69.97	0.19	0.42	92.91	86.27	0.38	0.59	87.58	81.85
42	BDL	0.76	—	80.16	BDL	0.16	—	94.77	BDL	0.38	—	88.31
49	BDL	BDL	—	—	BDL	BDL	—	—	BDL	BDL	—	—

* Figures are average of two replication; BDL = Below Detectable level; SE = Sesamum sole crop; SE + GN = Sesamum + Groundnut; SE + PP = Sesamum + Pigeonpea.

Both the tables revealed that higher amount of carbofuran residues persisted both in soil as well as plant in sole crop as compared to the intercropping systems. Inter cropping with pigeonpea showed persistence of carbofuran for a longer period both in soil and plant than the intercropping with groundnut This is perhaps because the groundnut roots are more spreading type and shallow, so they absorb more insecticides from the soil in rows of sesamum than pigeonpea. During, *kharif* 1983, rainy days were more and so the insecticidal dissipation in sole and intercroping systems led to summarise that probably the higher level of moisture during this season accelerated the root development of the intercrop which led to the lateral movement of the insecticide and also there might be some downward movements due to leaching. This is in confirmity with Gorder *et al.* (1982) that persistence is influenced by moisture. A similar phenomenon had also been reported by Choudhary (1985) in sesamum and Deshumukh (1985) in linseed when cultivated alongwith an intercrop. Sesamum seed, oil and oil cake samples from trials of both year did not contain any detectable carbofuran residue.

Residue half life (RL_{50}) and safety interval (T_{tol})

In soil: RL_{50} values in sole crop of sesamum were 8.47 and 10.31 days and T_{tol} values were 53.93 and 64.30 days during 1983 and 1984, respectively. However, where sesamum was grown with groundnut and pigeonpea respective, RL_{50} values were worked out to be 6.28 and 6.53 days during 1983 and 6.30 and 7.56 days during 1984, and T_{tol} values to be 40.72 and 42.87 days during 1983 and 41.57 and 47.94 days during 1984 (Table 4.)

In plant: During 1983, lower RL_{50} values of 10.20, 5.81 and 7.40 days and lower T_{tol} values of 65.86, 42.07 and 51.04 days were obtained in sesamum sole crop, sesamum + groundnut and sesamum + pigeonpea, respectively as compared to higher RL_{50} values of 12.92, 7.10 and 8.96 days and higher T_{tol} values of 79.42, 47.55 and 58.87 days in sesamum sole crop, sesamum + groundnut and sesamum + pigeonpea, respectively during 1984 (Table 4).

The RL_{50} determined was much shorter than reported by Harris (1969) and Caro *et al.* (1973). They reported that RL_{50} ranges from 47 to 117 days. This discripancy may have been due to the fact that the soil in which experiment was conducted was alkaline (pH 8.2) and carbofuran molecules are quickly degraded under alkaline conditions. The lower values of RL_{50} and T_{tol} during *kharif*, 1983 compared to *kharif* 1984 was probably due to comparatively high soil moisture during the preceeding year. Caro *et al.* (1973) also suggested that the difference in half life values and the waiting period of carbofuran might be due to weather conditions, soil moisture, temperature and cropping systems.

The carbofuran can, therefore, be considered as safe from residue point of view and hence can effectively be fit in overall strategies of pest management in sesaumm.

TABLE 4. **Residue half life (RL_{50}) and safety interval (T_{tol}) for carbofuran in soil and sesamum plants under different cropping systems during *kharif* 1983 and 1984.**

Cropping system	Carbofuran 3G @ 0.5 kg ai.. per ha		
	Regression equation Y = a + bx	Residue half-life RL_{50} (days)	Safety interval T_{tol} (days)
Soil	*Kharif*, 1983		
Sesamum sole crop	Y = 2.9145 + (–0.0355x)	8.47	53.93
Sesamum+Groundnut	Y = 2.9506 + (–0.0479x)	6.28	40.72
Sesamum + Pigeonpea	Y = 2.9761 + (–0.0461x)	6.53	42.87
Plants	*Kharif*, 1983		
Sesamum sole crop	Y = 2.9428 + (–0.0295x)	10.20	65.86
Sesamum + Groundnut	Y = 3.1971 + (–0.0518x)	5.81	42.07
Sesamum + Pigeonpea	Y = 3.0771 + (–0.04007x)	7.40	51.04
Soil	*Kharif*, 1984		
Sesamum sole crop	Y = 2.8774 + (–0.0292x)	10.31	64.30
Sesamum + Groundnut	Y = 2.9873 + (–0.0478x)	6.30	41.57
Sesamum + Pigeonpea	Y = 2.908 + (–0.0398x)	7.56	47.94
Plant			
Sesamum sole crop	Y = 2.8505 + (–0.0233x)	12.92	79.42
Sesamum + Groundnut	Y = 3.0398 + (–0.0429x)	7.10	47.55
Sesamum + Pigeonpea	Y = 2.9779 + (–0.0336x)	8.96	58.87

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Short Communications

STABILITY FOR SILIQUA TRAITS IN TARAMIRA

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Taramira (*Eruca sativa* L.) is mainly grown on mositure conserved in the soil during preceding rains. Sowing time of the crop is, therefore, need to be adjusted accordingly to the quantum and the pattern of rainfall. A cultivar stable to long range of sowing dates and responsive to nitrogen fertilization is, therefore, desired. Present experiment was thus, designed to obtain information on the phenotypic stability of 4 siliqua traits in 15 strains of taramira as no such information is available in this oilseed crop.

In a RBD with 3 replications 15 strains were raised on rainfed land under 5 environments viz., 15 kg N/ha with October 20, November 75 and December 10, 1982 sowings; and No-N with October 20 and November 15, 1982 sowings. Each entry was represented by 5 m long single row spaced 30 cm apart with an intra row spacing of 10 cm. Observations on 10 random plants from each row were recorded on number of siliquae on main shoot, siliqua length, number of seeds/siliqua and number of siliquae/plant. Analysis for stability was done using Eberhart and Russell (1966) model.

Barring siliqua length, the mean squares due to varieties and the environments when tested against pool error and pooled deviation were highly significant ($P = 0.01$), suggesting enormous variation among the cultivars and the environments (Table 1). Highly significant interaction due to varieties $\times$ environment ($g \times e$) indicated that the former interacted considerably with the environments in the expression of all the traits except siliqua length. Significant differences of higher magnitude due to environments (linear) depicted their marked influence on the expression of the traits. Highly significant differences due to linear (except siliqua length) and non-linear components (excepting siliqua length and seeds/siliqua) of $g \times e$ interaction indicated the importance of both linear (bi) and non-linear (S^2di) components in the expression of siliqua traits.

The strain TC 32 possessed minimum siliquae on main shoot whereas, TC 12 had maximum siliquae (Table 2). TC 66 and TC 57 were the only strains with significant positive linear component, whereas TC 21 was least responsive. All the genotypes but TC 66 and ITSA were stable for this trait. TC 63, above average in responsiveness was the most stable ($S^2di = 0.15$) genotype for siliquae number on main shoot.

Siliqua length with a narrow range of variation 1.70 (RTM 1) to 1.96 cm (T 27)

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TABLE 2. Stability parameters of 4 siliqua traits for 15 taramira strains.

Strains	Number of siliquae on main shoot			Siliqua length			No. of seeds per siliqua			No. of siliquae per plant		
	Mean	bi	s^2di	Mean	bi	s^2di	Mean	bi	s^2di	Mean	bi	s^2di
TC 6	12.93	-0.22	8.70	1.90	-1.29	0.04	16.57	0.29	4.76*	71.84	2.08*	111.14*
TC 7	13.58	0.75	6.22	1.88	1.31	0.02	17.01	-0.34	0.52	77.29	0.96	116.28*
TC 12	14.95	0.85	5.14	1.86	-0.28	0.06	17.69	-0.34	1.65	74.83	0.31	40.86
TC 15	14.85	-0.51	10.99	1.89	-0.26	0.01	17.11	-0.41	0.71	70.40	0.13	48.93
TC 21	14.57	0.26	10.29	1.86	-0.54	0.03	17.72	-0.41	1.29	71.77	-0.01	93.71
T 27	13.25	-0.02	9.4	1.96	0.31	0.03	17.17	4.49	1.42	72.19	0.12	59.59
TC 32	12.25	1.55	2.42	1.85	0.64	0.08	16.58	2.09	1.19	73.50	-0.40	52.36
TC 48	13.94	1.62	6.22	1.77	2.29	0.005	16.67	1.07	1.18	72.41	2.01*	25.83
TC 55	12.99	1.68	8.52	1.87	4.43*	0.04	16.70	2.72	1.89	67.07	2.10*	93.41
TC 57	12.99	2.11*	4.43	1.86	2.32	0.05	15.39	0.87	3.88	69.18	2.19*	227.75*
TC 63	13.48	1.42	0.15	1.92	3.14	0.01	17.38	1.25	4.84*	75.26	2.02*	101.11*
TC 66	14.53	2.65*	20.12*	1.88	1.01	0.01	17.71	1.44	1.77	64.29	0.87	85.19
TC 68	12.66	1.49	2.96	1.69	-1.70	0.03	15.56	0.02	2.74	62.57	-0.62	127.18*
ITSA	14.27	1.72	22.82*	1.89	2.54	0.008	19.93	1.75	0.61	68.62	2.86*	147.67*
RTM 1	12.50	-0.35	0.56	1.70	-0.08	0.009	16.28	0 81	0.72	64.21	0.37	1.49
Mean	13.58	1.00	—	1.85	1.00	—	16.90	1.00	—	70.36	1.00	—
SE ±	1.42	0.89	—	0.08	1.27	—	0.80	0.73	—	4.76	0.78	—

* P = 0

TABLE 1. Stability analysis (mean squares) for siliqua traits.

Source	df	No. of siliquae on main shoot	Siliqua length	No. of seeds per siliqua	No. of siliquae per plant
Varieties	14	3.93**++	0.03	2.92**++	94.41**++
Environments	4	38.52**++	0.06	17.85**++	560.47**++
Var. × Env.	56	8.92**++	0.03	4.46**++	119.39**++
Env. (var × env.)	60	10.89**++	0.03	5.36**++	148.79**++
Env. (linear)	1	154.06**++	0.23	71.36**++	2244.67**++
Var. × Env. (linear)	14	9.75**++	0.05	9.73**++	185.77**++
Pooled deviation	45	2.07**++	0.03	1.53	40.79**++
Pooled error	140	0.50	0.006	0.44	4.86

* P = 0.05; ** P = 0.01 with the pooled error

\+ P = 0.05; ++ P = 0.01 with the pooled deviation

was the most stable component, for none of the cultivar had significant non-linear component. TC 55 was the only strain responsive to better environment. TC 6 and TC 68 were above average in responsiveness to poor management.

Number of seeds per siliqua was minimum in TC 57 (15.4) and maximum in ITSA (19.9). Out of the 15 strains, none was responsive to existing environments. All the strains except TC 6 and TC 63 were stable. ITSA with maximum number of seeds per siliqua was above average in response (bi = 1.75) and was the most stable except TC 7.

Number of siliquae per plant were maximum in TC 7 (77.29) and minimum in TC 68 (62.57). The strains viz., TC 6, TC 48, TC 55, TC 57, TC 63 and ITSA which exhibited significant bi component were considered responsive to better environment. TC 7 with maximum number of siliquae per plant was unstable. TC 48 responsive to existing environments was stable whereas, TC 57 was responsive and non stable for tihs trait. The strain RTM 1 with below average in responsiveness was the most stable for siliquae per plant.

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ASSOCIATION ANALYSIS IN SAFFLOWER

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Safflower, like other crops, also exhibits various plant types (Chavan, 1961). It is, therefore, necessary to study the nature of association of different characters separately in each of the plant types so as to identify the different genetic mechanisms operating inside the plant for the manifestation of yield.

The experiment was conducted in two phases. In the first phase, 1000 strains collected from all over India were grown in a RBD with three replications at the Experimental Farm of Calcutta Univeristy at Baruipur, 24-Parganas during three consecutive *rabi* seasons. In each year observations were recorded on ten randomly selected plants for three characters viz. plant spread, widest angle of the branching to main stem and plant height. Four phenotypically distinctive varietal groups viz. (i) Tall compact, (ii) Tall lax, (iii) Dwarf compact and (iv) Dwarf lax could be established exploiting the variability in these traits. The strains exhibiting values one S.E. unit below and values one S.E. unit above the population mean consecutively for three years in regard to two characters viz. plant spread and widest angle of branching to main stem were termed respectively as compact type and lax type. Similarly, the strains attaining a height one S.E. unit below and a height one S.E. unit above the population mean for three experimental years were termed respectively as dwarf type and tall type.

The second phase of the investigation comprised of 20 strains in tall compcat group, 40 strains in tall lax group, 15 strains in dwarf compact group and 25 strains in dwarf lax group grown groupwise separetely under RBD with 3 replications for another three years to record observations on characters viz. plant height, number of primary and secondary branches, number of effective heads/plant, number of seeds/head, width of OIB, diameter of head, 100 seed weight and yield/plant. The data averaged over years were subjected to statistical analysis for ascertaining the associationship separately in each group.

The results revealed that four groups identified through the study of phenotypic variability may ultimately be classified into two distinct types (Table 1). In one type-(Tall lax) maximum number of heads/plant and secondary branches were noticed, while the other type (Tall compact) exhibiting minimum values for these two traits demonstrated the highest values for head diameter and number of seeds/head (Table 2). Furthermore, these two types did not differ significantly in regard to yield.

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TABLE 1. Phenotypic range, mean, variances coefficients of variability and standard error for three traits in a collection of safflower germplasm.

Characters	Range	Mean	Phenotypic variance	Phenotypic Coefficient of Variability	Standard Error
Plant spread[1] (cm)	10.8–68.5	36.06	164.06**	26.65	±1.32
Branching angle[2] (degree)	10.2–49.4	21.55	17.73**	22.00	±0.43
Plant height (cm)	42.8–140.5	90.32	244.92**	17.00	±1.61

** Significant at P = 0.01

[1]Linear distance between two farthest branches

[2]Widest angle of branching to main stem

TABLE 2. Mean performances in respect of yield and yield component characters for four groups of safflower and comparison of these groups means.

Varietal group	Plant height (cm)	No.of primary branches	No. of Secondary branches	No. of heads/ plant	No. of seeds/ head	Width of OIB (cm)	Head diameter (cm)	100 seed wt. (g)	Seed yield plant (g)
Tall lax (TL)	124 80	16.00	33.50	35.00	18.34	0.17	1.85	4.77	22.25
Tall compact (TC)	139.15	7.70	20.53	21.40	33.05	0.24	2.30	4.69	26 83
Dwarf lax (DL)	66.00	9.50	23.33	24.25	19.50	0.14	1.51	3 66	13.35
Dwarf compact(DC)	80.00	10.00	21.00	26.20	23.59	0.16	1.75	5.19	17.14
Group Comparison									
TL vs TC	NS	*	*	*	*	*	*	NS	NS
TL vs DL	*	*	*	*	NS	NS	NS	NS	*
TL vs DC	*	*	*	*	NS	NS	NS	NS	*
TC vs DL	*	NS	NS	NS	*	*	*	NS	*
TC vs DC	*	*	NS	NS	*	*	*	NS	*
DL vs DC	NS	NS	NS	NS	NS	NS	NS	*	NS
C.D. at P=0.05	42 67	2.18	9.93	8 71	5.81	0 048	0.47	1.42	8.20

NS : Not significant

* : Significant at P = 0.05

The correlation analysis further demonstrated that all the types except tall compact possessed number of heads/plant as the common principal attribute for the manifestation of yield. In tall compact types, however, the main yield determinant was head diameter which in turn indicated high positive association with number of seeds/head. The OIB width in this type exhibiting very high positive correlation with yield indicated negative association with number of heads/plant (Table 3). A negative association

TABLE 3. Association (phonotypic correlation coefficiants) among different characters in four groups of safflower.

	Dwarf lax (DL)	Dwarf compact (BC)	Tall lax (TL)	Tall compact (TC)
Yield/plant vs. :				
Plant height	0 437	0 283	0.318	0.088
No. of primary branches	0.689**	0.528	0 633**	–0.371
No. of secondary branches	0.758**	0.551**	0.723**	0.283
Heads/plant	0.809**	0.741**	0.689**	0.132
Seeds/head	0.303	0 089	0.200	0.410
Head diameter	0.223	0 212	0.112	0.851**
Width of OIB	0.101	0.324	–0.198	0.852**
100 seed weight	0.388	0.481	0.208	0.128
Heads/plant vs. :				
Plant height	0.602*	0.534*	0.518**	0.301
No. of primary branches	0.712**	0.608*	0.586**	0.388
No. of secondary branches	0.882**	0.978**	0.832**	0.644**
Seeds/head	0.223	0.509	0.182*	–0.182
Head diameter	0.113	0.301	0 310	–0 302
Width of OIB	0.201	–0.086	–0.182	–0.484
100 seed weight	0.306	0.521*	0.082	–0.398
Seeds/head vs. :				
Plant height	0.210	0.415	0.198	–0.312
No. of primary branches	0.311	0.741**	0.208	–0.009
No. of secondary branches	0.082	0.524*	0.298	–0.090
Head diameter	0.388	–0.106	0.282	0.615*
Width of OIB	0.213	0.482	–0.180	0.209
100 seed weight	–0.268	–0.229	0.009	–0.348
Plant height vs. :				
No. of primary branches	0.687**	0.741**	0.548**	–0.681*
No. of secondary branches	0.788**	0.588*	0.412*	0.301
Head diameter	0.088	0.648**	0.008	0.270
Width of OIB	0.098	0.388	0.101	–0.602
100 seed weight	0.296	0.420	–0.501*	–0 080
No. of primary branches vs. :				
No. of secondary branches	0.810**	0.820**	0.688**	0.420
Head diameter	0.009	0 260	0.316	0.380
Width of OIB	0.123	0.348	–0.210	–0.095
100 seed weight	0.301	0.426	–0.110	–0.408
No. of secondary branches vs. :				
Head diameter	–0.082	–0.489	0.213	0.182
Width of OIB	0.096	–0.283	–0.705**	0.208
100 seed weight	0.211	0.524*	0.009	–0.398

Head diameter vs. :				
Width of OIB	-0.295	0.374	0.088	-0.380
100 seed weight	0.188	0.182	-0.211	0.109
Width of OIB vs. :				
100 seed weight	-0.086	0.384	0.301	-0.099

** Significant at P = 0.01

* Significant at P = 0.05

between width of OIB and number of heads/plant has also been reported by Ashri *et al.* (1974, 1976). Thus, it may be assumed that the principal effect of OIB width in tall compact type is the reduction in the number of heads/plant resulting thereby increased head diameter. As regards other types, yield besides its association with number of heads/plant was found to be highly correlated with primary and secondary branches in most of the cases.

Thus on the basis of present investigation the germplasm pool may be reasonably grouped at least into two plant types viz. head number type and head diameter type depending on the mode of action leading to the foundation for yield.

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POPULATION DYNAMICS OF *MYZUS PERSICAE* SULZER AND *LIPAPHIS FRYSIMI* KALT. ON RAPESEED AND MUSTARD IN UTTAR PRADESH

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Mustard aphis, *Lipaphis earysimi* Kalt. has so far been recognized as one of the main constraints in increasing rapeseed and mustard production, but during recent years alarming incidence of *Myzus persicae* Sulzer on these crops, especially in areas where potato + mustard cropping system is being followed, has diverted the attention to study its population dynamics in relation to enviromental conditions.

Brassica juncea (Var. Varuna) and *B. campestris* (Var. YSK-3) were sown in departmental insectary on 18th Nov., 1983 to observe the population fluctuations of aphids on these crops at 80:40:40 kg./ha NPK fertility level. Observations were recorded at weekly intervals on aphid indices by following the technique of Pradhan *et al.* (1960) the colonies of different species of aphids and their colour forms on five plants tagged randomly, on both the crops. The data on prevailing weather conditions were also collected from the observatory so as to workout their relationship with various observations on aphids.

(i) **Aphid infestation :**

Aphid population was noticed first on *B. juncea* which was in flowering stage in January and a week later on *B. campestris* (Table 1). However, intensity of aphids was more on *B. campestris* in later stages. The infestation of aphids usually appears on newer leaves but the red form of *M. persicae* behaved in some what different manner; its incidence was first noticed in bunches of flower buds and small colonies were formed in inflorescence or just adjoining to it and in later stages it also spread over other vegetative parts of plants like leaves, stem and green pods. The maximum attack of *L. erysimi* was to the extent of 4.50 and 4.37 on *B. juncea* and *B. campestris*, respectively in the middle of March, while *M. persicae* had 2.17 and 1.23 indices in 2nd and 3rd week of February on these crops (Table 1). The observations on more intensity of *L. erysimi* on *B. juncea* than *B. campestris* in early stage of infestation do not corroborate with the findings of Pathak (1961), Tripathi and Singh (1964), Prasad and Phadke (1980) and Singh *et al.* (1984), but certainly up hold the views of Prasad and Phadke (1980) who also asserted that stage of crop at a particular time is more important to harbour aphid population.

As regards the impact of weather conditions, minimum temperature and rate of evaporation were positively correlated with the increase in population of *L. erysimi* on both rapeseed and mustard. The population of *M. persicae* found to be negatively governed by maximum temperature on *B. juncea* (Table 1 and 2). In present study increase in maximum temperature more than 30°C and minimum temperature above 15°C with relative humidity below 75 per cent, increase in wind velocity more than 3 km.

TABLE 1. **Aphid indices, percentage of colonies and colour forms of *M. persicae* on rapeseed and mustard.**

Date of observation	Aphid indices		Percentage of colonies			Colour forms of *M. persicae*	
	L. erysimi	*M. persicae*	*L. erysimi*	*M persicae*	Mixed	Green yellow	Red
			B. juncea	(*Mustard*)			
25.1.84	0.60	0.33	**61.67**	38.33	—	49.67	50.33
1.2.84	0.90	0.57	**58.33**	30.00	11.67	29.67	70.83
8.2.84	1.90	1.40	**56.67**	25.00	18.33	38.33	61.67
15.2.84	2.27	2.17	**51.67**	21.67	26.67	60.00	40.00
22.2.84	2.53	1.63	**60.00**	11.67	28.33	76.67	23.33
29.2.84	3.27	0.57	**81.67**	6.67	11.67	98.33	1.67
9.3.84	3.37	0.07	**93.33**	3.33	3.33	—	—
14.3.84	4.50	0.07	—	—	—	—	—
			B. campestris	(*Rapeseed*)			
1.2.84	0.53	0.07	**90.33**	1.67	—	—	58.33
8.2.84	1.37	0.53	75.00	15.00	10.00	31.67	62.33
15.2.84	2.27	0.07	65.00	28.33	6.67	48.33	57.67
22.2.84	2.37	1.23	56.67	21.67	21.67	74.33	25.67
29.2.84	3.47	0.63	76.67	11.67	11.67	93.33	6.67
9.3.84	3.87	0.00	100.00	—	—	—	—
14.3.84	4.37	0.00	—	—	—	—	—

TABLE 2. Correlation Coefficient of aphid indices, their colonies and colour forms.

Parameter	Temperature (°C)		RH %		Wind Velocity (km/hr)	Evaporation (mm/day)
	Max.	Min.	Max.	Min.		
		B. juncea				
1. Aphid index :						
a. *L. erysimi*	0.476	0.851**	0.566	0.036	0.410	0.852**
b. *M. persicae*	-0.786*	0.140	0.589	0.300	0.060	0.440
2. Percent colony:						
a. *L. erysimi*	0.573	0.684	-0.920**	-0.300	0.586	0.916**
b. *M. persicae*	-0.026	-0.861*	-0.725.	-0.054	-0.878**	-0.853*
c. mixed	-0.839*	-0.405	0.770.	0.397	-0.095	0.637
3. Colour variation in *M. persicae* :						
a. Green	0.018	0.584	-0.700	0.848	0.850*	0.850*
b. Red	-0.018	-0.580	0.671	0.049	-0.854*	-0.856*
		B. campestris				
1. Aphid index:						
a. *L. erysimi*	0.750.	0.700	0.550	0.013	0.364	0.823*
b. *M. persicae*	0.262	0.424	0.186	0.147	0.540	0.154
2. Percent colony:						
a. *L. erysimi*	0.698	0.317	-0.476	-0.139	-0.247	0.274
b. *M. persicae*	-0.480	0.015	0.120	0.150	0.700	0.004
c. Mixed	-0.334	0.150	0.347	0.178	0 074	-0.050
3. Colour variation in *M. persicae* :						
a. Green	0.440	0.700	-0.800*	0.120	0.930*	0.840.
b. Red	-0.410	-0.574	0.836.	0.026	-0.965**	0.836

** Significat at 1 per cent level. * Significant at 5 per cent level.

per hour and rate of evaporation 5 mm per day, had their combined effect in a sudden fall of aphid population as observed in 3rd week of March (Table 1).

(ii) **Aphid colonies :**

Colonies of *L. erysimi* and *M. persicae* were quite distinct and their respective percentages were 61.67 and 38.33 in early stage of infestation on *B. juncea* (Table 1). Thereafter, population of *M. persicae* gradually decreased and *L. erysimi* went on multiplying and finally reached as high as 93.33 per cent as against *M. persicae* which had only 3.33 per cent by the end of Ist week of March (Table 1). The mixed population of both aphid species were to the extent of 21.67 and 28.33 per cent on *B. campestris* and *B. juncea*, respectively.

As far as the relationship of environmental conditions with aphid colonies is concerned, maximum temperature, wind velocity and rate of evaporation were found to have negative correlation with *M. persicae* on *B. juncea*, but rate of evaporation manifested positive correlation with *L. erysimi*. It could further be seen from Table 2 that higher relative humidity had its adverse effect on multiplication of peach aphid. It would also be worthy to mention that with the increase in temperature (20 - 25°C), mixed colonies also increase, but beyond 25°C, the population of *M. persicae* is adversly affected and contray *L. erysimi* continues to build up to 30°C (Table 1). These findings confirm the observations of Bakhetia and Sidhu (1983) and Bakhetia (1985) as they have also noticed the similar effect of minimum temperature on *L. erysimi*.

(iii) **Colour variation in** *M. persicae*

In the present experimentation, *M. persicae* had three colour forms namely green yellow, red and gray. The percentage of green yellow and red forms was almost equal in beginning but soon after red form increased up to 70.33 and 62.33 per cent on *B. juncea* and *B. campestris*, respectively. In later stages green yellow form of aphid dominated (Table 1), whereas gray form eliciated its low intensity on these *Brassica* species.

A decline in red form was found to be negatively correlated with wind velocity and rate of evaporation, while relative humidity was very conducive for this colour form (Table 2). Consequently, green yellow form predominated with the increase in rate of evaporation more than 2 mm per day and wind speed more than 3 km per hour. The existence of gray form of *M. persicae* is the first ever made record from India although red colour form has recently been reported by Singh and Singh (1983) but only on *B. campestris* from Hisar (Haryana) and Ueda and Takada (1977) on varoius hosts from Japan.

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PHENOTYPIC STABILITY OF YIELD AND ITS COMPONENTS IN INDIAN MUSTARD

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In recent years the interest of the plant breeders has been directed towards better adaptation of the crop varieties. In Indian mustard, diverse genetic stocks have been evolved through mutations and hybridization. In the present investigation elite genotypes of Indian mustard have been taken up to evaluate phenotypic stability under pertinent environmental conditions.

Twelve genotypes were evaluated for yield and its component traits in replicated trials, under twelve pertinent environments created by the combination of sowing dates and three fertilizer levels. The observations were recorded on per plant basis for plant height, main shoot length, number of siliquae on main shoot, siliqua length, seeds per siliqua, 1000-seed weight and seed yield per plant. The stability parameters were computed using the model of Eberhart and Russell (1966).

The analysis of variance for phenotypic stability is presented in Table 1. Genotypes were significantly different from each other for all the traits except length of main shoot. Genotype × environment interaction was significant when tested against pooled error. The partitioning of environment + genotype × environment interaction into different components revealed that the environment (linear) was significant for all the characters, as expected, indicating that the response to the evnvironments was predictable. Genotype × environment (linear) interaction was significant only for siliqua length and highly significant for 1000-seed weight and seed yield per plant but non-significant for rest of the characters. However, the pooled deviations from regression were significant for all the traits indicating the non-linear respons: of genotypes to environments. Thus, the parameter Sd^2 may be comparatively more important for interpreting the stability status of the characters viz., plant height, length of main shoot, siliqua number on main shoot and number of seeds per siliqua. The values of means, regression co-efficients on evnironmental index and deviation mean squares from regression for all the charecters are given in Table 2.

The desirable plant height was of RH 30, RH 7514, P. Rai and Varuna. Genotypes RLM 621 and RLM 240 were stable as they showed least deviation from regression. For siliqua on main shoot, RLM 514 and RLC 1005 were the stable genotypes. Further, RLC 1005 was found to be the ideal genotype as it combined high mean.

With the stability parameter, for siliqua length, the ideal combination of high mean, regression co-efficient and deviation from regression was observed only in Varuna

It is interesting to note that all the four genotypes which had less plant height

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TABLE 1. Pooled analysis of variance for phenotypic stability

Source	d.f.	Plant height	Length of main shoot	Siliqua on main shoot	Siliqua length	No. of seeds per siliqua	1000-seed weight	Seed yield per plant
Genotypes	11	0.2547**	37.62	145.93**	0.49**	1.84*	9.05**	3.55**
Environments	11	1.4991**	724.82**	528.29**	1.37**	9.67**	0.39**	8.92**
Geno. + Env.	121	0.0072**	68.77**	12.34**	0.06**	0.33**	0.13**	1.29**
Env. +(Geno. × Env.)	132	0.1315	81.42	55.34	0.17	1.11	0.15	1.93
Env. (Linear)	1	16.4900**	7973.01**	5811.22**	15.08**	106.37**	4.27**	98.16**
Geno. × Env. (Linear)	11	0.0046	9.04	3.18	0.97**	0.09	2.82**	2.47*
Pooled deviation	120	0.0068**	22.29**	12.15**	0.05**	0.33**	0.11**	1.08**
Pooled error	264	0.0017	5.67	3.43	0.02	0.24	0.28	0.38

*, ** Significant at P = 0.05 and 0.01 respectively

TABLE 2. Stability parameters of different morphological characters.

	Variety	Plant height (m)			No. of siliqua on main shoot			Length of Siliqua		
		Mean	b	Sd^2	Mean	b	Sd^2	Mean	b	Sd^2
1.	RLM 29	1.70	1.02	0.24	31.75	0.96	4.95	4.02	0.93	n.s
2.	RLM 84	1.69	1.05	0.36	32.49	1.03	17.27	4.09	1.38	0.06
3.	RLM 198	1.69	1.04	0.29	34.50	1.12	4.26	3.84	0.82	0.03
4.	RLM 240	1.73	1.05	0.21	33.34	0.98	7.92	4.00	0.67	0.03
5.	RLM 514	1.61	0.97	0.36	31.34	0.98	n.s.	3.91	0.93	0.02
6.	RLM 621	1.70	1.03	0.16	33.67	0.93	5.64	3.89	0.48	0.02
7.	RLC 1005	1.64	1.05	0.24	34.72	1.15	2.37	3.72	0.82	0.02
8.	RL 18	1.61	0.00	0.31	32.81	1.04	7.94	3.95	1.40	0.06
9.	RH 30	1.27	0.88	1.41	23.84	0.96	0.09	4.24	1.15	0.02
10.	RH 7514	1.51	0.99	0.77	28.16	0.86	16.01	4.24	1.24	n.s.
11.	P. Rai 34	1.42	1.00	1.37	26.98	1.04	21.93	4.26	1.11	0.08
12.	Varuna	1.42	0.90	0.40	28.22	0.94	5.58	4.39	1.08	0.03
	Mean	1.58	1.00		31.07	1.00		4.05	1.00	
	S.E.	0.02	0.07		1.05	0.16		0.07	0.20	

TABLE 2. Contd.

	Variety	No. of seeds per siliqua			1000-seed weight (g)			Seed yield per plant (g)		
		Mean	b	Sd^2	Mean	b.	Sd^2	Mean	b	Sd^2
1.	RLM 29	10.64	0.80	n.s.	3.68	0.11	n.s.	5.67	1.29	1.01
2.	RLM 84	10.86	1.15	n.s.	3.21	0.47	n.s.	5.46	1.31	1.21
3.	RLM 198	10.20	0.98	n.s.	3.42	0.56	n.s.	6.10	0.85	1.12
4.	RLM 240	10.64	1.15	n.s.	3.40	0.38	n.s.	5.09	0.76	1.36
5.	RLM 514	10.91	1.02	n.s.	3.55	1.30	n.s.	5.60	0.96	1.24
6.	RLM 621	10.45	1.02	0.49	3.13	0.59	n.s.	5.85	0.22	0.70
7.	RLC 1005	11.03	1.08	n.s.	3.25	0.52	n.s.	6.42	1.35	1.24
8.	RL 18	10.45	1.02	n.s.	3.33	0.82	n.s.	5.52	0.73	1.13
9.	RH 30	9.61	0.98	0.27	6.05	3.36	0.54	4.39	0.57	0.65
10.	RH 7514	10.95	1.01	n.s.	4.05	1.22	n.s.	5.28	0.98	1.42
11.	P. Rai 34	10.51	0.93	n.s.	4.82	1.71	n.s.	5.18	1.26	0.70
12.	Varuna	10.39	0.86	n.s.	4.51	1.18	n.s.	5.75	1.74	0.70
	Mean	10.55	1.00		3.87	1.00		5.44	1.00	
	S.E.	0.17	0.19		0.10	0.56		0.31	0.36	

showed significantly higher siliqua length. These were RH 30, RH 7514, P. Rai 34 and Varuna. For number of seeds per siliqua, the performance of the genotypes may be considered consistent as their b values were non-significant for all and Sd^2 values were significant for most of the genotypes. For 1000-seed weight, RH 30 had very high mean but below average stability. P. Rai 34 and Varuna also had high mean seed weight but were classed under low and average stability categories, respetively.

For seed yield per plant, RLC 1005 had very high seed yield but low stability. Next high yielder was RLM 198 with comparatively more stability. Varuna had below average stability for the trait having very high regression co-efficent. RLM 621, a low yielding variety had b = 0.22, indicating high stability suggested that under very poor environments. This variety can be grown where other genotypes are likely to perform vary poor. The wide occurrence of genotype-environment interaction and need to pay attention to it for improvement of Indian mustard has also been emphasized by Labana *et al.* (1975) and Gupta *et al.* (1983).

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ESTIMATION OF YIELD LOSS IN SAFFLOWER DUE TO THE APHID

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Safflower aphid, *Uroleucon carthami* H.R.L. is the most destructive pest of safflower in India. It sucks sap from all above ground plant parts and in severe infestation the plants dry up. The yield losses due to safflower aphid has been estimated to range from 35 to 36 per cent (Bindra and Vaishampayan, 1965; Bhumannavar and Thontadarya, 1979), 55.9 to 67.7 per cent (Basavanagound *et al.*, 1981), 60 per cent (Rathore, 1983), 69 per cent (Carlson, 1972) and 55 to 60 per cent (Suryawanshi and Pawar, 1981). The present investigation, therefore, was undertaken to estimate the extent of losses caused by the aphids in safflower, with and without application of fertilizers and without plant protection measures.

Investigations here carried out during *rabi* seasons of 1982-83, 1983-84 and 1984-85 at Agricultural Research Station, Jalgaon. Bhima variety of safflower was sown at 45×20 cm spacing in the plots of 5.0×4.5m^2 size, replicated five times in a RBD with four treatments. The fully protected plots were applied with 0.05% dimethoate at 7 days interval. Aphids were counted from two 10 cm terminal twigs on five plants selected randomly from each treatment plot at 10 days interval, starting from infestation of aphids till the aphid population declined and cummulative number of aphids per plant was worked out. Seed yield after harvest was also recorded.

Pooled analysis of three years data, presented in Table 1 revealed that, the lowest cummulative number of aphids (10.05/plant) was observed in the plots, applied with fertilizers and full protection against the pest with 0.05% at weekly interval and it was on par with the treatment having full protection against the pest and without fertilizer application.

The highest seed yield (1441 kg/ha) was obtained when the crop was protected from aphids and was applied with recommended dose of fertilizers. It was 287 kg, 230 kg and 493 kg/ha more than the plots receiving only fertilizers, only full protection against aphids and than the plot without plant protection and fertilizers respectively. The loss in yield of seed was observed 19.91% and 23.94% from plot with fertilizers and no plant protection measure and the plot without fertilizers and no plant protection measures respectively. The average loss in seed yield of safflower was therefore, observed to be 21.9% due to lack of plant protection measures against aphid.

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TABLE 1. Cummulative number of aphids/plant and seed yield of safflower as influenced by the application of fertilizers and plant protection measures against the aphid.

	Treatments	Cumulative number of aphids per plant				Av. seed yield (kg/ha)				% loss due to lack of plant protection	Av. loss %
		1982-83	1983-84	1984-85	Pooled mean	1982-83	1983-84	1984-85	Pooled mean		
1.	Low monetary inputs + fertilizers + full protection	16.8	8.2	5.2	10.1	1049	1817	1458	1441		
2.	Low monetary inputs + fertilizers + No protection	224.0	22.4	94.5	133.7	664	1777	1020	1154	19.9	2.92
3.	Low monetary inputs + No fertilizer + full protection	19.5	9.8	5.4	11.6	923	1712	999	1211		
4.	Low monetary inputs	250.4	61.3	104.6	138.8	568	1503	694	921	23.9	
	S.E. ±	43.5	6.9	4.7	33.0	72.4	51.2	86.0	103.7		
	C.D. at P=0.05	133.5	21.0	14.3	94.7	222.5	157.7	264.9	297.4		

Low monetary inputs = Improved variety (Bhima) and optimum sowing time.

Fertilizers = 50 kg N + 25 kg P_2O_5/ha.

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A NOTE ON THE IDENTIFICATION OF CRITICAL CROP GROWTH STAGE OF SAFFLOWER FOR INITIATING THE CONTROL MEASURES AGAINST THE APHID

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Safflower aphid, *Uroleucon carthami* H.R.L. is the major pest of safflower causing severe damage to the crop throughout India. The nymphs and adults suck sap from tender shoots and leaves and affect plant growth. In case of severe infestation, the complete plants got dried up resultsing heavy loss in seed yield. Bhumannavar and Thontdarya (1979) reported that phosphamidon 0.25 kg a.i./ha or dicrotophos @ 0.5 kg a.i./ha applied twice at 20 days interval starting from 60 days after sowing gave effective control of aphids and increased seed yield. At Jabalpur, metasystox spray @ 250 ml a.i./ha was the most effective against safflower aphids for three weeks. It is economical and also selective to coccinellid predators (Rathore, 1983). The present study was taken up to find out the critical crop growth stages for adopting plant protection measures against aphids.

A field experiment was conducted, to study the various crop growth stages of safflower and to identify them for adopting plant protection measures against aphids in *rabi* seasons of 1982-83, 1983-84 and 1984-85 at Agricultural Research Station, Jalgaon. Ten treatments, replicated three times in a RBD using recommended variety Bhima. Sowing was done with a 45 × 20 cm spacing in plots having 5.0 × 4.5 m^2 size. Plants were protected with dimethoate 0.05% as per treatment details given in Table 1. The first spray of 0.05% dimethoate was given immediately after the incidence of aphid noticed and subsequent sprays were given at 15 days interval to these respective treatments. Aphid population counts were recorded on two apical twigs of 10 cm length of five randomly selected plants at 10 days interval from all the treatment plots, starting from the first incidence of pest till its decline, and cummulative numbers of aphids per plant were calculated. Seed yield of safflower was also record after harvest.

It could be seen from the Table 1 that significantly lowest cummulative number of aphids (10.4/plant) was recorded from the plots receiving 0.05 per cent dimethoate at 15 days interval starting from just after the incidence of aphid was noticed. Spraying of dimethoate 0.05% 1 and 2 weeks after the first incidence of aphids also recorded low incidence of aphids and was on par with spraying just after incidence of aphids. The significant increase in yield ranged from 377 kg/ha to 211 kg/ha over untreated controls and differences in the yield were not signiffcant in the treatments from one to five weeks after the incidence of the aphids. During this period of 1 to 5 weeks after incidence, the crop was at branch initiation stage to 50% flowering stage. Thus, it can be concluded that the most critical stage of safflower crop for the protection against the aphids is from branch initiation to 50% flowering.

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TABLE 1. **Identification of crop growth stages of safflower for insecticidal sprays against aphids** *Uroleucon carthami* **H.R.L.**

	Treatments	Crop stage when 1st spray started	Cummulative numbers of aphids per plant				Seed yield (kg/ha)				% increase over control
			1982–83	1983–84	1984–85	Pooled mean	1982–83	1983–84	1984–85	Pooled mean	
1.	Spray begins just after incidence of aphids	Branch initiation	9.7	13.5	7.9	10.4	778	1870	1384	1348	33.1
2.	Spray begins 1 week after incidence of aphids	Branching	4.3	18.6	37.6	20.2	783	1846	1346	1325	30.8
3.	Spray begins 2 weeks after incidence of aphids	Flower bud initiation	9.4	16.7	53.3	26.5	783	1972	1417	1390	37.2
4.	Spray begins 3 weeks after incidence of aphids	Do	9.1	27.1	103.7	46.6	672	2069	1350	1345	32.8
5.	Spray begins 4 weeks after incidence of aphids	50% flowering	104.3	20.5	107.5	77.4	477	1842	1293	1224	20.8
6.	Spray begins 5 weeks after incidence of aphids	Flowering	84.7	27.5	123.9	78.7	502	1857	1294	1200	18.5
7.	Spray begins 6 weeks after incidence of aphids	Flowering	107.0	34.4	131.1	90.6	491	1769	1282	1184	16.9
8.	Spray begins 7 weeks after incidence of aphids	Seed formation	99.9	35.9	135.4	90.4	567	1688	1278	1178	16.3
9.	Spray begins 8 weeks after incidence of aphids	Seed formation & maturity	101.6	44.5	132.9	93.0	514	1502	1242	1098	8.4
10.	Untreated control	120.0	120.9	39.6	141.1	100.5	462	1393	1186	1013	—
	S.E. ±		11.1	9.1	8.5	8.3	41.72	90.94	63.43	68.39	—
	C.D. at P=0.05		33.8	27.2	25.3	23.6	125.08	270.21	188.42	193.65	—

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J. Oilseeds Res. 3(1986) :261-263

EFFICACY AND RESIDUAL TOXICITY OF CERTAIN INSECTICIDES AGAINST *SPODOPTERA LITURA* F. INFESTING GROUNDNUT

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Spodoptera litura Fab. commonly known as tabacco caterpiller which was of no consequence to groundnut a dicade ago, has now became a major pest particularly on irrigated groundnut. It appeared in the serious form for the first time on groundnut crop in Saurashtra region of Gujarat State during 1979. Several workers (Chari and Patel, 1972, 1980; Krishnamurthy Rao *et al.*, 1977) have tried different insecticides against this pest on different host crops but the information is scanty particularly for groundnut crop. According to the Natesan and Balasubramaniam (1979), quinalphos 0.06% caused quick mortality of *Spodoptera* on the groundnut crop immediately after treatment and reported 98.2% larval mortality even after 144 hours of its application.

The present investigation was taken up to evaluate the efficacy of different insecticides against the second and third instar larvae of *Spodptera litura* F.

The experiments against *Spodoptera litura* F. were carried out at the Main Oilseeds Research Station, G.A.U. Junagadh Campus on groundnut crop during the years 1983 to 1985. The details of the insecticide treatments are given in Table 1. These insecticides were applied on 50 days old groundnut crop in 10 m row separately for each treatment. Groundnut twigs from the respective treatment rows were brought to the laboratory 24 hours, 48 hours, 4 days, one week and two weeks after insecticidal application. The twigs were kept in the specimen tubes and 10 larvae of second and third instars were released per tube and allowed to feed on the twigs. Each set was replicated thrice. The tubes were covered with muslin cloth and observations on the larval mortality were recorded 24 hours after each release. The per cent mortality values were subjected to angular transformation before statistical analysis.

Mortality data (Table 1) 24 hours after insecticidal application revealed that methomyl 0.05% exhibited maximum larval mortality (96.5%) followed by Chlorpyriphos 0.05% + dichlorvos 0.05% and chlorpyriphos 0.05% alone were at par. There were no significant difference in reduction of pest population among quinalphos 0.05% +dichlorvos 0.05%, endosulfan 0.07% + dichlorvos 0.05%, endosulfan 0.07%, monocrotophos 0.05%, phenthoate 0.05%, quinalphos 0.05% and fenitrothion 0.05% and all were equally effective at 24 and 48 hours after insecticidal application.

Perusal of the data (Table 1) further revealed that apart from larval mortality the field persistance (4 days one week and two weeks after spraying) against *Spodoptera* larvae was more incase of chlorpyriphos 0.05% + dichlorvos 0.05%, Chlorpyiphos 0.05%, methomyl 0.05%, quinalphos 0.05%,+dichlorvos 0.05% and endosulfan 0.07%.

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TABLE 1. Comparative efficacy and residual toxicity of certain insecticides against second and thrid instar larvae of *Spodoptera litura* F. (Pooled data of *Kharif* 1983-84, 1984-85).

Sr. No.	Treatment	Percentage mortality of *S. litura* larvae at different interval				
		24 hours	48 hours	4 days	One week	Two week
1.	*Quinalphos* 0.05% + DDVP 0.05%	46.1 (51.9)*	51.4 (61.1)	53.5 (64.6)	45.0 (50.1)	20.7 (12.5)
2.	Chlorpyriphos 0.05% + DDVP 0.05%	73.5 (92.0)	74.9 (93.2)	73.3 (91.8)	56.0 (68.8)	28.2 (22.4)
3.	Chlorpyriphos 0.05%	73.3 (91.8)	73.5 (92.0)	72.0 (90.4)	53.1 (64.0)	30.5 (25.8)
4.	Endosulfan 0.07%	55.2 (67.5)	50.0 (58-7)	51.1 (60.6)	41.1 (43.2)	13.6 (5.5)
5.	Endosulfan 0.07% + DDVP 0.05%	52.1 (62.3)	50.4 (59.3)	47.0 (53.4)	46 0 (51.7)	16.5 (8 0)
6.	DDVP 0.05%	55.6 (68.0)	48.2 (55.3)	46.0 (51.7)	43.1 (31.5)	12.2 (4.5)
7.	Monocrotophos 0.05%	50.0 (58.6)	50.4 (59.4)	46.1 (51.9)	47.0 (53.5)	21.7 (13.7)
8.	Methomyl 0.05%	79.3 (96.6)	75.1 (93.4)	70.1 (88.4)	59.5 (74.2)	38.2 (38.2)
9.	Phenthoate 0.05%	51.0 (60.3)	52.0 (62.0)	49.0 (57.0)	41.1 (43.2)	15.1 (6.8)
10.	Quinaplhos 0.05%	55.0 (67.1)	54.1(65.6)	47.0 (53.4)	45.1 (50.2)	18.0 (9.6)
11.	Fenitrothion 0.05%	39.0 (39.7)	45.4 (50.6)	41.1 (43.2)	39.2 (39.9)	19.6 (11.2)
12.	Control.	10.7 (3.4)	10.7 (3.4)	16.5 (8.1)	13.6 (5.5)	12.2 (4.5)
	S.Em. ±	5.7	5.7	6.8	2.6	2.2
	C.D. at P= 0.05	17.8	17.6	22.2	7.4	6.3
	C.V. %	13.9	14.1	13.2	14.6	26.3

* Figures in the paranthesis are retransformed values.

Similar trends in larval mortality of *Spodoptera* were obtained by Chari and Patel (1972) chari (1980), Ramprasad and Joshi (1982) for methomyl 0.05% and chlorpyriphos 0.04% and more persistant effect of chlorpyriphos alone and in combination with dichlorvos by Natesan and Balasubramanium, (1979) and Patel, (1979).

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TRANSFER OF TECHNOLOGY - A CASE STUDY OF GROUNDNUT

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Groundnut meets most of our edible oil requirements. Its cultivation has already gained wide popularity in the country. Most of the small and marginal farmers have accepted it as one of the good remunerative crops. Orissa covers about 2.60 percent in area and 4.65 per cent in production of groundnut in the country. Although it's cultivation has been attached with increasing importance, the productivity level has not been increased substantially. There is considerable gap in between expected and actual yield per hectare of land. There are a number of factors for low level of yield in groundnut. Among them, poor level of knowedge of the growers is one. At our Krishi Vigyan Kendra (KVK), Baliapal we offer training to farmers on a variety of subjects. As per damand, we had organised training programmes on groundnut cultivation for 170 practicing farmers during the year 1984-85. As a matter of regular practice, we normally record the level of knowledge of the trainees before we expose them into training about the technology in which they need and accordingly design our courses. The present note reveals the result of such survey which was undertaken with the following objectives in general.

OBJECTIVES

The Survey was undertaken to find out the level of knowedge of the pre-exposed farmer trainees on the following aspects of groundnut technology.

a. Varieties.

b. Agronomical practices

c. Use of fertilizers and

d. Plant protection measures.

1. Knowledge about Varieties

Erect type of groundnut is more popular among the farmers of north region of Balasore district. Farmers mostly depend upon Block Agency for seeds. Very often seeds are not available in time and quantities as per demand. It was opined that those who procure seeds from local market they face with the problem of low germination percentage. Although, all the growers procure seeds from either Block or local market, still do not know the names of varieties. On determining the knowledge level about varieties of groundnut the result was obtained as appear in Table 1.

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TABLE 1. Knowledge about varieties. (N = 170)

Variety		Mean Score
a.	A.K. 12–24	0.970
b.	Kissan	0.370
c.	Phule Pragati	0.000

The findings reveal that the groundnut variety A.K. 12-24 is widely used by the farmers. The variety Kissan released by OUAT is yet to gain popularity among the farmers of Balasore district.

II. Knowledge about agronomic practices

The agronomic practices like field preparation, seed rate, seed treatment, use of bacterial culture, line sowing with spacing, inter cultural operations etc. were taken into considerations for assessing awareness of the farmers against the recommendations of the subject matter specialists as shown in Table-2.

TABLE 2. Knowledge about varieties. (N = 170)

Practices		Mean Score
a.	Field preparation with four ploughings & fine tilth.	0.911
b.	Seed rate per acre	0.852
c.	Seed treatment	0.341
d.	Use of bacterial culture	0.100
e.	Sowing of seeds with spacing	0.864
f.	Intercultural operation	0.658

The survey reveals that many of the ground-nut growers are aware of field preparation with fine tilth, approximate seed rate per acre, sowing of seeds with approximate spacing, where as very few of them know the use of bacterial cultural, and seed treatment.

III. Application of Fertilizers :

Almost all the growers apply fertilizers in groundnut, but many of them do not use doses as recommended by subject matter specialists. The knowledge level of the farmers about of fertilizer swas determined as appeared in Table-3.

TABLE 3. Fertilizer application.

	Fertilizer	MOS	MSO	Gap in knowledge (%)
a.	Doses of NPK	3	1.058	64.73
b.	Time of application	2	1.611	19.45
c.	Method of placement	1	0.852	14.80

MOS: Maximum obtainable score

MSO: Mean score obtained

Findings reveal that there is considerable gap (64.73%) in knowledge of the farmers about doses of NPK in groundnut, where as knowledge about time of application and method of placement is not much lacking with them.

IV. Control of pests and diseases

Alertness of farmers against damage of pests and diseases is most important for higher production of groundnut. The plant protection measures in groundnut mostly include four important pests and two diseases which are commonly observed in the area of study. The knowledge about control measures of these pests and diseases of the trainees appears in Table 4.

TABLE 4. Knowledge about control measures of pests and diseases. (N = 170)

	Subject	Mean Score
	Pests	
a.	Termites	0.841
b.	Redhairy caterpiller	0.600
c.	Alphid	0.911
d.	White grab	0.423
	Diseases	
a.	Tikka disease	0.717
b.	Seedling blight	0.722
c.	Collar rot	0.323

Results indicate that trainees possessed very little knowledge about the control measures against the pests like white grab and hairy caterpiller and diseases of collar rot compared to other pests and diseases as contained in Table 4. Therefore, more emphasis should be given to train them on control measures against termite, aphid, tikka disease and seedling blight.

Conclusion

The findings of the study indicate the training needs of the groundnut growers in Orissa on the following areas.

1. Popularisation of Kissan variety of groundnut which matures in 95 days in *Kharif* and 135 days in *Rabi* season and is resistant to tikka disease with dormancy period of 15 days.

2. Seed treatment and use of bacteria culture in groundnut.

3. Application of proper doses of NPK, their time and method of application.

4. Control measures of pests like red hairy caterpiller, white grab and diseases like tikka and collar rot.

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BIOCHEMICAL FACTORS IN *HELIANTHUS ANNUUS* L. IN RELATION TO RUST, *PUCCINIA HELIANTHI* RESISTANCE

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Biochemical basis of disease resistance, disease development and host specificity in plants are not very well understood. Several workers have correlated the presence of phenolics in plants with resistance to various pathogens. Murthy and Bhagyaraj (1985) have correlated resistance to *Fusarium* wilt in pigeonpea to the quantity of phenols. Similar observations have been reported by Rao *et al.* (1968) in sugarcane and Burns (1971) ghum. The present study was carried to findout biochemical differences in Sor- associated with the resistant and susceptible cultivars of *H. annuus* to rust, *Puccinia helianthi.*

Leaf samples for analysis from both susceptible (17-1, 65, 235, 128-1 and 235) and resistant (BSH-1, 6D-1, 6D-5-3, 6D-5-3-5, 6D-5-3-7, 6D-9-5-3, 381) sunflower cultivars were collected from the field, which were grown under same agronomic practices during *kharif* season at GKVK, University of Agricultural Sciences, Bangalore.

The phenolic content was determined by following the method of Swain and Hillis (1959) using Folin-Dennis reagent. The tannin content was determined by the method of Burns (1971) using vanillin-HCl reagent. The total quantity of nitrogen chlorophyll and chlorophyll 'a', 'b' was determined by the procedure described in A.O.A.C. (1970) The free amino acids were analysed using KLA-3B Hitachi automatic analyser. The results of all the determinations were expressed in mg per 100 g sample.

The total nitrogen content remains almost same in both susceptible (21.1±2.8) and resistant (21.9±3.2) types respectively. The resistant cultivars contained higher amount of total phenols (13.5±1.65) when compared with the susceptible (10.5±1.3) cultivars. On the contrary, the susceptible cultivars contained more than twice the amount of tannins (1.24±0.21) as that of resistant (0.37±0.27) cultivars. The resistant cultivars contained higher amounts of free amino acids (90.2±14.6) than the susceptible (37.4±9.1) cultivars. Alanine (24.86±7.61) the major free amino acid in resistant cultivars as compared to susceptible ones (9.3±1.6). Tyrosine (16.03±5.2) is present only in resistant cultivars. There is a significant variation in the glutamic acid (8.7±1.3, 3.5±0.6), proline (7.76±1.6, 2.8±3.6), Valine (7.3±0.1, 5.67±1.15), Is oleucine (5.5±1.2, 3.36±0.25) and leucine (5.43±0.87, 3.13±0.41) between resistant and susceptible cultivars respectively. Histidine, arginine, phenyl alanine, aspartic acid, cysteine and methionine are absent in both susceptible and resistant lines. The resistant cultivars contained significantly higher level of total chlorophyll, chlorophyll 'a' and 'b' (32.0±6.9, 16.5±4.4 and 26.6±5.1) than the susceptible (16.5±4.4, 4.5±2.0 and 15.5±3.8) cultivars.

Studies have indicated that the oxidation products of naturally occuring phenols

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possess much higher fungitoxicity and increased occurence of phenols in resistant cultivars inhibit the pectinolytic enzymes produced by pathogenes. Patil (1974) and Wood (1974) have reported that the oxidation products of polyphenols inhibited th polygalactouronase activity produced by *Verticillium* wilt in resistance cultivars of potato. The susceptible cultivars synthesized phenolics too slowly to inhibit the multiplicity of pathogens as compared to the resistant cultivars. In addition, the invading mycelia also releases or stimulates the synthesis of tannins which increases the permeability of host cells. This altered permeability would disrupt the compartmentation of enzymes and cause uncontrolled oxidation of key metabolities, depriving the cell the energy needed for the bisoynthetic Pathway. This might also be true with sunflower as the susceptible cultivars show higher level of tannins than in resistant cultivars. The aromatic and long chain aliphatic amino acids were shown to be precursors for the biosynthesis of phenolicrs and related metabolites Durbin, (1983).

Platt *et al.*(1979) have reported increased levels of chlorophyll 'a' and 'b' in resistant plants. Rapid loss of chlorophyll rRNAs was observed by Tani *et al.* (1974) in oat leaves injected with *Puccinia caronomata avenae*. The present experiments on sunflower have shown that the resistant cultivars have high levels of chlorophyll 'a' and 'b' in addition to phenols and free aromatic and long chain aliphatic amino acids.

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